Essentials of Mini – One Anastomosis Gastric Bypass

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Introduction

In the late 1960s, after training in GI cancer, head and neck surgery, and intensive care in New York, I returned to Toronto where I became a surgeon at St. Joseph's Health Centre. I found that one of the major problems of GI surgeons was intestinal fistula, with patients slowly dying of malnutrition. Thus, after further training in trauma at Parkland Memorial in Dallas, I pioneered total parenteral nutrition (TPN) in Canada. Immediately, surgeons sent their complications to me, particularly GI fistulas, in which the patients healed without eating by the use of TPN. Accordingly, on a trip to Montpelier, France, I met Joel Faintuch of Sao Paulo, who had surgical nutritional interests in common with me, and we persisted in developing that field.

Because I was managing the starvation cases (which were particularly referred to me from other hospitals on late Friday afternoons), I began to be referred the opposite extreme—"morbid" obesity. These unfortunate patients, many with end-stage obesity, suffered their own set of serious medical problems. In 1970, I began performing the jejuno-ileal bypass, which had remarkable results in weight loss and resolution of co-morbidities. However, the major problem with the JI bypass was that it tied down the surgeon. Various complications, which could be readily treated and resolved, were not at all understood by internists and other surgeons.

We moved on to the loop gastric bypass and various forms of horizontal and vertical gastroplasties. Indeed, the vertical divided gastroplasty with the collar was similar to the sleeve gastrectomy which is being performed today. I followed this by >2500 Roux-en-Y gastric bypasses (RYGB), the later ones performed laparoscopically.

Because of the inability of bariatric surgeons to get their papers published in this new field, in 1991 I started and became Editor-in-Chief of a new journal published in Oxford, England, by Rapid Communications—*Obesity Surgery*. The journal initially did not do well, and it came under my ownership when it was about to be discarded. Within a few years, *Obesity Surgery* had an impact ranking of 17th, 12th, 7th, 6th, 6th and 6th out of 149 surgical journals, and ultimately metabolic surgery was blossoming. Indeed, we had written papers in the early 1980s concerning the major success of bariatric surgery in resolution of type 2 diabetes.

In 2001, I received a paper submitted by Robert Rutledge on a new and simpler operation with very good results—the mini-gastric bypass (MGB). There was prejudice by the reviewers who were performing the RYGB that this simpler operation could not have successful results. Accordingly, I was invited by Dr. Rutledge to work in his O.R. and pre- and post-operative clinics for 2 weeks, during which I became convinced that this operation, because of its safety and efficacy, was not to be discarded. Slowly, the MGB and its 2002 Spanish variant, BAGUA (one-anastomosis gastric bypass) reported in 2004, were both found to be superior operations for surgeons with open minds. I had found that when surgeons learn to do a complex procedure well (e.g. RYGB), they are reluctant to accept a simpler effective operation. I had previously seen that with the bilateral adrenalectomy for metastatic breast carcinoma (in which I had become a master), when that operation was no longer required because of the development of the pill Tamoxifen.

The mini-gastric bypass and one-anastomosis gastric bypass have spread widely and are now a most common form of bypass for bariatric surgery in India, Germany, France, Egypt, Israel, Mexico, Argentina, Italy and many other nations. Bariatric surgery for massive obesity and its co-morbidities has found its place. The world experts in MGB-OAGB have collaborated on this book, in order to manage pitfalls and contribute to this superlative surgery.

I thank my wife, Frances, and my two sons, Kevin, a spinal surgeon, and Wayne, a radiologist, for their understanding and support.

Toronto, ON, Canada Mervyn Deitel, MD

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1 A Brief History of Bariatric Surgery to the Present

Mervyn Deitel

1.1 How Did Obesity Develop To This Point?

Over the millennia, man has moved from a nomadic hunter-gatherer (consuming a diet high in protein), to a farming species consuming high loads of processed simple sugars [1]. Early man, in times of famine, developed "thrifty" genes which conserved energy [2]. These genes now, in times of plenty, have led to obesity, with insulin resistance and the metabolic syndrome (impaired glucose tolerance, type 2 diabetes, hypertension, atherosclerosis, dyslipidemia, fatty liver) [3]. In the past century, with the development of high-caloric fast-foods containing high levels of carbohydrate, saturated fat and salt, metabolic diseases became increasingly prominent. With the addition of computers and sedentary lifestyle, obesity has become the major form of malnutrition in the world [1, 4].

With the increase of obesity in the 1960s and the experience that conservative treatment for clinically severe obesity is frequently unsuccessful [5], bariatric operations developed for patients with body mass index (BMI) >40 kg/m^2 (or >35 with co-morbidities) [6]. These operations have resulted in significant excess weight loss (EWL), but the challenge has been to maintain the weight loss.

1.2 Operations for Morbid Obesity

The term "morbid" has been applied to obesity associated with serious, progressive, debilitating diseases. Osteoarthritis of weight-bearing joints, immobility, sleep apnea, hernias, certain cancers, urinary stress incontinence in women, infertility, and psychosocial-economic problems are associated with the obesity "epidemic".

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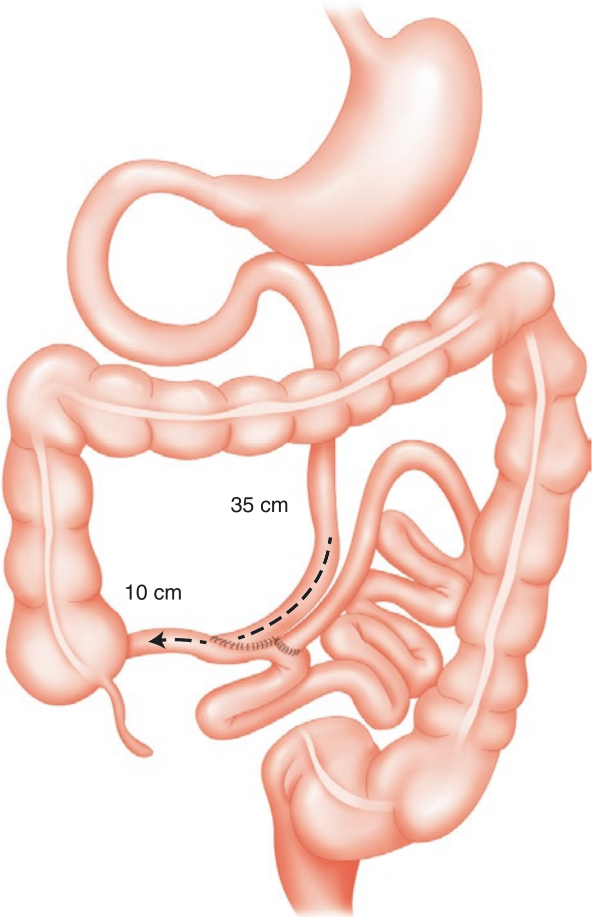

Fig. 1.1 A jejuno-ileal bypass that was very popular. The proximal 35 cm of jejunum was anastomosed to the side of the ileum 10 cm proximal to the ileocecal valve, constructing a Y-shaped anastomosis to inhibit reflux of digestive contents into the bypassed small bowel. The proximal closed jejunal stump was tacked to the ileum beside the anastomosis

1.2.1 Jejuno-Ileal Bypass

In the 1960s, jejuno-ileal bypass (JIB), using lengths determined surgically, was performed as a short-bowel malabsorptive syndrome, mainly for super-obesity (BMI >50) (Fig. 1.1). Postoperative weight loss resolved the obesity-associated diseases, particularly type 2 diabetes (T2D). However, complications occurred in many patients following JIB, which demanded constant availability of the surgeon [7]. The complications included episodic abdominal distension, migratory arthralgia and hepatic decompensation, from stasis and absorption of products from anaerobic bacteria in the bypassed bowel and from protein malnutrition. The arthralgia was controlled by oral metronidazole and the hepatic changes by oral sodium L-methionine (a lipotropic factor). However, steatorrhea led to oxalate nephrolithiasis in almost 10% of patients: ingested oxalate which is normally bound to calcium in the small bowel, was instead absorbed, because ingested calcium became bound to the non-absorbed fatty acids. Renal stone prevention required a low-oxalate diet.

Although the majority of JIB patients maintained the weight loss and continued into their old age [7], the occasional complications resulted in the JIB being reversed. Thus, JIB was abandoned.

1.2.2 Gastric Bypass

In the late 1960s, Edward Mason initiated bypass of 90% of the stomach with a loop gastrojejunostomy, as both a gastric-restrictive and malabsorptive operation (Fig. 1.2a) [8]. The weight loss resolved co-morbidities and appeared to have a safe course. However, at the operation, there was frequently tension on the loop anastomosis, with the potential for a devastating leak.

Thus, the gastric bypass was changed to a Roux-en-Y configuration (RYGB), and has been performed extensively (Fig. 1.2b, c), with 70% EWL at 5 years, but there has been variable regain later [9]. Complications consisting of early anastomotic leak, bleeding, internal hernia obstruction, and stomal (marginal) ulcer have occurred. Salicylates and smoking are prohibited.

Dumping syndrome occasionally follows RYGB due to rapid entry of sugary foods into the small bowel, and may beneficially prevent the patient from consuming sweets [10]. However, after many years, patients may resume sweet intake, which can induce dumping hypoglycemia, which the patient may treat by further intake of simple sugars with weight regain [11].

1.2.3 Gastric Partition

To simplify bariatric surgery, various restrictive gastroplasties were performed to leave a tiny food reservoir and produce satiety. In the 1970s, a *horizontal gastroplasty* was fashioned, with a narrow greater curvature outlet (Fig. 1.3a) [12]. However, the proximal gastric pouch and the outlet dilated significantly in many patients, allowing increased food intake.

In 1982, the horizontal gastroplasty was succeeded by a vertical gastroplasty with a lesser curvature channel, banded by a plastic mesh or a silicone band (Fig. 1.3b). The *vertical banded gastroplasty* (VBG) was extensively performed in the 1980s and 1990s with satisfactory initial weight loss, but the VBG was frequently followed by complications of pouch outlet obstruction, gastric partition breakdown, band erosion, and regain of weight [13]. The VBG often required revision to a RYGB, and thus was replaced by other procedures.

1.2.4 Gastric Banding

In the 1990s, a gastric band was placed around the proximal stomach to restrict intake (Fig. 1.4). This hollow band is connected by tubing attached to a

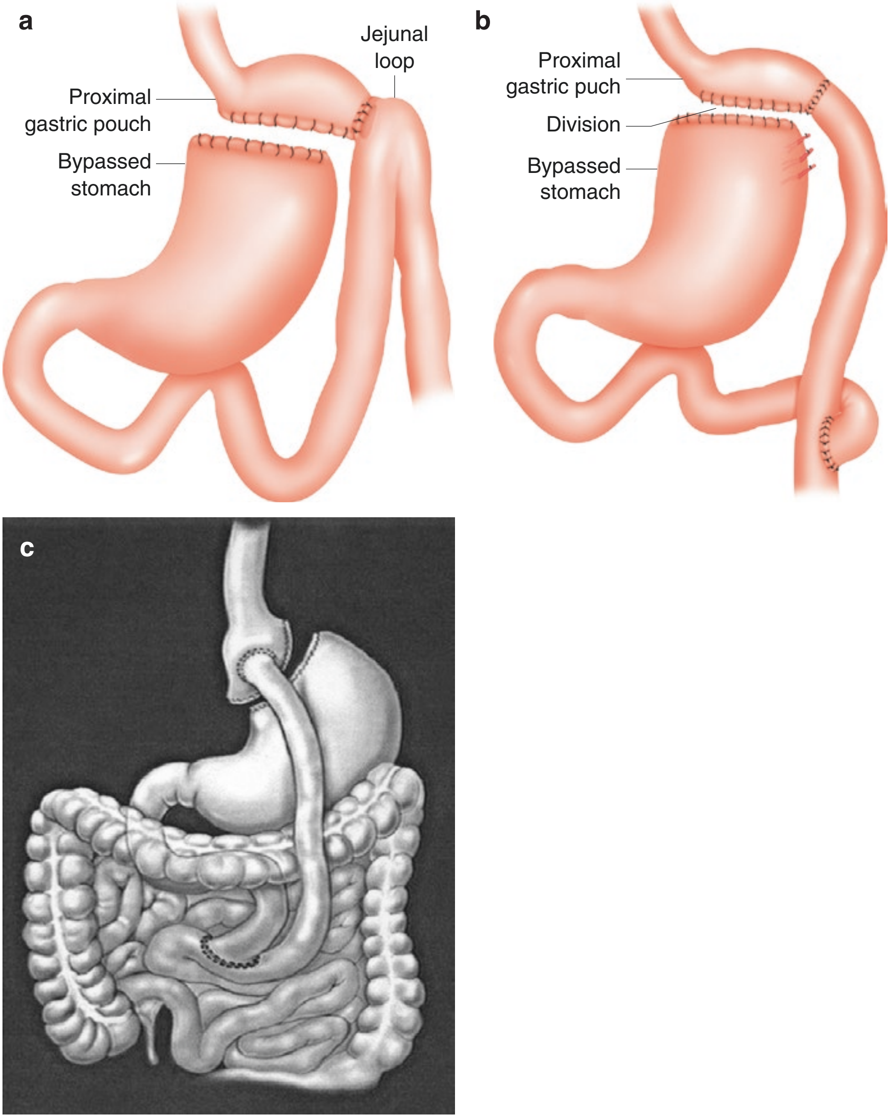

Fig. 1.2 (**a**) Original loop gastric bypass of Mason. The divided proximal 10% of the stomach was anastomosed to a loop of jejunum. (**b**) Roux-en-Y gastric bypass. The Roux limb prevents tension in construction of the gastrojejunostomy and also prevents reflux of intestinal contents into the tiny proximal gastric pouch. (**c**) The RYGB is now performed via the laparoscopic approach

subcutaneous reservoir; saline is added or withdrawn to control band size, necessitating frequent visits to supervise weight loss. The original *perigastric* technique of dissection (which was followed by occasional band erosion or slippage) was improved by a *pars flaccida* technique which produced minimal trauma to the

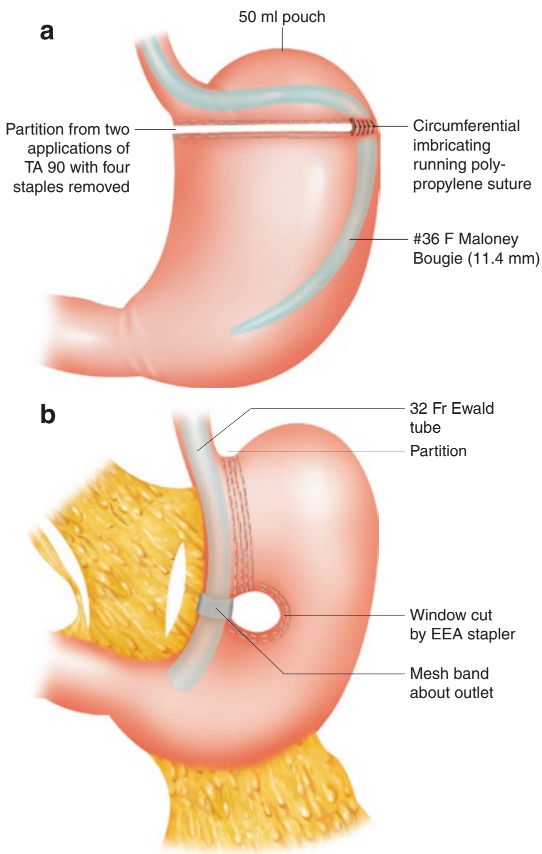

Fig. 1.3 (**a**) Horizontal gastroplasty of Gomez. The proximal stomach was partitioned by two applications of a linear stapler, leaving a greater curvature outlet which was reinforced circumferentially by a non-absorbable imbricating suture. (**b**) Vertical banded gastroplasty. A window was created which allowed introduction of a stapler for vertical partition of the stomach. A band prevented enlargement of the outlet of the gastric channel

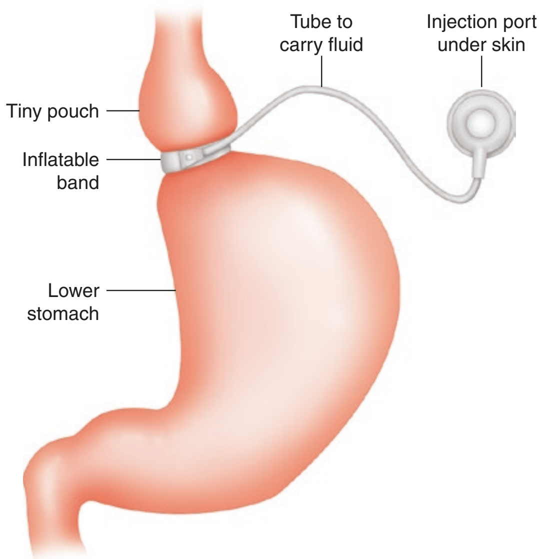

Fig. 1.4 Adjustable gastric band, leaving a tiny proximal gastric pouch. A subcutaneous reservoir on the fascia communicates by fine tubing with the hollow band; reservoir injection or withdrawal of saline tightens or loosens the band

gastric wall [14]. Mean EWL in patients who still had the band after 5 years was about 45%, but there have been occasional band erosions, band dislodgements, and reservoir problems [15].

1.2.5 Laparoscopic Technique

In the mid-1990s, bariatric operations began to be performed laparoscopically. The laparoscopic technique, working through tiny trocars into peritoneal cavity with a viewing scope and video monitor, has proved to be very safe in experienced hands, with even better results than the open approach. In super-obese patients, a high-protein low-carbohydrate diet for 2–4 weeks preoperatively has been consumed to shrink the fatty liver, to provide more space for the laparoscopic procedure [16].

1.2.6 Biliopancreatic Diversion

To avoid the complications of the jejuno-ileal bypass due to the blind loop, Nicola Scopinaro devised the biliopancreatic diversion (BPD) in the late 1970s (Fig. 1.5) [17]. This malabsorptive procedure resulted in ~85% EWL and excellent resolution of T2D. Starches and fats were absorbed in the distal 50 cm of ileum. However,

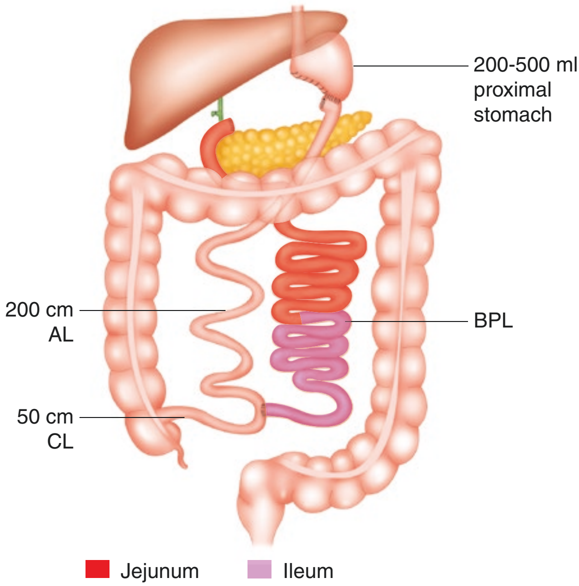

Fig. 1.5 BPD. Distal gastrectomy was performed. Small bowel was divided 250 cm proximal to ileocecal valve, and was anastomosed to the gastric remnant. Biliopancreatic limb (BPL) was anastomosed to side of the distal limb, 50 cm proximal to the ileocecal valve, leaving a 200 cm alimentary limb (AL) and a 50 cm common limb (CL)

the BPD had occasional complications of hypoalbuminemia with swollen ankles and vitamin-mineral deficiencies, which were difficult to manage despite supplementation.

1.2.7 Duodenal Switch

The BPD was modified to the duodenal switch (DS) (Fig. 1.6) in the 1990s, with long-term 70% EWL and a low risk of complications [18, 19]. Food enters a lesser

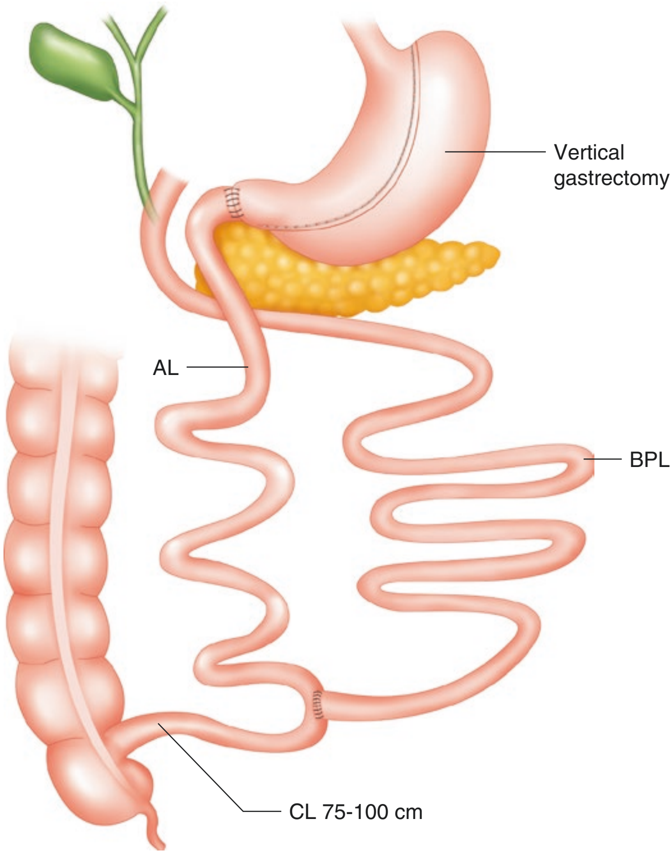

Fig. 1.6 Duodenal switch. The greater curvature portion of the stomach is excised, leaving a restrictive lesser curvature gastric channel. The small bowel is divided 250 cm proximal to the ileocecal valve, and the alimentary limb (AL) is anastomosed to the divided proximal duodenum. The biliopancreatic limb (BPL) is anastomosed to the side of the AL 75–100 cm proximal to the ileocecal valve, forming the *distal* common limb (CL) where digestion occurs

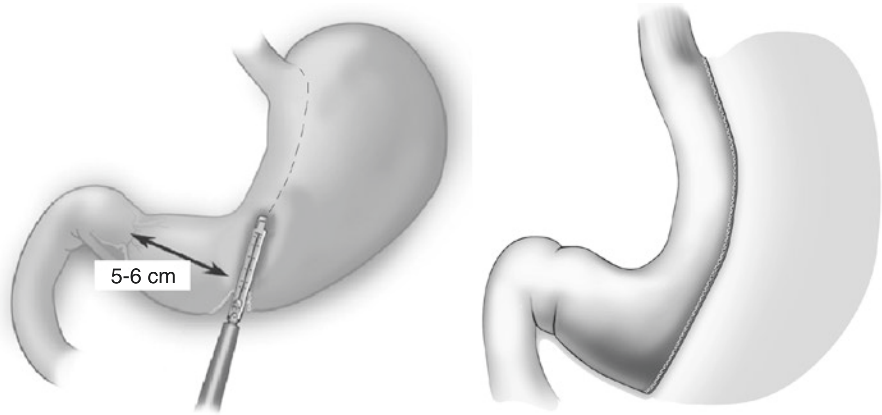

Fig. 1.7 (Left and right) Sleeve gastrectomy. Starting on the greater curvature going across antrum, the stomach is resected vertically over a 30–50 French oro-gastric tube

curvature sleeve, which restricts intake for about 9 months. The small bowel is divided 250 cm proximal to ileocecal valve, and is anastomosed to the divided first part of the duodenum. The biliopancreatic limb is anastomosed to the side of ileum ~100 cm proximal to the ileocecal valve. The malabsorption maintains the weight loss. There are problems of frequent stools and foul flatus, which can be controlled.

1.2.8 Sleeve Gastrectomy

In many super-obese and poor-risk patients, it was found that the DS operation should be staged. Accordingly, starting in 2001, only the sleeve portion of the DS was performed as a first stage; however, it was found that many patients had satisfactory weight loss, and did not require the second stage [20]. Thus, the sleeve gastrectomy (SG) is being performed commonly as a stand-alone operation (with a narrower channel than in the DS) (Fig. 1.7 left and right). Mean EWL at 5 years is ~60% (almost as high as the RYGB), but regain of weight frequently occurs.

With resection of the fundus and dissection of the angle of His and left crus in the SG, the serious complication of proximal leak may occur, which necessitates closure and drainage if early or if later, drainage, NPO, stents, TPN, jejunostomy feeding, or a Roux-jejunal loop. The leaks are frequently stressful but successfully treated.

Gastro-esophageal reflux and Barrett's esophagus may develop in one-third of patients after SG [21–23]. Stricture of the gastric channel may require dilatation or reoperation. Patients with regain of weight have been treated with a band around the sleeve, or conversion to a DS, RYGB or now, frequently, a MGB.

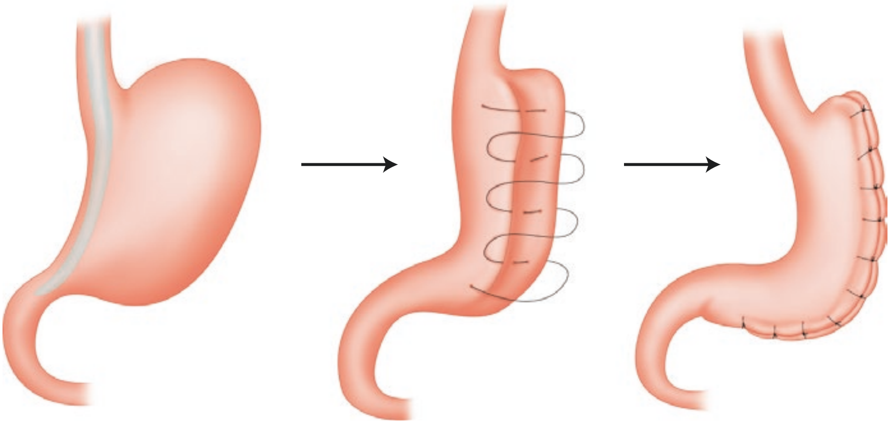

Fig. 1.8 Gastric plication. The greater curvature of the stomach is freed, and 2 layers of non-absorbable seromuscular suture are run from 1–2 cm beyond the angle of His to 3–4 cm proximal to the pylorus, against a 32-French oro-gastric tube, decreasing the lumen

1.2.9 Gastric Plication (GP)

GP was recently under trial (Fig. 1.8). The freed greater curvature of the stomach was imbricated in two running layers against a lesser-curvature calibrating tube [24]. This procedure was very safe, but dilatation of the gastric channel and regain of weight have been frequent.

1.2.10 Single-Anastomosis Duodenoileal Bypass with Sleeve Gastrectomy (SADI-S)

SADI-S is a simplified single-loop variant of the duodenal switch (Fig. 1.9). The SADI-S has the possibility of leak at the top of the SG, it requires duodenal mobilization in the right gutter, bowel measurement to prevent hypoproteinemia has difficulties [25], and bowel obstruction has been reported [26]. However, resolution of co-morbidities has been excellent. It is a longer operation than the MGB, and is more difficult to revise.

1.2.11 Mini-Gastric Bypass (MGB) and One-Anastomosis Gastric Bypass (OAGB)

The MGB [27] and its variant, the OAGB [28], are safe, rapid procedures, which have become the second most common of the bypass operations [29], and is increasing internationally.

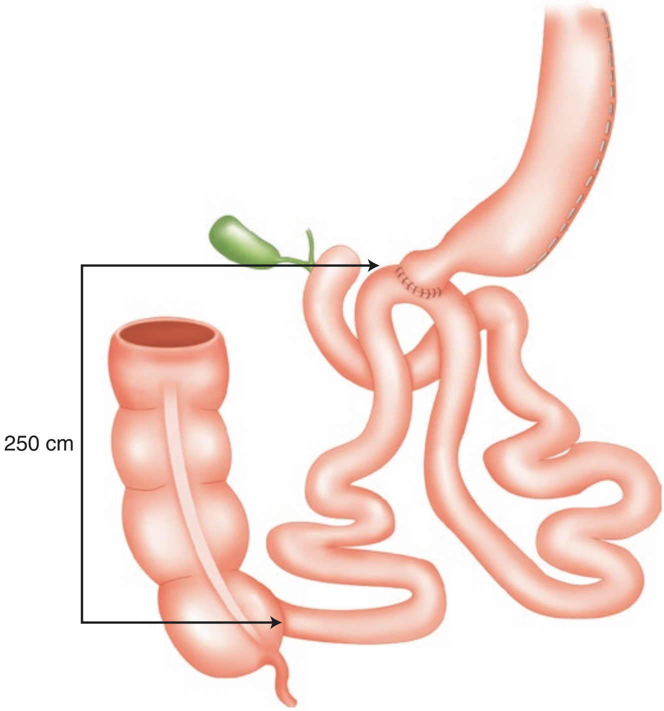

Fig. 1.9 SADI-S. Sleeve gastrectomy followed by end-to-side single-loop duodeno-ileostomy, with 250 cm between anastomosis and iliocecal valve. Anastomosis performed in antecolic, isoperistaltic fashion

The MGB (Fig. 1.10a) was first performed by Rutledge in 1997 in USA, to reconstruct the stomach when he was faced with a gastric gun-shot wound. A gastric channel is created by dividing the stomach horizontally *below* crow's foot, and then dividing vertically, avoiding the angle of His [30]. The *long* gastric pouch is anastomosed to an antecolic loop of jejunum, ~200 cm distal to Treitz' ligament (varied with the BMI) [31].

After Rutledge's work, in 2002 Carbajo and Garciacaballero in Spain (after having performed the RYGB for >10 years) initiated the OAGB variant of the MGB (the BAGUA—*Bypass Gastrico de Una Anastomosis*) to prevent potential gastroesophageal (GE) reflux (Fig. 1.10b) [32]. However, after the MGB with its low-pressure tube [33], GE reflux has occurred in <1% and cancer is almost unknown [34].

The MGB and OAGB are followed by superior resolution of co-morbidities, good quality of life, and usual lasting weight loss [35, 36].

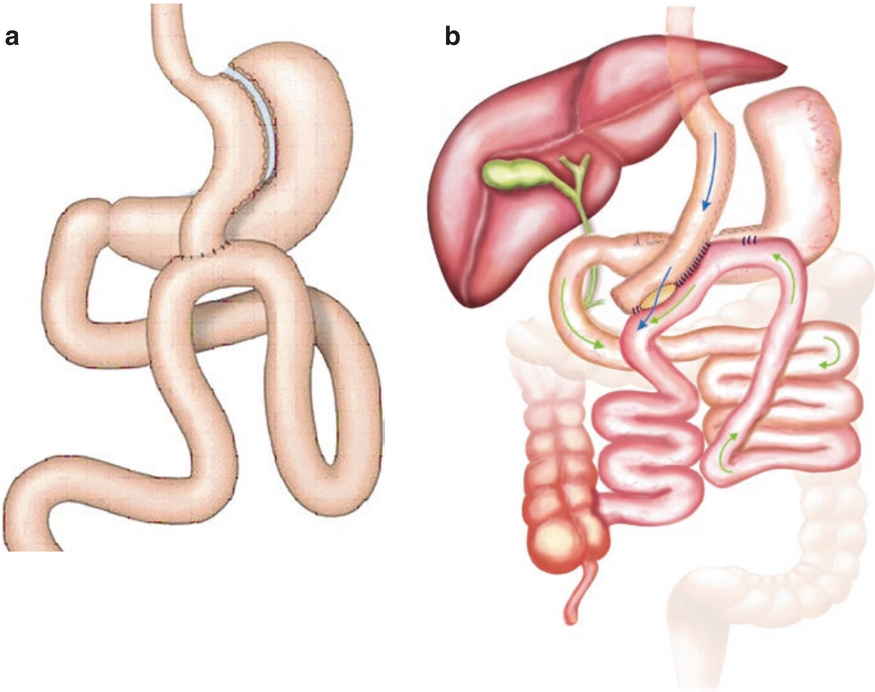

Fig. 1.10 (**a**) MGB. A vertical channel starting *below* the crow's foot is stapler-divided proximally going to the left of the angle of His; the long gastric pouch is anastomosed by a wide antecolic gastro-jejunostomy ~200 cm distal to Treitz ligament. (**b**) OAGB, with a 15–18 cm gastric channel (pouch). A 2.5 cm latero-lateral anastomosis is made between the pouch and antecolic afferent jejunal loop. The afferent loop is suspended above the anastomosis by a continuous suture, which secures the loop to the gastric pouch's staple-line. Apex of the loop is fixed by sutures to the bypassed stomach (diagram by Arturo Valdes Alvarez)

1.3 Resolution of Type 2 Diabetes

After bariatric operations, there is decreased intake or absorption of food, with decreased adipose tissue, accompanied by improvement in insulin sensitivity [37]. After gastric banding, resolution of T2D has been reported in 40% of patients [38]. After the operations with rapid entry of nutrients into lower small bowel (JIB, RYGB, DS and especially MGB-OAGB), resolution of T2D has occurred in ~80–95% of patients [39, 40]. Undigested food causes *incretins* (meal-stimulated intestinal hormones that stimulate beta cells) to be secreted into the bloodstream; glucagon-like peptide-1 (GLP-1) from the L-cells of the hindgut causes proliferation of pancreatic beta-cells [41, 42]. Furthermore, bariatric operations are being performed to treat T2D in patients who are less than morbidly obese, to enable rapid transit of food to ileum [43, 44].

An important hormone in weight control is ghrelin (*growth-hormone-releasing hormone*). Ghrelin is secreted by the stomach during hunger (fasting) and promotes intake of food [45]. After bariatric operations that include resection of stomach, plasma ghrelin is decreased.

1.4 Nutritional Complications and Their Prevention

Morbidly obese individuals preoperatively frequently have low serum vitamin D_3 and even secondary hyperparathyroidism. This may be due to lack of exposure of skin to sunlight. Following most bariatric operations, vitamin D_3, calcium and iron should be supplemented [46].

Metabolic bone disease may be increased after operations where calcium compounds do not acquire adequate gastric acid for their breakdown.

After restrictive operations, patients may have difficulty chewing red meat adequately to pass through the narrow pouch. In operations which bypass the duodenum (where iron absorption normally occurs), iron deficiency anemia may develop, especially in menstruating women after RYGB and MGB-OAGB (which requires intestinally-absorbed Proferrin®).

After gastric bypass or sleeve gastrectomy, crystalline vitamin B_{12} supplementation is indicated, because the site of intrinsic factor (fundus) has largely been removed [47]. Folic acid supplementation is necessary during reduced oral intake, particularly in women of reproductive age at time of conception, to prevent neural tube defects in the offspring.

In patients who experience excess postoperative vomiting, thiamine (vitamin B_1) deficiency can develop, leading to Wernicke's syndrome, which must be treated urgently with parenteral thiamine [48].

All patients require postoperative surveillance, and must have adequate protein intake and multiple vitamin/mineral supplementation. Female patients should avoid becoming pregnant until 12 months after a gastric restrictive operation and 18 months after a malabsorptive operation [49].

1.5 The Bariatric Team

Besides the bariatric surgeon, a bariatric team evaluates the patients preoperatively and follows them over the postoperative years. The team may include a dietitian/nutritionist, bariatric nurse, endocrinologist-diabetologist, internist, pneumonologist, and psychiatrist/psychologist.

Conclusion

On medical therapy, severe obesity has failed to lose significant weight. Thus, operations providing weight loss by gastric restriction with early satiety and especially by intestinal bypass with malabsorption have evolved over the past

50 years. The bypass operations are now being used to resolve T2D in patients with lesser obesity. Oral supplementation is necessary postoperatively for vitamin D_3, calcium, iron, B_{12} and folate. The MGB and OAGB operations are fairly rapid and simple, with excellent resolution of co-morbidities, durable weight loss and ease of reversal—as described in this book.

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2 Understanding the Technique of MGB: Clearing the Confusion

Robert Rutledge, Kuldeepak S. Kular, Sonja Chiappetta, and N. Manchanda

2.1 Introduction

Since the first Mini-Gastric Bypass (MGB) was performed by Dr. Robert Rutledge in 1997, the MGB has had a long and circuitous route from conception to widespread adoption. Much of the 20-year gestation of the MGB was related to misunderstanding and confusion of some basics of general surgery, their application and the specific technique of the MGB. There is now recognition of the MGB as a good and maybe the best form of bariatric surgery [1–3]. The aim of this chapter is to provide the correct surgical technique of the MGB (Fig. 2.1), to seek the best results and avoid short- and long-term complications.

2.2 What a Bariatric Surgeon Should Not Forget

The gastric pouch of the MGB is analogous to the Collis gastroplasty and the bypass is equivalent to an antrectomy and Billroth II. In contrast to the anatomy and physiology of the Lap-band, sleeve gastrectomy (SG), Roux-en-Y gastric bypass (RYGB), the "banded" RYGB, the "banded" SG and various sleeve plus distal bypass operations such as the single-anastomosis-duodeno-ileal bypass, the gastric pouch of the

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M. Deitel (ed.), *Essentials of Mini – One Anastomosis Gastric Bypass*,
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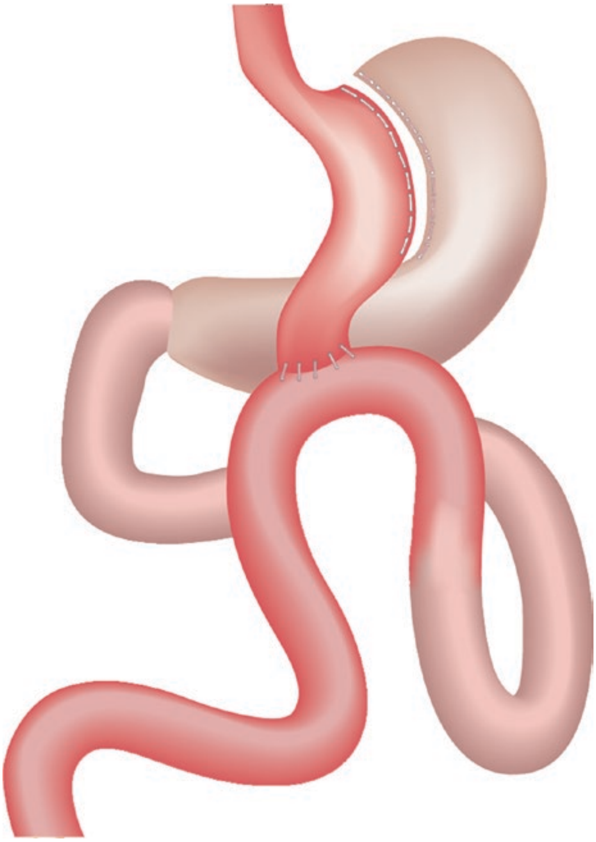

Fig. 2.1 MGB created by horizontal division distal to crow's foot and then vertical division upwards to the left of the angle of His. A wide antecolic gastro-jejunostomy is performed commonly 180–200 cm distal to Treitz' ligament

MGB is intentionally designed to be a "non-obstructive" conduit for food (like the esophagus) from its upper inlet to its outlet. Adding a moderate bypass to the MGB gastric pouch induces rapid gastric emptying into the mid-jejunum. This anatomy then produces an exaggerated post-gastrectomy syndrome physiology that makes sweets and liquid calories induce discomfort and any more than small amounts of fatty foods similarly relatively intolerable [4]. This effectively leads to an aversion to high calorie, high fat, "junk" foods, and encourages a six small meal diet of low sugar and low fat dietary choices that is equivalent to the standard general surgery "post-gastrectomy syndrome diet" and in many ways mimics the Mediterranean diet.

In this chapter, we will discuss the creation of the gastric pouch, the bilio-pancreatic limb and the end-to-side gastro-jejunostomy (GJ). The old Mason loop gastric bypass included a gastric pouch and loop-type GJ, but is not an MGB. Critics of the MGB often do not understand some of the basic components of the anatomy and physiology of the MGB, which are critical to differentiating the MGB from the old Mason loop horizontal gastric bypass [5].

To perform a safe and successful MGB, surgeons need to differentiate between the placement of a GJ within a few centimeters of the esophagogastric (EG) junction, as opposed to antrectomy and Billroth II type reconstruction, in which the GJ is placed in the antrum. As can be seen in the MGB done by surgeons knowledgeable in the MGB technique, the completed GJ should lie distant from the left upper quadrant and usually at the level of transverse colon, far distal to the EG junction.

Unfortunately, surgeons and surgeons' websites incorrectly claim that they are performing the MGB, but the diagrams, or postoperative endoscopy/radiological studies demonstrate a short gastric pouch. The low-pressure pouch designed for the MGB, must be created 1–2 cm distal to the crow's foot, to protect the esophagus from GE reflux. When the GJ is performed between the long gastric pouch and jejunum, the MGB has been shown to be a very effective and safe operation. If the small bowel with bile is placed adjacent to the EG junction, bile may reflux into esophagus, leading to serious "bile reflux esophagitis".

The work of Theodor Billroth 100 years ago ushered in gastric resectional therapy, first for cancer and later for peptic ulcer disease. In 1993, Goh reported that laparoscopic Billroth II gastrectomy offers a minimally invasive option that is remarkably less traumatic for gastric ulcer and cancer [6]. General surgeons know that following a total or high subtotal gastrectomy, a Billroth II should not be performed, because of possibility of bile reflux esophagitis, and a Roux reconstruction is used instead.

2.3 Critical Factors in Creation of the MGB Gastric Pouch

The creation of the gastric pouch in MGB is different in its goals and performance than the proximal gastric pouch created in the Lap-band, SG and RYGB, which are restrictive AND "obstructive." After "obstructive" restrictive procedures, patients are forced to have "pathologic eating." Usual bulky healthy foods such as broccoli, sandwiches and apples are problematic, and ice cream, Coca-Cola, candy and other soft calories are easily consumed, leading to pathologic eating and later to weight regain. The MGB pouch and physiology are different, restrictive but NOT obstructive. In the MGB, the bougie size between 28 and 36 Fr is not critically important. Focusing on bougie size is often a hold over from the use of bougie in the SG. The MGB does restrict the intake of food but not via a stricture type obstruction and must not create a stricture/obstruction.

The MGB pouch is designed for relatively rapid non-obstructive transport of food from the esophagus into small intestine. Food passes rapidly into the small bowel. This results in the well-known general surgical post-gastrectomy syndrome and is managed by the patient's following a post-gastrectomy syndrome diet, which intentionally avoids sweets and liquid/soft calories; after MGB, fresh healthy foods are often well-tolerated, whereas sweets, greasy, heavy and so-called junk foods are poorly tolerated. The pouch diameter is equal to the diameter of the esophagus. The pouch length, GJ and Loop Billroth II are designed to recapitulate the surgical analogue of antrectomy and Billroth II.

In a survey of >3000 of our MGB patients, the postoperative meals were approximately 25% of what they ate pre-operatively—significant restriction, without obstruction. The decrease is largely due to the “large” non-obstructive gastric pouch, the non-obstructive GJ leading to rapid gastric emptying, and the widely and well understood post-gastrectomy syndrome. After MGB, the patient is inhibited from eating sweets, high fat or high volume foods, and instead is induced into eating a “post-gastrectomy syndrome” type diet—high in relatively normal healthy food, such as an apple, sandwich or broccoli for example, which are often problematic for the Band/SG/RYGB patient.

The gastric pouch should lie such that the medial aspect (the mesentery of the lesser curvature) points directly the usual position of the ports to the patient’s right and the neo-greater curvature (staple-line) points directly to the patient’s left, with anterior and posterior walls of the pouch being equal.

It is important to avoid bleeding, which may occur if the staple-gun is applied rapidly. Rather, compression by the stapler is the primary component for the control of bleeding. The rapid firing of the stapler may lead to a need to control bleeding by cautery, clips and suture which may waste time and sometimes can compromise the staple-line.

A critical point in the performance of the MGB is management of the EG junction. SG surgeons have extensively focused on the need for extensive dissection of the EG junction. Numerous studies show that more than 90% of SG leaks occur at the EG junction [7]). SG leak at the EG junction is often a devastating complication. In the performance of the MGB, experience has shown that the EG junction should be avoided. The MGB technique explicitly avoids the EG junction, as there is no advantage to dissecting it and, as the SG experience shows, there is a great danger in this dissection. For the same reason, the final staple-line division of the stomach in the MGB is intentionally placed lateral to the EG junction (Figs. 2.2, 2.3, 2.4, 2.5, 2.6, 2.7, 2.8, 2.9, and 2.10). Always perform the proximal division in the MGB lateral to the EG junction. Leaving a small amount of fundus behind is always acceptable (Fig. 2.11).

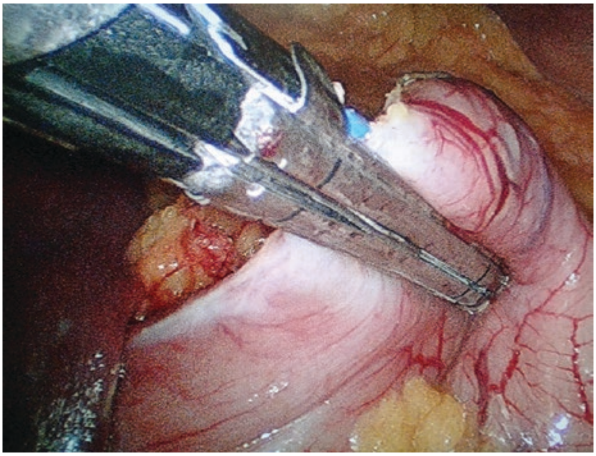

Fig. 2.2 The first fire, 45 mm blue, through the epigastric port

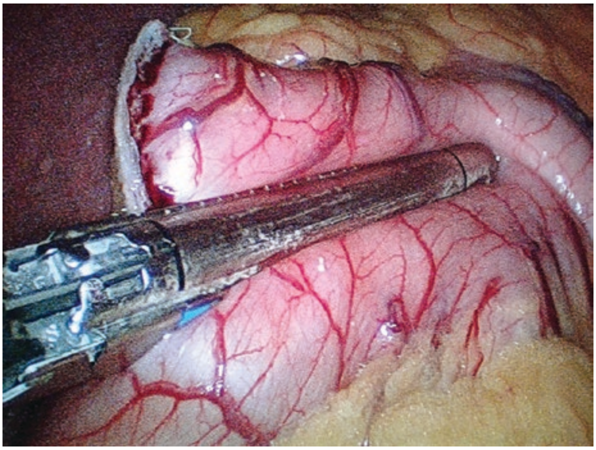

Fig. 2.3 Second fire from right subcostal port, parallel to the lesser curvature

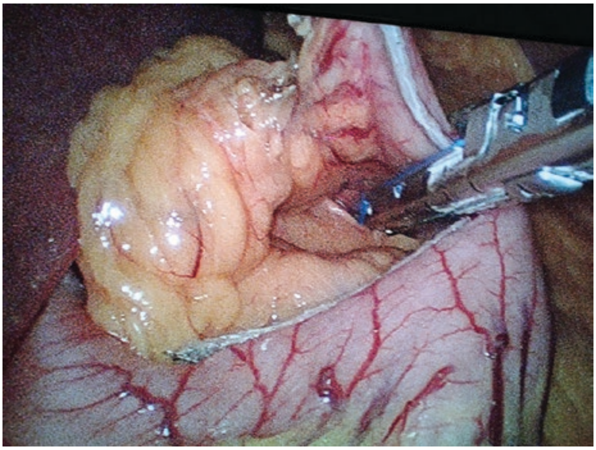

Fig. 2.4 Third fire from the left subcostal port, vertically upwards, along the lesser curvature

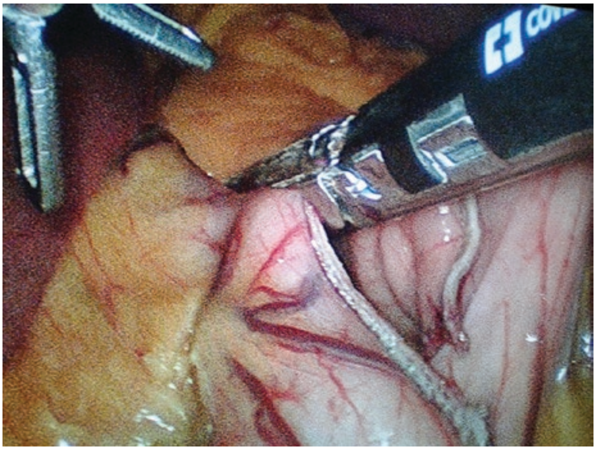

Fig. 2.5 Making the tube along the lesser curvature loose over the bougie

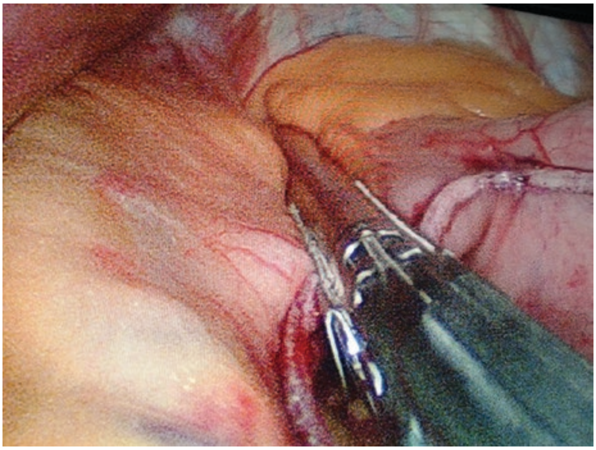

Fig. 2.6 Last fire on the gastric tube

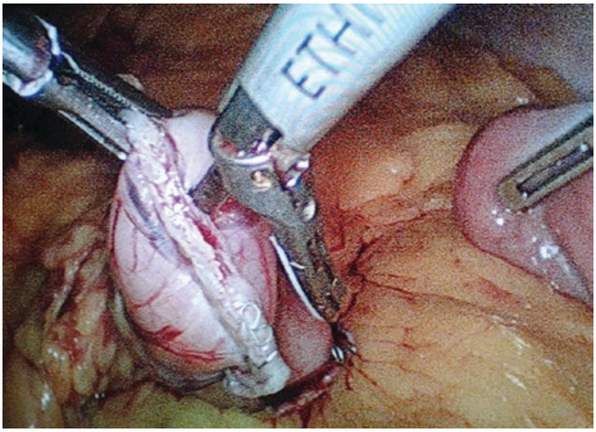

Fig. 2.7 Anterior gastrotomy at the tip of the gastric tube

Fig. 2.8 Antimesenteric jejunotomy, keeping the harmonic, the jejunum and the assistant's instrument in one line

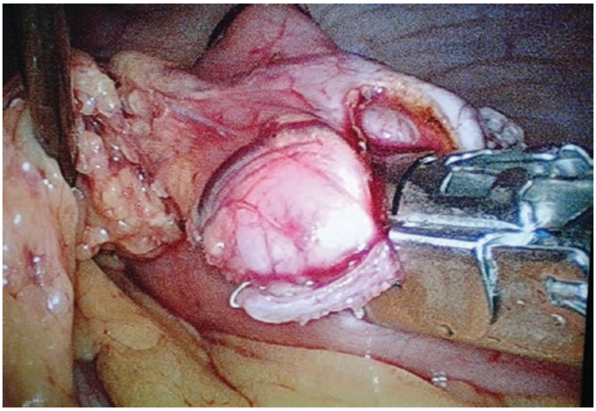

Fig. 2.9 Gastro-jejunostomy with 45 mm blue through the umbilical port, cutting the first staple in the middle

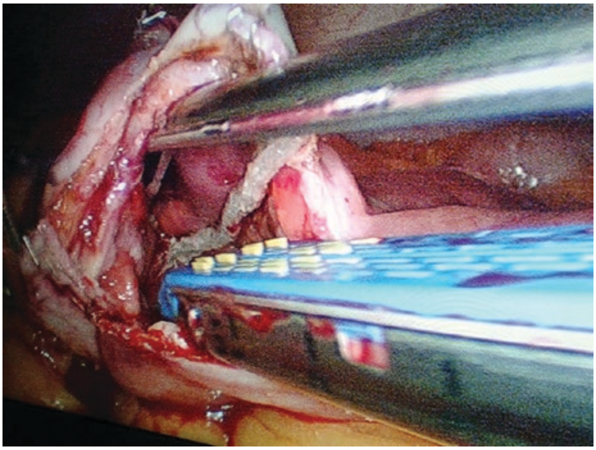

Fig. 2.10 Checking the anastomotic hemostasis

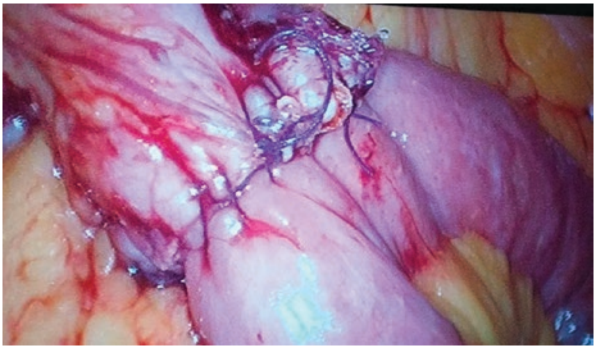

Fig. 2.11 Final gastro-jejunostomy view

2.4 Port Placement

Five ports are placed in a diamond-shaped pattern in the upper abdomen.

(Fig. 2.12). Location of the ports is as follows: 12-mm camera port in the midline, 2 handbreadths below the xiphisternum; 12-mm retractor port in the right midclavicular line, 2–3 fingerbreadths below the costal margin; 12-mm midline working port, 2–3 fingerbreadths below the xiphisternum; 12-mm left working port, 2–3 fingerbreadths below the left costal margin in the midclavicular line; and 5-mm assistant port in the left anterior axillary line, 2 fingerbreadths below the costal margin.

2.5 Management of Hiatal Hernia

In patients with or without gastro-esophageal reflux disease (GERD) and a hiatal hernia (HH), the MGB technique explicitly avoids dissection of the EG junction, i.e., the MGB does *not* dissect the hiatus nor repair the crura. For a variety of reasons, including the fact that the MGB creates a low-pressure tube, the MGB leads to resolution of GERD to >85% [8]. Our experience of >6000 patients demonstrates that repair of a HH rarely needs secondary treatment. However, in the case of a massive HH, the stomach is reduced as a usual step of creating the gastric pouch and the patient is referred for further evaluation in 12 months.

The success rate of MGB in treating GERD is higher or equal to the success rate of Nissen or other forms of HH repair, without the attendant risks and complications of dissection of the EG junction proven by the experience with sleeve gastrectomy. In the uncommon event that repair of an HH remains necessary, this should be done 12–18 months later when the patient is healthier and thinner. In the author’s experience, follow-up CT Scan and endoscopy have led to further intervention in only two cases with the placement of mesh in an uncontaminated field.

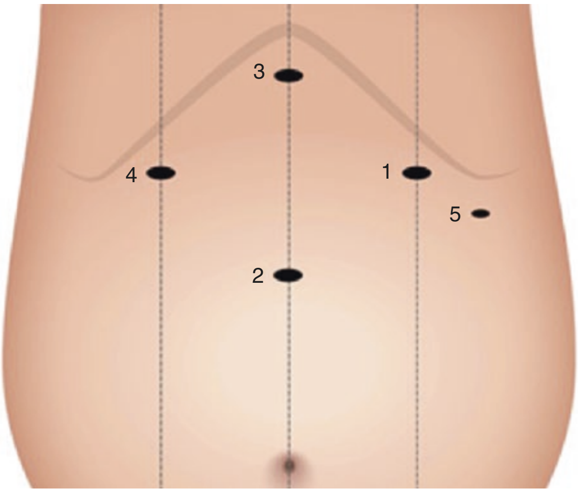

Fig. 2.12 Usual location of ports for the MGB

2.6 The Biliopancreatic Limb

The performance of the MGB should never require division of the omentum. Division increases reactive scar tissue and increases the risk of internal hernia and bowel obstruction. Leave the omentum alone; simply retract it medially. Run the small bowel hand-over-hand in the left mid-abdomen with atraumatic bowel clamps. With this technique also important visceral fat mass can be handled easily. Gentleness in handling the tissue is critical to avoid damage to the small bowel.

It should be recalled that the small intestinal length changes due to food, cold, pain and other forms of both parasympathetic and sympathetic tone. The bowel length varies moment to moment so that "perfect" bowel length is impossible to determine at operation. It is more important to be sure of having at least 2–3 m of small bowel distal to the GJ to avoid malnutrition. The MGB is unique in allowing the surgeons in consultation with the patient and referring physician to select either a conservative approach for biliopancreatic (BP) limb length or in selected cases the BP limb length may be tailored to meet the needs and desires of the patient, family and their physician. In certain circumstance where the patient has justification for a more aggressive approach, e.g., super-obesity or severe or progressive disease, the MGB allows the patient, family and surgeon to discuss a more aggressive approach on an individual basis, i.e., a longer bypass.

For example, 150 cm is relatively conservative with a predicted outcome of excess weight loss needing revision of 1/1000 cases. Whereas a longer bypass of 200 cm obtains 80–85% excess weight loss, it increases the risk of excessive loss to as much as 1% of cases, including malnutrition and vitamin deficiency. Either approach has merit, depending upon the needs and wants of the patient as well as the preference of the surgeon. Factors such as the patient's dietary choices (vegetarian), knowledge, follow-up capability, the surgeon's experience and outcomes with the MGB, as well as family and the societal issues all may be taken into account.

2.7 Measuring the Bowel Length

It needs to be understood that any attempt to measure bowel length is necessarily imperfect. Measuring the length of grasper tip (usually between 1.5 and 3 cm) and run the bowel length approximately 60 steps which translates to 3 cm (1.2 in.) at each grasp. Creating a biliopancreatic limb of ~180 cm is a reasonable choice, depending on the patient. Situations that may determine the choice of limb-length include overall illness of the patient, diabetes, older age, heart disease, a vegetarian diet, and problematic follow-up.

After identifying the site of the proposed GJ and the length of the BP limb and prior to proceeding, confirm that at least 2–3 m of small bowel is present distal to the GJ. Specifically, it is *not* necessary to run the entire small bowel.

2.8 Creation of the Gastro-Jejunostomy

The gastro-jejunostomy of the MGB is a critical part of the procedure, and it is not similar to the GJ created in the RYGB. GJ could be considered one of the most important steps in the MGB. Most surgeons new to the MGB have little idea of the importance of the GJ in the procedure. The sometimes stated and sometimes implicit in the SG, the Band and the RYGB is the idea of a high-grade obstruction, a stricture as the tool, which blocks eating and is the critical factor in the success or failure of the operation. This is not the goal or the mechanism of action of the MGB. This misunderstanding is so widespread as to be critical, so that it be restated in this chapter on several occasions. To restate this issue again: the goal of the GJ in the MGB is a wide open and non-obstructive GJ that allows easy and rapid emptying of the gastric pouch, mimicking the rapid and non-obstructed passage of food through and out of the esophagus. This new gastric pouch with the large non-obstructed gastro-jejunostomy then contributes to the mechanism of action of the MGB. The GJ is integral in the induction of the post-gastrectomy syndrome which acts to modify: (1) the types of foods that can be eaten, (2) the amounts of foods that can be eaten, and (3) the timing of when foods can be eaten. To reach these goals and avoid the failed obstructive restriction that occurs in the SG, the Band and the RYGB, the GJ must be formed correctly.

The technique of the GJ in the MGB follows the basics of usual general surgical principles that are often violated by other bariatric surgeons in other forms of bariatric surgery. The specific technique is described as follows:

After identifying the site on the bowel for the GJ, gently grasp the bowel loop to be anastomosed and move it to the left upper quadrant, making sure not to twist the afferent and efferent limbs of the bowel. The grasper holding the bowel is carefully given to the assistant to hold the loop in place in the left upper quadrant. Now attention is turned to the gastric pouch.

Carefully expose the tip of the gastric pouch. Evaluate the pouch and make certain it is not twisted.

The Gastrotomy: The initial gastrotomy is made immediately anterior to the lateral gastric pouch staple-line. It should be placed lateral to the medial aspect of the pouch (the lesser curvature of the stomach, the mesenteric border) and medial to the lateral border of the pouch, i.e., the *neo-greater curvature* of the pouch, the lateral pouch staple-line. The gastrotomy should be carefully sized equal to the diameter of the stapler anvil and no bigger.

The Jejunotomy: A jejunotomy is made on the anti-mesenteric border about 180 cm (150–200 cm) distal to Treitz' ligament. The biliopancreatic limb length depends on the choice as described above. The goal is to make the jejunostomy equal to and no larger than the staple cartridge itself. First dilate the jejunotomy with the anvil of the 60-mm cartridge. Remove the anvil, and place the staple cartridge in the bowel. Thread the edge of bowel all the way up to the cartridge junction with the anvil.

Now stop. The surgery is almost over, but we recommend at this point that you take your time. Critical factors in performing the gastro-jejunostomy include careful and meticulous positioning of: (1) the staple cartridge, (2) the gastric pouch, and (3) the bowel which must be exactly aligned for a successful surgery. Proceeding slowly and carefully at this point will result in a good outcome. Ignoring these points means failure and post-operative problems for the patient. Take care here.

Once again, to emphasize the several important points: the gastric pouch and the bowel edges must meet exactly at the junction of the cartridge and the anvil of the staple-gun.

Warning: Inspect the stomach and bowel before proceeding and confirm the alignment of the gastro-jejunostomy. There should be no twist or “kink” in either the bowel or the gastric pouch.

The ideal MGB GJ has certain characteristics. Think again of the geometry of the GJ of the MGB. The gastric tube is defined as a tubular structure with an anterior and posterior surface; the medial border is defined as the lesser curvature, mesenteric border of the stomach, and the lateral aspect defined as the neo-greater curvature is the staple-line. These two borders should, in a “good” or ideal MGB, lead to an equal anterior and posterior surface. In an untwisted ideal MGB gastric pouch, the GJ anastomosis should be placed on the posterior wall exactly half way between the medial and lateral borders of the gastric pouch.

Distal Tip of the Gastric Pouch: Another critical and often misunderstood aspect of the MGB is the importance of the shape of the distal tip of the gastric pouch. The diameter of most staple-guns used in laparoscopic bariatric surgery is 12 mm. Thus, the minimum of 1.2 cm of the posterior wall of the gastric pouch of the MGB will be directly impinged upon by the staple-line and the staples and the damage of the staples crushing and coapting the two layers of tissue from the bowel and the stomach. On the medial aspect, the distance from the lesser curvature of the pouch to the staple-line of the GJ is not a concern, because the area is very well vascularized. However, remember that the lateral GJ staple-line creates an “ischemic zone” between the neo-greater curvature of the pouch and the lateral staple-line of the GJ. The area of concern is more and more at risk as the tip of the gastric pouch is narrowed. The potential for perfusion of this “at risk area” is increased as the size of the tip of the pouch increases. All this is simply to say “Make a large diameter tip to the distal end of the MGB gastric pouch,” which is not similar to the teachings of the SG and the RYGB procedures.

In summary: when creating the gastric pouch for the MGB, it is important to avoid a “Bird’s Beak” deformity with a narrowed distal tip of the pouch. In the ideal MGB pouch, the distal tip of the pouch should be larger than the body of the pouch, allowing for a wide “cobra head” effect of the distal tip to provide a wide perfusion field for the lateral aspect of the distal gastric portion of the GJ.

2.9 Proper Positioning of the GJ Stapler: Beware the Lateral Gastric Pouch Staple-Line

When applying the GJ staple-line, it is important to recall the power as well as the problems of the stapled GJ. In particular, it is important to realize that the security of the GJ staple-line is compromised if the GJ staple-line crosses the lateral staple-line of the gastric pouch. To remind the surgeon, a staple-line may cross another staple-line at a perpendicular angle, but it may not be secure if it runs across the staple-line for a longer distance. The staple cartridge and anvil should not run longitudinally along the gastric pouch staple-line. Keep the gastric pouch staple-line out of the jaws of the stapler and more than a centimeter from the GJ anastomosis staple-line. There should be visible space on the posterior gastric wall between the lateral gastric staple-line and the staple cartridge and anvil (to avoid an ischemic island).

All the while remember to avoid tension or sudden motions that would tear the fragile small intestine, while creating the anastomosis.

2.10 Further GJ Points

Be careful to keep the gastric mesentery out of the GJ staple-line. Before firing, carefully and slowly evaluate the gastric pouch, the bowel and the staple-gun. Do not proceed until each element is perfectly placed. The authors have seen that in many cases new MGB surgeons struggle in this area, because of poor port placement and experience, and poor assistance. This step is one that needs preparation and attention, and the surgeon needs to be well prepared for this step along with his or her team ahead of time.

Be careful to assess the surgeon and assistant's arm and hand placement. Use appropriate arm and hand placement, so that this step is done smoothly. Dr. Rutledge moves the camera port to allow this to help with this step. Again, do not proceed until each port is perfectly placed. Now carefully and slowly close the stapler, and fire the stapler very slowly to use maximum compression to avoid bleeding.

"Slowly" is the watchword, e.g., 30 s of compression before firing. The staple-line MUST NOT BLEED.

The staple-line should not bleed post-operatively, because blood in this area leads to nausea and vomiting, and the enclosed space can result in rupture of the GJ or severe discomfort, with blood clot in vomit.

The stapled GJ is then completed, and the stapler removed.

Now the GJ should lie perfectly with the sweep of the bowel from the patient's left to right, with the GJ located approximately at the level of greater curvature of the stomach and the transverse colon.

If it is not perfect, consider dividing the GJ and performing another accurate and precise GJ. Do not leave it as "Good enough." If necessary, divide the GJ, advance 10–15 cm distal to the failed anastomosis and revise the anastomosis. Do not leave an imperfect GJ. This is one of the most critical steps of the operation.

2.11 GJ Closure

The final step is closure of the GJ. Here again, we see frequent violations of basic well-researched general surgery tenets by new MGB surgeons who are led into errors by either fear of leaks or residual application of the ideas behind the SG, the band, and the RYGB. Recall that the diameter of the GJ in the MGB should be large.

A few comments: Either a stapled or hand-sewn closure of the GJ is acceptable. A closure in one or two layers is acceptable, but NEVER MORE. Usually one layer is best when one layer is done well, as it avoids narrowing the GJ outlet.

Remember the basics of general surgery: the anastomosis heals with diffusion of oxygen in blood cells in the spaces between the sutures. This means that there must be 1–3 mm between sutures, and the sutures should not strangulate the tissue. Simple, but we have routinely seen these basics violated by new MGB surgeons.

2.12 Leak Testing

For the first 150 cases, we recommend leak testing of the anastomosis with air and/or methylene blue for demonstration of technical errors. After the first 150 cases, if the surgeon still finds leaks with air or methylene blue, he/she should consider retraining for laparoscopic surgery with another more experienced surgeon.

The critical factor is that a leak should be recognized early and managed easily, if the surgeon takes the appropriate interventions.

2.13 Discussion

MGB has been described as a “simple” straightforward technique; however, in the hands of physicians and surgeons with an incomplete knowledge of the underlying anatomy and physiology, the operation can lead to serious complications. Most importantly, the GJ must not be placed high on the stomach near the esophagus, so that bile GE reflux will not occur. A long gastric pouch will minimize this complication. Patient and family education, strict daily supplements, and follow-up surveillance are mandatory to prevent severe hypoalbuminemia, especially in vegetarians, and anemia, especially in menstruating women. Limb lengths, prevention of GE reflux, diet and nutrition, and related essentials are covered in this book by the experts.

Conclusions

The MGB has been misunderstood for almost 20 years, primarily by American surgeons, who failed to differentiate the old Mason loop gastric bypass which violated basic general surgical principles, from the MGB. The MGB is nothing more than a close analog to the widely used and well researched antrectomy and Billroth II operation that was and is a foundational procedure in GI surgery for more than 100 years. Whereas the old Mason loop placed the Billroth II loop high on the stomach adjacent to the EG junction, the MGB places the Billroth II loop distal to the EG junction at the level of the antrum. New surgeons are still today making this same mistake and calling that procedure an MGB. The MGB mechanism of action is different from the obstructive restriction that is the foundation of the SG, the Band, the VBG and the RYGB. Instead the MGB models itself on the well known post-gastrectomy syndrome that leads to restriction of so-called junk foods like sweets, liquid calories, fatty and greasy foods, while encouraging a diet of healthy foods in 6 small feedings. This leads to anatomic differences in the MGB from older operations (SG, Band, RYGB) that new MGB surgeons need to understand to avoid resultant failure of the MGB. The MGB, when well and completely understood and only when well understood, is a short simple and very powerful operation, which has added advantages of the ability to tailor the operation to the desires and opinions of the surgeon and the patient and family. It is also easily reversible and revisable. For all of these reasons, we urge surgeons to spend the time to understand the details of this very powerful operation for the treatment of obesity and metabolic diseases.

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3 Physiology of the MGB: How It Works for Long-Term Weight Loss

Kuldeepak S. Kular, Naveen Manchanda, and Robert Rutledge

3.1 Introduction

According to WHO data [1] last updated in June 2016, worldwide obesity has more than doubled since 1980. Over 600 million adults were obese in 2016. Obesity is now the most common form of malnutrition and is predicted to double by 2025. Conservative approaches to morbid obesity, like lifestyle modification, diet, and pharmacotherapy, have been successful only to a limited extent. Diet induced 4–6 kg of weight loss after 12 months on average [2]. Drug therapies have reported up to 11% weight loss [3]; however, these results have not been possible to be maintained in the long-term.

The average reported excess weight loss with Roux-en-Y gastric bypass (RYGB) has been 68.2% [4]. Mini-Gastric Bypass (MGB) is now widely acknowledged as a safe alternative to the RYGB. In a comparative analysis of RYGB and MGB over a 10-year period, Lee et al. found that at 5 years, MGB had a significantly higher weight loss (72.9% vs 60.1%) with fewer complications [5]. A randomized study by the same group [6] showed a lower complication rate with MGB than RYGB (7.5% vs 20%, $p < 0.05$) and a higher percentage of patients achieving excess weight loss of >50% (95% vs 75%, $p < 0.05$).

Rutledge published his initial experience with 1274 MGBs in 2001 [7]. Carbajo in Spain [8] started a variant of the MGB as "BAGUA" technique or the One Anastomosis Gastric Bypass (OAGB) in 2004. The MGB-OAGB did not pick up initially, because of the stigma of bile reflux attached to the old Mason loop horizontal gastric bypass.

Kular and Manchanda started MGB for the first time in India in 2006 [9]. After documenting very good results in India, MGB was adopted by most of the bariatric

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surgeons throughout India. Moreover, the Obesity Surgery Society of India took a lead to become the first in the world to officially recognize and add MGB to the list of commonly recommended and performed bariatric procedures in India.

The MGB-OAGB Club came into being when a dinner-meeting of 38 Founders was held in Vienna in 2015 at the 20th Anniversary Congress of IFSO [10] under the leadership of Prof. Mervyn Deitel, a Founding Member of the ASMBS and the Founder-Editor of the *Obesity Surgery* Journal. Dr. K.S. Kular was elected as the Founding President of this Club for his relentless efforts and contribution to the rise, recognition and worldwide acceptance of the MGB. The MGB has become commonly performed throughout Europe, and in September 2014, the British Obesity & Metabolic Surgery Society (BOMSS) issued a position statement for MGB-OAGB use [11].

3.2 Physiology and Mechanisms of MGB-OAGB

3.2.1 Functional Restriction—Not Mechanical Obstruction—The Kular-Rutledge Hypothesis

The MGB-OAGB does not cause 'obstructive restriction,' as there is a wide outlet at the gastro-jejunostomy (GJ) of the gastric pouch [12]. The diameter of the gastric tube is approximately that of the esophagus. Thus, where does the restriction of the MGB-OAGB come from? It is proposed that the MGB-OAGB pouch acts as a wide bore feeding jejunostomy because it only delivers the food to the distal jejunum. This is very well documented when we do a contrast study after MGB-OAGB.

If we look at all the published series on MGB-OAGB, the restrictive component reduces the diet of the patient to about one-quarter to one-third of the original capacity [12]. MGB takes away the reservoir function of the stomach by converting it into a tube delivering the food directly to the jejunum. When the bolus of food enters the jejunum, that portion of the jejunum distends and brings about the feeling of fullness.

It is pertinent to mention here that in MGB-OAGB, the neuronal (Purkinje) fibers of the jejunum are not disturbed, unlike the Roux limb of the RYGB. The loop of the jejunum is in a constant state of peristalsis like the normal gut, and the gastric tube of the stomach is working as a wide bore feeding jejunostomy. As we know from our knowledge of general surgery, if jejunostomy feed is given fast and in bulk, the patient starts having abdominal bloating [13]. This mechanism teaches the MGB-OAGB patient to eat slowly and less.

Here we emphasize that the "T" connection of the MGB-OAGB is altogether different from the RYGB "gastro-jejunostomy." This is the reason why the tightness of the GJ plays a major role in the RYGB, whereas in the MGB-OAGB, there is a wide outlet, yet giving similar or better long-term weight loss as documented in the literature.

3.2.2 Malabsorption—The Long 150–200 cm BP Limb

Looking at the structure of the MGB-OAGB, it becomes very clear that the whole of the bypass is a "biliary bypass," as there is no Roux limb in MGB-OAGB. There is a strong evidence that MGB-OAGB is a metabolically more efficient procedure than the RYGB [12]. On comparing the structures of RYGB and MGB, the Roux limb is 150 cm and the biliary limb is 50–70 cm in the classical RYGB [14], whereas in MGB-OAGB there is only one limb which is a 150–200 cm biliary limb [12]. The common channel in both procedures is almost the same. Then, why does MGB-OAGB show better metabolic controls? All this is coming from a longer biliary limb in MGB-OAGB.

The Roux limb of the RYGB starts breaking down and absorbing carbohydrates as soon as food enters the Roux limb, as we know that "sucrase" is present in the villi of the small bowel [15]. In MGB-OAGB, the food is delivered to the distal jejunum, thus bypassing the major portion of the jejunum.

Fat absorption is significantly decreased in MGB-OAGB, as is clear from the higher incidence of steatorrhea after MGB-OAGB than after RYGB which is primarily a restrictive procedure due to the short biliopancreatic (BP) limb of 50–70 cm [16]. This contrasts with the long (150–200 cm) BP limb of the MGB [9]. This can be routinely documented with a fat challenge test on a MGB-OAGB patient: by asking the patient to take a high fat dinner, the patient will evidently find oil floating on the toilet water!

Thus, it is well acknowledged that the BP limb in bariatric surgery is the limb which matters [17]! This is further clear from the double blind RCT done in Norway, comparing the classical RYGB to the distal RYGB (i.e., RYGB with 150 cm Roux limb and a 50 cm BP limb versus the distal RYGB with a 150 cm common channel and the same 50 cm BP limb). There was no advantage in terms of weight loss, but the complications like malnutrition increased many-fold [17]. Thus, the literature suggests that the 150 cm BP limb of MGB-OAGB makes it more effective than the 50 cm BP limb of RYGB.

At the same time, multiple MGB-OAGB publications conclude that increasing the length of the biliary channel further, causes more weight loss but occurs at the cost of more nutritional complications [18]. Other bariatric procedures using a very short common channel, such as BPD, DS, etc. result in good weight loss, but with a high incidence of nutritional complications [19]. In this scenario, MGB-OAGB gives an ideal combination of restriction and malabsorption from a 150–200 cm BP limb—thus the published reports of good long-term sustained weight loss.

3.2.3 Change in Dietary Behavior After MGB-OAGB—"A Tilt Towards the Mediterranean Diet"

We need to go back to the 1950s when "the post-gastrectomy diet" was formulated. Billroth II patients could tolerate this diet much better than the routine high carbohydrate, high fat and high-calorie diet [20].

Thus, it should not come as a surprise that MGB patients also favor the same post-gastrectomy diet.

When a bolus of a complex carbohydrate-rich diet passes rapidly into the jejunum, it sequestrates fluid into the lumen of the gut, thus causing distension, tachycardia, lowering of the blood pressure and dizziness [20, 21]. The patient learns from this type 1 dumping and avoids this type of food. This is beneficial, although the severe kind of type 1 dumping is rarely seen after MGB-OAGB. The patient prefers small frequent meals, rich in fiber, low in carbohydrate and fat, and also learns to chew well.

3.3 Role of Type 2 Dumping

The incidence of significant type 2 dumping is low (2–4%) after MGB-OAGB, compared to RYGB where the incidence of significant type 2 dumping is 12% [22]. This could be because the small pouch and the tight outlet of the RYGB shift the patients towards a soft-calorie diet, whereas in MGB-OAGB, because of the non-obstructive nature of the gastric pouch and wide gastro-jejunostomy, the patient is not pushed towards soft calories and can easily take a solid and healthy diet.

However, most patients experience mild type 2 dumping and realize that taking high sugar or carbohydrate-rich foods makes them somewhat uneasy after an hour or so. They develop an aversion to such foods.

3.4 Gut Hormones and the Effects of MGB-OAGB on β-Cell Function

The MGB-OAGB brings about a favorable change in β-cell function, but the exact mechanism is unsettled. Improvement in glycemic control becomes evident soon after the surgery, before any significant weight loss has occurred [23]. This is due to an abrupt decrease in intake immediately post-operatively, with resulting *up-regulation* of insulin receptors and increase in insulin sensitivity. Moreover, rapid transit of food causes secretion of glucagon-like peptide-1 (GLP-1) from L-cells in the ileum and other incretins (entero-endocrine hormones), which stimulate pancreatic β-cell activity [24, 25]. Also improving type 2 diabetes are gut microbial metabolites (e.g., lipopolysaccharides, short-chain fatty acids) [26] and circulating bile acid changes that favor appetite suppression, metabolic rate, and insulin action [27]. There is also a possible role of adipose-derived factors (e.g., pancreatic fat content, adiponectin) on β-cell function [28]. The early improvement in diabetic control after MGB-OAGB appear to be weight-independent and related to incretin-mediated effects on postprandial glucose metabolism and insulin sensitivity [29, 30].

3.5 Change in Gut Flora

It is well known that the intestinal flora has a role in carbohydrate metabolism of the GI tract. This, in turn, affects energy homeostasis. These bacteria ferment the polysaccharides into shorter chain fatty acids in the colon. Obese subjects have a different population of flora. Gut flora have been divided into two broad groups: the Firmicutes (Lactobacillus and Clostridium species), and the Bacteroides (Bacteroides or Prevotella species) [31].

The Firmicutes to Bacteroidetes group ratio is elevated in obese subjects. Following gastric bypass, this ratio is reversed in 3–6 months. In another study by Kaplan in mice, gastric bypass led to a rapid and sustained increase in the population of Escherichia and Akkermansia throughout the GI tract [31]. Transfer of these organisms into non-operated germ-free mice led to weight loss independent of caloric restriction. The same may be happening in the MGB, or even stronger, as the length of the BP limb—having no food, is longer in MGB as compared to the RYGB.

3.6 Physiology of Foul Smelling Flatus and Foul Breath—Patient Moves Away from Carbs

Carbohydrates not digested in the small intestine, including resistant starch foods such as potato, bean, oat, wheat flour, and several monosaccharides, oligosaccharides, and starch, are digested invariably when they reach the large intestine. The bacterial flora metabolizes these compounds anaerobically in the absence of oxygen. This produces gases (hydrogen, carbon dioxide, and methane) and short-chain fatty acids (acetate, propionate, butyrate). The gases are absorbed and excreted by breathing or through the anus (flatulence) [32]. To avoid this flatulence, the patient should be educated to avoid these foods.

Conclusion

All published long-term series on MGB show substantial sustained weight loss and good control of the metabolic syndrome. With an almost equal length of common channel as in RYGB, MGB has a longer BP limb of 150–200 cm compared to 50–70 cm in the RYGB. This brings more power to MGB in terms of metabolic control at the cost of no more complications due to a similar common channel. The complications are less with MGB because there is only one and a wider anastomosis (reduces leak and stricture rate) and the intestinal mesentery is not incised (reducing the incidence of internal hernia).

The gastric outlet in MGB is 5 cm, compared to a nearly half or even lesser diameter of the RYGB outlet. Still, the MGB patient experiences restriction after eating a moderate volume of food. This could be the effect of functional restriction (subclinical type 1 dumping), as opposed to the mechanical restriction by the tight outlet in the RYGB.

The overall effect of the MGB cannot be explained merely by its malabsorptive or restrictive component. MGB significantly alters the eating behavior and shifts the patient towards a Mediterranian diet. There is a change in the neural response of the brain food centers.

MGB also affects the gut hormones in a way like the RYGB, and also changes the population of gut flora, which further affects the weight loss. The research into the mechanisms of MGB, to understand its better-sustained effects on the weight loss and co-morbidities compared to the RYGB, is interesting and may open new corridors to newer tools to control morbid obesity and existing co-morbidities.

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Ten Crucial Steps for the MGB Operation

4

S. Shivakumar, Om Tantia, Tamonas Chaudhuri, Shashi Khanna, Anmol Ahuja, and Ghanshyam Goyal

4.1 Introduction

Obesity is a pandemic problem regardless of developed or developing countries. Various procedures have been described for the treatment of obesity since 1954. Many operations such as jejuno-colic and jejuno-ileal bypass, and Mason's loop gastric bypass have been abandoned due to procedure-related complications. Various operations are performed as surgical treatment for obesity in the modern day: Roux-en-Y gastric bypass (RYGB), laparoscopic sleeve gastrectomy (LSG), and Mini-gastric bypass (MGB) are a few popular ones. However, these procedures are not free of occasional short- and long-term complications [1]. Fear of these complications make a surgeon or a patient think twice before deciding on a bariatric procedure.

Features of an ideal bariatric procedure are [2]:

1. Safe and effective
2. Easy to perform
3. Fewer associated complications, both short- as well as long-term
4. Easy to reverse or revise
5. Should cause no or fewer adhesions
6. Hernias both internal as well as abdominal wall should be of very low incidence
7. Relatively less expensive

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In view of the results of the various procedures available over the past 50 years, the search for an ideal procedure is still on. MGB was first performed and reported by Dr. Rutledge [2]. It has become a valuable operation for treatment of morbid obesity. With various studies and data published, MGB has emerged as a safe, well-tolerated, simple and effective bariatric procedure [3–7]. Even with its long-term results equivalent to RYGB [8], it is not free from controversies. In earlier years, the relative safety of the procedure had been under question [9].

A procedure is termed safe when its pre-operative preparation is easy, is technically reproducible and post-operatively free of short- and long-term complications. In this chapter, we describe the steps in MGB which are crucial to make this safe procedure safer and avoid possible intra-operative injuries and complications, thereby resulting in a better outcome.

4.2 Pre-operative Preparation

Our patient selection criteria is strictly based on the IFSO-APC (International Federation for the Surgery of Obesity and Metabolic disease Asia-Pacific chapter) guidelines. After a battery of investigations including hematological, radiological and endoscopic evaluations, the patient goes through a multidisciplinary approach, evaluating fitness for the procedure from Physician, Cardiologist, Clinical/Bariatric Nutritionist, Psychiatrist, Gastroenterologist, Anesthetist and Pulmonologist if required.

The patient follows a strict pre-operative very low calorie diet (VLCD) as prescribed by our registered nutritionist, preferably for 15 days. The patient follows incentive spirometry exercises and, if need be, pre-operative chest physiotherapy and CPAP/BIPAP non-invasive ventilation.

Cefoperazone sulbactam 1.5 gm I.V. is used as antibiotic prophylaxis, and Enoxaparin sodium 40 IU S.C. 12 h before surgery is used for DVT prophylaxis.

4.3 Ergonomics and Patient Position

Under general anesthesia with endotracheal intubation, the patient should be in supine position, although many surgeons prefer the French position or modified Lloyd Davies position. Foley catheterization is done with aseptic precautions. Sequential Compression Devices (SCD)/Deep venous thrombosis (DVT) compression stockings are applied.

Proper strapping of the patient to the table is the vital step to avoid accidental fall and other non-surgical complications, keeping in view the different table positions that the patient attains during surgery. The theater layout consists of the surgeon standing on the right side of the patient, camera surgeon on the right and assistant surgeon on the left. The patient is placed in steep head rise and a tilt of 45 degrees towards the right.

4.4 Operative Steps

4.4.1 Port Position

We use 5-port technique as described by Dr. Rutledge [2]. Some variations in port positions in the form of semilunar-shaped port placements at the level of the umbilicus instead of diamond shape are also being practiced. The following port positions are followed by us (Fig. 4.1):

- A: 12 mm, subxiphoid 2 cm below the xiphoid process
- B & D: 12 mm, Rt and Lt subcostal 2 cm below costal margin at MCL
- C: 12 mm, 18 cm below xiphoid
- E: 5 mm, Lt ant. axillary line below costal margin

M monitor, *S* Surgeon, *CA* Camera assistant, *A1* Assistant.

The basic principle of MGB is to create a moderate-sized stomach pouch based on the lesser curvature which forms the mildly restrictive component, and perform a loop gastrojejunostomy bypassing 150–200 cm of proximal small bowel, thereby adding malabsorption.

4.4.2 Creation of Lesser Omental Window

After inspection of the small bowel, liver and any other grossly detectable abdominal pathology on initial laparoscopy, the first step is the creation of the lesser omental window. Rarely, lifting up of the bulky falciform ligament is required by placing a suture across.

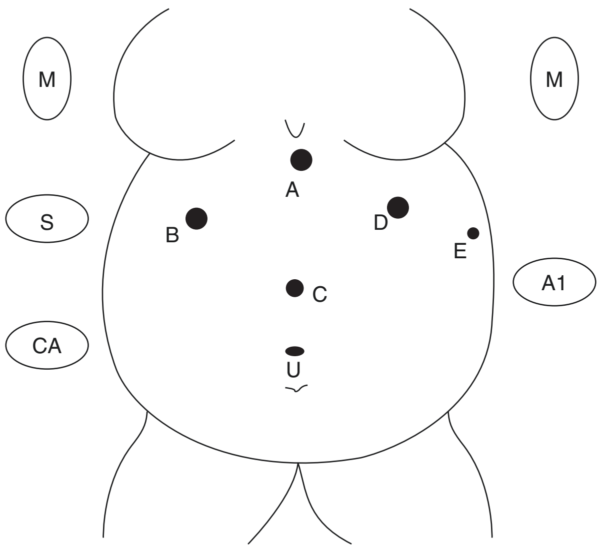

Fig. 4.1 Port positions and theater layout

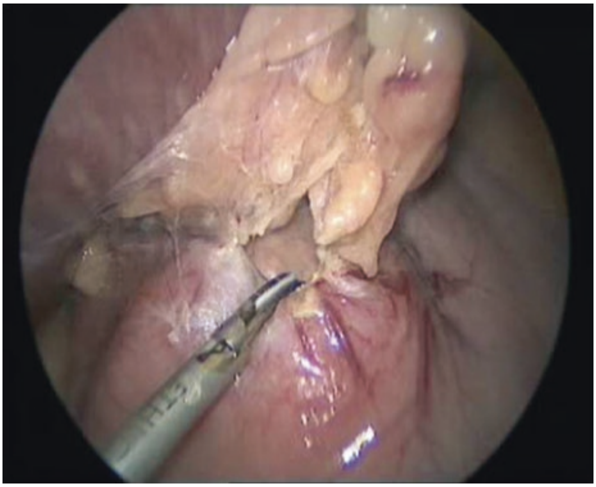

Fig. 4.2 Initial point of dissection on the lesser curvature of the stomach

Dissection is started beyond the crow's foot on the lesser curvature of the stomach about 3–4 cm proximal to the pylorus. The window is created for about 2–4 cm, lysing all the anterior and posterior adhesions to stomach, and the lesser sac is entered. Liver retraction is done by the assistant surgeon, using blunt instruments without traumatizing the organ. Paddle retractors can also be used for the same.

Various mesogastric veins, especially near the crow's foot, need to be respected and even the smallest bleeding should be immediately arrested (Fig. 4.2).

4.4.3 Antral Division

Through the epigastric port, an endo-GIA stapler, usually 45-mm gold/green is engaged across the antrum of the stomach at right angles to its axis. An adequate lesser omental window free of adhesions is a necessary prerequisite for this step. This first vertical firing should not transect antrum more than 60% of its width. This takes care of the passage of the contents from the bypassed stomach. Anterior and posterior walls of the stomach must be grasped equally by the stapler to avoid a twist and "bird beaking" of the edges, thereby avoiding trouble in the gastro-jejunostomy as well as to the next subsequent firing (Fig. 4.3).

4.4.4 Creation of the Gastric Pouch

A moderate-sized stomach pouch is the hallmark of MGB. The pouch is neither tight like that of a LSG, nor is it small-sized like that of a RYGB. Unlike LSG, a long wide and low pressure tube is characteristic of this pouch [10] and is the reason for low leak rates. Unlike RYGB, a low placed wide gastro-jejunostomy stoma on a

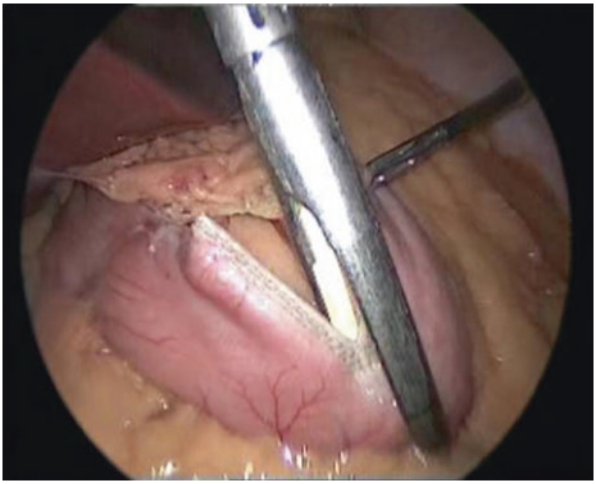

Fig. 4.3 Vertical firing

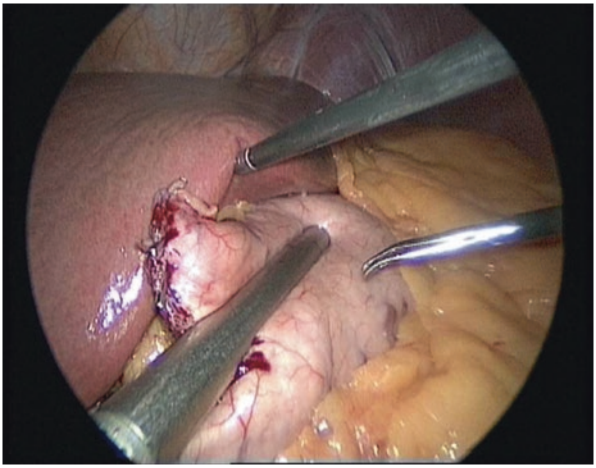

Fig. 4.4 Stomach pouch creation—second stapler firing

long gastric tube far away from gastro-esophageal (GE) junction helps the low incidence of biliary reflux, marginal ulcer and better food tolerance.

First, transverse firing from the left hypochondrial port using an articulating gold/green/purple cartridge from the edge of the previously divided stomach is done. The axis of division should be perpendicular to the first firing and parallel to lesser curvature of the stomach, making sure to divide the antrum longitudinally almost at the center [2]. Care must be taken to lyse all the adhesions in the lesser sac, be it the flimsy adhesions or adhesions to pancreas (Fig. 4.4).

Subsequent firings are done along a 36-Fr bougie which is engaged after the third firing using blue/purple cartridge. The bougie must be engaged until it reaches the tip of the pouch. The left hypochondrial port also can be used for the subsequent firings to get the axis right. Care should be taken not to hug the bougie and to have

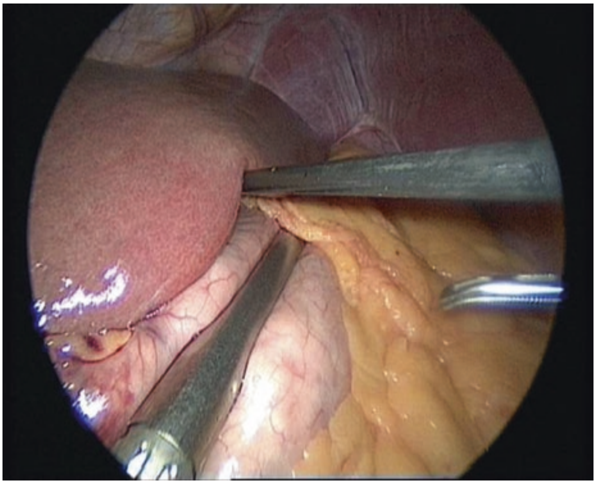

Fig. 4.5 Stomach pouch creation—subsequent stapler firing

a moderate-sized pouch. This results in a ~2 cm wide loose pouch which was fashioned over the bougie (Fig. 4.5).

4.4.5 Dissection Near the Angle of His

Creating a window lateral to the angle of His is like a rate-limiting step of MGB. The dissection should be lateral to the left crus of the diaphragm, leaving a minimum cuff of 1 cm from the angle [11, 12]. The peritoneal layer along the lesser curvature of the stomach is stripped off, taking care of the lesser curvature vasculature and division of flimsy adhesions, done for a better and safe dissection around the hiatus, creating adequate space for stapler engagement.

Care is taken to avoid inadvertent injury to short gastric [2], inferior phrenic vessels and spleen. After the final stapler firing, the bypassed stomach lies on the left of the patient and the pouch is on the left or midline.

Final shape of the stomach pouch should be a long tube without any twist, and the entire staple-line should be visible (Fig. 4.6).

4.4.6 Hemostasis

Attaining perfect hemostasis is a pivotal step for better outcome of both intra-operative and post-operative stages of the MGB, as the stomach is known for its rich vascular supply and notorious for bleeding. The risk of leak is comparatively less than LSG, as the MGB pouch is a low-pressure tube [10].

Hemostasis can be attained by hemostatic clips, sprays, foam and suturing the staple-line on the pouch and also on the bypassed stomach's side. No literature is available to determine the best technique among the above-mentioned methods.

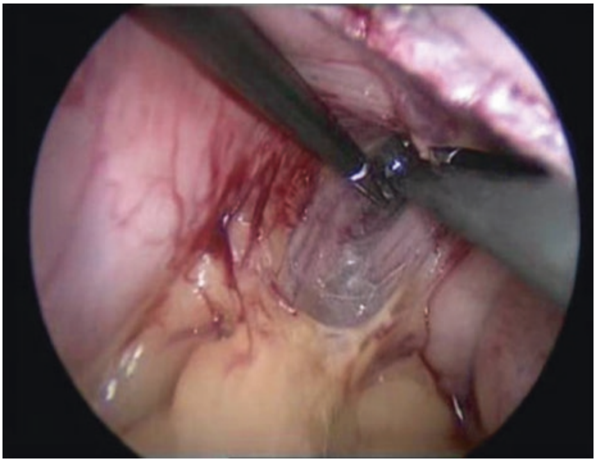

Fig. 4.6 Dissection near the angle of His—creation of the window

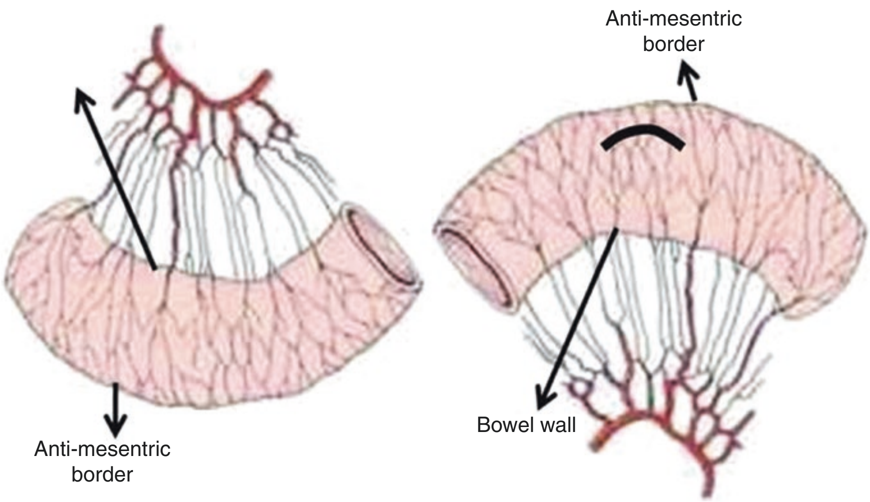

Fig. 4.7 Diagram showing the enterotomy site

4.4.7 Jejunal Loop Measurement and Enterotomy

An antecolic loop gastro-jejunostomy is done in MGB. In contrast to RYGB, MGB does not require any mesenteric division and thus minimizes the chance of any internal hernia. An enterotomy is made on the jejunum 150–200 cm from ligament of Treitz [13], 5 mm from the precise antimesenteric border towards the posterior wall of the jejunum, to avoid a twist of the loop at the anastomotic site (Figs. 4.7 and 4.8).

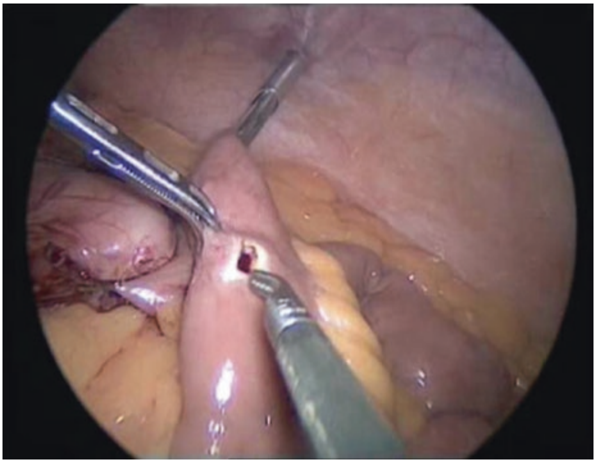

Fig. 4.8 Enterotomy

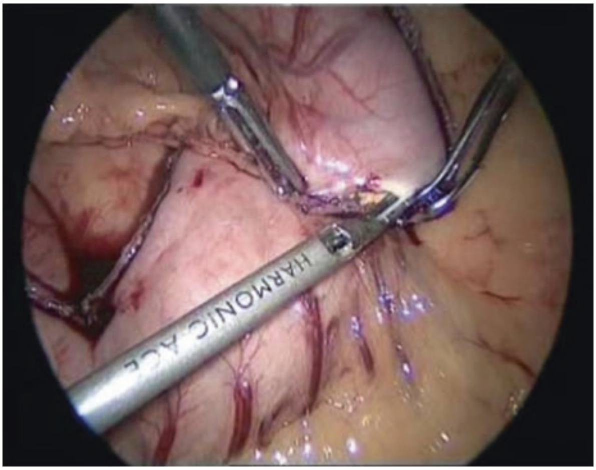

Fig. 4.9 Gastrotomy

4.4.8 Gastrotomy

Gastrotomy is done on the anterior surface of the pouch midway between the two inferior angles and parallel to the previous staple-line. The bougie can be used to stabilize the pouch during gastrotomy and also as a guide by abutting the anterior wall. Care must be taken to confirm that the gastrotomy should be a direct entry rather than an oblique one, to avoid entering different planes in the layer of stomach wall. Use of conventional hook or ultrasonic device for gastrotomy is left to the surgeon's discretion (Fig. 4.9).

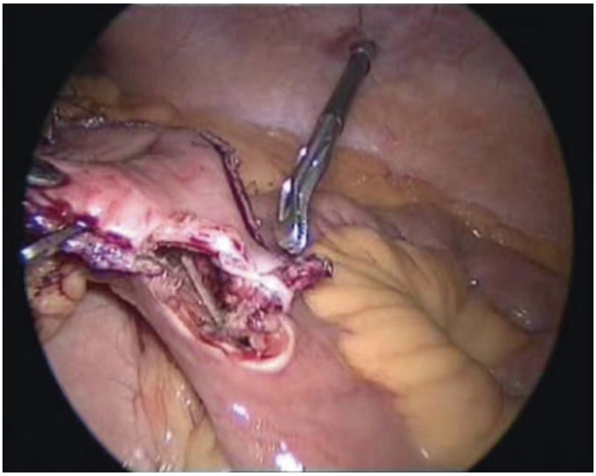

Fig. 4.10 Gastro-jejunostomy

4.4.9 Gastro-Jejunostomy

A posterior gastro-jejunostomy is performed using a 45-mm blue cartridge. The staple-line is inspected for bleeding. The bougie is passed across the anastomosis under vision at this point (Fig. 4.10).

4.4.10 Closure and Leak Test

The gastrotomy and enterotomy are closed either by a blue cartridge stapler [2] or by using 2-0 Vicryl continuous extra-mucosal hand-sewn sutures. Patency is checked by passing the bougie again across the anastomosis, and the leak test is done by using methylene blue to check the integrity (Fig. 4.11). A flat drain is placed between the gastric pouch and the bypassed stomach.

4.5 Precautions To Be Taken

1. The gastric pouch should be long and wide.
2. The Initial point of antral division on the lesser curvature of the stomach should be distal to crow's foot, so as to maintain the vascularity of the tip of the gastric pouch, preserving the blood supply arising from the lesser curvature of the stomach, as well as avoiding GE reflux.
   (a) Adequate channel of the bypassed stomach has to be maintained for the drainage of secreted fluid.
   (b) Care must be taken to avoid twist in the gastric pouch.

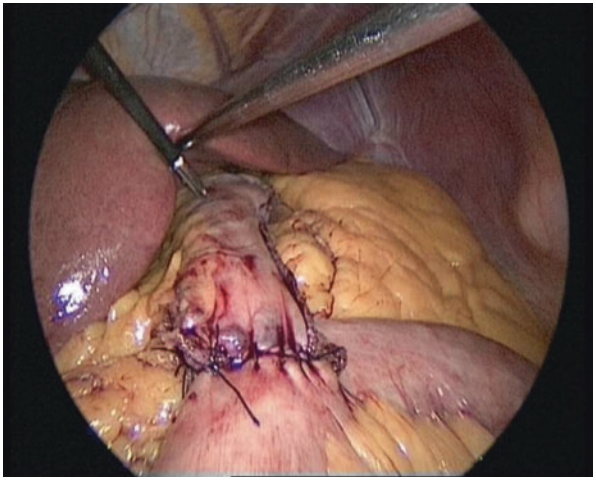

Fig. 4.11 Closure of gastrotomy and enterotomy

(c) Perfect hemostasis has to be attained. Energy sources should never be used to achieve hemostasis on the staple-line area.
(d) Gastro-jejunostomy should never be less than 45 mm in diameter, maintaining proper alignment of the anastomosis and avoiding twist in the same.

Conclusion

MGB is an excellent surgical modality for the treatment of morbid obesity and its co-morbidities, with results even better than RYGB and LSG. However, it is very important to follow the correct steps, to avoid complications and give the best standard of care.

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The Ideal Length of Jejunal Limb in MGB

5

Karl Peter Rheinwalt and Andreas Plamper

5.1 General Considerations

Excluding a part of the jejunum from contact with aliments probably is the most important step of MGB-OAGB, as it leads to several entero-hormonal effects as well as to moderate malabsorption of fat, carbohydrates and proteins. These two mechanisms in combination with a rather mild restriction (created by the very long and narrow gastric pouch) are responsible for the excellent results of this procedure.

Only little is known about the physiological consequences regarding the fact that in MGB, diluted alkaline bowel juices are partially drained into the gastric pouch. By elevating the gastric pH, the protein digestive effect of gastric acid and pepsin may be diminished, which could be another reason for the stronger malabsorptive effect of MGB-OAGB in comparison to Roux-en-Y gastric bypass (RYGB). This finding is not well proven in humans, but has been detected in a study with rodents comparing MGB, RYGB and sham-operated animals [1]. Thus, the bypass construction with one gastrojejunal anastomosis might itself have effects different from constructions involving a Roux-limb. Besides this, a Roux-limb in Y-shaped bypass constructions reacts differently towards predigested food than the efferent limb in the MGB-OAGB where the food is instantly mixed with diluted biliary and pancreatic juices. This means that we cannot simply equalize the biliopancreatic limb in MGB-OAGB with the arithmetic sum of biliopancreatic and alimentary limb in Roux-en-Y constructions.

Length but also sole persistence "keeping in place" of the biliopancreatic limb itself seems to play an important role in the action of MGB-OAGB far beyond the pure malabsorptive effect of exclusion of a part of jejunum from nutrient passage.

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This was the result of a rodent study from Miyachi et al. where metabolic effects of gastric bypass were much less after having excised the excluded biliopancreatic limb. This effect was explained by positive changes in the gut microbiota, as well as elevated plasma bile acid levels in the BP-limb [2].

However, it should not be ignored that possibly a lot of knowledge about the issue of the consequences of excluding small intestine from the physiological nutritional pathway might be concluded from results with older bowel-sparing procedures, such as Biliopancreatic Diversion (BPD), BPD with Duodenal Switch (BPD-DS) and RYGB with different limb lengths.

While discussing the ideal length of bypass, we must remember the **limitations of bowel measurement** intraoperatively, which is influenced by the degree of stretching of the bowel, effects of anaesthetic drugs and surgeons' accuracy [3]. The possibility of IT-navigated intraoperative measurement of the bowel length (so far experimental), as demonstrated by a study group from Heidelberg, might improve the accuracy of this important step in the future [4].

Weight and BMI of obese patients are largely different. It is well accepted that bariatric surgery in super-obesity results in less short and long-term excess-weight-loss than with BMI <50 kg/m^2. For decades, in order to fight this tendency, bariatric surgeons performed "stronger," i.e., more malabsorptive, operations like BPD or long limb RYGB especially in super-obese patients. Series of highly malabsorptive operations with extended length of excluded small bowel like Scopinaro's BPD and the later variation of this operation with duodenal switch (BPD-DS) showed excellent weight control even in super-obese patient groups. However, these procedures carry rather high risks for protein, iron, calcium and vitamin deficiencies, even under the condition of adequate supplementation and follow-up [5, 6]. With this experience, the named malabsorptive operations today have become almost exclusively accepted as options for special situations like super-super-obesity or in case of failure of less aggressive standard procedures.

As we know from our annual meetings of the MGB-OAGB Club, **sociocultural factors** without doubt play an important role in the choice of biliopancreatic limb length. A private patient demanding an OAGB in a Spanish obesity center might be much more sensible concerning insufficient weight loss (possibly due to a too short bypass) as may be a vegetarian patient in India with resulting malnutrition.

The importance of the **quality of follow-up** examinations cannot be overestimated. Poor postoperative follow-up, as is common in many countries (including in highly developed countries like Germany), might result in uncontrolled weight regain but, even worse, in uncontrolled lack of micronutrients and protein, leading to conditions like Korsakov's, osteoporosis, liver failure, anemia, vision impairment, and others. Obviously, this risk of malnutrition becomes more important with greater length of bypassed small bowel.

Although highly malabsorptive procedures like BPD have proven in the literature to show the best results regarding remission of **co-morbidities** like diabetes type 2, this finding may be a rather weak argument to systematically bypass excessive lengths of small bowel. Shorter bypass lengths like in RYGB as well as in MGB-OAGB give almost comparable metabolic results without a strongly elevated burden of malnutrition.

Total small bowel length (TBL) in humans varies greatly between about 300 and 1200 cm [7, 8]. It seems obvious but not necessarily proven that 200 cm jejunal exclusion in TBL of 500 cm has completely different effects than the same length in a patient with 1000 cm TBL. The same suggestion probably applies to the Single-Anastomosis Duodenoileal Bypass with Sleeve-gastrectomy (SADI-S) where a fixed length of excluded small bowel is measured from distally only [9].

These reflections led to the claim of some MGB-OAGB surgeons to systematically measure the TBL before individually adapting the length of excluded jejunum. As published by Carbajo et al, in their experience with 1200 patients, this method in combination with meticulous follow-up might give excellent long-term results [10].

Controversially, measuring of TBL elevates the operative time as well as the risk of unrecognized small bowel injury. Therefore, it should only be considered justified and mandatory if a large proportion of small bowel is intended to be bypassed. This only applies to situations where excellent follow-up is provided and slightly extended operative times are not important.

Frequently, for several reasons, we find conditions with rather poor follow-up and with **health systems** where operative times are crucial for economic issues. In this situation, it may be an acceptable compromise to have slightly less weight loss, not to measure TBL, and consequently to exclude a shorter segment of jejunum. This makes poor follow-up less dangerous as well. This strategy of "one size fits all" might have the advantage to allow cheaper (shorter) operations for more concerned obese patients with less need for extensive and costly follow-up. At this point, we enter the field of sociopolitical discussion.

5.2 Experiences from Large MGB-OAGB Series

For results with different bypass lengths, we evaluated results of larger series of MGB-OAGB. Most of these series present excellent outcomes from around 1000 patients or more (Table 5.1) with either fixed or variable bypass lengths, depending on BMI and/or on total bowel length.

Rutledge, Kular, Chevallier and Lee applied mainly fixed limb lengths of 180–200 cm, and found weight loss failure of maximum 5%. Only between 0.2 and 1.0% had to be revised for excessive weight loss or malnutrition [11–15].

A **tailored approach according to BMI** as described by Lee 2008 with 2-years follow-up in 644 patients was applied by Noun, the Italian group around Musella, and the group around Taha in Egypt [16–19]. It must be emphasized that the authors of the latter study use the term omega loop gastric bypass, but their technique in fact describes a classic MGB [19].

In this early study from 2008, Lee did neither comment on rates of weight loss failure nor on rates of malnutrition leading to revisional surgery [16].

The rate of weight loss failure in the other studies applying tailored approaches was more variable—between 0.2% [18] and 10.2% [17], but not clearly less than in the above-mentioned studies with shorter and fixed limb lengths. However, revisions for malnutrition were comparably low with the fixed limb length groups—between 0.1% [18] and 0.4% [17].

Table 5.1 Experience of some larger MGB–OAGB series regarding bypass length and rates of weight loss failure and malnutrition

Study	Year	Cases	BP-length (cm)	Follow-up (years)	Weight loss failure	Deficiencies/excessive weight loss
Rutledge	2005	2410	Fixed 180	6.5 (mean 38.7 months)	<5% more than 10 kg weight regain	110 (4.9%) pts. with iron-deficiency anemia, 31 (1%) pts. with excessive WL revised to gastroplasty
Kular	2014	1054	"Approximately" 200	6	Not reported	68 (7.6%) pts. with iron-deficiency anemia, 1 (0.1%) with hypoalbuminemia and 1 with excessive WL, both were reversed completely, both pts. had 300 cm MGB!
Chevallier	2015	1000	Fixed 200	7 (mean 31 months)	*N* = 49 (5%), 4 (0.4%) re-operated	2 (0.2%) with excessive weight loss and hypoalbuminemia (reversal planned), n.a. on anemia or other parameters (not screened)
Lee [2011, SOARD, 2012 Obes Surg]	2011	1322	Fixed 200	9	8 (0.6%)	9 (0.7%) pts. converted to RYGB or LSG due to malnutrition (either intolerance, albumin, iron or calcium, not differentiated in the study)
Noun	2012	1000	150 (+10 cm per each BMI point above 40)	5	10.2% after 5 years	4 (0.4%) pts. with excessive WL, 2 of them reversed completely, 2 revised to LSG
Musella	2014	974	BMI-Tailored according to Lee[ ]224.6 ± 23.2	5	Weight regain 2/818 (0.2%) 1 of 2 revised	44 (5.3%) pts. With iron-deficiency anemia, EWL >100% 1/818(0.1%) 1/1 Revision
Taha	2017	1520	150–300 BMI-tailored	3	18(1.2%) none treated operatively	47 (3.1%) with iron-deficiency anemia, 3 pts. (0.2%) Revision for excessive weight loss
Carbajo	2017	1200	250–350 (400??) 50% of TSBL plus BMI depending 10–50 cm, leaving at least 250–300 cm CC	12	"Almost none" (no revision within 12 Yr. FU)	14 (1.1%) pts. with hypoalbuminemia, 15 (1.25%) with severe(30 % with mild) iron-deficiency anemia, 20% with Vit. D deficiency, 3% Vit. A, 0.5% Vit. K, 2% Folic acid and B12, 2% calcium, 3% zinc and copper, *No reoperations due to malnutrition, only prolonged (or i.v. in severe cases) supplementation*
Own series (unpublished)	2017	450	246.9 ± 36.6	6	6 (1.3%) pts. Re-operated	4 revisions (shortenings of bypass) for non-malabsorptive reasons (=efferent limb was not too short in these cases)

pts. patients, *n.a.* no announcement, *EWL* excessive weight loss

Only Carbajo et al. were systematically measuring the TBL and tailored the biliopancreatic limb both on TBL and on BMI [10]. In detail, they bypassed about half of the small bowel, adding an additional 10–50 cm to the BPL according to the BMI. However, they made sure not to leave less than 250–300 cm of CL distally. In practice, they usually bypassed 250–400 cm of jejunum. With follow-up of maximum 12 years (with only 30% lost to follow-up), they revealed excellent results regarding weight loss and remission of co-morbidities, and surprisingly none of their patients had to be revised for weight loss failure or for malnutrition. Studying their paper, this is obviously due to the excellent and tight follow-up with mostly patients from the same country (Spain), frequent laboratory check-ups and disciplined supplementation. This is the study supplying the most detailed long-term results including deficiencies of micronutrients.

Our own (yet unpublished) series of 450 MGBs within 6 years in a mainly super-obese patient group with rather long BPL-length of almost 250 cm on average (tailored as proposed by Lee in 2008 [16]) led to the necessity of 6 revisions with bypass lengthening up to 550 cm for insufficient weight loss, whereas none of the 4 revisions with shortening of the bypass was done for malnutrition (but for bypass intolerance).

In conclusion, among those series, a short BP-length was more likely to create problems and need for revision than a long bypass length.

5.3 Arguments Favoring Longer Bypass Lengths

As described above, the Spanish group under Carbajo achieved excellent results with BPL mainly between 250 and 400 cm (tailored by systematic measuring of TBL and additionally adjusted for BMI). In 1200 patients with OAGB and tight follow-up, none had to be revised to adjust the bypass length [10].

Lee et al. altered BPL-length in 644 patients between 150 and 350 cm depending on BMI and found excellent 2-year results, surprisingly with significantly lower hemoglobin-levels in the shortest bypass (150 cm) in the BMI-group <35 [16].

The large series of Noun, Musella, Taha, and ours also applied BMI-tailored bypass lengths exceeding 250 or even 300 cm in a part of the cases without systematically measuring TBL [17–19]. None of these series resulted in reversal rates of >0.4% for malnutrition.

Thus, even with slightly longer biliopancreatic limbs, MGB-OAGB is a very safe procedure in regard to severe malnutrition requiring revision of the bypass.

More arguments favoring longer bypasses revealed from results with other types of procedures are summarized further below in this chapter.

5.4 Arguments Towards Shorter Bypass Lengths

Jammu in his Indian experience with vegetarian patients found that bypass >200 cm should be avoided with liver disease, nephropathy and TBL shorter than 800 cm; he recommended bypass >250 cm only after having measured and found TBL >800 cm in super-obese patients [20].

Fatal liver failure after MGB with only 200 cm biliopancreatic limb length was published in a single case with TBL being only 308 cm at autopsy [21]. This is the shortest published TBL (in non-operated humans) that we could find in the medical literature. Taking this exceptional case as a reference, measuring of TBL would have to be considered as an absolute obligation in any type of obesity surgical procedure involving the small intestine.

Trying to convert inconclusive findings with other types of gastric bypass procedures (RYGB, BPD, BPD-DS) towards MGB and OAGB (see the following paragraph), we could suggest that about 200 cm of biliopancreatic limb length in patients with BMI <50 should be both effective and safe.

5.5 Experiences with Other Types of Procedures

As mentioned above, the absence of a Roux-limb in MGB-OAGB creates different physiological and enterohormonal consequences than RYGB and other procedures like BPD. Respecting this, one must be extremely careful by transferring results with these procedures towards recommendations how a MGB-OAGB should be performed.

Nevertheless, as RYGB and other bypass procedures had been done in large numbers for about 5 decades, we summarize some of their published results regarding the length of bypassed small bowel as follows:

Several published series find better results partially with non-super-obese, partially with super-obese patient groups regarding weight loss and remission of co-morbidities like diabetes type 2 with longer bypass lengths (alimentary limb and/or biliopancreatic limb) respectively with shorter CL, in procedures like so-called distal or long-limb RYGB or different types of biliopancreatic diversions (BPD) [22–30].

However, it seems to be obvious that the so-called “distal gastric RYGB” with CL-length <200 cm carries a higher risk of protein malnutrition (especially if the remaining proximal intestine mainly consists of the biliopancreatic limb) [31–33]. Classical highly malabsorptive bypass procedures like BPD and BPD-DS show hypoalbuminemia in the long-term in 5–30% [5, 6].

Several RYGB-groups did not find better results (or better results only in super-obesity) with longer bypasses than so-called “standard-RYGB” with total bypass-length of about 150 cm [34–37]. Ralki published a case with need for liver transplantation after long-limb RYGB [38].

Nergaard et al. compared RYGB with short versus long BL and found superior weight loss for the group with short AL and long BL. This more successful variation of RYGB can theoretically be interpreted as an approach of Roux-en-Y towards the MGB-principle [39].

In conclusion we realize that the available results regarding different bypass lengths in RYGB and other Y-shaped bypass procedures are inconclusive and cannot really serve as a reliable reference for MGB-OAGB.

5.6 Discussion

In general, there seems to be a tendency in the MGB-group of surgeons to apply either rather fixed and shorter bypass lengths [11–15] or alternatively BMI-adapted cautious variations of limb lengths [16, 17, 19, 20], whereas the OAGB-group led by M. Carbajo (Spain) [10] tends to individual tailoring of the bypass length after systematic measurement of TBL. The latter approach can be considered as a kind of "luxury version," because measuring of TBL and antireflux stitches in OAGB are time-demanding, and the longer bypasses need extensive follow-up and supplementation to avoid adverse effects of malnutrition and malabsorption.

Otherwise an acceptable compromise in our opinion might be to alter the standard **"One-size-fits-all strategy"** (with 150 to a maximum of 200 cm bypass limb) towards a **"BMI-adapted not-too-long bypass strategy"** which matches many of the above-mentioned critical points. This type of compromise is realized in our own center with a bypass length of 200 cm for BMI <50 kg/m^2 and 250 cm for BMI >50 kg/m^2 without measuring TBL in primary cases. Before 2017, we did longer bypasses (without measuring TBL) with bypass of up to 350 cm of jejunum (for BMI >65 kg/m^2). With this former strategy, we observed a tendency towards iron deficiency, anemia, mild hypoalbuminemia and hyperparathyroidism. Although we never had to shorten the bypass in this series because of a too long biliopancreatic limb, this caused us to slightly shorten the limb length towards a maximum of 250 cm in primary operations.

Rutledge and other MGB-surgeons with huge experience meanwhile recommend diminished biliopancreatic limb-lengths of 120 to a maximum of 200 cm, which we believed was too short, especially if predominantly super-obese Caucasian and non-vegetarian patients receive the bypass surgery (as in countries like Germany for instance).

Analyzing the literature on MGB-OAGB in general, the need for lengthening the bypass to treat (rare) weight loss failure is more frequent than relevant malnutrition demanding its shortening. Yet the fear of surgeons to create malnutrition by MGB seems to be predominantly much higher than the fear of not achieving adequate weight loss. This is due to the psychological fact that with post-operative malnutrition, the surgeon may be accused of having done malpractice, whereas in weight loss failure the patient may have contributed to the poor result.

These considerations reaffirm that we cannot overestimate the value of the sociocultural background where obesity surgery is realized. Regarding the low rates of failure in both directions (malnutrition, weight loss failure), the sociocultural evaluation and the quality of follow-up seem to be much more important for choosing the best length of bypass than basing the decision on varying results from different study groups.

Conclusions

With the lack of large comparative studies which take into consideration the TBL as well as results of different absolute and relative lengths of excluded small bowel, we conclude that the following variations seem to be advisable:

With systematic measuring of TBL, a diet high in protein, excellent supplementation and follow-up, it is possible to exclude “tailored” parts of jejunum which (also depending on BMI) might even reach 300–400 cm. With this method, excellent and stable long-term results can be expected even in super-obesity. In rare revisional cases, the biliopancreatic limb might even be longer than that.

However, under “simpler” conditions which for several reasons (training of surgeon, importance of short operative time) do not allow systematic measuring of TBL, and in addition are typically associated with a “poorer” diet, supplementation and follow-up, we recommend to choose bypass lengths between 150 and at the maximum 250 cm. The decision about individual length might be fixed on the basis of the mentioned factors, as well as BMI and sociocultural conditions.

We do not advice systematic jejunal exclusion of more than 250 cm in primary MGB-OAGB without measuring TBL, as mainly excessive weight loss might be considered as a surgical mistake.

With higher weight and BMI, a diet rich in protein, calcium and vitamins, excellent patient compliance and tight follow-up examinations, a bypass with longer biliopancreatic limb might lead to better and stable long-term results, whereas in less ideal situations a shorter bypass might be the better compromise.

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6 Perioperative Care in the MGB and Anesthetic Management

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6.1 Introduction

The perioperative care for the bariatric patient varies globally and nationwide, but it may also vary within a hospital due to different opinions of surgeons, anesthesiologists or physicians involved in bariatric surgery. The perioperative practice may also vary between different types of bariatric operations or between different patients, sometimes to offer tailored care based on evidence-based literature, sometimes based on gut feelings or years of experience. There is a growing consensus that in high volume bariatric centers with a lot of surgical and anesthetic experience, bariatric surgery has shifted from low-volume high-complex major abdominal surgery to high-volume low-complex surgery. This development warrants standardization of perioperative protocols and clinical pathways.

In the past 5 years, there has been a growing interest in the use of *clinical pathways*; i.e., more standardized perioperative protocols based on available evidence [1, 2].

These clinical pathways underwent a serious development in colorectal surgery, with clear benefits for the patients, resulting in the concept of *Enhanced Recovery After Surgery* (ERAS) [3–6]. After successful implementation of ERAS protocols in colorectal surgery, other types of surgical procedures followed [7, 8]. Until recently, there was a lack of Enhanced Recovery After *Bariatric* Surgery (ERABS) protocols. This was due to a fear of complications among bariatric surgeons and anesthesiologists in the bariatric patient [9].

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Several ERABS protocols have been successfully implemented, providing sufficient data for guidelines; systematic reviews on this topic have recently been published [10–16]. In most hospitals, the peri-operative practice of MGB-OAGB is not much different from other bariatric operations, like laparoscopic Sleeve Gastrectomy (SG) and Roux-en-Y Gastric Bypass (RYGB).

The perioperative practice and clinical pathways or ERABS in MGB have been under serious development. The use of a standardized protocol in a clinical pathway is a huge improvement in healthcare. One of the most innovative aspects is that clinical pathways use best available evidence-based literature. Implementation of these multimodal programs resulted in reduction of length of stay (LOS), reduction in the use of nasogastric tubes and drains, and reduction in total costs without an increase in complications [3–5].

Similar to ERAS programs in colorectal surgery, clinical pathways in bariatric surgery seem to be beneficial [10]. Multimodal aspects of these ERABS programs encompass: standardized preoperative counseling, pre-habilitation, smoking cessation, preoperative weight loss diet programs, highly experienced laparoscopic surgeons, stress reducing circumstances, short working anesthetic agents which support quick surgery, reduction in the use of nasogastric tubes and drains, thrombosis prophylaxis, early mobilization, early oral intake, reduction of opioid pain medication and the use of local anesthetics, and early discharge. Important elements of ERABS are listed in Table 6.1.

Basic standardized information before surgery is a key element of ERABS, and reduces the stress that the patient has, and is a possibility for the multidisciplinary team to explain that the surgery is safe and effective. We organize evenings in which we provide information for patients and their relatives before the start of their bariatric program.

Although it seems logical that preoperative exercise is beneficial to the patient, no clear benefits have been specifically demonstrated for bariatric patients [11]. Preoperative weight loss, however, results in lower liver volume, reduces surgical complexity, reduces complications, and results in better weight loss [12–16].

The most important factor for a reduction in complications is the experience of the surgical team. Experienced bariatric surgical teams reduce operative time and postoperative complications [17]. Short operating time is an important element to enhance recovery after surgery.

Equally important to the experience of the surgeon is the experience of the anesthesiologist. An experienced anesthesiologist can work with short working agents, have special attention for difficult airway management, positioning of the patient, ventilation, pain management, and focus on prevention of *postoperative nausea and vomiting* (PONV) [18]. Reduction of opioid medication is a key element in the latter [19]. An experienced surgical team which cooperates well with the anesthetic team becomes one team; this reduces stress of the patient due to the good atmosphere in the operating-room.

Although thrombosis prophylaxis and the use of Low Molecular Weight Heparin (LMWH) is recommended after surgery [11], early mobilization in combination with short operating time is probably the most important factor in reducing thromboembolic vascular events. A recent French study by Blanchet et al. reported that

Table 6.1 Elements of enhanced recovery after bariatric surgery

Preoperative elements/alterations
Standardized information
Avoid prolonged fasting
Initiate thrombosis prophylaxis
Preoperative diet-induced weight loss
Psychological motivation
No premedication/avoid sedation
Intraoperative elements/alterations
Multidisciplinary integrated approach
Mini-invasive surgery
Experienced surgeons
Short-acting anesthetics
Non-opioid pain medication
Loco-regional anesthetics
Normothermy
Protective ventilation
Postoperative elements/alterations
Awake/(reversed) extubation
Lung exercise
Non-opioid pain medication
PONV prevention
Avoid catheters and drains
Avoid NG tubes/early oral feeding
Early ambulation
Results
Improved quality of care
Less pain
Improved logistics
Reduced costs/improved health economics
Decreased complications (?)

thrombosis prophylaxis may not be necessary in patients without a thrombotic history and who have uncomplicated surgery [20].

The use of local anesthetic drugs reduces postoperative pain and the use of opioids [21]. We use local anesthetics even prior to incision [22], and believe this also reduces early postoperative stress.

All these aspects lead to early, enhanced recovery and make early discharge possible. In most hospitals, discharge on the first day after surgery is feasible and safe.

6.2 Fast-Track Bariatric Surgery

Although ERABS is a multimodal program which has the goal to improve perioperative results, a reduction in complications has not clearly been demonstrated. The most benefits described are a reduction in LOS [23–26], and costs [24]. It seems logical from this point of view that the concept of ERABS is often mixed up with *Fast-track Bariatric Surgery*. Fast-track Bariatric Surgery implies that ERABS has mainly logistical advantages, as a result of early discharge and short operative times [23–26]. In our clinic, implementation of ERABS resulted in increased hospital admissions, and an increased number of operations performed per day [26]. Thereby, hospitals can increase production with lower costs per patient.

In the preoperative phase, one can organize information evenings for groups of future patients, schedule multiple appointments in one hospital visit ("one stop visit"), and standardize multi-disciplinary meetings to discuss complex patients.

In the peri- or intraoperative phase, logistical benefits arise when patients are admitted early to the operation complex; this way, operating teams never have to wait for the patient. Also, there should be attention for the timing of preoperative antibiotics. In our clinic, clear protocols are implemented which define that extensive cleaning in-between operations is not necessary when there is no extensive soiling in the operating-room (most of the times in laparoscopic surgery). When dedicated operating-teams work with standardized operating kits or instruments, the risk of delay due to substitution is decreased.

In the postoperative phase, most improved logistics are realized when there is a clear protocol for early discharge. In order to reach this, patients need to be informed that the scheduled discharge is on the first postoperative day. Thus, patients expect to go home on the first postoperative day, provided that they are physically and medically capable.

There are multiple reports which describe that early discharge after bariatric surgery is feasible and safe [25–29]. In our clinic, we experience benefits from the use of a specially designed checklist for early discharge [28]. It comprehends a few items which must be checked by the (mostly inexperienced) resident on the ward (Table 6.2). When one or more of these items are outside clearly defined thresholds, the supervisor must be directly informed.

Table 6.2 Discharge criteria ERABS [11]

Parameter	Score	Cut-off points
History		
VAS[a] for pain	0–10	≥4
Nausea score	1–4	≥4
Ate liquid food?	Yes/no	No
Mobilizing?	Yes/no	No
Patient is willing to go home?	Yes/no	No
Physical examination		
Abdominal guarding?	Yes/no	Yes
Heart rate		≥120 bpm
Oxygen saturation		≤90%
Drain production in 24 h		≥30 mL
Laboratory findings		
Hemoglobin decrease		≥1 mmol/L, or ≥1.6 g/dL
White blood cell count post-operative		$\geq 14 \times 10^9$/L
C-reactive protein post-operative		≥79 mg/L

[a]*VAS* visual analogue scale

In our experience, this checklist is a safe tool for the decision of early discharge, but it is not a good predictor of complications due to the low positive predictive value (PPV) of 6%. A drop in hemoglobin concentration >2 g/L is a significant predictor of complications, even before tachycardia [28].

We experience improved benefits from standardized postoperative group information meetings by dieticians and physiotherapists before discharge. Most ERABS protocols are suitable for all bariatric patients, including those scheduled for MGB. In our clinic, no additional specific perioperative measures are taken for MGB patients, except for an extended prescription for postoperative proton pump inhibitor (PPI) to prevent marginal ulcer in the first year.

6.3 Anesthetic Preoperative Care

Directly after approval for surgery, the patients are scheduled for one-stop work-up where the patient is screened by the surgeon and the anesthesiologist, and the operation is planned. Assessment of possible airway difficulty is an important factor of the preoperative evaluation. Neck size, tooth to tooth distance (mouth opening), neck movement and the thyro-mental distance are especially noted. Preoperative evaluation with ECG, hemoglobin, glucose, and renal function are standard, and if necessary (e.g., due to the presence of asthma or myocardial ischemia), there is extra consultation by a pulmonologist or a cardiologist [30].

Co-morbidities like diabetes and smoking are noted. The BMI and the STOP-BANG questionnaire are recorded as part of the preoperative consultation, because obstructive sleep apnea (OSA) is often missed in obese patients, but is very relevant for respiratory outcome [11, 31–33].

6.4 Perioperative Anesthetic Management

Preoperative fasting: Intake of clear fluids up to 2 h prior to surgery and intake of solid food is allowed up to 6 h prior to surgery, according to international guidelines from anesthesia societies [6, 34, 35]. Beware of autonomic neuropathy in patients with diabetes with possible slower gastric emptying [11, 30]. With regard to carbohydrate loading, there is one randomized study in bariatric patients with SG comparing enhanced recovery versus standard care; there were no differences in overall complications, but the study was limited because only 15% in the enhanced recovery group used carbohydrate conditioning [11, 24]. Therefore, carbohydrate loading is currently not indicated in ERABS protocols.

All patients are admitted to hospital on the day of surgery. Patients receive an intravenous line, but no sedative premedication is given, which allows each patient to make transfers from his/her own bed onto the operating table. High-risk patients, i.e., patients with OSAS or super-obesity, as well as diabetic patients, are scheduled first on the O.R. list, to allow longer postoperative monitoring in recovery.

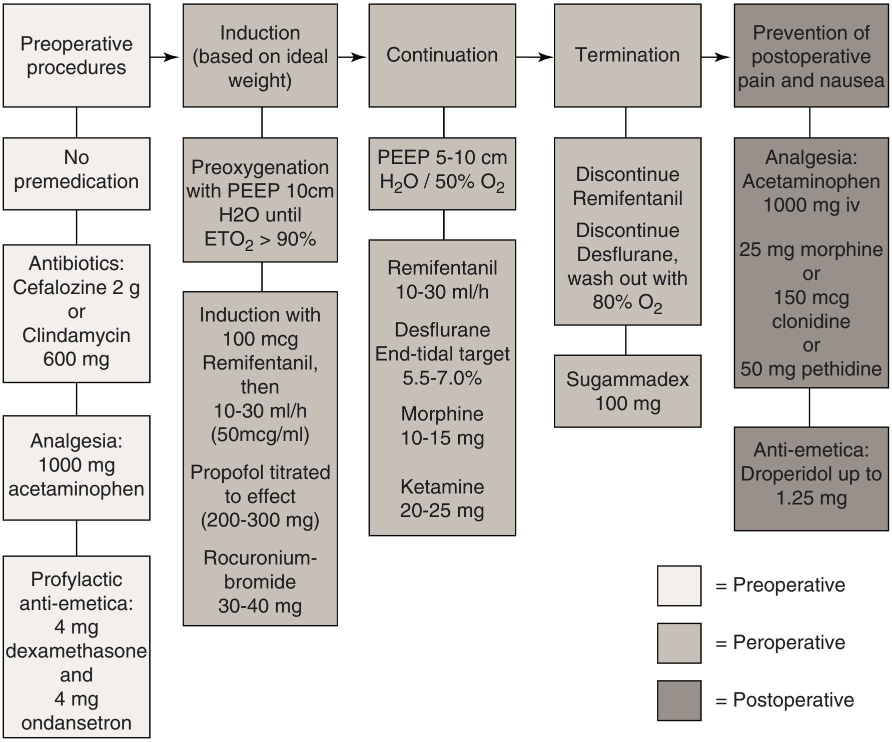

Fig. 6.1 The ERABS anesthesia protocol [11]

Fifteen minutes before surgery, the patient receives intravenous antibiotics, analgesia, and anti-emetics [36] (Fig. 6.1). PONV prophylaxis is advised in all bariatric patients with a multimodal approach [11, 36, 37]. In 2014, a RCT in bariatric surgery compared opioid-free total intravenous anesthesia (TIVA) with volatile opioid anesthesia, and found better results on rate and severity of PONV in the opioid-free TIVA group [38]. Standard monitoring is used: a blood pressure cuff, ECG leads, a pulse oximeter and train of four (TOF) muscle relaxation monitor, which remain connected throughout all preoperative procedures to assure maximum efficiency. Positioning on the OR table is done while the patient is awake, to prevent pressure ulcers or nerve injuries [39]. The legs are fixed with soft reusable leg fixator bands. Throughout the procedure, patients are monitored using a Bispectral-Index (BIS), applied to the patient's forehead [40]. BIS monitoring can be used, but the effect of ketamine on the reliability is not fully clear [41]. Current evidence does not allow recommendation of specific anesthetic agents or techniques, so we will describe our own experience [11]. The surgery team is the same during the day to facilitate using the same protocol and the team concept, which is proven to lower the procedure times [42].

In our protocol, anesthetic induction and surgical preparation of the patient are performed simultaneously. After pre-oxygenation for at least 3 min (set value etO2

Fig. 6.2 The HELP position

90%), the protocol, depicted in Fig. 6.1, is followed for induction of anesthesia [26, 43]. Rocuronium bromide (30–40 mg, 0.5 mg/kg IBW) is administered after the patient is sufficiently anesthetized, using the eyelid reflex to confirm the sleeping state. Patients are intubated 2–3 min after administration of the induction medication. All medication used is calculated using the Ideal Body Weight (IBW) [30, 31, 43].

Airway management: Anesthetists should be aware of the specific difficulties in managing the bariatric airway (up to 15% of the patients may be difficult to ventilate) [11, 26, 31, 44, 45]. Tracheal intubation remains the gold standard for airway management [46, 47]. Especially a supraglottic airway could dislocate when manipulating with a large size gastric tube during the procedure. The patient's head is positioned on a special Head Elevated Laryngoscopy Position (HELP) cushion to maximize sniffing position and facilitate mask ventilation and intubation, the ramp position [11, 26, 31, 48] (Fig. 6.2). A short handle laryngoscope is recommended, because the angle with an obese chest and the mouth can be difficult to pass, which is illustrated in a study with sport players [49] (Fig. 6.3). The immediate availability for a video-laryngoscope, gum elastic bougie and other airway adjuncts needed in the difficult airway protocol is obligatory. Anesthesia is maintained according to the flow chart (Fig. 6.1). Since desflurane and remifentanil are non-lipophil anesthetic agents, quick wash-out and awakening after termination can be ensured in this particular population. This may contribute to reduced costs and quicker recovery [24, 26, 30, 50–54].

Multimodal analgesia opioid-sparing techniques have to be used in bariatric surgery, preventing postoperative ventilation problems [11, 18, 26, 33, 43]. Analgesics used during maintenance are morphine, with co-analgesics esketamine (15–20 mg single shot) and clonidine (75–150 mcg) on demand perioperatively or postoperatively. Dexmedetomidine is also used in bariatric surgery as co-analgeticum [55].

Fig. 6.3 Short handle laryngoscope

Local infiltration of the wounds with ropivacaine is used. Although it has not yet been studied in bariatric surgery, the expectation from studies in other surgical procedures is that there is less need for opioids postoperatively [56]. Aerosolization of long-acting local anaesthetics in the abdominal cavity has also been used for this purpose [57]. There are still no RCTs on ultrasound-guided transversus abdominal plane block, which also can be used in bariatric surgery versus local infiltration [58].

A limited amount of fluids is given [11, 18]. In a study comparing more conservative intraoperative fluid regimens (15 mL/kg) versus more liberal strategies (40 mL/kg), the rate of rhabdomyolysis (RML) following laparoscopic bariatric surgery was not different [11, 59]. RML is defined by elevation of serum creatine kinase (CK) of >1000 IU/L and could lead to renal failure [6]. Lung protective ventilation should be adopted for elective bariatric surgery, but there is no proven superior ventilation strategy (volume versus pressure controlled) [11, 60]. The use of PEEP is necessary to keep the FRC as high as possible and prevent airway collapse [18, 61]. The use of the Anti-Trendelenburg Position can help to prevent atelectasis [44, 62, 63]. In recent studies, deep neuromuscular relaxation can have several advantages, such as more workspace for the surgeon, improving surgical performance and less postoperative pain. This practice needs further confirmation [11, 64, 65]. Routine use of a nasogastric tube is not recommended in the guideline postoperatively, so it is removed just before tracheal extubation [11, 66].

At the end of the operation, discontinuing desflurane and remifentanil and administrating sugammadex to reverse residual neuromuscular block stops the anesthetic state [67]. Sugammadex can rapidly reverse the muscle relaxation with positive additional effects on economics [68]. The endotracheal tube is removed after adequate respiration is assured and after eye-opening on demand. The patient is asked to slide over from the operating table onto the hospital bed in order to achieve early ambulation [18, 69]. All patients are transferred to the recovery room for postoperative monitoring and will be treated for pain and nausea [36] according to the protocol (Fig. 6.1). The patients are discharged to the ward, preferably within 2 h postoperatively. Standardized pain protocol includes four times daily 1000 mg acetaminophen and oral opioids when required, for 24 h maximally. Care must be taken for the respiratory depressing effects of opioids in selected cases [33].

6.5 Postoperative Anesthetic Care

Ventilation: Postoperative oxygenation: Obese patients without OSA, should all been given oxygen prophylactically in head-elevated or semi-sitting position in the immediate postoperative period [11, 70, 71]. There is low evidence for prophylactic oxygen, but strong evidence for the sitting position [11]. Monitoring of apneic episodes is warranted. A low threshold for initiation of positive pressure support must be maintained in the presence of signs of respiratory distress [11]. CPAP: According to the guidelines, CPAP therapy should be considered in patients with BMI 50 kg/m^2, severe OSA or oxygen saturation under 90% on oxygen supplementation [4, 11]. Beware that in patients using CPAP at home there can be a low compliance of using the CPAP. The STOP-BANG questionnaire can help to identify the need for special observation and monitoring of saturation and respiratory rate [31]. Obese patients with OSA on home CPAP therapy should use their equipment in the immediate postoperative period [11, 43]. A meta-analysis demonstrates more risk of apnea with higher FiO2 postoperatively [72]. The use of incentive spirometry is advised in the early recovery period to prevent atelectasis [18].

A special subcategory is the patient with Pickwickian syndrome or the Obesity Hypoventilation Syndrome with hypoxemia, hypercarbia and high bicarbonate, who is at risk for serious respiratory complications and has a high sensitivity to opioids. Prophylactic BIPAP/NIV for 24–48 h reduces the risk for these complications, and patients must be closely monitored especially in the first 24 h [11, 73–75].

None of the patients are routinely admitted to the ICU, since it increases the risk of DVT/PE, as patient's mobility is compromised due to extra lines and catheters [75]. When patients return to the ward, they are directly encouraged to drink full liquid diet and to ambulate, since early mobilization decreases the incidence of DVT [18].

Postoperative analgesia: Multimodal systemic medication and local anesthetic infiltration techniques should be combined [11, 18, 19, 44, 76]. In laparoscopy, there is little place for thoracic epidural analgesia because of minimal advantage for pain management, limitations of mobilization and the need for a urine catheter [11, 77]. Within 24 h post-operatively, the standardized post-operative analgesia protocol will be changed into four times daily 1000 mg of acetaminophen and three times daily 50 mg of tramadol, if necessary [26]. Caution is advised in prescribing NSAIDs due to the possible gastrointestinal side-effects [78]. Adequate analgesia is highly important for enhanced recovery, because it supports early mobilization and thereby decreases the incidence of DVT/PE and atelectasis [79]. Postoperative nausea is preferably treated with a single dose of 4 mg ondansetron [26].

Type 2 diabetic patients can decrease the dosage of their anti-diabetic medication by 50% immediately after surgery. Blood glucose levels should be monitored closely [26, 30].

Intravenous fluid administration is calibrated on urine production, with an accepted minimum average production of 50 mL per h. An overload of intravenous fluids can delay gut function activation and thereby prolong hospital stay [80].

In summary, the 12 most important aspects of the principles of anesthesia in bariatric surgery are [30]: (1) Difficulty to control diabetes, (2) Asthma, (3) Unhealthy lifestyle and smoking habits, (4) Sleep apnea, (5) Cardiac problems, (6) Difficulties with mask ventilation and (7) Intubation, (8) Ventilator problems, (9) Uncertainty about the exact pharmacokinetics and (10) Pharmacodynamics, (11) Risk of thromboembolic complications, and (12) The risk of postoperative airway obstruction when opioids are given to this group of patients [30].

6.6 Perioperative Practice and MGB-OAGB

Few articles describe perioperative practice of MGB-OAGB patients. A recent article by Blanchet et al. reported experience with ERABS and MGB [20]. MGB fits well in an ERABS program due to its relative simplicity and short operating time. It is interesting that in that study, operating times were short, within 1 h, and under these conditions, the use of systemic thrombosis prophylaxis may not be necessary. However, a reduction of bleeding has not been demonstrated.

Conclusions

ERABS and fast-track bariatric surgery have led to improved perioperative practice. Improvements in surgical and anesthetic protocols and dedicated surgeons and anesthesiologists adhering to all the elements of ERABS have greatly contributed to these improvements. All these alterations lead to a reduction in LOS, and reduced costs. Most patients can be safely discharged on the first postoperative day. This seems to be a benefit for the patient, but also for hospital management. Future studies should focus on real patient benefit: reduction of complications, improved quality experienced by patients, and improved quality of life. A recent study showed that ERABS in MGB patients is safe and feasible. MGB-OAGB surgeons who work with a clinical pathway using ERABS, or elements of ERABS, should feel comfortable that their perioperative practice is evidence-based and should be considered as best practice.

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7 Early Complications of the MGB: Prevention and Treatment

Mario Musella and Nunzio Velotti

7.1 Introduction

From its introduction by Rutledge in 1997 [1], the mini-gastric bypass (MGB) has encountered the favor of a large number of surgeons, becoming the fourth most performed bariatric operation in Europe and in the Asia/Pacific area [2], with an increasing trend [3]. Against first scepticism in this technique, different authors have reported favorable results in terms of weight loss, low rate of mid- and long-term postoperative complications and resolution of obesity-related comorbidities [4].

Although Roux-en-Y gastric bypass (RYGB) has been performed for more than 30 years [5], it is still a technically demanding procedure with a learning curve of >75 cases and its complication rate is 5–10% in highly experienced centers [6, 7].

Compared with other bariatric procedures, MGB has the advantage of being technically simple and easy to learn with a lower morbidity and mortality rate, especially in super-obese patients with high operative risk [8]. In this contest, early complications are defined as complications occurring within the first 30 postoperative days.

In a recent Italian multicenter study [9] on 2678 patients, a retrospective analysis was conducted to define the complication rate related to the MGB in the short and mid-term period, describing their management as well. In this study, a total of 84/2678 patients (3.1%) suffered from early complications. Among them, 74/2251 patients (3.2%) developed an early complication following a primary procedure, while 10/427 patients (2.3%) presented a complication following revision to MGB. According to the Dindo-Clavien classification [10] (Table 7.1), 10 patients presented a grade IIIA complication (0.3%), 47 patients presented a grade IIIB complication (1.7%), and 1 patient presented a grade IVA complication (0.03%), while 3 patients died during the early period (grade V, 0.1%). We can divide these complications into four categories (Table 7.2).

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Table 7.1 Dindo-Clavien classification of surgical complications

	Definition
Grade I	Any deviation from the normal postoperative course without the need for pharmacological treatment or surgical, endoscopic, and radiological interventions Allowed therapeutic regimens are: drugs as antiemetics, antipyretics, analgetics, diuretics, electrolytes, and physiotherapy This grade also includes wound infections opened at the bedside
Grade II	Requiring pharmacological treatment with drugs other than such allowed for grade I complications Blood transfusions and total parenteral nutrition are also included
Grade III	Requiring surgical, endoscopic or radiological intervention
Grade IIIa	Intervention not under general anesthesia
Grade IIIb	Intervention under general anesthesia
Grade IV	Life-threatening complication (including CNS complications)* requiring IC/ICU management
Grade IVa	Single organ dysfunction (including dialysis)
Grade IVb	Multiorgan dysfunction
Grade V	Death of a patient

Table 7.2 Early complications rate and treatment

	Complications *n.* (%)	Treatment
Bleeding		
Endoluminal	25/2678 (0.93)	14—transfusion 9—endoscopic hemostasis 1—thoracic surgery unit 1—laparoscopic revision
Intra-abdominal	21/2678 (0.78)	20—laparoscopic revision/hemostasis 1—transfusion
Leaks		
Anastomotic	5/2678 (0.18)	2—laparoscopic revision/Braun anastomosis 1—laparoscopic repair 1—laparoscopic reversal surgery 1—conservative treatment/laparotomic surgery
Gastric pouch	7/2678 (0.26)	5—laparoscopic repair 1—conservative treatment 1—revision/laparotomic surgery
Small bowel perforation	6/2678 (0.22)	5—laparoscopic repair 1—RY laparoscopic conversion
Anastomotic stenosis	5/2678 (0.18)	3—conservative treatment 2—laparoscopic repair
Abdominal wall hernias	4/2678 (0.14)	3—laparoscopic repair 1—laparotomic repair
Gastroparesis	1/2678 (0.03)	1—conservative treatment
Abdominal abscess	2/2678 (0.07)	1—conservative therapy 1—laparoscopic revision
Wound infection	1/2678 (0.03)	1—Wound healing
Pulmonary embolism	2/2678 (0.07)	2—intensive care unit
Pleural effusion	1/2678 (0.03)	1—Thoracic surgery unit

7.2 Bleeding

According to our study [9], bleeding is the most common complication; it has to be divided in endoluminal bleeding, coming from both gastric pouch or anastomosis suture line, and intra-abdominal bleeding.

Intraluminal bleeding has a general rate of 0.93% and it is significantly more prevalent in patients in whom no sealant is used and in whom separate stitches are used, as well as in patients operated during the early phase of the learning curve. Patients with intraluminal bleeding also generally have a longer operative time.

On the other hand, intra-abdominal bleeding has an incidence of 0.78% and correlates significantly with the use of stapler cartridges higher than 1.5 mm, the utilization of interrupted sutures to close the stapler holes, a longer operative time, and preoperative hypertension.

About endoluminal bleeding, chances for conservative and/or endoscopic management in this situation are usually higher and the management is based on clinical grounds. Commonly, bleeding ceases spontaneously and staple-lines are assumed to be the source [4]. In the case of intra-abdominal bleeding, a laparoscopic revision with surgical hemostasis is often the suggested solution.

In comparison to some other large series and long-term follow-up papers, the total bleeding rate in the Italian study (1.71%) was higher when compared with the rate observed by Carbajo [11] (0.9%) and Kular [12] (0.2%). Moreover, our bleeding rate is higher than that observed by Lee [6] in his 10-years experience (0.2%) and by Chevallier [13] in his 7-years follow-up (0.2%).

7.3 Leaks

Leaks are the second most common complication, and include both anastomotic leaks and gastric pouch leaks. Complication rate in the Italian series was 0.18% for leaks on the anastomotic suture-line; in this case, a surgical revision is highly recommended, and could vary from a laparoscopic revision with a Braun anastomosis to a reversal operation or to a laparoscopic defect repair by a laparotomic approach if the conditions of the patient require it. On the other hand, the Italian experience shows a rate for gastric pouch leaks of 0.26%; most of them can be managed with a laparoscopic repair [9].

These results (total rate 0.44%), when compared with large series mentioned above [6, 11, 13], are lower than the leakage rate described by Carbajo (1%), Chevalier (0.6%) and Lee (1.3%). Only Kular, with his analysis on 1054 patients who underwent MGB, found a lower rate for this complication (0.1%) [12].

As in other bariatric procedures, conservative management is not common in MGB because leaks may be difficult to treat and even fatal.

Even if uncommon, the anastomotic characteristics of MGB allow on occasion a conservative treatment of leaks. Since there is no enteric sectioning and all intestinal arcades supply the area, blood-flow in the MGB may sustain tissue healing; moreover, the long low-pressure pouch [14] and MGB's antireflux mechanism provide less vascular grip. This may contribute to positive results with non-surgical treatment.

7.4 Small Bowel Perforation

This is the third complication in terms of rate (0.22%). Similar to RYGB, perforation in MGB seems to be strongly associated with marginal ulcer, but unlike RYGB, it may be easier to treat because of the ease of reversal or revision of the surgical technique. Though ulcer perforations have been reported after MGB, it appears to be restricted to smokers and can be treated by a simple laparoscopic repair. In few cases, a laparoscopic conversion to RYGB may be necessary [6].

7.5 Anastomotic Stenosis

The rate for early stenosis in the Italian multicenter series was 0.18%, and it is probably due to anastomotic tension, ischemia and subclinical leaks. To prevent stenosis after MGB, an anastomotic size of ≥2.5 cm is highly recommended.

Management of this complication provides a successful conservative approach by pneumatic endoscopic dilations. The rate recorded in MGB is better than most RYGB series where anastomotic stenosis reaches up to 27% of cases [15].

7.6 Other Complications

Abdominal wall hernias (rate 0.14%), gastroparesis (0.03%), abdominal abscess (0.07%), and wound infection (0.03%) have been reported as possible other complications of MGB; their treatment is usually conservative except for abdominal wall hernias which require surgical repair. Another aspect to consider is the obesity condition itself, which could determine postoperative complications such as pulmonary embolism (0.07%) and pleural effusion (0.03%) [9].

Following Rutledge's first report [1], some bariatric surgeons expressed concern regarding use of MGB [7, 16]. Conversely, multiple authors have subsequently reported excellent results and low intraoperative, early, or late complication rates in patients who underwent MGB [17–21].

If we consider the early complication rate (3.1%) with other large series, we observe that MGB-OAGB outperforms RYGB and LSG; in the Italian multicenter experience [9], it is interesting to observe the statistical correlation of bleeding with some technical details, or with both operative time and a learning curve lower than 50 cases.

Leaks following MGB-OAGB are especially dangerous due to the presence of both acidic and alkaline fluids. Considering a leak rate in the early period of 0.4%, it is interesting to consider that Hutter [22] reported a 0.7% leak rate for both LSG and RYGB on 28,616 patients observed between 2007 and 2010, and Rausa [23] reported 0.6% leaks following laparoscopic RYGB on 69,494 patients. The same favorable outcome for MGB is confirmed when considering early bleeding: the 0.7% rate observed in the Italian study [9] can be compared with 0.6% and 1.1% for LSG and laparoscopic RYGB reported by Hutter [21], with 1.8 ± 3.1% for LSG reported by Gagner [24], and 1.8% for laparoscopic RYGB in the series of Rausa [22].

Conclusion

Early complications following MGB (bleeding, leaks, small bowel perforation, anastomotic stenosis, etc.) are uncommon, but the surgical team must be vigilant. MGB has shown safety and efficacy. It is not inferior to other bariatric operations and is particularly suited for metabolic and diabetic surgery. From a procedural point of view, the long low-pressure pouch and single anastomosis make it a valid option for technically difficult super-obese patients.

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Late Complications of MGB: Prevention and Treatment

8

Mario Musella and Alessio Bocchetti

8.1 Introduction

Late complications are defined as complications occurring from the second postoperative month and up to 10 years from surgery. The most frequent complications, their rate and the suggested management are shown in Table 8.1. In a recent multicenter review from Italy, the late complications rate of MGB-OAGB was 10.9% for primary procedures and 7% for revisional/redo operations [1]. The learning curve, intended as the first 50 cases, significantly influenced the late complication rate [1].

Table 8.1 Late complications of MGB: rate and treatment

Complications	Rate (range)	Treatment
GER	0.5–4%	– Conservative (PPI) – RYGB laparoscopic conversion – Braun laparoscopic anastomosis
Anemia	1.7–30%	– Drug therapy/Iron supplementation
Weight regain	1.6%	– Laparoscopic pouch resizing – Loop resizing
Marginal ulcer	0.6–4%	– PPI treatment – Laparoscopic repair – Laparotomic repair
Excessive weight loss	0.2–1.2%	– Conservative treatment – Restorative laparoscopic surgery – Loop resizing
Internal hernia	0.1–0.4%	– Laparoscopic repair
Anastomotic stenosis	0.1–0.4%	– Endoscopic repair – RYGB laparoscopic conversion

GER gastro-esophageal reflux, *PPI* proton pump inhibitors, *RYGB* Roux-en-Y gastric bypass

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8.1.1 Gastro-esophageal Reflux (GER)

Gastro-esophageal reflux (GER) is defined as the presence of duodenal contents coming up the gastric pouch into the esophagus [2, 3]. GER has been mainly addressed by clinical findings identified through validated questionnaires [4]. In the presence of symptoms, endoscopy and high-resolution impedance manometry are used to detect histological damage caused by alkaline reflux affecting a normally acid environment [2, 3].

This complication is reported to range between 0.5 and 4%, and a correlation with a gastric pouch shorter than 9 cm and with the presence of preoperative gastro-esophageal reflux disease (GERD) has been observed. However, *de novo* GER has been reported in 2% of patients [1].

EG junction function has been evaluated pre- and postoperatively [5] through endoscopy, high-resolution impedance manometry, and 24-h pH-impedance monitoring, and in MGB demonstrates low intragastric pressure with a lack of GE reflux. These results have been compared with patients who had undergone laparoscopic sleeve gastrectomy (SG), who demonstrate a high-pressure gastric pouch with GE reflux [6]. After MGB, no heartburn or regurgitation, esophagitis, or presence of bile, were reported. After MGB, intragastric pressure, GE pressure gradient, and GE reflux events (acid, weakly acid, and even weakly alkaline) all significantly diminished. The need for surgical revision following MGB-OAGB due to intractable bile reflux is rare, especially when standard operative techniques are performed [7–9]; this ranges from 0% to 0.7%.

In Chevallier series, seven patients presented with an intractable biliary reflux. They were reoperated after a mean of 23 months when mean BMI was 25.7 kg/m^2. These patients were then cured after conversion to a RYGB: the bile reflux (GER) then disappeared [7].

In other series, sporadic clinical GER was reported in ~2%, and the few episodes were associated with dietary transgressions, especially at night. Endoscopic studies revealed the presence of some bile in the stomach with mild to moderate pouch gastritis, but did not document any esophagitis [8–10].

The main condemning argument against MGB-OAGB through years has been the potential consequences for bile reflux. Although biliary reflux into the stomach may be frequent both physiologically [11] and after some operations [12], symptomatic, endoscopic, and histologic repercussions have neither been relevant nor conclusively proven [13].

The anatomical configuration makes gastric and/or esophageal symptomatic bile reflux after MGB-OAGB quite rare [6, 14–16], especially when a correct technique is performed.

Treatment of GER includes dietary and healthy lifestyle recommendations, continued follow-up by nutritionists, PPIs (40 mg/day for 6 months), and sucralfate (1 g before every meal and before bedtime for 3 months, followed by 1 g before bedtime for another 3 months) [10].

When conservative treatment fails (42.8% of all patients presenting GER), a surgical revision is advised. The suggested procedures, in such cases, are

RYGB laparoscopic revision, or Braun side-to-side anastomosis between the afferent and the efferent limb, about 15–20 cm before to beyond the gastrojejunal anastomosis [1].

8.1.2 Malnutrition

After MGB-OAGB, a few patients develop excessive weight loss (WL) and/or nutrient deficits (usually within the first 2–3 postoperative years). This complication ranges between 0.2 and 1.2%. Revisional surgery, by reducing the length of bypassed bowel, or reversal surgery, by restoring original anatomy, is then required. This occurs in 0.7% of patients presenting malnutrition [1, 7, 8, 17, 18]. Most patients are in fact generally controlled and treated on an ambulatory basis, and recover with dietary recommendations, once intestinal adaptation is complete [10]. Iron deficiency is rather common, especially in fertile women with copious menstrual bleeding. Up to one-third require oral supplements beyond the expected time for intestinal adaptation, and up to 1.3% may require parenteral iron [10].

The relatively low rate of anemia (1.7%) in some experiences [1] can be explained by the large use of iron, vitamins, and folate implementation prescribed postoperatively. Furthermore a relationship between anemia and the learning curve has been reported [1].

Excessive weight loss is basically due to loop length >250 cm. Nevertheless, over time, Carbajo et al. have progressively increased the extent of bypassed small bowel from <200 cm, to a range of 250–305 cm, based both on total small bowel length and preoperative BMI [10]. This small bowel tailoring, has also been suggested by other MGB-OAGB surgeons [19–21]. Although increased malabsorption could theoretically lead to more side-effects and malnutrition, only 14 patients (1.1%) suffered protein malnutrition [10]. In this series, severe malnutrition occurred in two patients who had excessive weight loss (%EBMIL >100% and albuminemia <30 g/L). Their mean BMI at 5 years was 19 kg/m^2 and %EBMIL was 124 and 122%. They were treated in a specialized medical unit with parenteral alimentation and psychiatric support, before a reversal of the OAGB was performed [10].

Malabsorption is only one of many factors that lead to malnutrition; among others, these include psychologic, personal, family, social, and even economic issues. Malnutrition can thus be seen after procedures which entail none, or less malabsorptive components [22–24]. Malnutrition is often temporary; after a support program including I.V. therapy followed by a strict program of enteral supplementation and counseling (aimed at improving all other factors that influence nutritional status), and once intestinal adaptation is reached [25], it often poses no further problems [10].

Rutledge reported excessive WL in 1% in his series [26] and suggested selected reversal to normal anatomy as the reoperation of choice. Lee revised 23 of 1322 patients (1.7%) [8]; the most common cause was malnutrition in 9 patients (0.7%). A conversion to SG, due to efficacy in improving malnutrition without regaining body weight, was in this case recommended. Noun et al. [20] reported excessive weight loss in 4 patients (0.4%) with reversal in 2 and conversion to SG in the other

2. The Italian group [27] submitted 7 of 818 patients (0.8%) to late reoperations; indication was EWL of >100% in only one (0.1%).

Although the argument remains debated, the ideal length of small bowel to be bypassed has been estimated to be about one-third of its total length.

8.1.3 Weight Regain

Weight regain is measured as both postoperative body mass index (BMI) and excess weight loss (EWL%) changes [7, 17]. It is mostly associated with the learning curve, and is due to pouch and loop size. In weight regain, the use of a surgical approach (pouch and loop resizing) is suggested. Five percent (n = 49) of patients from a French series had ≤25% EBMIL and were considered as weight-loss failures. Dilatation of the gastric pouch occurred in four patients 24 months following MGB-OAGB. The dilatation was assessed by an x-ray upper gastrointestinal series. Revision surgery was done by pouch resizing using a calibration tube in all patients [7]. A lower rate from an Italian series was reported in 11/683 patients (1.6%) with 5-years follow-up; the management was pouch resizing in 4 and loop lengthening in 7 patients [1].

8.1.4 Marginal Ulcer

The pathogenesis of marginal ulcers (MU) is probably different from that of peptic ulcers, and might involve acid secretion and impaired blood supply to gastric mucosa. MU is reported only when it is extremely bothersome or of surgical interest, being therefore probably underestimated. It is a common complication following RYGB, ranging from 1 to 9% [28], while the MU rate seems to be lower following MGB-OAGB, ranging from 0.5 to 4% in a recent systematic review [16]. An association with smoking and the learning curve has been suggested [1, 14]. MU is commonly diagnosed with endoscopy.

A total of 6 patients (0.5%) in Carbajo's series developed anastomotic or marginal ulcers; 5 were acute and presented without warning signs or symptoms, with upper GI bleeding [10].

Critics of MGB-OAGB emphasized that it would lead to a higher rate of MU and with less responsiveness to medical management [29]. Various risk factors independent of bile reflux have been identified [30]. Increased acid production in an oversized pouch is a potential cause, but some authors hypothesized that the presence of bile within the anastomotic area in MGB-OAGB may actually have a protective effect by buffering acid ulcerogenic action [7]. In Carbajo's series, the marginal ulcer rate of 0.5% is one of the lowest reported for any type of gastric bypass [10]. Moreover, this longer follow-up demonstrates that MU was as responsive to medical therapy as MU after RYGB. Patients in most MGB-OAGB series [1, 10, 14, 16, 20] normally respond to PPIs, sucralfate, and HP eradication [10]. Treatment with PPI is the first step. When conservative management fails, the therapy is surgical.

8.1.5 Internal Hernia

Unlike RYGB, in which the internal hernia rate may reach a worrisome 16.1% [22], MGB-OAGB presents a negligible rate of internal hernias (0.1%–0.4%) [1, 7, 8, 10]. It is likely due to the different surgical technique; in MGB-OAGB there is no interruption of mesenteric continuity. CT scan may be of help in reaching a diagnosis. When this complication appears, the only treatment is surgical.

8.1.6 Anastomotic Stenosis

Anastomotic stenosis is due to anastomotic tension, ischemia, or subclinical leaks. However, the linear anastomosis described for the MGB-OAGB [10, 26] is large, ranging from 3 to 6 cm. This is in opposition to the RYGB which includes a narrower (~1.2 cm) anastomosis [30]. The stenosis rate reported recently for MGB-OAGB on 3/683 patients at 5 years from surgery was 0.4% [1, 7, 10].

Carbajo had 6 stomal stenosis (0.5%), 4 successfully treated by a single session endoscopic dilation 2 to 3 months following surgery. Another patient (lost at follow-up) was submitted at another hospital to repeated dilations and suffered a perforation that required urgent operative treatment [10].

The recommended management of this complication is endoscopic balloon dilation, or laparoscopic RYGB conversion when endoscopic treatment fails.

Conclusion

Late complications after MGB are uncommon, but important. Alkaline GER, anemia, weight regain, malnutrition, excess weight loss, internal hernia and anastomotic stenosis demand follow-up and proper management.

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Diet, Supplements and Medications After MGB: Nutritional Outcomes; Avoidance of Iron Deficiency; MGB in Vegetarians

9

Sarfaraz Jalil Baig and Pallawi Priya

9.1 Introduction

Obesity is a multifactorial disease. Although chronic caloric excess is a principal cause, other mechanisms such as metabolism, hormonal, genetic, and gut microbes have been identified. The treatment has largely focused on calorie restriction through dieting and increasing calorie expenditure through physical activity. This strategy has been shown to meet often with failures. Bariatric surgery, by influencing food intake and other biological processes, has emerged as the most effective method of significant and sustained weight loss in the obese.

However, the surgery has its limitations if not supplemented by a strict nutritional follow-up. With time, the restriction and malabsorption may lead to a deficiency of essential nutrients. Physiological and functional adaptations slowly take place and may cause weight regain if diet and eating habits are not adjusted and maintained. Therefore, for the long-term success of bariatric surgery, it is important to monitor and follow-up individuals undergoing the procedures. The elements of nutritional follow-up include actively looking for possible deficiencies, correcting them, monitoring the weight, and adjusting the diet to get the optimal results from the surgery.

The first attempt at standardization of screening and supplementation of these patients was done in 2008 in the ASMBS guidelines [1] which were subsequently modified in 2013 [2]. Still, considerable variations occur with BMI, geography, and type of procedure performed. In addition, very little data is available about the nutritional outcome of relatively newer procedures such as MGB-OAGB.

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9.2 Pathophysiology of Nutritional Changes After MGB and OAGB

MGB-OAGB produces weight loss partly by restriction of food intake but mainly by malabsorption of ingested food by virtue of the bypassed segment of the duodenum and about one-third of jejunum, in addition to gut hormonal manipulation. The decreased absorption coupled with the bypassed gut produces a deficiency of many essential nutrients. Figure 9.1 gives a schematic idea of the nutrient deficiencies due to gut bypass.

Other factors that may play a role in the nutritional outcome are: (1) decreased gastric surface leading to less acid production and alteration of pH; (2) decreased acid and pepsin that leads to insufficient breakdown of protein; (3) gastric exclusion translating into a deficiency of intrinsic factor leading to insufficient absorption of vitamin B12; (4) unhealthy food choices.

Because of the diversion of the proximal gut, the following nutrients are more prone to malabsorption (as shown in Fig. 9.1): (1) amino acids; (2) iron, calcium,

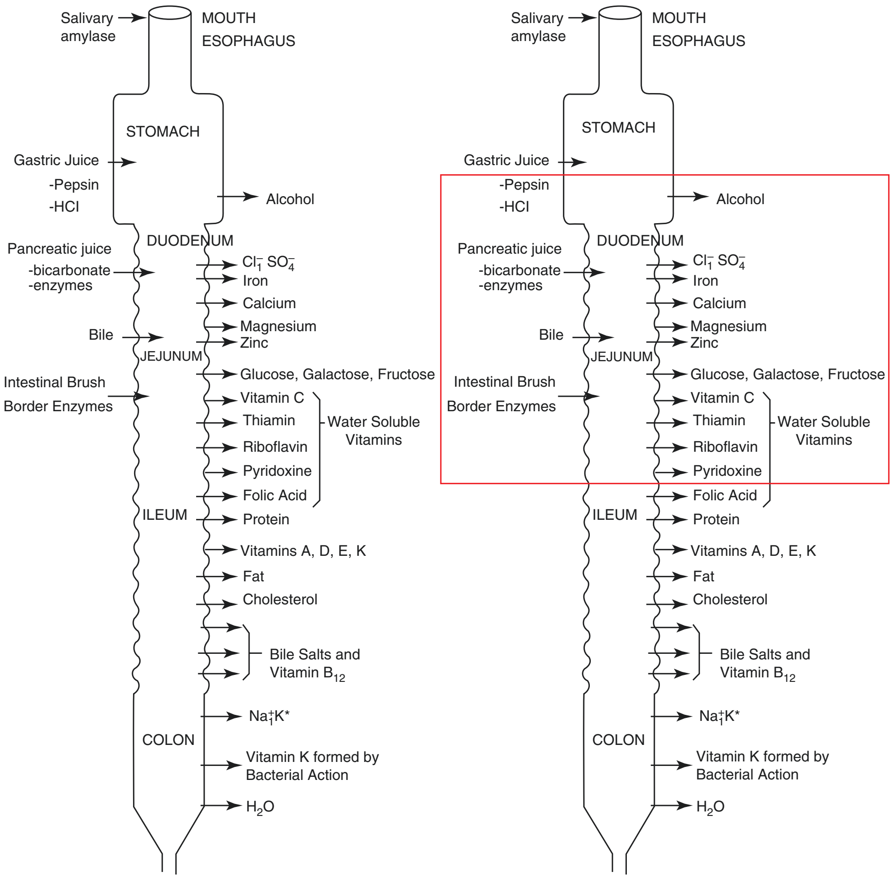

Fig. 9.1 Schematic representation of sites of absorption of various nutrients in the GI tract. Figure on the right shows nutrients absorbed from the excluded portion of GI tract in MGB-OAGB in the red box

magnesium, zinc; (3) water-soluble vitamins such as B1, B2, B6, B12 and folate. It is fair to assume that longer bypass leads to more malnutrition.

Because water-soluble vitamins are not stored in the body, their deficiencies may be seen early in the post-operative period. These deficiencies are more pronounced in patients with post-operative vomiting.

Fat is malabsorbed significantly in MGB and OAGB due to the long biliopancreatic limb. The absorption of fat-soluble vitamins is consequently also affected, although their deficiencies present late since they are stored in the body. Vitamin D deficiency is common after bariatric procedures. Vitamin A deficiency is also seen after the diversionary bariatric procedures.

Another factor that may influence the absorption of nutrients is intestinal adaptation. This is a compensatory response over time, which increases the digestive and absorptive capacity of the non-bypassed gut to compensate for the decreased absorptive area caused by the bypass. This biological process may influence the long-term nutritional outcome. However, the intensity and durability of this mechanism are not fully known. At the end of this chapter, Appendix 9.1 and 9.2 summarize the commonly seen deficiencies after MGB-OAGB.

9.3 Nutritional Assessment of Patients Before MGB

The pre-operative assessment is to understand the patient's motivational level, assess fitness for surgery and anesthesia, screen for nutritional deficiencies, and educate about healthy eating and need for change in eating habits before and after surgery. Our practice has been to send people willing to undergo a bariatric procedure to a nutritionist for a detailed evaluation during the first visit itself. The 2008 ASMBS guidelines [1] give a comprehensive recommendation for the pre-operative assessment.

9.3.1 History and Physical Examination

A thorough assessment needs to consider the individual as a whole and as a unit of the society where the surroundings play as important a role as the diet in the well-being of a person.

Figure 9.2 gives a broad idea of the recommended preliminary assessment. It summarizes the salient points that need to be covered in the history. Referral to appropriate professionals should be considered for mental health evaluation and specialized activity instruction.

9.3.2 Nutritional Education

Nutritional education is an important determinant of long-term success after a well-performed bariatric operation. The components of nutritional education are an assessment of the pre-existing knowledge, expectation management with realistic goal setting, and preparing for the post-operative dietary changes and common gastrointestinal complaints.

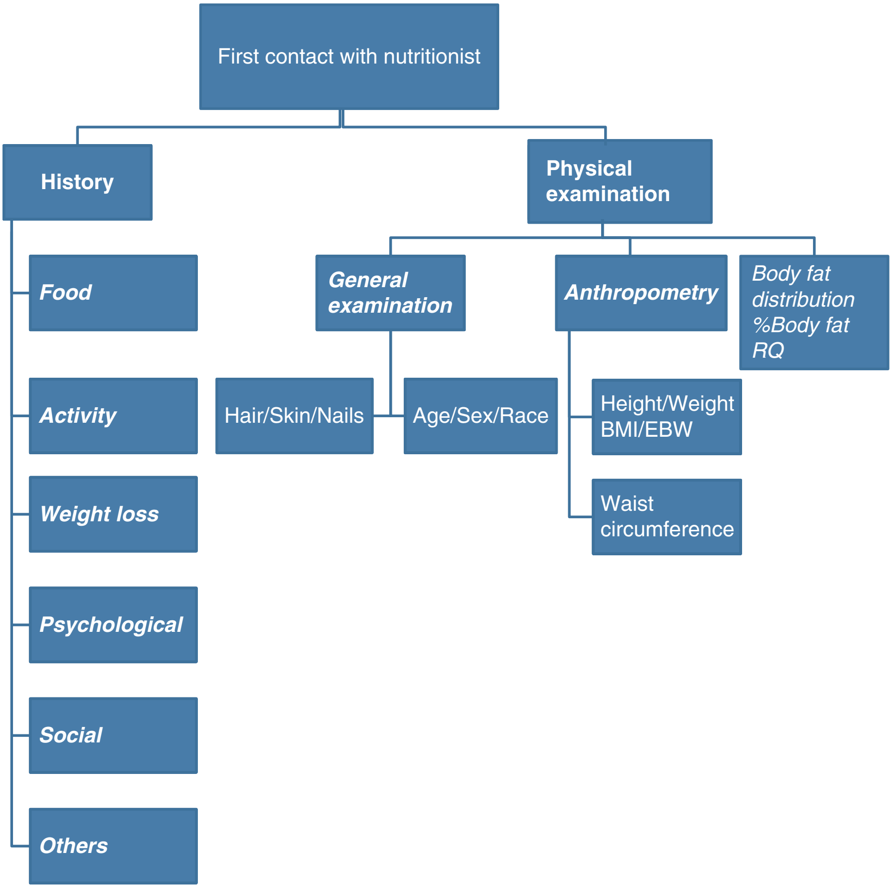

Fig. 9.2 Flow-chart summarizing salient points to be covered in pre-operative nutritional assessment. (Adapted from 2008 ASMBS guidelines by Linda Aills et al. [1])

There are often many unhealthy eating habits and misconceptions deeply rooted in the cultural and social background of the patient, which may get in the way of a successful outcome if not addressed.

As a second step, we teach our patients about post-operative diet. Texture progression, the importance of protein, vitamins, and mineral supplementation, meal planning and spacing, and desired diet composition are discussed. The importance of adequate hydration is emphasized, as lower stomach volume may translate into insufficient water intake. This is a good time to discuss the possibility of weight regain and methods to minimize it.

Patients must be told about the common post-operative complaints, such as dehydration, nausea/vomiting, anorexia, dumping syndrome, reactive hypoglycemia, flatulence, lactose intolerance, hair loss, and the return of hunger.

As a long-term measure, patients need to be taught about self-monitoring measures, healthy cooking techniques, and healthy food choices. Managing the diet in case of restaurant eating is taught.

This phase of pre-operative preparation usually involves more than one sitting and sometimes a psychiatrist and a physical therapist. It is important that patients are not taken for the surgery until they are educated and understand the need for the lifestyle changes to follow.

9.3.3 Pre-operative Nutritional Screening

All patients to undergo bariatric surgery should be evaluated for nutritional deficiencies which are frequently present. Table 9.1 summarizes the deficiencies as reported by various authors [3–8]. There is considerable variation in the reported rates, according to the geography, BMI, and cut-offs.

Apart from complete blood counts for hemoglobin status, and protein assay, the ASMBS [1–9] recommends routine screening of the micronutrients summarized in Table 9.2.

We check complete blood counts, albumin, vitamin B12, vitamin D, iron, ferritin and folate routinely and the rest only if there is any clinical suspicion of deficiency. If any deficiency is detected on pre-operative investigations, it is corrected before surgery is undertaken.

Table 9.1 Nutritional deficiencies in the obese population [3–8]

Nutrient	Deficiency (In percentage)
Albumin	0–12.5
Prealbumin	6.4–27.1
Hemoglobin	2.6–2.2
Ferritin	0–23.9
Iron	9–35.1
Vitamin A	0–16.9
Vitamin D	67.7–92.2
Vitamin E	0
Vitamin K	0
Calcium	0–4.8
Phosphate	0–21.6
Parathyroid hormone	22.6–41
Vitamin B1	7.2
Vitamin B6	15.9
Vitamin B12	2.2–18.1
Folic acid	0–25.2
Zinc	0–73.9
Copper	0–67.8
Magnesium	4.7–35.4
Selenium	3.2

Table 9.2 Pre-operative nutritional screening

Nutrient	Tests	Comments
Thiamine	• Whole blood thiamine diphosphate	• Grade C recommendation, all patients
Vitamin B12	• Serum MMA • Serum vitamin B12	• Grade B recommendation, all patients • Serum B12 levels alone may not be adequate to identify deficiencies
Folic acid	• Low RBC folate along with increased homocysteine and normal MMA are indicative of deficiency	• Grade B recommendation, all patients
Iron	• Serum iron • Serum ferritin (indicative of iron status and not deficiency) • Serum transferrin saturation • TIBC	• Grade B recommendation, all patients
Vitamin D and Calcium	• Serum 25-OH vitamin D • Serum ALP • Serum PTH • 24-h urine calcium • Serum type 1 collagen NTX levels in peri/postmenopausal women	• Grade A recommendation, all patients
Vitamin A, E and K	• Serum vitamin levels	• Grade C recommendation, all patients
Zinc	• Serum zinc levels	• Grade D recommendation, patients undergoing diversionary procedure • To be interpreted as physical signs and symptoms
Copper	• Serum copper • Serum ceruloplasmin • Erythrocyte superoxide dismutase	• Grade D recommendation, patients undergoing diversionary procedure

Adapted from 2008 ASMBS guidelines by Linda Aills *et al.* [1] and 2016 guidelines by Parrot J *et al.* [9]

Abbreviations: *MMA* methylmalonic acid, *TIBC* total iron binding capacity, *ALP* alkaline phosphatase, *PTH* parathyroid hormone, *NTX* N-telopeptide

9.4 Post-operative Care of Bariatric Patients

Guidelines published in 2013 by Mechanick et al. [2] give comprehensive guidelines for post-operative diet and supplementation. We will discuss postoperative care in terms of early post-operative care, diet and supplementations, follow-up, and therapeutic interventions.

9.4.1 Early Post-operative Care: Diet and Texture Progression

- A low-carbohydrate liquid meal is initiated in the early post-operative period. The patient can progress to a pureed diet under a nutritionist's supervision followed by a normal solid diet.

- Hydration needs to be monitored carefully in the early postoperative period.
- Patients are educated regarding chewing food properly and eating and drinking slowly. They are advised not to drink while eating.
- The protein intake is individualized. Recommended is 60–1.5 g of protein/kg ideal body weight per day.
- Patients are advised to avoid concentrated sweets to prevent dumping.
- Nutritional supplements and medications for associated co-morbidities are started as soon as permissible. The dosage of the supplements is given below. A chewable tablet is preferable, to begin with. Iron (Proferrin®, intestinally absorbed polypeptide) and calcium supplements should be consumed at least 2 h apart.
- Medicines in liquid form are preferred. Tablets are crushed, and chewable tablets are desirable. Extended-release drugs to maximize absorption are avoided.

9.4.2 Postoperative Nutritional Deficiencies

Although there are not enough data available to provide clear guidelines yet, reports are slowly coming in. Prevalence of iron deficiency anemia has been reported to be 4.9%–26.6% [10–14] in short to long-term follow-up. Jammu *et al.* [15], in his earlier patients with longer bypassed limbs, found that prevalence of hypoalbuminemia was 13.1%; Luger et al. [16], with a long bypass, also reported 8.1% hypoalbuminemia and 41.7% hypoproteinemia. Vitamin D deficiency was found to be 80% at 1 year [16]. However, the supplementation in that study was well below the currently recommended levels. Severe malnutrition has been reported after MGB-OAGB in rare patients [14, 17, 18]. Two unpublished audits from India report the rates of deficiencies 1 year after MGB shown in Table 9.3.

9.4.3 Nutritional Supplements—Dosage

Currently, we follow the supplementation protocol for MGB and OAGB as per ASMBS 2013 Guidelines. A recent recommendation by Parrot J *et al.* [9] has modified prophylactic doses of certain supplements. We have summarized the recommendations for important nutrients in Table 9.4.

Table 9.3 Nutritional deficiencies after MGB as reported by two unpublished audits from India

	Baig *et al.*	Tantia *et al.*
Number	56	100
Anemia	35.7%	–
Serum Iron	–	43%
Serum ferritin	3.6%	26%
Vitamin B12	10.7%	10%
Albumin	17.8%	5%
Vitamin D3	28.5%	23%

Table 9.4 Prophylactic doses of micronutrients to be given after diversionary procedures to avoid deficiencies

Nutrient	Dose	Level of recommendation
Thiamine	50 mg/d	Grade D
Calcium	1200–1500 mg/d Carbonate is taken with meals Citrate can be taken with or without meals	Grade C
Vitamin D	At least 3000 IU/d to be titrated to keep the blood levels within normal	Grade D
Iron	45–60 mg/d Should be taken separately from calcium supplements and foods reducing acidity	Grade C
Vitamin B12	Given to maintain blood levels within normal limits 350–500 mcg/d orally or, 1000 mcg/month intramuscular/subcutaneous	Grade B
Folic acid	400–800 mcg/d 800–1000 mcg/d in women of childbearing age	Grade B
Copper	2 mg/d	Grade C
Zinc	8–22 mg/d	Grade C
Vitamin A	10,000 U/d	Grade C
Vitamin E	15 mg/d	Grade D
Vitamin K	90–120 mcg/d	Grade D

Adapted from 2008 ASMBS guidelines by Linda Aills *et al.* [1] and 2016 guidelines by Parrot J *et al.* [9]

Medical practitioners should check that the prescribed multivitamin-multimineral tablets for bariatric patients contain micronutrients as per guidelines. Usually, iron and calcium would necessitate additional tablets.

9.4.4 Monitoring and Follow-up

Our patients are seen at 1, 3, 6, 12, 18 and 24 months after surgery and yearly thereafter. Patients follow up with both the surgeon and the nutritionist. Referrals are made to the psychologist, physician, and physical therapist as needed. Support group meetings, when available, help to maintain compliance and adjust to the lifestyle changes.

The following factors are considered at each follow-up:

Evaluation by a surgeon:

- Changes in weight, waist circumference and BMI.
- Co-morbidities are evaluated and their remission response noted.
- Addictions and substance abuse are noted and strongly discouraged. Alcohol interferes with the absorption of nutrients, may exacerbate deficiencies, and is rapidly absorbed.
- The status of physical activity is noted and actively encouraged.

Evaluation by the nutritionist:

- Dietary habits and compliance are noted. The patient is educated regarding the adequacy of protein and fibre intake.
- Assessment of nutritional status. Clinical evaluation is done by noting the condition of skin, hair, nails, eyes and mouth. A thorough search for hair loss, Bitot's spots, glossitis, phrynoderma, brittle nails, pedal edema and muscle strength is made.
- Compliance to supplementation is noted and its importance emphasized.
- Reasons for non-compliance to follow-up are sought and addressed. Ignorance, economic limitations in procuring expensive supplements, and not liking the taste of the changed diet are some of the factors responsible for patients not adhering to diet and supplement.
- Patients are taught to deal with common problems such as dumping, dehydration, and dyspepsia.

The symptoms and signs of nutritional deficiencies are often vague and overlapping. Thus, lab tests are important. Deficiency of one nutrient is usually a surrogate marker of multiple deficiencies. Therefore, one should evaluate completely if one deficiency is detected. The lab tests performed in follow-up are mentioned in Table 9.5.

Table 9.5 Parameters to be checked at each follow-up

Tests	Frequency
Complete blood counts *Should include a peripheral smear examination to know RBC morphology*	At every visit
Serum lipid profile	Every 6–12 months based on risk
Serum Vitamin B12 *May additionally require MMA and HCy for complete evaluation*	At every visit
Serum iron TIBC Ferritin Soluble transferrin receptor if available	At every visit
24-h urinary calcium	At 6 months and then annually
Serum vitamin D PTH Bone density (DEXA)	Serum vitamin D at every visit Bone density at 2 years
Folic acid *RBC folate optional*	At every visit
Vitamin A	At the first visit and 6 monthly thereafter
Copper, zinc and selenium	If clinical suspicion of deficiency
Thiamine evaluation	If clinical suspicion of deficiency

Adapted from 2008 ASMBS guidelines by Linda Aills *et al.* [1] and 2016 guidelines by Parrot J *et al.* [9]

Abbreviations: *MMA* methylmalonic acid, *Hcy* homocysteine, *PTH* parathyroid hormones, *DEXA* dual energy X-ray absorptiometry

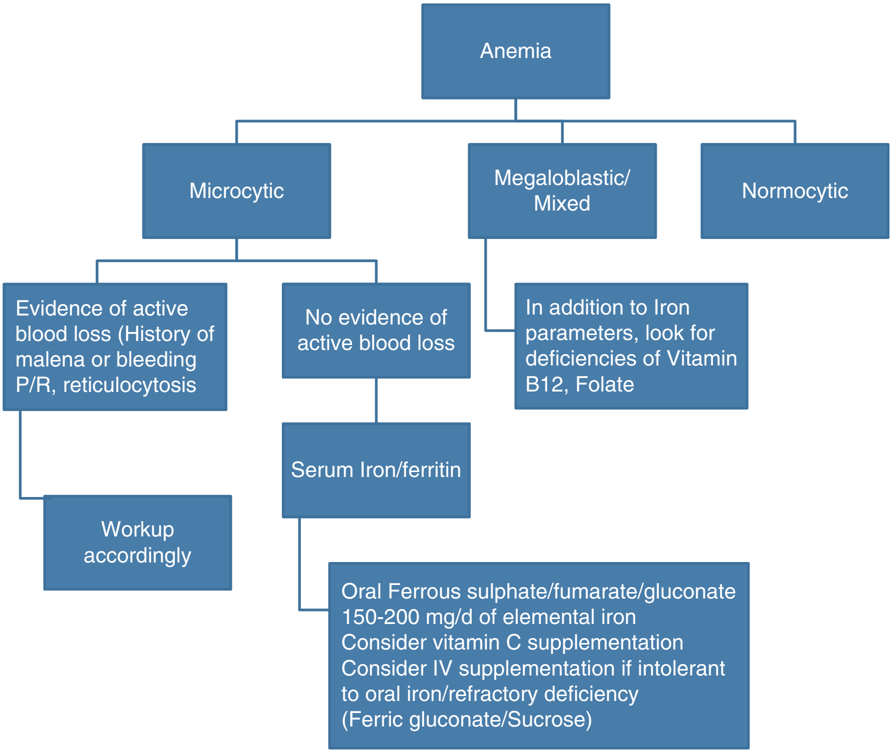

Fig. 9.3 Flow-chart summarizing management of anemia in post-operative period

Owing to a higher incidence of anemia that we see in MGB-OAGB, we give special emphasis to it and follow an evaluation protocol elaborated in Fig. 9.3.

9.4.5 Therapeutic Supplementations

Any patient found deficient during follow-up needs to be supplemented to prevent exacerbation. In the following Table 9.6, we summarize the recommended therapeutic doses for post bariatric surgery patients [2]. It is important to prevent deficiencies rather than treat them, because untreated deficiencies of micronutrients such as vitamin B12 and thiamine [1, 19, 20] can lead to irreversible neurologic damage if not detected in time.

Folic acid supplementation is particularly necessary in women of reproductive age pre-conception, to prevent neural tube defects in the offspring [20].

Any protein deficiency encountered is initially treated by increasing the protein intake. In severe cases, parenteral support and reversal to normal anatomy may be required.

Table 9.6 Therapeutic supplementation in case of deficiencies encountered in follow-up

Nutrient	Recommended supplementation
Thiamine	• 100 mg orally two to three times a day till symptoms resolve • 200 mg IV three times a day to 500 mg once or twice daily for 3–5 days until symptoms resolve followed by 100 mg/d orally • 250 mg IM once daily for 3–5 days followed by 100–250 mg monthly • Consider simultaneous repletion of Magnesium, Potassium, and Phosphorus in patients at risk of repletion syndrome
Vitamin B12	• 1000 mcg/d to achieve normal levels
Folic Acid	• 1000 mcg/d • Do not give more than 1 mg/d to avoid potential masking of B12 deficiency
Iron	• 150–200 mg elemental iron/d. May be increased to up to 300 mg 2–3 times/d • IV supplementation in case of intolerance to oral iron
Vitamin D and Calcium	• Vitamin D3 up to 6000 IU/d, or 50,000 IU one to three times a week • 1200–1500 mg/d of calcium
Vitamin A	• 10,000–25,000 IU/d till clinical improvement in patients without corneal changes • 50,000–100,000 IU/d IM in patients with corneal changes followed by 50,000 IU/d for 2 weeks • Evaluate for copper deficiencies as it can impair resolution of vitamin A deficiency
Vitamin E	• 100–400 IU/d
Vitamin K	• 10 mg/d parenterally • In patients with chronic malabsorption, 1–2 mg/d orally or 1–2 mg/week parenterally
Zinc	• Can be given up to 60 mg/d of elemental zinc carefully to avoid precipitation of copper deficiency
Copper	• Mild to moderate deficiency 3–8 mg copper gluconate or sulphate/d orally till normal levels • Severe deficiency:2–4 mg IV till serum levels normal and neurological symptoms resolved

Adapted from 2008 ASMBS guidelines by Linda Aills *et al.* [1] and 2016 guidelines by Parrot J *et al.* [9]

9.5 Our Experience

We are pleased with the results of MGB-OAGB as a procedure. These patients can eat better, compared to sleeve or RYGB patients. The common deficiencies noted are protein and iron. We have noticed cases of severe malnutrition when a limb length of >200 cm was used. Therefore, in our centre in India, we have limited the BP limb to 150–180 cm and have focused on increasing dietary proteins. We have also been supplementing our patients with 100 mg of elemental iron per day, which is higher than recommended in the guidelines. We have observed that with this protocol, we have been able to decrease iron deficiency in our cohort.

9.6 MGB-OAGB in Vegetarians

The two major deficiencies in MGB are iron and protein. Since meat is an important source of these nutrients, vegetarians are at higher risk of these deficiencies. Because a sizeable percentage of our patients are vegetarians, we have considerable experience on this subject. We have observed an incidence of 17.8% and 13% deficiency of albumin and iron respectively in our series. When we did a subgroup analysis, we found that the following factors influenced nutritional outcome – vegetarian status, limb length and compliance. Based on this observation, we recommend a conservative length of biliopancreatic limb bypass for the vegetarians. These patients need to monitor more closely for protein deficiency with a low threshold for dietary intervention.

Vegetarians consume legumes (lentils, beans, chick peas, peanuts and quinoa), yoghurt, milk, soy (tofu), whey protein, bran, brown rice, etc. Vegetables have incomplete protein, but inclusion of multiple vegetables provides total amino acid requirements [21].

9.7 Future Direction

The subject of bariatric nutrition is continuously evolving. The guidelines may change as more data comes from studies and research. The MGB-OAGB surgeons must publish their data on nutritional outcome. Short and long-term data on the nutritional outcome, vis a vis the procedural details, will help to standardize nutritional policy for MGB-OAGB. It will also help in determining the limb length.

Conclusion

Our experience suggests that we need to change our policy for certain supplements in MGB-OAGB patients, like iron. Protein deficiency needs to be avoided by improving supplementation and employing conservative length of biliopancreatic limb bypass.

Appendix 9.1: Commonly Seen Nutritional Deficiencies After MGB-OAGB

Key Points

Nutritional deficiencies seen after MGB are

- Protein
- Bivalent Ions like Iron, calcium, magnesium, and zinc.
- Water soluble vitamins such as Vitamin B1, B2, B6, B12, folate.

Because water soluble vitamins are not stored in the body, their deficiencies are seen early in the postoperative period.

Severe Thiamin deficiency in the form of irreversible neurological symptoms can be noted as early as 1 month after surgery if there is nausea and vomiting in the postoperative period.

Appendix 9.2: Salient Points to be Covered in History Taking. (Adapted from 2008 ASMBS guidelines by Linda Aills et al. [1])

History Taking in Preoperative Assessment

- ***Food*:**
  24-h food recall
  Food frequency
  Cravings/Grazing/Binge
  Restaurant meal intake
  Food preference
- ***Activity*:**
  Current activity level
  Physical limitations
  Enjoyable/Preferred activities
  Attitude towards physical activity
- ***Weight loss:***
  Successful/failed attempts with diet
  Any precipitating event for weight gain
  Personal goals
- ***Psychological:***
  Emotional connection to food/stress eating
  Eating disorders/Mood disorders
  Willingness for a major lifestyle change
- ***Social:***
  Cultural/religious influences on food
  Economical limitations to taking supplements
  Meal preparation skills
  Marital status/Children
  Identifying enablers/Feeders
  Work schedules
  Support systems
- ***Others:***
  Comorbidities/Medications/Allergies
  Literacy/Language barrier
  Substance abuse
  Dentition/Eyesight

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10 Patient Contraindications to Undergoing MGB

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10.1 Introduction

Obesity is a chronic disease that has reached pandemic proportions and is becoming one of the leading causes of death and disability worldwide. Weight loss induced by surgery has proven to be highly efficacious in treating obesity and its co-morbidities. The indications were extended by IFSO in 2016 to obesity and weight-related diseases [1]. The body mass index (BMI) is no longer the only indicator for surgery in the presence of obesity.

10.2 Absolute Contraindications

The contraindications for obesity surgery have changed in the past decades. Current absolute contraindications are only:

(a) Unacceptable risk (e.g., left ventricular output function <10%)
(b) Liver cirrhosis CHILD C
(c) Unstable psychopathological conditions
(d) Active drug dependency

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10.3 Background and Reasons

The benefit-risk ratio is a fundamental part in all fields of modern medicine and is not specific for obesity surgery. Liver cirrhosis was a general contraindication for obesity surgery from the beginning. Later on, the improvement in liver function and the downstaging of NASH and early stages of cirrhosis has been demonstrated [2]. However, the status CHILD C does not meet the benefit-risk ratio.

Obesity is associated with a significant psychosocial burden. Some candidates for surgery for obesity and weight-related diseases present with significant psychopathology, which may impact the outcome of surgery, and, in some cases, represent a contraindication to surgery (IFSO statement: Level of evidence 2, grade of recommendation C) [1].

Several studies have identified the presence of psychopathology according to the Diagnostic and Statistical Manual of Mental Disorders V (DSM-V) in candidates for surgery for obesity and weight-related diseases [3–6]. Current American and European guidelines, as well as some reviews [7–9] have emphasized that the presence of specific psychiatric disorders are considered risk factors for suboptimal outcomes after surgical treatment.

Bulimia nervosa is considered a contraindication for surgery for obesity and weight-related diseases [10, 11] (Level of evidence 2, grade of recommendation B). Bulimia nervosa is relatively rare among individuals who present for surgery for obesity and weight-related diseases. Patients with this diagnosis are recommended for psychiatric treatment and a period of symptom remission, before being offered surgery for obesity and weight-related diseases.

Active or recent substance abuse and dependence, including alcohol abuse, is a contraindication to surgery for obesity and weight-related diseases (IFSO statement 3.7.4.: Level of evidence 3, grade of recommendation C) [1].

10.4 Specific Contraindications for MGB-OAGB

(a) Primary short gut (total small intestine length <350 cm) or secondary short bowel syndrome (after intestinal resections)
(b) Crohn's disease

10.5 Background and Reasons

There are two papers with reports of patients who died after MGB due to postoperative malnutrition and consequent liver dysfunction [12, 13]. The shortest recorded total small intestinal limb length was 302 cm. In the report of Motamedi et al. [13], a biliopancreatic limb (BPL) of 200 cm was used. The patient died 13 months after MGB, and autopsy revealed a common channel of 108 cm. On the back of this data and the fact that there can be errors in measurement, it is safer to have a cumulative length of >150 cm as BPL during Roux-en-Y gastric bypass (RYGB) and MGB-OAGB.

Crohn's disease can affect all parts of the GI tract. Therefore, bariatric intestinal surgery should be avoided with Crohn's disease, because one cannot predict when and which patterns this autoimmune disease will affect the small intestine.

10.6 Relative Contraindications for Obesity Surgery

(a) Relative contraindications for obesity surgery:

Inadequate drug treatment of pre-existing endocrine medical conditions is a contraindication to surgery for obesity and weight-related diseases (IFSO statement 3.8.2). In fact, the re-evaluation and optimization of the treatment of these conditions are necessary to reduce perioperative morbidity and mortality [1].

(b) Specific for MGB-OAGB: none.

Smoking is a relative contraindication for all types of gastric bypass surgery, based on the higher incidence of marginal ulcerations. Smoking is the most common reason for recurrent ulcerations after RYGB [14].

GERD is an additional indication and **not a relative contraindication** for MGB-OAGB. Due to the low pressure system, MGB-OAGB present an important therapy option in GERD. In a study by Tolone et al., manometric features and patterns did not vary significantly after MGB-OAGB, whereas the intragastric pressures and gastroesophageal pressure gradient statistically diminished [15]. In contrast, sleeve gastrectomy (SG) induced a significant elevation in both parameters [15]. Revision to MGB-OAGB offers a second option to treat GERD after SG or SADI [16], with the same efficacy as RYGB, but more effective with respect to weight loss [17, 18].

Conclusion

MGB-OAGB is an increasingly performed weight-loss operation with low morbidity and mortality. The principle is a lowered food uptake without any obstruction, but with a reduction of hunger feeling and earlier satiety caused by creating a wide sleeve-like gastric pouch anastomosed to jejunum. The low pressure system prevents GERD and can treat GERD after SG, BPD-DS and SADI, as a rescue operation. The long biliopancreatic limb offers extended bile reabsorption before fat assimilation starts in the common channel. The malabsorptive effect is lesser than after all forms of biliopancreatic diversion (with or without duodenal switch), which are bile losing procedures. In contrast to BPD, no bile-induced colitis can be expected. A short small intestine in MGB (<350–400 cm) is a contraindication to a MGB-OAGB.

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11 Understanding the Morbidly Obese Patient

David E. Hargroder, Jan Snider Kent, and James R. Clopton

11.1 Introduction

In the early days of Bariatric Surgery, and to some extent even today, surgeons were often criticized for attempting to treat a psychological disorder with a surgical procedure. Unattractive, lazy, overindulgent, and lacking motivation or willpower—that is how many view obese patients. Their slow movements, avoidance of physical activity and social situations, and consumption of large portions of food fuel this perception. The 2013 decision by the American Medical Association to declare obesity a disease has helped somewhat to change the attitudes of physicians and the public, but the fact remains that those suffering from obesity and morbid obesity continue to be subject to ridicule, prejudice, and discrimination. Understanding the emotional and psychological profile of the bariatric patient will help the bariatric surgeon provide more complete and compassionate care for his or her patients. In this chapter, we will explore some of the psychological and sociological aspects of the morbidly obese patient and the effect that the MGB-OAGB has on this patient population's human experience.

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11.2 Early Childhood to Adolescence

From a very young age, obese individuals are subject to negative judgment and stigmatization in both the home and school environment [1]. Mistreatment typically begins in early childhood and continues throughout adolescence and increases with increasing body mass index [2, 3]. Frequently, this mistreatment can lead to an increase in disordered eating behaviors [4]. By the time these youths reach high school, their reputation as lazy and self-indulgent has become well-established and results in lower college acceptances and less financial support from families compared to normal weight students [5].

11.3 A Lifetime of Social Stigma

By the time bariatric patients present to their surgeon, they have been the object of a lifetime of social stigma. Life experiences vary from patient to patient, but the clear majority, especially among female patients, will report experiencing one or more of the following: discrimination in the workplace, body image dissatisfaction, poor interpersonal relationships, social isolation, and overall poor quality of life [6]. Simple tasks of daily living that most people take for granted, like putting on shoes and socks, crossing legs, fitting into a restaurant booth or theater seat, walking down stairs or even wiping one's self are major obstacles for the morbidly obese [7].

11.4 Medical Bias

The medical profession is not exempt from stigmatizing the obese. Obese patients frequently report feeling judged or mistreated by their primary care or attending physician because of their weight, which may actually lead to avoidance of care, mistrust of doctors, and poor adherence among patients with obesity [1, 8]. Some of this behavior arises from the false notion that shaming patients for their current condition will somehow motivate them to lose weight. This approach, however, clearly lacks any evidence of its effectiveness. As Puhl and Heuer point out in their report on obesity stigma: "…if weight stigma promoted healthier lifestyle behaviors and weight loss, then the documentation of increased weight stigmatization over the past several decades should be accompanied by a reduction in obesity rates, rather than the alarming increase" [9].

Despite the growing popularity of Bariatric Surgery, it is not uncommon to encounter patients who are having a difficult time getting the support of their primary-care physicians. Again, they focus on the patient's behavior, emphasizing more exercise and a healthier diet as the proper approach to weight loss. Although a healthy diet and exercise regimen are certainly good for one's health, even under the best of circumstances, overweight and obese individuals can expect to lose only 5–10% of their total weight, and most will gain some or all of it back over 5 years [9, 10].

Physicians are not the only ones that patients must deal with when pursuing Bariatric Surgery. Many insurance companies exclude weight loss surgery from their covered services, labeling it as cosmetic surgery or giving no explanation at all. Others will require patients to jump through multiple hoops, including 6 months of supervised weight loss by a physician, dietary consultations, psychological consultations, and a host of other requirements that often delay or prevent patients from receiving the definitive, lifesaving care that they seek. This has been particularly true for the MGB, which is frequently excluded from many insurance plans even though they cover other types of weight loss surgeries.

11.5 Psychological Characteristics

Compared to individuals in the general population, patients presenting for bariatric surgery tend to have a higher incidence of anxiety, depression, stress, food craving, and symptoms of eating disorders. They also have lower self-esteem and a lower quality of life, which appears to correlate with increasing BMI [11, 12]. As BMI increases, the incidence of co-morbidities increases, which may offer an additional explanation for the higher levels of depression and anxiety, since the co-morbidities themselves, may be associated with increased psychopathology [13, 14]. One must be cautious, however, about assuming that all obese and morbidly obese patients have a single psychological profile. The reality is, despite this lifetime of discrimination and prejudice, many patients live psychologically healthy and relatively stable lives [15].

11.6 The Surgeon's Role

It is important for the surgeon to recognize his/her role, not only as surgeon, but as patient advocate. From the patient's perspective, they have finally encountered a healthcare provider who understands that their struggles have been physiological more than psychological, and that the solution is metabolic and is accomplished through surgical intervention. Psychological support and positive reinforcement certainly do play a role, but the reality is that successful weight loss comes with a successful and properly selected operation. Besides the metabolic and physiological effects of the MGB and OAGB, these procedures also provide surgical behavior modification. It is essential to provide proper education to the patient pre-operatively regarding potential complications and side-effects of the surgery, such as marginal ulcer, vitamin and mineral deficiencies, bacterial overgrowth, and dumping syndrome. It is also essential that surgeons make sure that patients have counseling regarding the necessary changes in diet and lifestyle and also have long-term follow-up, both for data collection and for ongoing positive reinforcement to improve patient compliance.

11.7 The Psychiatrist's/Psychologist's Role

There is debate among bariatric surgeons whether a formal psychological work-up should be required to determine the candidacy of a patient for surgery. Although more than 80% of bariatric programs require pre-operative mental health evaluations, there is little consensus as to how results should be used in the context of surgical care [12]. Whether you agree or disagree with the need for a psychological evaluation, there is no question that in addition to a caring and compassionate office staff, the involvement of a qualified health-care professional to assist your patient with pre- and post-operative experiences is beneficial. The mental health care provider should be there for reassurance and reinforcement of the significant changes occurring in the patient's life after surgery. In addition, since pre-operative patients often experience depression, anxiety and other psychological issues associated with obesity and morbid obesity and the co-morbidities that accompany these conditions, the mental health care provider serves as a valuable member of the bariatric team to address these issues as well.

11.8 Life After Surgery

Few things in life are more satisfying to the professional life of a bariatric surgeon than to watch his patients grow and flourish in health and personality after a successful bariatric operation. Stories abound of the patients who go from couch potato to exercise enthusiast, or those who spent much of their life on the side-lines watching life go by and now are actively engaged in their work and family life. Promotions at work, new relationships, and new adventures are the stories eagerly told. Patients report significant improvement in their quality of life after MGB-AOGB surgery [16, 17]. There is still a need, however, to be vigilant about the doubts and insecurities common among individuals in this patient population. Weight loss plateaus, episodes of dumping, hair loss, sex and fertility, and changes in personality that can lead to stress in marriage are all very real mental-health problems that patients must deal with despite their improved physical health. The Bariatric Team must keep these very human elements in mind as they continue to care for their patients post-operatively.

Conclusion

Obese patients present with a lifetime of ridicule, prejudice, and discrimination. They have a higher incidence of depression and anxiety than individuals from the general population. As surgeons, we should strive to connect with these individuals on a human level and to provide the resources necessary for them to cope with the many life-changing events that occur because of surgery. Careful attention and sensitivity to the psychological needs of the bariatric patient are facilitated by having a caring and compassionate office staff and the inclusion of a qualified mental health care provider who is involved in both pre-op and post-op care. Providing long-term follow-up is a challenge, but should be emphasized to maximize patient compliance and to be able to report meaningful patient outcome data.

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Effects of MGB on Obesity-Related Co-Morbidities: Lipids, Hypertension, Non-Alcoholic Fatty Liver, etc.

12

Jean-Marc Chevallier

The MGB results in weight loss are now well-reported, but its impact on co-morbidities is still not well-known. We will first focus on metabolic syndrome, then obstructive sleep apnea (OSA), and finish with joint pain, calcium and vitamin D data (Table 12.1).

12.1 Metabolic Syndrome

The metabolic syndrome includes dyslipidemia, glucose intolerance or type 2 diabetes (T2D) and hypertension. It must be studied in its globality, because it is responsible for a high mortality. Besides glucose [metabolic markers].

12.1.1 Type 2 Diabetes

In all reports on efficiency of MGB on T2D, the remission rate has been very high [1–5] (Tables 12.2, 12.3 and 12.4).

The remission rate from T2D is defined by the American Diabetes Association as glycated hemoglobin (HbA1c) <6.5% without any medication.

In a recent study, we published the outcome of 100 diabetics out of the first 1000 MGBs performed in our institution [2]. The remission rate was 85.7%, after a mean follow-up period of 26 months, without any recurrence of diabetes.

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Table 12.1 Metabolic syndrome

Three or more out of:
• Blood glucose >1 g/L or diabetic treatment
• Blood pressure
– Systolic >130 mmHg
– Diastolic >85
• Triglycerides >150 mg/dL
• HDL <40 mg/dL
• Waist (cm): Man >102 cm Woman >88 cm

Table 12.2 Evolution of the co-morbidities at 5 years [1]

	Before MGB/0AGB n = 126	60 months after MGB n = 126	p
Hypertension	48 (38%)	23 (18.5%)	<0.001
Hyperlipemia	31 (25%)	6 (5%)	<0.001
Joint pain	52 (41%)	33 (26.5)	0.014
T2DM	28 (22%)	5 (4%)	<0.001
Sleep apnea	24 (19.5%)	12 (9.5%)	0.029

Table 12.3 Resolution of co-morbidites, comparing MGB to sleeve gastrectomy [3]

	MGB		LSG	
	Preop comorbidity (%)	Remission (%)	Pre-op comorbidity (%)	Remission (%)
T2D	63 (60.4%)	92	61 (24%)	81
Hypertension	66 (58.3%)	76	56 (47.3%)	74
Hyperlipemia	65 (62.2%)	90	64 (54.3%)	72
Sleep apnea	28 (26.8%)	97	26 (22.2%)	86
GERD	5 (4.9%)	72	6 (5.5%)	33

Table 12.4 Follow-up outcome [4]

	12 months n (%)	36 months n (%)	60 months n (%)
Patients in follow-up/patients eligible for follow-up	795/838 (94.8%)	510/570 (89.4%)	201/254 (79.1%)
Weight	91.5 ± 18.5	79.1 ± 8.55	81.7 ± 23.15
BMI (kg/m^2)	31.88 ± 4.91	27.5 ± 2.12	28 ± 2.25
EWL (%)	70.12 ± 8.35	81.5 ± 4.95	77 ± 5.14
Diabetes pts. in remission/diabetes pts. in follow up	175/201 (87)	160/186 (86)	87/103 (84.4)
Hypertensive pts. healed/hypertensive pts. in follow up	172/190 (90.5)	132/155 (85.1)	84/96 (87.5)

In our series, the decrease in glycated hemoglobin level remained stable after 5 years (Fig. 12.1). At 2 years, 71/81 patients (87.6%) had complete remission, and 10 (12.3%) had improvement in their diabetes (Fig. 12.2).

On patients receiving a single treatment (n = 30), the remission rate was 93.3% (28/30) with a mean time to remission of 7 months. Patients treated with biotherapy had a remission rate of 96% (25/26) and a mean time to remission of 7.5 months. Among the patients receiving three oral hypoglycemic drugs (n = 6), the remission rate was 56.6% and the mean time to remission was 4.3 months. The results were less marked in patients treated with injectable hypoglycemic drugs. Among these 12 patients, the remission rate was 50% and the mean time to remission was 18 months.

Duration of T2D before the MGB was also a predictive factor of success: patients with diabetes for <3 years had a higher remission rate over follow-up than those with T2D for >3 years (Fig. 12.3) .

After 5 years, the indian experience [3] (Table 12.3) showed a T2D remission rate of 92%, higher than the 81% after sleeve gastrectomy (SG).

Musella [4] (Table 12.4) reported a multicentre experience in Italy showing a T2D remission rate of 85%, which was stable with time at 12, 36 and 60 months after surgery.

This efficiency seems not to be dependant on the pre-operative BMI: in 2008, Lee compared diabetic patients with BMI <35 kg/m² with those of BMI >35 kg/m² [5].

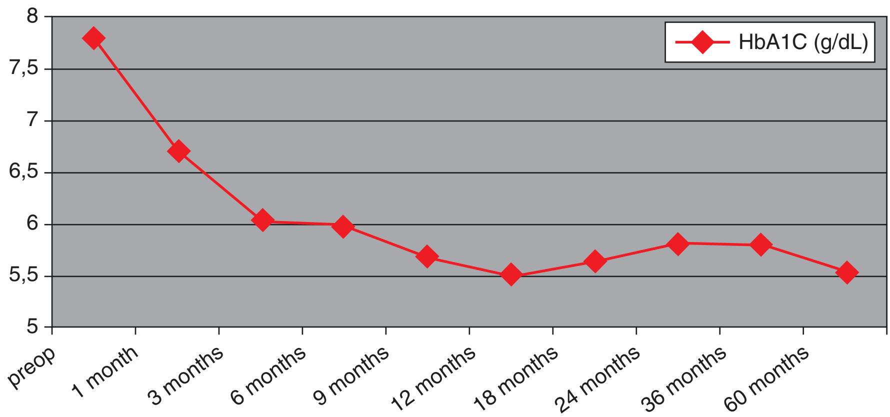

Fig. 12.1 Evolution of glycated hemoglobin (HbA1c] after MGB [2]

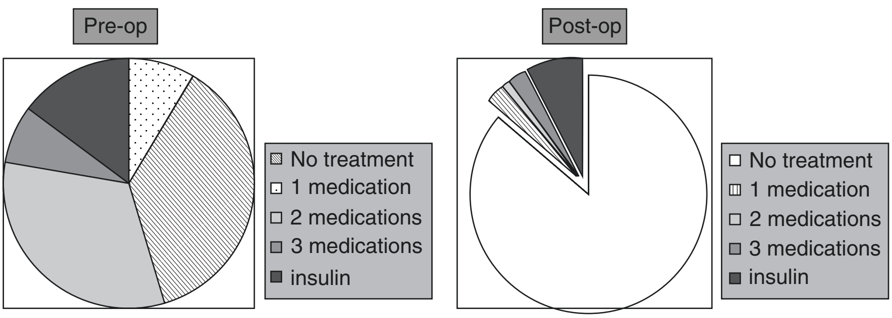

Fig. 12.2 Evolution of hypoglycemic treatment before and after MGB [2]

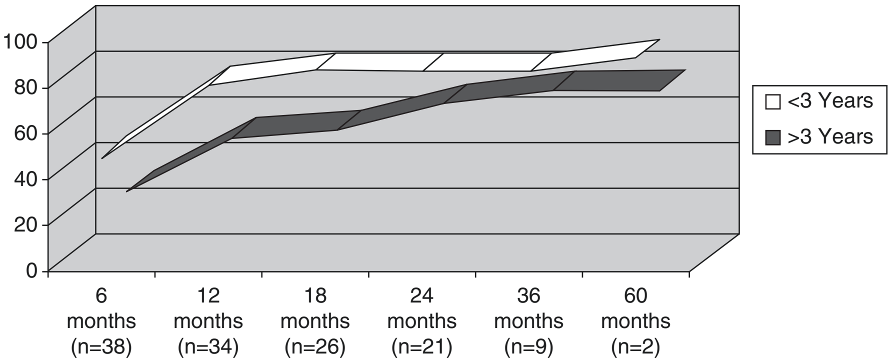

Fig. 12.3 Remission rate according to duration of diabetes [2]

Among the 201 patients who had impaired fasting glucose or T2D (out of 820 who underwent MGB from 2002 to 2006), 44 (21.9%) had BMI <35 kg/m^2, 114 (56.7%) had BMI 35–45 kg/m^2, and 43 (21.4%) had BMI >45 kg/m^2. One year after surgery, fasting plasma glucose returned to normal in 89% with BMI <35 kg/m^2 and 98.5% with BMI >35 kg/m^2 ($p = 0.087$). He concluded that MGB resulted in significant and sustained weight loss with successful treatment of T2D in 87.1%, which is similar to our results [2] (Table 12.2). Despite a slightly lower response rate in T2D after MGB, patients with BMI <35 kg/m^2 still had an acceptable T2D resolution, and this treatment can be offered to this group of patients.

A recent European survey [6] compared the efficacy of MGB and sleeve gastrectomy (SG) in T2D at 1 year of follow-up. A significant BMI decrease and T2D resolution unrelated to weight loss were recorded for both procedures. On univariate and multivariate analyses, MGB appears to outperform significantly SG. Four independent variables able to influence T2D remission at 12 months have been identified. Three were negative predictors: high baseline HbA1c, pre-operative consumption of insulin or oral antidiabetic agents, or T2D duration >10 years. MGB was a positive predictor of diabetes remission. This was also confirmed by our results [2] and the Asian experience [7].

12.1.2 Dyslipidemia

At 2 years, the resolution rate in our series was 80.6% for dyslipidemia. After 5 years, the rate of hyperlipemia decreased from 25 to 5% (Table 12.2). In India, hyperlipemia resolution rate at 5 years was 90% after MGB and 72% after SG (Table 12.3).

12.1.3 Blood Pressure

Hypertension seems to be one of the co-morbidities which is the most difficult to improve. Blood pressure remains mostly high, but the rate of hypertension decreased

Table 12.5 Comparison of clinical characteristics of patients 5 years after laparoscopic Roux-en-Y (RYGB) vs. Mini-gastric bypass (MGB) [10]

	RYGB (n = 71)	MGB (n = 277)	p-value
BMI (kg/m^2)	29.2 ± 5.3	27.7 ± 5.8	0.041*
Excess weight loss (%)	60.1 ± 20.4	72.9 ± 19.3	0.040*
Metabolic syndrome n (%)	10 (14.1)	15 (5.4)	0.012*
Albumin (g/dL)	4.5 ± 0.3	4.4 ± 0.4	0.680
WBC (10^3/μL)	6.1 ± 0.8	5.9 ± 2.3	0.949
Hemoglobin (g/dL)	12.5 ± 1.4	10.1 ± 2.8	0.006*
MCV (fL)	85.3 ± 5.5	74.9 ± 13.5	0.019*

*$p < 0.05$

from 38 to 18.5% at 5 years in our experience. Kular reported 76% remission which was equivalent to the 74% after SG (Table 12.2). The results on hypertension in Italy are even better because the resolution remained stable around 85–90% at 1, 3 and 5 years (Table 12.3).

12.1.4 Liver Metabolism/Non-Alcoholic Fatty Liver (NASH)

There is actually no study on the efficiency of MGB in non-alcoholic fatty liver disease. One can presume that MGB could at least be as efficient as RYGB on NASH [8].

The impact of MGB on hepatic markers has been recently studied [9] in non-diabetic morbidly obese patients who underwent either RYGB (n = 25) or MGB (n = 25). The MGB was a regular 200 cm bypass MGB. MGB showed a greater weight loss. Liver transaminase dropped in RYGB, while it rose in MGB. Gamma glutamyl transferase decreased significantly in RYGB over the first 3 months, while it increased in MGB. They found higher levels of triglycerides, insulin, homeostasis model assessment of insulin resistance (HOMA2-IR) and liver fat percentage in RYGB at baseline, despite matching the groups for age, sex and BMI. Those differences disappeared except for triglycerides, within 1 year.

They concluded that MGB resulted in greater weight loss but with a transitional deterioration of several liver parameters in the first post-operative year, which was not associated with weight loss.

Considering the high frequency of non-alcoholic steatohepatitis with fibrosis progression in obese patients, this must be taken into account and surveyed.

12.1.5 Comparison of MGB with RYGB

When comparing MGB to RYGB [10], a follow-up study disclosed an improvement of obesity-related clinical parameters in both groups without significant difference at 5 years after surgery (Table 12.5). The resolution rate of metabolic syndrome was >80% for both groups. Both groups had a significant decrease of hemoglobin (Hb)

Table 12.6 Comparison of the outcomes of co-morbidities after primary and revisional MGB at 5 years [12]

	Revisional MGB (n = 30)	Primary MGB (n = 96)	p
Hypertension	58% (7/12)	50% (18/36)	NS
Hyperlipemia	75% (6/8)	82% (19/23)	NS
Joint pain	33% (3/10)	38% (16/42)	NS
T2D	85% (6/7)	81% (17/21)	NS
Sleep apnea	50% (3/6)	50% (9/18)	NS

level after bypass surgery, but MGB patients had a lower level of Hb and mean corpuscular volume (MCV) than RYGB patients.

12.1.6 Obstructive Sleep Apnea (OSA)

Sleep apnea is common in morbidly obese patients. Bariatric surgery is rapidly efficient on sleep apnea, and MGB is reported to have a significant efficiency on OSA. In our experience, at 5 years the rate of obese patients who required continuous positive airway pressure treatment (CPAP) decreased from 19.5 to 9.5% (Table 12.2). In India, the resolution rate was 97%, better that the 86% after SG (Table 12.3).

12.1.7 Joint Pain, Vitamin D, Calcium

In our recent study (Table 12.2), 52 out of 126 MGB suffered from joint pain before surgery (41%); 5 years after MGB, there were only 33 out of 126 (26.5%).

The effects of MGB on vitamin D level and bone metabolism are not very well known. An Austrian team has studied a cohort of 50 patients having undergone MGB between 2011 and 2012 [11]. BMI was 45.4 kg/m^2 pre-operatively and decreased to 29.1 kg/m^2 after 12 months, corresponding to a total body weight loss of 36%. Pre-operatively the prevalence of vitamin D deficiency was 96%. They received individually adjusted vitamin D supplementation of 2000–3000 IU/day. Nevertheless, about one-third of patients remained vitamin D deficient at 12 months (80%). In patients with pre-operative BMI >45 kg/m^2, we observed a threefold higher risk for vitamin D deficiency over 12 months. Morbidly obese patients, especially those with higher pre-operative BMI, should be regularly screened pre- and post-operatively and standard post-surgical supplementation must be adequate (Table 12.6).

12.1.8 Comparison Between Primary MGB and MGB After Gastric Banding Failure (Revisional MGB)

At 5 years we did not find any significant difference in the improvement on co-morbidities whether the MGB has been done primarily or after a gastric band failure [12]. The difference was in the quality of life: according to the GIQLY (GI quality of life) test, primary MGB had less upper gastrointestinal symptoms than revisional MGBs.

Conclusion

MGB is efficient on obesity-related co-morbidities. The resolution of the metabolic syndrome is stable with time, with a T2D remission rate >80%, outperforming sleeve gastrectomy. Hypertension and hyperlipemia decreased between 70 and 80%. Severe OSA no longer required CPAP in >90% of the cases. Joint pain decreased also mainly, but vitamin D deficiency must be screened and supplemented. There is until now no data on the efficiency of the MGB on non-alcoholic fatty liver disease, but a recent article showed that MGB resulted in greater weight loss, with a transitional deterioration of several liver parameters in the first postoperative year, which was not associated with weight loss. In summary, MGB brings a great improvement in dangerous obesity-related co-morbidities like T2D, hyperlipemia, hypertension and joint pain, but requires continuing surveillance.

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13 Effects of MGB on Type 2 Diabetes in Morbid Obesity, and Comparison with Other Operations

Ahmed M. Forieg

13.1 Introduction

The latest epidemiological data regarding Type 2 Diabetes (T2D) shows that we are in the midst of an epidemic. T2D is one of the most common non-communicable diseases. It is the fourth leading cause of death in most high-income countries, and there is substantial evidence that it is epidemic in many economically developing and newly industrialized countries. T2D is one of the most challenging health problems of the twenty-first century. It is estimated that there are now 415 million adults aged 20–79 with diabetes worldwide, including 193 million who are undiagnosed. A further 318 million adults are estimated to have impaired glucose tolerance, which puts them at high risk of developing the disease. By the end of this year, diabetes will have caused five million deaths and have cost between US$673 billion and US$1.197 trillium in health-care spending [1].

The global prevalence of T2D is rising dramatically, driven by an 'obesogenic' environment that favors increasing sedentary behavior and easier access to convenient calorie-dense foods acting on susceptible genotypes. The most recent global predictions by the International Diabetes Federation (IDF) suggest that there are 285 million people with diabetes currently worldwide. This is set to escalate to 642 million by 2040, with a further half billion at high risk [1, 2].

The IDF estimates that there are 34.6 million people with T2D in the Middle East and North Africa, a number that will double to 67.9 million by 2035, if concerted action is not taken to tackle the risk factors fueling the epidemic of diabetes throughout the region. In 2017, there were >7.8 million cases of T2D in Egypt, which is reported as one of the top ten countries for number of people affected with T2D. Prevalence in adults is 15.4% for age 20–79 years [1]. Furthermore, T2D is the leading cause of kidney failure, non-traumatic lower limb amputations, coronary heart disease, stroke, and visual impairments among adults [3]. In Egypt, 42%

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of people with T2D have early-stage eye disease and 5% of diabetics are classified as legally blind [1]. The onset of T2D is characterized by a non-reversible complex cycle that includes severe deleterious effects on glucose metabolism. Glycemic control is the most important step in the prevention of microvascular problems, while broader management, focusing on lipids, blood pressure, and glycemia, showed better performance in patients with macrovascular disease [4]. The problem is complex and will require strategies at many levels [5].

New drugs were recently made available, such as glucagon-like peptide-1 (GLP-1) analogs and dipeptidyl-peptidase-4 (DPP4) inhibitors. Nonetheless, the average glucose control in patients with T2D remains suboptimal [6, 7]. The overall risk of death among people with T2D is at least double that of their peers without T2D [8].

Medications and lifestyle interventions in patients with T2D may delay cardiovascular events and other major complications, but require patient compliance, frequent medical surveillance, and lifelong medications. However, with major advances, T2D control remains elusive [6], with <20% able to achieve the three end-points of metabolic control (glycemic, blood pressure, and lipids). However, gastrointestinal (GI) surgery is effective in the treatment and prevention of T2D, reducing the mortality rate in the long-term when compared with medical treatment of morbidly obese patients in major longitudinal studies [8].

Metabolic surgery involves any intervention that alters the food passage through the GI tract, resulting in improved T2D control. Such a result does not solely depend on weight loss. In some cases, the effects can be observed days after bariatric operations, before substantial weight loss, precluding a direct antidiabetic effect. The term “bariatric” is gradually being replaced by “metabolic”, because the operations previously recommended for morbid obesity (defined as BMI >40 kg/m^2 or >35 kg/m^2 with co-morbidities) have demonstrated excellent results in T2D remission.

In 2011, the IDF released its position statement that bariatric surgery is an accepted option for T2D patients with BMI >35 and may be an alternative therapy for patients with BMI < 35 who do not respond to standard medical therapy. Metabolic surgery includes conventional bariatric operations (RYGB, BPD with or without duodenal switch, sleeve gastrectomy, and MGB) and new procedures (ileal interposition) designed to have metabolic effects irrespective of massive weight loss [5].

Reversal of T2D occurs due to mechanisms such as the increase in insulin sensitivity associated with an improvement in β-cell function, as a consequence of increase of GLP-1 production. Remission of T2D is observed in the first postoperative days after the operation [9].

13.2 Definition and Description of Diabetes Mellitus

T2D is a group of metabolic diseases characterized by hyperglycemia resulting from defects in insulin secretion, insulin action, or both. The chronic hyperglycemia of T2D leads to long-term damage, dysfunction, and failure of different organs, especially eyes, kidneys, nerves, heart, and blood vessels. The basis of the abnormalities in carbohydrate, fat, and protein metabolism in T2D is deficient action of insulin on target tissues. Deficient insulin action results from inadequate insulin secretion and/or diminished tissue responses to insulin at one or more points in the complex pathways of hormone action [10].

Impairment of insulin secretion and defects in insulin action frequently coexist. Symptoms of marked hyperglycemia include polyuria, polydipsia, weight loss, polyphagia, and blurred vision. Susceptibility to certain infections may accompany chronic hyperglycemia [10].

Patients with T2D have an increased incidence of atherosclerotic cardiovascular, peripheral arterial and cerebrovascular disease. Hypertension and abnormalities of lipoprotein metabolism are often found. The vast majority of cases of diabetes fall into two broad etiopathogenetic categories [11]:

1. In **type 1 diabetes** (T1D), the cause is a deficiency of insulin, by progressive *autoimmune* destruction of the pancreatic β-cells.
2. In the much more prevalent **type 2 diabetes** (T2D), the cause is a combination of resistance to insulin action and an inadequate compensatory insulin secretory response.
3. In g**estational diabetes**, hyperglycemia occurs during pregnancy.

In T2D, a degree of hyperglycemia sufficient to cause pathologic and functional changes in various target tissues, but without clinical symptoms, may be present for a long period before diabetes is detected. During this asymptomatic period, it is possible to demonstrate an abnormality in carbohydrate metabolism by measurement of fasting plasma glucose or after a challenge with an oral glucose load or by elevated hemoglobin A1c (HbA1c) [11].

Prediabetes is a condition where blood glucose levels are higher than normal, but not high enough for the diagnosis of T2D. People may have this condition for several years without noticing anything and before becoming diabetic. The degree of hyperglycemia (if any) may change over time, depending on the extent of the underlying disease process [11].

In some individuals with T2D, adequate glycemic control can be achieved with weight reduction, exercise, and/or oral glucose-lowering agents. These individuals therefore do not require insulin. Other individuals who have some residual insulin secretion may require exogenous insulin for adequate glycemia. Individuals with extensive β-cell destruction and therefore no residual insulin secretion require insulin for survival. The severity of the metabolic abnormality can progress, regress, or stay the same. Thus, the degree of hyperglycemia reflects the severity of the underlying metabolic process and its treatment more than the nature of the process itself [11–13].

The pathogenic mechanisms in T2D involve not only insulin, but also glucagon, and the interplay between these two processes is the key component in understanding the pathophysiology of T2D.

13.3 Type 2 Diabetes

T2D accounts for 90–95% of diabetes, previously referred to as non–insulin-dependent diabetes or adult onset diabetes. T2D encompasses individuals who have insulin resistance and usually have relative (rather than absolute) insulin deficiency (ranging from predominantly insulin resistance with relative insulin deficiency to predominantly an insulin secretory defect with insulin resistance). At least initially, and often throughout their lifetime, these individuals do not need insulin treatment to survive [14].

The pathogenic mechanisms involved in the development of T2D are peripheral insulin resistance resulting in decreased metabolic responses to insulin, and progressive decline of pancreatic islet cell function resulting in reduced insulin secretion and inadequate suppression of glucagon secretion.

Patients with insulin resistance require more insulin to promote glucose uptake by peripheral tissues, and the genetically predisposed ones may lack the necessary β-cell secretory capacity [15]. There are probably many different causes of this form of diabetes. Most patients with T2D are obese, and obesity itself causes insulin resistance. Patients who are not obese by traditional weight criteria may have an increased percentage of body fat distributed predominantly in the abdominal region. Ketoacidosis rarely occurs in T2D; when seen, it usually arises in association with the stress of another illness such as infection. T2D frequently goes undiagnosed for many years because the hyperglycemia develops gradually, and at earlier stages, T2D is often not severe enough for the patient to notice any of the classic symptoms of diabetes [14].

13.4 Pathophysiology of T2D

Following glucose ingestion, the balance between endogenous glucose production and tissue glucose uptake is disrupted. The increase in plasma glucose concentration stimulates insulin release from the pancreatic β-cells, and the resultant hyperinsulinemia and hyperglycemia serves to stimulate glucose uptake by splanchnic (liver and gut) and peripheral (primarily muscle) tissues and to suppress endogenous glucose production by the liver [12, 13].

The majority (80–85%) of glucose that is taken up by peripheral tissues, in an insulin-dependent manner, is disposed of in muscle, with only a small amount (4–5%) being metabolized by adipocytes. Another 10% is disposed of by splanchnic tissues through non-insulin dependent mechanisms. Although fat tissue is responsible for only a small amount of total body glucose disposal, it plays a very important role in the maintenance of total body glucose homeostasis. Insulin is an inhibitor of lipolysis, and even small increments in the plasma insulin concentration exert a potent anti-lipolytic effect, leading to a marked reduction in adipose tissue release of fatty acids and subsequently a decrease in plasma free fatty acid (FFA) levels [11].

The decline in plasma FFA concentration facilitates an increased glucose uptake in muscle and contributes to the inhibition of hepatic glucose production. Thus, changes in the plasma FFA concentration in response to increased plasma levels of insulin and glucose play an important role in the maintenance of normal glucose homeostasis [14, 15]. Glucagon also plays a central role in the regulation of glucose homeostasis. During the post-absorptive state (10–12 h fasting overnight), hepatic glucose output depends on a delicate equilibrium between basal glucagon secretion (stimulatory effect), and basal insulin secretion (inhibitory effect). About 75% of the total effect depends on the stimulatory action of glucagon [15].

13.5 Normal Glucose Homeostasis

The metabolic response to ingested carbohydrate is markedly different in individuals with normal glucose tolerance compared to those with T2D. Individuals with normal glucose metabolism have a typical insulin, glucose, and glucagon profile in plasma in response to the ingestion of a carbohydrate meal [15].

In the post-absorptive state, the majority of glucose that is removed from the body occurs in insulin-independent tissues; ~50% of glucose utilization occurs in the brain, another 25% of glucose uptake occurs in the splanchnic area (liver plus GI tissues), and the remaining 25% in the post-absorptive state occurs in insulin-dependent tissues (primarily muscle). Basal glucose utilization averages ~2.0 mg/kg/min and is precisely matched by the rate of endogenous glucose production. ~85% of endogenous glucose production is derived from the liver, with the remainder produced by the kidneys. Approximately half of basal hepatic glucose production is derived from glycogenolysis and half from gluconeogenesis.

13.6 Prediabetes

Prediabetes can be separated into two different conditions: impaired fasting glucose (IFG), diagnosed by a fasting glucose test, and impaired glucose tolerance (IGT), diagnosed by a postprandial glucose test. Both IFG and IGT represent intermediate states of abnormal glucose regulation that exist between normal glucose homeostasis and T2D. IFG is defined by an elevated fasting plasma glucose (FPG) concentration (≥100 and <126 mg/dL). IGT is defined by an elevated 2-h plasma glucose concentration (≥140 and <200 mg/dL) after a 75-g glucose load on the oral glucose tolerance test (OGTT) in the presence of a FPG concentration <126 mg/dL [16].

The pathophysiology of IFG includes the following defects: reduced hepatic insulin sensitivity, stationary β-cell dysfunction and/or chronic low β-cell mass, altered GLP-1 secretion, and inappropriately elevated glucagon secretion. Conversely, the prediabetic state of isolated IGT (IGT without IFG) is mainly characterized by reduced peripheral (muscle) insulin sensitivity and a reduced second-phase insulin secretion. Individuals developing combined IFG/IGT exhibit severe defects in both peripheral and hepatic insulin sensitivity, as well as a progressive loss of β-cell function [17].

13.7 Type 2 Diabetes and Obesity

Obesity is a complex disorder, where genetic predisposition interacts with environmental exposures to produce a heterogeneous phenotype [18]. Some of these obesity phenotypes are associated with a high risk of developing T2D [19]. There is also strong evidence that, for a given adiposity, there is a large heterogeneity in the metabolic risk mainly linked to the location of excessive adipose tissue. Visceral adipose tissue accumulation is an important predictive factor of lipid, glucose or atherogenic disturbances, while location of adipose tissue in the lower part of the body is not associated with increased metabolic alterations.

Studies have shown that BMI is a powerful predictor of T2D. Visceral fat is an important source of inflammatory cytokines such as tumor necrosis factor alpha (TNF-α), transforming growth factor β (TGF-β), interleukin-6 (IL6), resistin, and plasminogen activator inhibitor type 1 (PAI-1) that can directly affect insulin-mediated glucose uptake (insulin resistance). On the other hand, there is a reduction of secretion of other factors such as adiponectin that reduce insulin resistance. This imbalance leads to a pro-inflammatory state which is related to an increased risk of cardiovascular complications [11].

β-cell secretory function and β-cell mass play complementary roles in the development of T2D; this process includes islet amyloid deposits and increased β-cell apoptosis. Abnormal α-cell function (glucagon secretion) is an important determinant of the magnitude of the hyperglycemia found in T2D, and lipotoxicity characterized by an increase in circulating free fatty acids (FFAs) may contribute to progressive β-cell failure (β-cell lipotoxicity) in individuals genetically predisposed to T2D [20].

13.8 GLP-1: Influence in T2D

GLP-1 is an intestinal hormone that exerts profound effects in the regulation of glycemia, stimulating glucose-dependent insulin secretion, proinsulin gene expression, cell proliferative and anti-apoptotic pathways, as well as inhibiting glucagon release, gastric emptying, and food intake. Although the proglucagon gene is expressed in enteroendocrine L-cells and pancreatic β-cells, GLP-1 is synthesized by post-translational processing of proglucagon only in the intestine. The L-cells are located in the ileum and colon, and have been identified as open-type epithelial cells that are in direct contact with nutrients in the intestinal lumen.

L-cells are located in close proximity to both neurons and the microvasculature of the intestine. Bioactive GLP-1 exists in two equipotent forms in the circulation, GLP-$1^{7–36}$ and GLP-$1^{7–37}$, of which the first one is predominant. Secreted GLP-1 is rapidly degraded by the ubiquitous enzyme DPP-4, resulting in an extremely short half-life for GLP-1 of 2 min. Nutrient ingestion is the primary stimulus to the L-cell and results in a biphasic pattern of GLP-1 secretion. An initial rapid rise in circulating GLP-1 levels occurs 15–30 min after a meal, followed by a second minor peak at 90–120 min. Glucose and fat have been found to be potent stimulators of GLP-1 secretion when ingested, but also after direct administration into the intestinal lumen or into perfused ileal segments [21]. Studies suggest that impairments at the level of the L-cell may account for the reduced GLP-1 secretion that is observed in patients with T2D, as well as in obesity.

This common view that GLP-1 secretion in T2D is deficient and that this applies to a lesser degree in individuals with impaired glucose tolerance has been recently reviewed by Nauck et al. [22]. The findings do not support the contention of a generalized defect in nutrient-related GLP-1 secretory responses in T2D, which has been the rationale for replacing endogenous incretins with GLP-1 receptor agonists or re-normalizing active GLP-1 concentrations with dipeptidyl peptidase-4 inhibitors [23].

T2D is associated with other metabolic abnormalities in the “metabolic syndrome”, which include obesity, hypertension, nonalcoholic steatohepatitis (NASH), gastroesophageal reflux disease (GERD), sleep apnea, cardiopulmonary failure, asthma, polycystic ovary disease, infertility, cancer, atherosclerosis, depression, deep venous disease, pulmonary emboli, neuropathy, increased risk of infection, and renal failure [24].

13.9 Diagnosis and Medical Treatment of T2D

The diagnostic criteria of T2D, according to the American Diabetes Association (ADA), are [10]:

1. HbA1c >6.5%
2. Or fasting glycemia >126 mg/dL
3. Or glycemia >200 mg/dL 2 h after the glucose tolerance test.

The test should be performed as described by the World Health Organization (WHO), using a glucose load containing the equivalent of 75 g anhydrous glucose dissolved in water. In a patient with classic symptoms of hyperglycemia or hyperglycemic crisis, a random plasma glycemia >200 mg/dL (11.1 mmol/L) is di1agnostic.

The use of HbA1c became increasingly accepted by the scientific community after 1993, after being validated by two major clinical studies assessing the impact of glycemic control on chronic complications of diabetes: the DCCT study (Diabetes Control and Complications Trial) and UKPDS (United Kingdom Prospective Diabetes Study) [25, 26]. HbA1c reflects serum glucose levels 2–3 months prior to its measurement. In a non-diabetic individual, approximately 4–6% of HbA1c is observed, while in the uncontrolled diabetic this percentage may reach levels two to three times above normal. HbA1c levels above 7% are associated with a progressively higher risk of chronic complications. Therefore, current T2D treatment goals set 7% as the upper limit. If HbA1c is >7%, revision of the therapeutic regimen is indicated [27].

Treatment of T2D and its complications focus on control of glucose levels, initially based on diet, encouraging physical activity and losing weight, and oral hypoglycemic drugs (sulfonylureas, meglitinides, biguanides, pioglitazone, and DPP-4 inhibitors). GLP-1 analogues (exenatide or liraglutide) are used subcutaneously and may increase insulin secretion. Along the evolution of the disease and the impairment of insulin secretion by the pancreatic β-cells, patients may need insulin therapy [9].

A strategy of intensive glucose control to lower the HbA1c to 6.5% yielded a 10% relative reduction in major macrovascular and microvascular events [28]. However, more intensive glucose control in patients with poorly controlled T2D had no significant effect on the rate of major cardiovascular (CV) events, microvascular complications, or death, due to complications related to hypoglycemic episodes [29].

13.10 Surgical Treatment of T2D

Medical therapy for T2D is ineffective in the long-term due to the progressive nature of the disease, which requires increasing medication doses and polypharmacy. From the moment that the objectives of medical treatment of T2D are not being achieved, metabolic surgery emerges as a therapeutic possibility. Initially, workers postulated that improvement of T2D was due to bypass of the foregut [30–32].

13.11 History of Diabetes Surgery

In 1925, a case report in The Lancet documented rapid resolution of T2D in a patient with peptic ulcer after gastrectomy and gastrojejunostomy [33]. Other clinical observations of improvement of T2D after partial or total gastrectomies were reported. Based on metabolic findings that GI interventions may have an antidiabetic effect not initially related to weight loss, efforts became directed toward bariatric operations that reroute food through the GI tract. RYGB, BPD, SG, and MGB have been found to significantly improve glycemic control [34–36].

13.12 Surgical Techniques

Conventional bariatric operations are divided into: (1) *restrictive* with decreased intake and weight loss (gastric banding, sleeve gastrectomy); and (2) *Combined Malabsorptive and Restrictive* with rapid passage of food into ileum (RYGB, BPD and MGB).

Ghrelin is a hormone synthesized by the proximal stomach, and is involved in hunger sensation in the empty stomach. With SG, RYGB and BPD-duodenal switch (which includes a SG), ghrelin cells are resected or excluded from nutrient contact. Ghrelin levels decrease maximally after SG.

Glucagon-like peptide-1 (GLP-1) is an incretin released from lower intestinal L-cells, and stimulates β-cell proliferation and insulin secretion, and delays emptying of the intact stomach ("ileal brake").

13.13 Results of the MGB on T2D

T2D remission has been reported to varying degrees after all current bariatric operations. However, after SG, leaks, weight regain, GERD and Barrett's esophagus occur [37, 38]; after RYGB, weight regain and multiple complications ensue [39, 40].

The MGB consists of a gastric tube from below crow's foot, proximally towards the left of the angle of His, with an antecolic gastro-jejunostomy constructed 180–200 cm (as indicated) distal to Treitz' ligament. Studies show that the MGB is simple, rapid, readily learned, highly effective in resolving co-morbidities, with good quality of life, durable weight loss, revisable and reversible if ever required [41–49].

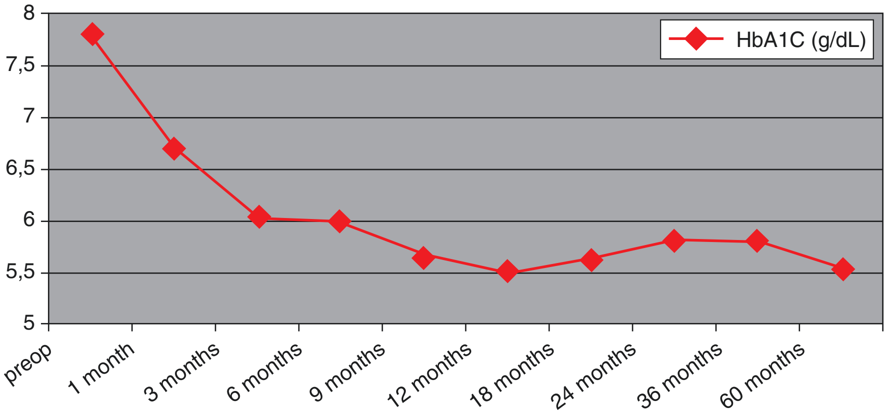

Fig. 13.1 Evolution of glycated hemoglobin after MGB. From Guenzi et al. [64]

The MGB and OAGB have been documented to be dependable bariatric operations in large series [50–52]. They have shown superiority in resolution of co-morbidities, in comparative studies to the RYGB and SG [53–60]. Furthermore, the MGB and OAGB have resulted in resolution of T2D in 85–95% of diabetics followed >5 years, requiring no medication [61–65], which is superior to more complex operations. In a careful study, Jammu reported resolution of T2D in 94.7% of Punjabi diabetics [66]. Following MGB with the rapid passage of food contents into lower bowel, significant rapid elevation in levels of GLP-1 has been found [59, 64, 67] (Fig. 13.1), compared to the other operations.

Lee et al. [59] found that MGB and SG can rapidly augment the incretin effect, which persists up to 5 years. However, they demonstrated that MGB had a significantly better incretin effect than SG at longer follow-up. The improvement of the incretin effect is explained by the increase of GLP-1 serum levels.

Conclusion

Type 2 diabetes is an increasing and complex metabolic disease. MGB has been found to be an effective operation to treat morbid obesity, and causes remission of T2D reaching nearly 95%. Because of its relative simplicity, short operating time, low complication rate, generally durable weight loss, and associated significant amelioration of obesity-related co-morbidities such as hypertension and dyslipidemia, MGB is a very favorable metabolic operation for T2D patients.

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14 Effects of MGB on Type 2 Diabetes in Lower BMI Patients

Tarek Mahdy and Waleed Gado

14.1 Introduction

The worldwide epidemic of type 2 diabetes (T2D) is increasing at a rate far exceeding previous predictions. It is now estimated that the number of people with T2D in 2030 will be 552 million [1]. Because diabetes is the cause of 40–55% of end-stage renal disease, 50–60% of coronary artery disease, frequent loss of vision in adults and the majority of non-traumatic lower extremity amputations, it has enormous impact on population health and health-care costs [2].

Obesity and T2D are related and difficult to be controlled by current medical treatment, including diet, exercise, oral hypoglycemic agents and insulin therapy [3, 4]. Weight loss is effective for treatment of T2D [5, 6].

Diversionary gastrointestinal surgery alters the GI tract hormonal status [7], and results in not only weight loss but also cures most of the associated medical co-morbidities, especially T2D in morbidly obese patients [8, 9]. A systematic review and meta-analysis of large series of patients demonstrated an overall 78.1% complete resolution of T2D after bariatric surgery [10]. Frequently, glycemic control after bariatric surgery has been found to occur before significant weight loss. The current indication for bariatric surgery is set at body mass index (BMI) >35 kg/m^2 with co-morbidities.

Some reports suggest that the criteria can be lowered to BMI <30 [11], and increasing evidence indicates that bariatric/metabolic surgery is of great benefit for T2D in non-severely obese or even non-obese patients [12–14]. However, recent data suggest that the reduction in cardiovascular events and mortality from weight loss in patients with T2D and moderate obesity may be less than that of patients with severe obesity.

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A comparison of three different operative methods (gastric banding, MGB and SG) found that BMI, body weight, waist circumference, glycemic control and lipid profile significantly improved [15]. MGB emerged as a safe, easily reversible, and effective operation, with even better results than SG or RYGB for T2D control [16, 17], and had a dramatic effect on T2D (90% resolution) at >1 year after surgery [18].

Substantial evidence favoring bariatric surgery for T2D in patients with morbid obesity convinced influential scientific associations, such as the International Diabetes Federation Taskforce in 2011 [19], to consider bariatric surgery for T2D patients with BMI <35, if their weight is increasing or other co-morbidities (blood pressure, dyslipidemia, obstructive sleep apnea) are not responding to conventional therapy or if the T2D is difficult to control with lifestyle and pharmacologic therapy. This was a cautious position, because evidence in favor of the efficacy of metabolic surgery for T2D with BMI <35 is less strong than for morbid obesity, particularly in the long-term [19].

14.2 Bariatric Surgery for Treatment of T2D

In 1955, surgeons Friedman et al. [20] demonstrated the involvement of the digestive tract in metabolic disease in their report of T2D resolution following gastrectomy in non-morbidly obese patients. In the 1970s and 1980s, bariatric surgeons identified the key mechanisms of the relationship between morbid obesity and T2D. Bosello et al. [21] observed that in the jejuno-ileal bypass, weight loss was a primary factor in decreasing hyperglycemia. Ackerman [22] and Halverson et al. [23] noted that soon after malabsorptive bariatric operations, most T2D patients became euglycemic and were free of medication before the major weight loss. Herbst et al. [24] followed morbidly obese T2D patients who underwent restrictive bariatric operations, noting their improvement in T2D by increased available insulin receptors. In the late 1970s, Scopinaro et al. pioneered the biliopancreatic diversion (BPD), and observed that the decreased caloric intake and absorption were associated with resolution of T2D, with euglycemia on an unrestricted diet [25].

In 1987, Pories et al. [26] hypothesized that post-RYGB euglycemia may result from hormonal changes, possibly secondary to bypass of the duodenum. In 1995, Pories [8, 27] postulated that bariatric operations may be equally effective for T2D in non-morbidly obese patients, whether overweight BMI 25.0–29.9 or mildly obese BMI 30.0–34.9. Resolution to normal levels of fasting plasma glucose, fasting plasma insulin, and glycated hemoglobin (HbA1C), without requirement for oral hypoglycemic drugs, occurred after all three traditional bariatric operations [14, 28] (i.e., restrictive, malabsorptive/restrictive, and primarily malabsorptive), but was greater after malabsorptive and malabsorptive/restrictive procedures (Fig. 14.1).

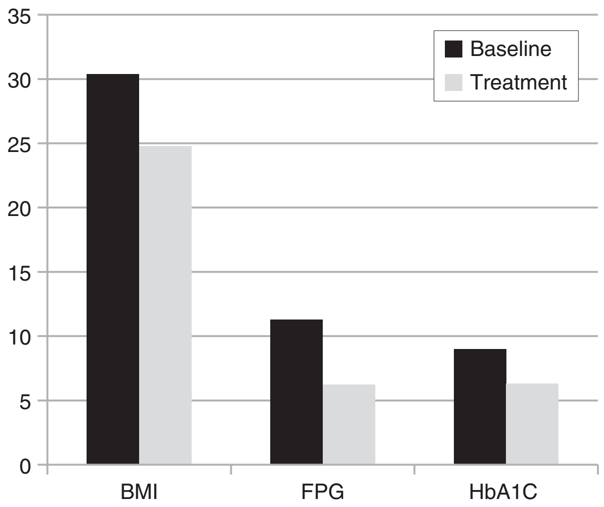

Fig. 14.1 Results of metabolic surgery in patients with T2D and BMI <35. The data are the result of meta-analyses from 14 studies for change in BMI, 12 studies for change in fasting plasma glucose (FPG), and 10 studies for change in HbA1C. Data derived from Shimizu et al. [32]

14.3 Studies of Bariatric Surgery with T2D and BMI <35

Studies evaluating the effects of bariatric/metabolic operations specifically in patients with T2D and BMI <35 are increasing, and meta-analysis/systematic reviews have been published. Li et al. [29] evaluated 13 studies with total 357 patients with T2D and BMI <35. Reis et al. [30] analyzed 29 studies with 1209 patients with T2D and BMI <35 before bariatric surgery, and likewise found significant improvement in T2D.

Shimizu et al. also found improvement in T2D following RYGB in patients with BMI <35 (Fig. 14.2) [32]. Working with the preceding group, Schauer et al. [33] in a 3-year randomized, controlled trial [33] found that after surgery, patients with T2D and BMI 27–34 had improvement in glycemic control that was similar to that of surgical patients who had BMI >35, and was superior to that of patients who received medical therapy alone.

14.4 Mechanisms by Which Bariatric Surgery Decreases Hyperglycemia in Patients with Metabolic Syndrome and T2D

It has been demonstrated that caloric restriction, independent of weight loss, improves glycemic control [34]. Obese patients with T2D put on a 600-kcal diet for 8 weeks showed rapid improvement in fasting plasma glucose (FPG) and HbA1c,

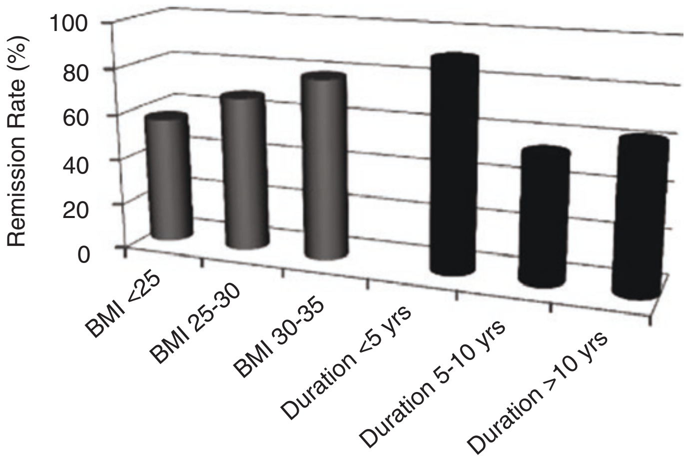

Fig. 14.2 Relationship between baseline BMI and baseline duration of known T2D with the percent of patients with remission of their diabetes 1 year after metabolic surgery. The data are derived from 87 of 200 patients who had achieved a 1-year follow-up in a multi-institutional Asian study. Data derived from Lee et al. [15, 31]

after 1 week despite the small decrease in body weight and BMI. The most dramatic changes after 1 week of caloric restriction were the decrease in liver triglycerides and in fat mass. After 8 weeks, FPG and HbA1C had normalized. Body weight and BMI had decreased 14.8 and 14.6% respectively, but again the most dramatic effects of the caloric restriction were a 77% decrease in hepatic triglycerides and a 33% decrease in body fat [35, 36].

Improvement in T2D after metabolic surgery may be due to:

1. "Upregulation" (increased availability) of insulin receptors and resulting insulin sensitivity after caloric restriction [24, 34].
2. Diminished secretion of gastric ghrelin.
3. Improvement of the action of glucose-dependent insulinotropic polypeptide (GIP) from the foregut.
4. Increased secretion of incretins (glucagon-like peptide-1, i.e. GLP-1) from the L-cells in the lower ileum, due to duodenal bypass with early transit of nutrients to the ileum, thereby stimulating the β-cells [37–39].

14.5 MGB-OAGB for Treatment of T2D in Morbid Obesity

Mini-gastric bypass (MGB) and the Spanish variant one-anastomosis gastric bypass (OAGB) are emerging as simple, easy to learn, rapid to perform, and safe compared to other bariatric operations, because of the single anastomosis, lower location of the anastomosis, better blood supply to the gastric tube, lack of mesenteric division, lower early complication rates, and lower early mortality [40–44]. In addition, MGB-OAGB has shown durable weight loss and is easier to revise and reverse compared to sleeve gastrectomy and RYGB [15, 39]. MGB-OAGB causes weight loss and metabolic effects by mildly restrictive but particularly malabsorptive mechanisms. It has excellent weight loss and resolution of co-morbidities, including diabetes.

14.6 How MGB-OAGB Decreases Hyperglycemia in T2D Patients with BMI <35

MGB bypasses the proximal 180–200 cm of jejunum, with rapid transit of contents to ileum. After 1 year, the decrease in BMI begins to plateau from adaptive mechanisms, consisting of increased size and number of villi and widened efferent loops.

Kim and Hur [11] in 2014 reported results of MGB in T2D patients with BMI <30, and found that the levels of FPG, 2-hour postprandial glucose, and HbA1C decreased continuously despite the plateauing BMI. They noted that levels of fasting C-peptide and insulin showed a decreasing pattern [11]. The levels of HbA1C and plasma glucose decreased more between the second and third year after MGB; patients developed further pancreatic β-cell mass in response to incretins [39]. Lee et al., comparing MGB in T2D patients with BMI >35 and <35, found resolution in both groups, but more durable remissiond in those with BMI >35 lasting 5–18 years (Fig. 14.2) [15, 31].

Likewise, kular et al. found significant improvement in T2D patients witn BMI <35; however, results were superior in patients who underwent MGB earlier and had BMI >35 [12]. Kular found in the diabetic patients with BMI <35 that HbA1c at 7 years was 5.7 ± 1.8%, and earlier intervention resulted in higher remission rates. In the Indian population, T2D with co-morbidities of the metabolic syndrome often present at BMI 25.

A series with T2D patients with normal weight BMI 24–29 treated by the OAGB operation has likewise documented a high incidence of resolution of T2D and the metabolic syndrome [45].

In T2D over the years, if there is poor glycemic control and prolonged elevated HbAic, then irreparable β-cell deterioration results [46].

The bariatric team must be sure that the patient does not actually have *latent autoimmune diabetes of the adult* (LADA), which is an adult onset *type 1* diabetes (T1D) with slow permanent autoimmune destruction of the β-cells. T1D comprises about 10% of diabetes at age 30–55, and is more prevalent in low BMI individuals [47, 48].

14.7 Comparison of MGB for T2D with Other Bariatric Operations

After LSG and RYGB, regain of weight has been reported in the long-term [49, 50]. Greater resolution of T2D has been found after MGB [51, 52]. After the Spanish variant OAGB, the same resolution of T2D and other co-morbidities has been found [53].

Conclusion

Following bariatric/metabolic surgery in T2D patients with BMI <35, there is resolution or improvement in the diabetes. This is greater in operations with a malabsorptive component, especially MGB-OAGB. The improvement is less in patients with lower BMI and where the T2D has existed for many years.

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Effect of MGB on the Obese Type 1 Diabetic

15

Mervyn Deitel

15.1 Introduction

Type 1 diabetes (T1D) is an *autoimmune* disorder with *permanent* destruction of the insulin-secreting β-cells of the pancreas [1, 2]. Bariatric surgeons frequently have confusion regarding type 2 diabetes (T2D) which is common in obesity, and T1D which is much less common and often occurs in normal weight individuals. Diabetologists often do not dissociate between T2D and T1D, because if weight loss or medications are not effective in T2D, they move on to insulin by injection [3]. In T1D, exogenous insulin is always necessary.

15.2 Juvenile Diabetes

T1D is the usual form of diabetes with onset in children, adolescents, and teenagers. This represents a permanent autoimmune destruction of the pancreatic β-cells, with no functioning β-cells remaining. Insulin post-receptors are located on the cell membrane of muscle and fat cells. Without insulin, glucose cannot pass through the cell membranes. Thus, metabolism switches to oxidation of fatty acids for energy purposes. If exogenous insulin is not prescribed, breakdown of fatty acids can lead to diabetic ketoacidosis, which may be present when the T1D is diagnosed in the child or young adult.

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15.3 Adult-Onset T1D: LADA (Latent Autoimmune Diabetes in the Adult)

Type 1 diabetes in the adult (LADA) has a slow onset (6 months to 6 years), with progressive relentless autoimmune destruction of β-cells, with onset generally between ages 30 and 55 [4]. It makes up 9–25% of the adult-onset diabetic population. If the diabetes was actually a type 1, LADA may be a cause of failure of resolution of diabetes after bariatric surgery, which is known to occur in 5–10% of diabetics after MGB-OAGB [5]. LADA may be diagnosed by the presence of auto-antibodies to glutamic acid decarboxilase (anti-GAD antibodies), anti-insulin and/or anti-islet cell antibodies [6, 7]. Endogenous insulin (from pancreatic β-cells) disappears as the autoimmune destruction progresses. Oral diabetic medications may still be effective until only 25% of the β-cells remain. However, subcutaneous insulin is ultimately necessary [8].

Normally, when pro-insulin is released from the pancreas into the bloodstream in response to a rise in plasma glucose, each pro-insulin molecule (manufactured by the β-cell) is split into one insulin and one C-peptide ("Connecting"-peptide) molecule. LADA patients, with autoimmune destruction of β-cells, are eventually unable to produce insulin, so that fasting C-peptide levels become very low. Thus, in LADA, there is extremely low plasma C-peptide and meal-stimulated C-peptide.

LADA progresses to no surviving β-cells. If insulin replacement is inadequate and permits glucose to remain elevated (with high HbA1c), the elevated plasma glucose leads to vascular complications (retinopathy, nephropathy, peripheral neuropathy, cardiovascular disease). This is the same as in T2D, although the macroangiographic complications are more typical of T2D. However, type 1 diabetics generally do not develop the metabolic syndrome (dyslipidemia, hypertension, fatty liver, etc.), unless they develop obesity (i.e. excess adipose tissue). Also, in the LADA patient, other autoimmune diseases may be present.

15.4 Obesity in T1D and Potential Need for Bariatric Surgery

The T1D patient must inject insulin to survive. However, if patients take excess insulin, they may develop hypoglycemia and then have to eat more and elevate glucose, then have to take more insulin (a vicious cycle). This can lead to overeating and obesity, if they take too much insulin. This obesity and insulin excesses can be controlled by dietary surveillance by the diabetologist, endocrinologist or internist. If the obesity is intractable, with the added features of the metabolic syndrome, bariatric surgery can become necessary to decrease the body mass index, the amount of insulin required, the HbA1c, and physical problems [9]. However, the intake after bariatric surgery must be careful with the insulin required, to avoid episodes of hypoglycemia, which may be complicated by a varying amount of food intake enabled after the operation. If bariatric surgery is advisable, it is important that the T1D patient understands that insulin will always be required, but at a much lower dose postoperatively [10].

In the normal-weight type 1 diabetic, bariatric surgery has no indication. GLP-1 released from the lower bowel has no β-cells to act upon.

15.5 Why Does Need for Insulin Persist in Some Type 2 Diabetics After Bariatric Surgery?

Initially, a T2D patient has elevated or normal plasma insulin and elevated plasma C-peptide. Bariatric surgery, and especially the MGB-OAGB, result in weight loss, increased plasma insulin, and increased insulin sensitivity, with cure of the T2D in a very high percentage of patients [11].

However, T2D uncommonly may not resolve after bariatric surgery. Insulin resistance in T2D is associated with lipogenesis and lipotoxicity. In *longstanding* uncontrolled T2D (e.g. ~10 years with elevated HbA1c), muscle and fat cells become "starved" for glucose, continually signaling a compensatory increase in insulin production. This action eventually leads to β-cell apoptosis, with resulting permanent plasma insulin deficiency, ultimately requiring exogenous insulin [12].

Conclusions

T1D is a different disease than T2D. T1D with adult onset has slow relentless autoimmune destruction of β-cells. T2D is generally associated with obesity. Early LADA will frequently respond to anti-diabetic oral medication or a GLP-1 analogue, because some β-cells may still be present; however, these patients will ultimately progress to requiring insulin. LADA has decreasing plasma insulin level, and very low fasting and meal-stimulated plasma C-peptide.

In normal weight T1D, bariatric surgery has no indication. However, if there is refractory obesity in T1D, bariatric surgery will decrease the BMI and associated diseases and lower the HbA1c, with a much lower requirement for insulin. After a bariatric operation in T1D, caloric control may have some difficulty.

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16 The Question of Bile Gastro-Esophageal Reflux

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16.1 Introduction

Mini-Gastric Bypass (MGB) is a modification of the Mason loop gastric bypass with a longer lesser curvature based pouch, along with a side-to-side gastro-jejunostomy performed ~200 cm distal to Treitz' ligament [1, 2]. MGB and OAGB are believed to be a better alternative to Roux-en-Y gastric bypass (RYGB), because of shorter operative time, fewer sites for anastomotic leaks and internal herniation, shorter learning curve, ease of reversibility and revision, with equivalent or even superior results in terms of weight loss and co-morbidity resolution [3–5].

However, despite its advantages, there are still concerns about the risk for chronic or symptomatic biliary reflux gastritis, esophagitis and consequently gastric pouch/esophageal cancer due to alimentary limb reconstruction ("the Billroth II reconstruction"), which could possibly increase both acid and biliary reflux [6]. Thus, there is an urgent need to clarify this controversial issue due to the fact that this surgery is becoming popular within the worldwide bariatric community [7]. It is importance to mention that duodeno-gastric bile reflux is a physiologic phenomenon, but excessive duodeno-gastric biliary reflux can lead to intestinal metaplasia, esophageal mucosal damage, symptomatic gastritis/esophagitis, Barrett's esophagus, and finally to gastric/esophageal cancer [6].

The old Mason loop gastric bypass with a small horizontal high gastric pouch and the loop adjacent to the esophagus could result in an alkaline reflux esophagitis [8]. However, alkaline reflux esophagitis may not be a problem in MGB, because this surgery includes a long gastric tube that produces intrinsic pressure and increases lower esophageal sphincter pressure, and the anastomosis is placed low in the stomach and distant from the esophagus [1, 8, 9].

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16.2 Available Methods to Diagnose Bile Gastro-Esophageal Reflux

Gastro-esophageal reflux disease (GERD) is a manifestation of pathologic levels of reflux into the esophagus of acidic, non-acidic, and/or bilious gastric content [10]. This phenomenon can be difficult to diagnose, because symptoms alone are often not enough, and thus, objective testing is often required [10]. Moreover, it is almost impossible to distinguish bile reflux from acidic reflux in terms of signs and symptoms [11].

Upper gastrointestinal (GI) endoscopy is the first clinical examination that must be performed when clinical suspicion is present [7]. Although this examination is not highly sensitive, it allows visual documentation of the presence of bile within the stomach and/or esophagus and can detect some of the pathological changes seen in the gastric and esophageal mucosa [7, 12]. However, a negative endoscopy does not rule out GERD [13]. Hepatobiliary scintigraphy is a radionuclide diagnostic imaging study that evaluates hepatocellular function and patency of the biliary system, by tracing the production and flow of bile from the liver through the biliary system into the small intestine [14]. This method is superior to upper GI endoscopy in the detection of duodeno-gastric bile reflux and also has the advantage of being non-invasive [14].

Second line examinations include spectrometric technique and monitoring pH impedance, which have higher sensitivity and specificity to detect reflux [7]. Moreover, the combination of pH monitoring and pH impedance can also be used to characterize all reflux episodes as acidic or non-acidic [7]. However, measuring esophageal pH alone is insufficient and cannot provide an exact diagnosis of non-acidic reflux, because many associated artifacts lead to nonspecific results [7]. Additionally, if esophageal content is aspirated when there is reflux, a biochemical analysis can be used to identify the presence of bile in the liquid that refluxed into the esophagus [11]. An alternative method, the Bilitec monitoring system, was developed years ago to identify changes in the color of the bilirubin in the esophagus [11]. This technique lacks specificity as other substances with an absorption spectrum in the range of bilirubin are also detected and cause false positive results. Moreover, the absorption spectrum of bilirubin changes in an acidic environment, which might confound measurements in GERD patients with high esophageal acid exposure [12].

16.3 Manifestations of Bile Gastro-Esophageal Reflux Following MGB

A clinical diagnosis of biliary reflux after MGB remains difficult, except when the patient experiences biliary regurgitation with a bitter and/or sour sensation and/or biliary vomiting, particularly during the night [7, 15]. Other symptomatology can include heartburn, nausea, belching, epigastric fullness and bloating [7].

16.4 Management of Bile Gastro-Esophageal Reflux

In general, the treatment for bile reflux is the same as the treatment for acidic reflux, and everything that can reduce acidic reflux can reduce bile reflux [11]. Examples are lifestyle changes, avoidance of tobacco, alcohol, chocolate and citrus juice, avoidance of eating immediately before sleep and being in the supine position immediately after meals [11, 13]. Likewise, the same drugs can be used to treat acid and bile reflux including antacids, H2 receptor antagonists (H2RAs), PPIs and pro-kinetics [11, 16].

Reoperations after MGB due to "intractable" bile reflux are relatively rare [15], but in some series, conversions mainly to RYGB and Braun entero-enterostomy have been reported [8, 17–22]. It is important to be familiar with post-operative phases of GI adaptation to MGB, so as not to blame bile reflux as the culprit of any dyspeptic symptom [15].

16.5 The Incidence of Bile Gastro-Esophageal Reflux and its Complications Following MGB

Table 16.1 presents the studies which explored the incidence of bile gastro-esophageal reflux and its complications following MGB. According to the current literature, biliary reflux rarely has been found, and if present, has been symptomatic only in a small number of patients [27]. To date, only three studies used direct measurements of bile gastro-esophageal reflux following MGB [6, 17, 23], and all other studies present mostly non-direct measurements (Table 16.1).

Research has established that exposure to chronic bile reflux in rats and humans (in non-bariatric patients) induces esophageal intestinal metaplasia and esophageal adenocarcinoma [7]. However, controversy remains regarding the long-term theoretical risk of gastric/esophageal cancer due to biliary reflux following MGB [7].

MGB is similar to Billroth type II reconstruction, and we have more than 75 years of experience using this procedure. Currently, there is no evidence to prove an increased risk of gastric cancer after Billroth type II gastric bypass, nor for MGB [30].

Authoritative warnings against the cancer risk coming from Billroth type II gastric bypass were published starting from the mid-1980s. However, during the same period, the potential carcinogenetic role of *Helicobacter pylori* was not yet completely understood [27, 31].

According to previous study review, only four cases of cancer secondary to loop gastric bypass have been reported in the literature; three of these were in the excluded stomach (unrelated to the surgical montage) and one was detected in the gastric pouch at several years after surgery [32]. Cancer arising in the gastric pouch or esophagus has never been reported after MGB [21], and the only case of cancer reported so far originated in the bypassed stomach in a patient in Taiwan 9 years following the surgery [33].

Cancers have been reported also after procedures like gastric banding and sleeve gastrectomy, which can lead to an increased risk of acid reflux in some patients, and

Table 16.1 Studies which explored the incidence of bile gastro-esophageal reflux and its complications following MGB

Direct measurement of bile gastro-esophageal reflux			
Authors	No. of participants	Measurements	Outcomes
Tolone et al. [6] 2016	N = 15 without diagnosis of GERD or hiatal hernia at baseline with 1 year follow-up 66.6% females Mean Age = 38 years	* Clinical assessment for reflux symptoms * Endoscopy plus high- resolution impedance manometry (HRiM) * Endoscopy plus 24-hour pH-impedance monitoring (MII-pH)	* At endoscopic follow-up 1 year post-surgery esophagitis, biliary gastritis and presence of bile were absent in all patients * Significantly decrease of esophageal acid exposure and total number of reflux episodes were found
Salama et al. [23] 2017	N = 50 with 1.5 years of follow up 64% females Mean age = 35.5 years	* Upper GI tract endoscopy was performed for all patients * Endoscopic biopsies were taken from any suspicious lesion * 24-hour pH metry was done if any abnormalities were detected by the endoscopy	* Reflux esophagitis was detected in 3 patients (6%); 2 cases (4%) showed acidic reflux esophagitis and 1 case (2%) had experienced gastroesophageal biliary reflux esophagitis * No metaplasia or dysplasia was detected in the endoscopic biopsies
Saarinen et al. [17] 2017	N = 9 with 1 year follow-up 44.4% females Mean age = 56 years	* Hepatobiliary scintigraphy * A reflux symptom questionnaire	* Transient bile reflux is common after MGB (55.5%) in the gastric tube, but not in the esophagus * One patient required conversion surgery to RYGB due to difficult reflux symptoms and malabsorption
Non-direct measurements of bile gastro-esophageal reflux			
Authors	**No. of participants**	**Measurements**	**Outcomes**
Rutledge et al. [2] 2001	N = 1274 with 2 years of follow-up 89% females Mean Age = 40 years	Complication rates	* 6 patients (0.5%) have had documented esophagitis postoperatively
Wang et al. [9] 2005	N = 423 with 2 years of follow up 79.4% females Mean age = 30.8 years	Endoscopy, barium swallow, and 24-hour pH-meter studies, but only for patient complained of symptoms of bile reflux or marginal ulcer	* No Barrett's esophagitis related to bile reflux was found by endoscopic examinations

Table 16.1 (continued)

Direct measurement of bile gastro-esophageal reflux			
Authors	No. of participants	Measurements	Outcomes
Carbajo et al. [24] 2005	N = 209 with 2 year of follow-up 82% females Mean age = 41 years	* Complication rates * 24-hr pH metry and endoscopic examination in the first 20 patients	* None of the patients have reflux symptoms
Johnson et al. [18] 2007	N = 32 patients were identified who presented with complications after undergoing an MGB procedure and required revision surgery	The databases of 5 medical centers were retrospectively searched to identify patients undergoing surgical revision after a MGB	* 20 patients (62.5%) were suffer from intractable bile reflux gastritis and needed revision surgery
Chakhtoura et al. [25] 2008	N = 100 with 1 year of follow-up 77% females Mean age = 40.9 years	Complication rates	* Two patients (2%) developed postoperative biliary reflux that was ameliorated by prokinetic drugs
Piazza et al. [1] 2011	N = 197 with a 3 years of follow-up 75% females Mean Age = 37.9 years	Complication rates	* Severe esophagitis was reported in 2 (1%) of patients
Lee et al. [8] 2012	N = 1657 gastric bypass patients (N = 1163 MGB* and N = 494 RYGB) with 1–10 years of follow-up **73% females **Mean age = 32.3 years	Complication rates	* MGB had a higher but not statistically significant incidence of intolerance due to bile reflux which required a revision surgery [0.3% (4/1163) vs. 0% (0/494), p = 0.192] * There was no difference between the groups in symptoms of heartburn or regurgitation
Noun et al. [26] 2012	N = 1000 with 5 year of follow-up 66.3% females Mean age = 33.15 years	Complication rates	* Four (0.4%) patients, all with revisional MGB, presented with severe bile reflux and were cured by stapling the afferent loop and by a latero-lateral jejuno-jejunostomy
Musella et al. [27] 2014	N = 818 with 5 years of follow-up 51.2% females Mean age = 39.4 years	* Complication rates * Endoscopic studies, but only for patients who presented prolonged dyspepsia, heartburn, vomiting, or gastric pain symptoms	* Bile reflux gastritis was symptomatic, with endoscopic findings reported for 8 (0.9%) and acid peptic ulcers for 14 (1.7%) * No patient required revision surgery due to biliary gastritis

(continued)

Table 16.1 (continued)

Direct measurement of bile gastro-esophageal reflux			
Authors	No. of participants	Measurements	Outcomes
Bruzzi et al. [19] 2015	N = 126 patients with 5 years of follow-up 79% females Mean age = 50 years	Complication rates	* Incapacitating biliary reflux developed in 2 (1.6%) who required conversion into RYGB * No significant differences in GERD symptoms was found between the preoperative and the postoperative periods
Chevallier et al. [21] 2015	N = 1000 with 12–82.9 months of follow-up 71.2% females Mean age = 41.8 years	Complication rates	* 7 patients (0.7%) had an intractable biliary reflux and converted to RYGB
Jammu et al. [28] 2016	N = 473 with 7 years of follow up 70.4% females Mean age = 46.5 years	Complication rates	* Bile reflux was seen in <1% in the MGB series * GERD was low following MGB (0.6%)
Lessing [29] et al. 2017	N = 407 with 1 year follow-up 62.4% females Mean age = 41.8 years	Complication rates	* None of the patients demonstrated signs of bile reflux
Musella et al. [20] 2017	N = 2678 with 5 years of follow-up 70.4% females Mean age = 42.2 years	* Complication rates * Validated questionnaires * In the presence of symptoms, esophago-gastro-duodenoscopy and high-resolution impedance manometry (HRiM) were used	* Bile reflux was diagnosed in the long term in 28/683 patients (4.0%) * Among them 4 (0.5%) required conversion to RYGB
Carbajo et al. [15] 2017	N = 1200 with 6–12 years of follow-up 62% females Mean age = 43 years	* Complication rates * Postoperative endoscopic studies were planned for all patients completing a 5-year follow-up as well as for those referring persistent upper GI symptoms	* Sporadic clinical reflux was reported by 26 patients (2%) * Endoscopic studies revealed the presence of some bile in the stomach with mild to moderate pouch gastritis, but did not document any esophagitis

Abbreviations: *GERD* Gastroesophageal reflux disease, *MGB* Mini-gastric bypass, *RYGB* Roux-en-Y gastric bypass, *GI* Gastrointestinal also after RYGB, which is widely believed to be the best anti-reflux procedure for morbidly obese patients being considered for bariatric surgery [32, 33].

An important step to prevent gastric cancer after any gastric bypass surgery is probably to screen and eradicate *Helicobacter pylori* infection before performing the surgery [30]. In addition, systematic upper endoscopy with biopsies in operated patients with >10 years of follow-up will be useful to evaluate the potential long-term exposure to biliary reflux [7].

The duration of exposure is a main determinant in the pathogenesis of complications related to biliary reflux [7]. Biliary reflux and the risk of cancer after MGB is theoretical and has not been confirmed in >20 years. However, cancer may take 20–30 years to develop [21]. Only long-term studies could give an accurate answer regarding the incidence of gastric/esophageal cancer following MGB, but presently, the findings from MGB series do not raise any significant alarm [27, 34].

Conclusions

Although MGB can theoretically induce chronic biliary reflux, the incidence of biliary reflux and its possible complications have not been prospectively evaluated. However, currently, reports on symptomatic gastric and/or esophageal bile reflux and reoperations after MGB due to "intractable" bile reflux are extremely rare.

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Treatment of Marginal Ulcer

17

Chetan D. Parmar

17.1 Introduction

Musella et al. discuss MU following MGB in Chap. 8 in this book, and Luque-de-Leon and Carbajo discuss MU following OAGB in Chap. 25 in this book. The MGB and the OAGB are increasingly being performed for obesity. Marginal ulcer (MU), although infrequent, is a challenge. Understanding the pathology, symptoms, investigations and management options is essential to deal with MU.

17.2 Incidence

MU or stomal ulcer is defined as a peptic ulcer produced on the jejunal mucosa distal to the gastro-jejunal anastomosis after partial gastrectomy for benign diseases such as gastric or duodenal ulcer or after surgery for morbid obesity. Csendes, with the Roux-en-Y gastric bypass (RYGB), divided MU into early (<12 months) and late (>12 months) [1]. In the 2015 MGB-OAGB Consensus before IFSO Montreal, a SurveyMonkey® filled out by 73 highly experienced MGB and OAGB surgeons (having performed a total of 24,983 MGB-OAGBs) reported a MU incidence of 1.6 ± 1.8% (range 0–5%) [2]. The incidence of MU after MGB has been less than after RYGB [3–5]. However, Georgiadou, in a systematic review of 4899 MGB patients, found that the MU rate was comparable to that of RYGB [6], with the rate quoted as 1–14.3%; however, the 14.3% rate was in a small series of seven super-obese patients (one developed MU) from a single center in their early learning curve.

The incidence in a small recent series of Parmar was 3.2% [7]. Taha in a large series of 1520 patients reported MU in 0.2% [8]. Carbajo et al. reported a 0.5% MU

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rate in a series of 1200 OAGB patients [9]. All had risk factors such as *Helicobacter pylori* (HP), alcohol and tobacco consumption.

All these patients were managed conservatively. Rutledge [10] reported a MU rate of 4% in his series of 2410 patients: they were treated with antacid regimes and antibiotics. All 0.6% of the MUs in a series of 1000 patients by Noun et al. were managed conservatively [11]. Kular [12] in a series of 1054 MGB patients reported a 0.6% MU rate.

Wang et al. [13] found MU in 8.0% of their MGB patients; however, they observed that the majority of their patients with MU had a wider diameter of the gastric tube. All patients were successfully managed by proton pump inhibitors (PPIs) and HP eradication when positive.

The size of the gastric pouch is one of the important factors for prevention of MU. A long narrow gastric pouch is ideal. Neutralization of gastric acid by alkaline bile and pancreatic juices and the long gastric pouch causing less tension on the gastro-jejunal anastomosis compared to RYGB are factors leading to the difference [2, 14].

17.3 Symptoms and Presentation

Smoking, NSAIDs, and eating lots of fried foods late at night are prohibited. Heavy alcohol intake is also forbidden, but large intake of whisky as in India, does not appear to be associated with MU.

Incidentally, it is noted that after MGB (as after RYGB), alcohol is absorbed fairly rapidly into the intestine [2].

With persisting dyspepsia, *H. pylori* should be ruled out. HP stool antigen or breath test may be checked pre-operatively and treated if positive. HP may be eradicated with helikit control before surgery.

The common presenting symptom of MU is vague upper abdominal pain, which can present as burning epigastric pain, nausea, vomiting or dysphagia. MU can also present as anemia. MU can rarely presents as an acute surgical emergency with upper GI bleeding or perforation.

17.4 Diagnosis

MU diagnosis requires a high index of suspicion and a low threshold for endoscopic evaluation. Gastroscopy is standard for diagnosis of MU. Contrast studies such as barium or Gastrografin® may be used. For refractory MU, pH studies should be considered to establish acid as the cause. In patients with recurrent MU, anatomical abnormalities such as gastro-gastric fistula, enlarged gastric pouch and strictures should be ruled out. In patients with refractory ulcer and smoking, urine may be tested for nicotine to confirm smoking cessation.

In the emergency situation of perforation, CT scan with contrast can confirm the diagnosis. Gastroscopy or CT angiography should be considered for MU presenting with bleeding.

17.5 Treatment

The majority of MUs can be managed medically with antacids and PPIs, e.g. PPI for 8 weeks and repeat endoscopy to check for healing [7]. If the MU persists, then sucralfate can be added to the regime. Repeat endoscopy may be performed at 8 weeks. HP should be tested for and eradication therapy prescribed if positive. MU presenting with perforation should be preferentially operated upon laparoscopically. Normally, the MU occurs on the anti-mesenteric border just distal to the GJ anastomosis, and thus is suitable for laparoscopic omental patch repair.

Patients not responding to medical management can be considered for surgery. If bile is established to be the cause of MU, then Braun's anastomosis (jejuno-jejunal anastomosis ~40–70 cm distal to the GJ anastomosis) can be performed. Other surgical options include revision of the GJ, conversion to RYGB, reversal of bypass or transthoracic vagotomy. Rutledge [10] had three patients with MU who failed medical treatment and underwent revision. Lee et al. [14] reported conversion to RYGB of 0.6% for MU. In his series, the revision rate in patients with RYGB having MU was also 0.6%. Musella et al. [15] had 14 patients with MU; 4 (0.4%) with gastric pouch enlargement needed surgical revision.

Azagury et al. after RYGB identified diabetes mellitus and hypertension as risk factors for MU [16].

17.6 Prevention

Smokers, NSAIDs, antiplatelet therapy, steroids, and alcoholics are at risk for developing MU. They should be considered for long-term PPI.

Lessing et al. [17] prescribe PPI routinely post-operatively, but did not specify duration. Noun et al. [11] advise PPI prophylaxis for 6 months. Taha et al. [6] prescribe PPI for 6 months after MGB. Parmar et al. [4] routinely prescribe PPI for 6 months after MGB. Carbajo [6] prescribes PPI and sucralfate for the first post-operative month after OAGB.

Conclusion

Most MUs can be managed with medical therapy, but surveillance is necessary.

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18 Quality of Life After MGB Compared to Other Operations

Mohamed M. AbouZeid, Mohamed Talaat, and Osama Taha

18.1 Introduction

Health-related quality of life (HRQOL) refers to the impact of health conditions on an individual's general life functioning. It reflects the way that patient's perceive and react to their health status and the effect their health has on other aspects of their lives, such as work, leisure activities, and social relationships [1].

In obese patients, HRQOL is significantly impaired; therefore, HRQOL improvement is one of the primary outcome measurements after bariatric surgery; however, recent studies reported great variation in the effect of bariatric surgery upon HRQOL because of two possible reasons. First, HRQOL is assessed with numerous questionnaires, because there is no specific questionnaire to assess HRQOL in bariatric surgery patients. Second, weight loss may also influence HRQOL [2–5].

There are several questionnaires for evaluation of the quality of life (QoL) after gastric bypass. They include the short-form 36 (SF-36) questionnaire and the Moorehead-Ardelt Quality of Life Questionnaire II (MA II) [6]. MA II questionnaire is specifically designed to measure subjective QoL in obese subjects in the following six key areas: self-esteem, physical well-being, social relationships, work, sexuality and eating behavior. The different items are scored from −0.5 to +0.5. The total score is the sum of the six aspects (from−3 to +3). The sum below −2.1 is "very poor", between −2.1 and −1 is "poor", from −1 to +1 is "fair", between +1 and 2.1 is graded "good" and above 2.1, it is "very good" [7].

The results of this questionnaire were combined with scores for weight loss and improvement of medical conditions in the Bariatric Analysis and Reporting

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Outcome System (BAROS), which is a quantitative measure used to measure the outcome of bariatric surgery [6]. The BAROS consists of standardized clinician ratings of surgical complications, post-surgical weight loss and medical changes, and a brief, patient-rated measure of QoL. The BAROS generates subscale scores for weight, medical co-morbidities, and QoL, and a total outcome score of surgical success, ranging from 0 (failure) to 9 (excellent) [7, 8].

The SF-36 estimates the physical and the mental well-being of the patients. It is divided into eight aspects: general health, physical functioning, role-physical, role-emotional, social functioning, bodily pain, vitality and mental health. The scores range from 0 to 100 for each dimension [9].

The SF-36 is a general health status measure that contains 36 items in eight domains of functioning: physical functioning, role limitations due to physical health problems, bodily pain, general health perception, vitality, social functioning, role limitations due to emotional problems, and mental health. Each of these items is scored from 0 to 100, with a high score being associated with a high level of functioning in that domain. The SF-36 also contains a single item where patients are asked to estimate their overall health status compared with 1 year before, termed a health transition (HT) score. The scale ranges from 1 to 5, where 1 = much better, 2 = somewhat better, 3 = about the same, 4 = somewhat worse, and 5 = much worse [9, 10]. Reliability values (Pearson r) range from 0.89 to 0.94 for the Physical Component Summary (PCS) and from 0.84 to 0.91 for the Mental Component Summary (MCS) [11].

The World Health Organization Quality of Life—Brief (WHOQOL BREF) is a generic QoL instrument designed to assess physical, psychological, social and environment domains. It has been shown to have good validity for use across different countries and different patient groups, including those with morbid obesity [12, 13].

Other measures for assessment of QoL after bariatric surgery include the Impact of Weight on Quality of Life-Lite Questionnaire (IWQOL-Lite), the Beck Depression Inventory (BDI) and the Rosenberg Self-Esteem Scale (RSE) [14].

The IWQOL-lite is a 31-item questionnaire which assesses the impact of weight on QoL in five domains. This questionnaire has shown good validity and reliability in obese patients and has been was used in the bariatric population. In addition to a total score, there are scores on five scales: physical function, self-esteem, sexual life, public distress, and work [15, 16].

The Beck Depression Inventory (BDI) is a standard self-report questionnaire consisting of 21 multiple-choice items designed to assess the presence and severity of depressive symptomatology. On the BDI, higher scores indicate more severe depression [17].

The Rosenberg Self-Esteem Scale (RSE) is a widely used self-report instrument consisting of ten items that measure overall self-esteem. On the RSE, higher scores indicate poorer self-esteem [18].

Bariatric surgery has been demonstrated to contribute to dramatic improvements in QoL after surgery compared to other weight loss methods [19, 20].

Gastric bypass surgery (GBS) is an accepted and effective means of managing morbid obesity, not only for weight loss but also for reducing or eliminating associated co-morbid conditions. These benefits may result in improved HR-QoL, enhanced functional abilities, and improved cardiorespiratory fitness [21].

Dymek et al. [14], in their cross-sectional study found that there were significant differences among patients before and after RYGB, regarding weight, body mass index (BMI) and BAROS outcome data. Also, significant differences were noted in the results of BDI and RSE before and after surgery, denoting that depressive symptoms and self-esteem were outstandingly improved especially in the first year after RYGB [14]. Using SF-36 and IWQOL-Lite questionnaires, there was significant post-operative improvement of physical and mental health states which increased gradually [14].

Chang et al. [22], reported that improvements were documented in various domains and aspects of QoL for the first 3 months, after which there was a slight downward trend in physical and psychological domains between 3 and 6 months that seemed to be associated with complications, followed by further improvement up to the end of the first year. Their study showed that laparoscopic gastric bypass could improve both physical and mental health dimensions of the SF-36 [22, 23].

The laparoscopic mini-gastric bypass (MGB) is a modification of the Mason loop gastric bypass (but with a long lesser curvature pouch) with weight loss results similar to laparoscopic RYGB [24, 25].

In their comparative study using gastrointestinal QoL Index (GIQLI) for assessment of QoL after laparoscopic MGB and RYGB, Lee et al. [26] reported that GIQLI scores after MGB were significantly higher than pre-operative scores. Physical, social and emotional functions were markedly improved after surgery. MGB patients had a better score in abdominal pain but lower score in eating with pleasure and trouble with diarrhea than RYGB patients.

In this study, the GIQLI detected no significant difference between RYGB and MGB. At 5 years after surgery, both operations can significantly improve the total score on QoL, but the improvement was confined to psychological, physical, and social domains. The disease-specific and core symptom domains decreased after surgery because many patients developed certain gastrointestinal symptoms, mainly related to vomiting, eating disorders, and abdominal discomfort. In specific symptoms analysis, RYGB patients experienced a higher frequency of abdominal pain than MGB. MGB patients, on the other hand, experienced higher frequency of oil stool passage and diarrhea, likely related to the short bowel effect. However, there was no difference between the groups in symptoms of heartburn or regurgitation [26].

RYGB patients had a higher incidence of internal hernia (1–4%) and intestinal obstruction requiring more frequent revisional surgery compared to MGB [27].

Lee et al. [26] concluded that MGB is an effective bariatric operation which significantly increases the QoL and has the advantage of being simpler with lower need for revisional surgery compared to RYGB.

The authors have assessed the outcome of MGB on the QoL in 1520 patients over a period of 6 years (between 2009 and 2015) [28], and the following data were obtained:

- *Physical functioning*

Physical functions were markedly improved in most patients apart from a few patients who developed post-operative iron deficiency anemia that negatively affected patients' daily physical activities. This problem was managed by medical treatment with supplementation of iron and other trace elements, and physical activity improvement was regained.

- *Social relationships*

In general, there was significant improvement of patients' relationships which can be attributed to marked weight loss and improvement of physical activities and other co-morbidities. However, some issues were reported by a small percentage of patients, such as offensive flatus and stools and diarrhea, which were managed by diet and probiotics.

- *Psychological impact*

The majority of patients reported that they perceived a marvelous change in their psychological status after surgery. Almost all patients who were receiving pre-operative antidepressant drugs completely discontinued these medications at various periods after MGB. Self-esteem was significantly elevated for most patients, and positive mood changes were progressively acquired. Few patients (<3%) reported poor outcome after surgery, and this was attributed to alterations in dietary habits, inadequate excess weight loss (EWL), limitation of physical activities and gastrointestinal symptoms including diarrhea, nausea, abdominal pain and GERD symptoms.

- *Sexual activity*

More than 70% of patients of both genders declared that their sexual activity improved after surgery especially in the late post-operative period (after 6 months); however, 23% complained of post-operative hypofunction, possibly because of nutritional and psychological disruption in the early post-operative period. This problem could be solved by dietary adjustment, correction of malnutrition, supplementation of vitamins and trace elements and reassurance.

- *Mental health*

Few patients (<2%) developed post-operative amnesia due to thiamine deficiency, which was corrected by dietary control. However, the majority of patients reported that their mental health remains unchanged or slightly enhanced.

- *Resolution of co-morbidities*

MGB is a very efficient bariatric measure in resolving obesity-related co-morbid conditions. This was confirmed in the follow-up period, because at 3-year follow-up, 90.9% of diabetic patients had complete remission [28], which is comparable to other studies [29, 30]. Also the remission rate of hypertension at the end of 3-year follow-up was 91.6% [28], which is comparable to other results [29].

With follow-up, various co-morbidities including respiratory, cardiovascular and musclo-skeletal, were improved by varying degrees over varying periods after surgery. Postoperative co-morbidities improvement contributed to optimizing physical, social and psychological functions of the patients.

- *Eating behavior*

MGB helps to change the poor dietary habits of patients to post-operative healthy Mediterranean diets, as reported by Rutledge [31]. Some patients may exhibit inconvenience with the nutritional program after surgery and this may lead to nutritional or emotional disorders. Thus, continued surveillance of patients' nutritional status after surgery is essential.

- *Percentage of excess weight loss (%EWL)*

MGB has proved to achieve higher %EWL compared to other bariatric measures [32]. The authors found that %EWL at 3-year follow-up was 80.2% [28], which is comparable to other published studies.

Conclusion

MGB is a competent bariatric option for management of morbid obesity, and significantly improves the QoL, especially physical, social and psychological aspects.

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Mini-Gastric Bypass Using Single or Reduced Number of Ports

19

Mohit Bhandari and Winni Mathur

19.1 Introduction

Obesity has become a major pandemic, and young individuals are affected in equal proportions as compared to adults. As a whole, obese individuals are viewed as having a physical, emotional and moral impairment, and they hugely suffer discrimination in diverse domains.

The attitude towards undergoing bariatric surgery, which is one of the most powerful tools to tackle morbid obesity, is not very positive, and we as one bariatric surgical community are operating on only 1% of the morbidly obese out of many who deserve the surgery. Considering the taboo associated with obesity and its treatment, most individuals feel comfortable in concealing it.

Use of single incision and reduced port surgery are in demand, because scar-less operations are preferred by many undergoing elective abdominal surgery [1, 2]. Unmarried males and females prefer a scar-less weight loss bariatric procedure, given the option.

Pelosi MA [3] described the first SILS surgery known at that time as single puncture appendectomy. With the increased acceptability of MGB [4], single incision MGB is becoming one of the frequently performed procedures, because it is preferred by young unmarried females who want bariatric metabolic surgery.

Laparo-endoscopic single-site surgery (LESS) is the term coined by a multidisciplinary consortium in 2008 for single-incision laparoscopic surgery [5]. Single incision laparoscopic surgery (SILS) is the term commonly used to describe the

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Fig. 19.1 Gel Point Port

Fig. 19.2 SILS port—Covidien®

single incision abdominal approach [6]. These are complementary technologies with similar difficulties of access, lack of triangulation and inadequate instrumentation as of date [7].

SILS is an extremely popular procedure and surgeons have performed cholecystectomies, adrenalectomies, hernia, and colorectal surgeries by this approach [8–11]. SILS is a good bridge between Natural Orifice Transluminal Endoscopic Surgery (NOTES) and laparoscopic surgery [12]. SILS are of two types. It can be a single incision multi-port or a single incision-port based surgery where multiple ports are inserted on a SILS port based platform [13]. The overall concept of the surgical technique remains the same, but the learning curve and certain major technical challenges faced during the procedure still remain one of the major deterrents for the single incision MGB.

Apart from single incision, a reduced port approach is also preferred by some of the surgeons [14, 15]. Multiple ports for single incision surgery are available commercially, but a Gel Point Port (Fig. 19.1) and a SILS port-Covidien

(Fig. 19.2) are the most frequently used ports. The concept of making a long gastric tube with a wide gastro- jejunal anastomoses remains the mainstay of the MGB [16]. The anastomoses can be performed hand-sewn or by a stapled approach [17].

19.2 Selection of the Patient

The patient should be carefully selected for the single incision approach. The following can be the selection criteria:

1. The Body Mass Index (BMI) of the patient: The BMI of the patient is an important consideration for choosing patients for the single incision approach [18]. BMI >50 can become a difficult approach due to more amount of visceral mesenteric fat and greater peritoneal fat. A good BMI is between 35 and 50 where it becomes more feasible to perform surgery via this approach [19].
2. The xiphoid umbilical distance: The xiphoid umbilical distance between 15 and 25 cm is a good option for the single incision approach. The more the xiphoid umbilical distance, the more is the difficulty in working at areas close to the gastro-esophageal junction [7, 20].
3. The liver preparation: A good liver preparation is required for the single incision and is of utmost importance. Fatty liver and massive liver can obstruct vision, making dissection difficult.
4. Laxity of abdominal wall: A lax abdominal wall is more suitable for the single incision. Muscular abdomen can cause a large amount of torque during dissection and can make surgery difficult. Also, a lax abdominal wall gives more space to work inside the abdomen due to optimal pneumoperitoneum.
5. A young unmarried female patient is more suitable for the single incision procedure considering the liver, laxity of abdominal wall, and quality of visceral fat. The demand for cosmesis [21] is more with young unmarried females [19, 22].
6. No previous abdominal surgery is a favorable condition but not strictly necessary. The more the adhesions, the more will be the difficulty in performing a SILS procedure [7, 17].

19.3 Instrumentation

Conventionally, the SILS was performed with articulating instruments and a complicated system. However, the development of newer type of SILS ports with more ease of working has made it simpler to use this as a modality without the complicated articulating instruments [8].

A Gel-point port (Applied Medical®) Fig. 19.1 or a SILS port (Medtronic®) Fig. 19.2 are two prominently used ports for SILS Bariatric procedures across the world. Some procedures are performed with single incision multi-port technique. It depends on the expertise of the surgeon and the center's experience.

19.4 Technique

A trans-umbilical incision 3 cm long is made. The Gel-point platform is a wax-based platform, and a maximum up to four ports can be inserted on it. The subcutaneous tissue is dissected, and the fascia is cut open. Once the peritoneum is breached with the knife, the abdomen is open. The Gel-point port is inserted and carbo-peritoneum is achieved. The lesser omentum is opened at the area 2–3 cm below the crow's foot. Once the lesser sac is entered, the adhesions between the pancreas and the posterior wall of the stomach are dissected for the space to be clear to insert the stapler.

One horizontal blue load is fired of size 6 cm, and then vertical firing is done with the blue load until the remnant is separated. A gastric calibration tube of size 38 French is used to calibrate the pouch. The long vertical pouch is made free of fat on the posterior wall. A gastrotomy is made using a harmonic scalpel. The ligament of Treitz is then traced and a bowel of length 175 cm is counted with a sterile ruler introduced inside the abdomen through one of the ports.

An enterotomy is made, and anastomosis of size 4–6 cm is made using a blue cartridge. The anastomosis is made posterior to the staple-line of the stomach. The gastro-enteral defect is closed with a 2–0 Vicryl. Hemostasis of any staple-line bleeding is achieved with titanium clips.

19.5 Difficulties Encountered During the Procedure

1. Lack of triangulation: Due to a single incision approach, there is insufficient triangulation, which we get substantially in conventional laparoscopy [17].
2. Swording of instruments is a common problem with the single incision approach. As there is a limited space to maneuver, the swording effect is pronounced.
   (a) Vision becomes challenging at the specific angles in the SILS approach with limited space for the camera.
   (b) Articulating staplers are the necessity, as without them the stapling becomes very difficult.
   (c) Suturing requires more skill and practice to do a safe and secure anastomosis. The umbilical incision is closed meticulously to avoid umbilical scarring.

There are multiple published reports of single incision gastric bypass, and different techniques are described by different authors [14, 17, 18]. Most of them have concluded the single incision approach as feasible and cosmetic for young patients.

19.6 Complications

Just like in conventional laparoscopy, the SILS approach can also have complications. Leak from the staple-line or anastomotic line, bleed, stenosis and stricture are surgical complications which have been noted [19]. Early and late post-operative complications may occur, but the incidence in most studies is similar to the laparoscopic counterpart [23].

SILS MGB is a technically challenging procedure. The main challenge is suturing the gastro-jejunal defects.

With the bile pouring through the complex anastomoses area, it is pertinent to have a robust and leak-proof anastomosis.

The learning curve to perform a Single Incision MGB is steep. There is a totally stapled technique to perform a Single Incision MGB as shown in Figs. 19.3, 19.4, 19.5, 19.6 and 19.7.

Fig. 19.3 Use of conventional laparoscopy instruments, energy source, and camera system for the SILS procedure

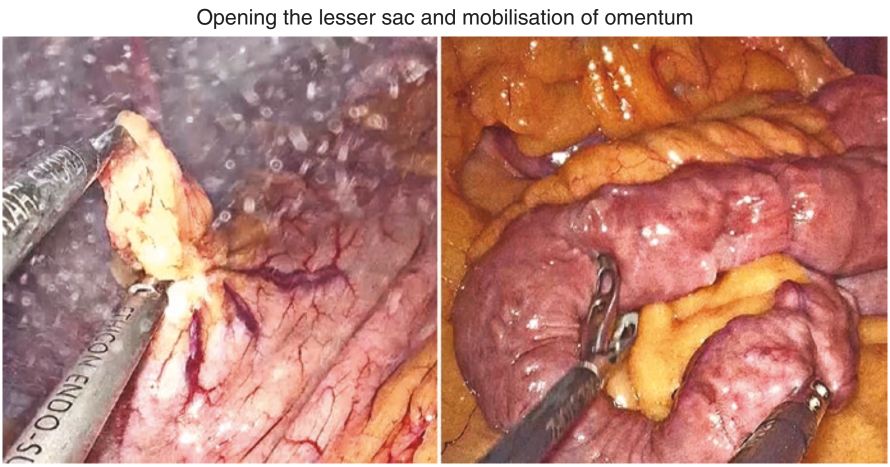


Fig. 19.4 Opening of the lesser sac and mobilization of omentum

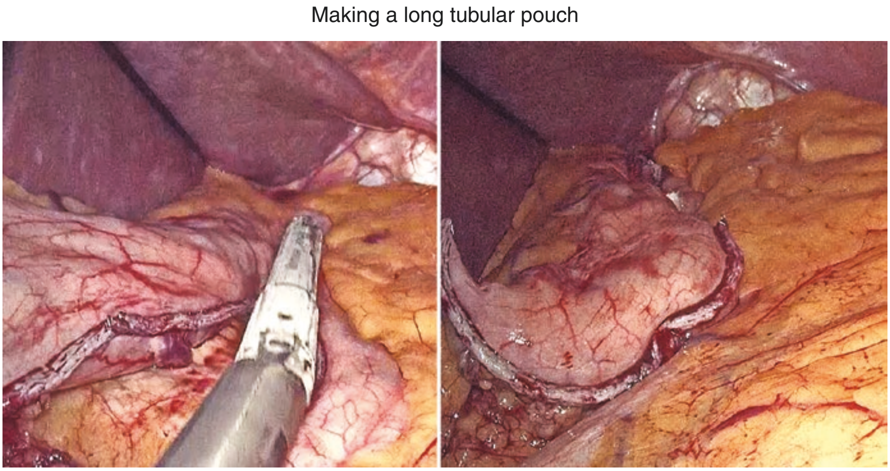


Fig. 19.5 Making a long tubular pouch

Fig. 19.6 Loop gastrojejunostomy

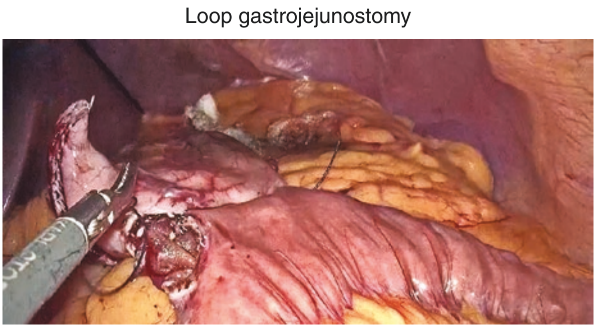
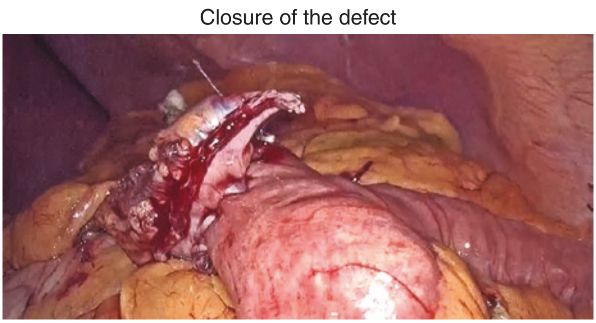


Fig. 19.7 Closure of the defect



19.7 Mini-Lap Approach to MGB

A mini-lap approach or reduced port approach may be used to perform a MGB. The size of the ports is reduced to 3 mm—a minimum to avoid potential scarring. The instruments with the latest development are sturdier and can assist adequate dissection (Fig. 19.8).

Fig. 19.8 Mini-lap instruments for MGB

Conclusion

Single incision MGB is being preferred by young individuals. It is technically more challenging than the conventional multi-port approach. If done with a wide-based single incision port with a standardized technique, it can be performed safely.

Use of conventional laparoscopic instruments is possible with the latest ports without compromising the safety of the single incision procedure.

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Robotic Mini-Gastric Bypass

20

Arun Prasad

20.1 Introduction

In recent years, robot-assisted laparoscopic surgery has become more widely available to surgeons. Robotic systems contain 3D vision and camera control by the surgeon. They are especially useful for delicate dissections and offer benefits when suturing in relatively small, confined spaces due to its instruments that can mimic wrist-like motions. They have been shown to improve intracorporeal suturing performance and safety in the operating room [1].

Robotic surgery was initially focused on urological procedures [2]. General and gastrointestinal surgery in general and bariatric surgery in particular started late, because of the concerns of robotic surgery being suitable for only one small quadrant in the abdomen [3].

For the robotic Roux-en-Y gastric bypass (RYGB) surgery, there is the 'hybrid technique' where part of the surgery involving formation of the Roux-en-Y loop is done by laparoscopy, and robotics is used for the gastrojejunostomy anastomosis [4]. Then there is the technique of dual docking, where the robotic arms or robot itself are re-docked for surgery in the supracolic compartment after the initial surgery in the infracolic compartment [5].

Mini-gastric bypass (MGB) has shown good results in many recent series and is considered by many as a good alternative to the RYGB [6–8]. Robotic MGB is possible without the need for hybrid or dual docking.

While laparoscopic MGB is a technically sound procedure, the addition of robotic technology simplifies some of the steps. MGB has the advantage of having all dissection and anastomosis in the supracolic compartment and is therefore suitable technically for robotic surgery.

First robotic MGB was done by Prasad in New Delhi in July 2012 [9]). Subsequently, the procedure has been done at other centers in India, Turkey and USA.

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Although in initial studies no differences have been detected between robot-assisted and conventional laparoscopic surgery with respect to surgery time, length of hospital stay, complications, or rate of conversion to open surgery [10–12], post-operative anastomotic leaks have been shown to be significantly less in robot-assisted surgery [13].

Despite these conflicting results, robotic surgery has the advantages of 3D imaging, tremor filter, and articulated instruments, and it also compensates for some limitations of the laparoscopic surgery, such as restricted range of motion of the instruments and poor ergonomic positioning of the surgeon [14]. Being a newer and evolving technique, the results of robot-assisted bariatric surgery should not be discounted unless learning curve analysis is performed.

20.2 Operative Technique

20.2.1 Patient Positioning

Patient is supine with reverse trendelenberg position of 30°. There is no need for a steep table tilt that is used in laparoscopy. Also no lithotomy or leg spreading is needed (Fig. 20.1). A sequential pneumatic compression device is placed on both lower extremities before induction of anesthesia.

20.2.2 Trocar Placement

The camera port is placed about 5 cm above the umbilicus in the midline using a long disposable cannula. One robotic port is placed in the right hypochondrium about 5 cm below the costal margin and about 10 cm superolateral to the camera port. A second robotic port is placed in the left hypochondrium as a mirror image to the first port. A third robotic port is placed laterally at the same level as the camera port ensuring a 10 cm distance from the second port (Fig. 20.2).

20.2.3 Robot Positioning

The robot is wheeled in on the cranial end side of the patient as close to the head as possible, and the surgical arm cart of the da Vinci Surgical System (Intuitive Surgical, Inc., Sunnyvale, CA, USA) is carefully positioned ensuring the camera arm movement does not come in contact with the patient at any stage. Robotic arms are docked to the robotic cannulae (Fig. 20.3). Graspers are introduced from the second and third arms and the energy device from the first arm to start the surgery (Fig. 20.4).

Fig. 20.1 Supine patient with 30° table tilt and no spreading of legs

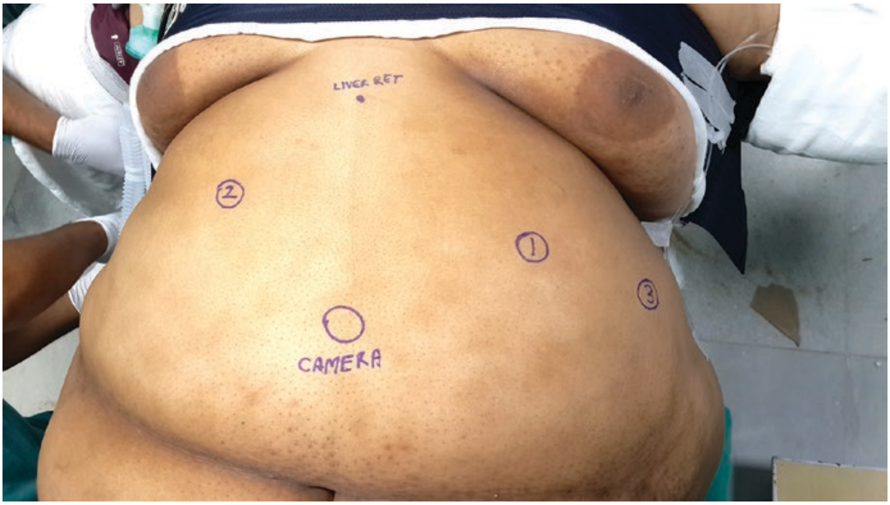

Fig. 20.2 Port positions

Fig. 20.3 Docking of the robot

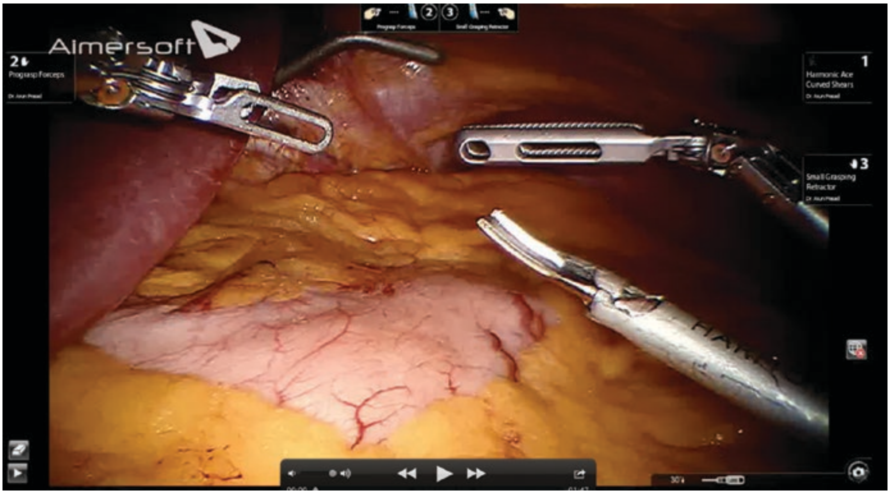

Fig. 20.4 Robotic instruments used during surgery

20.2.4 Robotic Surgery

Surgery starts with identification of the crow's foot distal to the incisura on the lesser curve of the stomach (Fig. 20.5). Dissection is commenced at that level to enter the lesser sac. The wide jaws of the graspers act as a retractor once the opening is made. From the right 12-mm robotic cannula, the stapler is introduced, articulated and angled from the lesser curve opening towards the greater curve. The articulating robotic instruments assist in manipulating the stomach to position it in the stapler jaws in the desired angle. About 45-mm of the stomach is stapled. A 36-French bougie is then passed to this angle, and the stomach sleeve is created

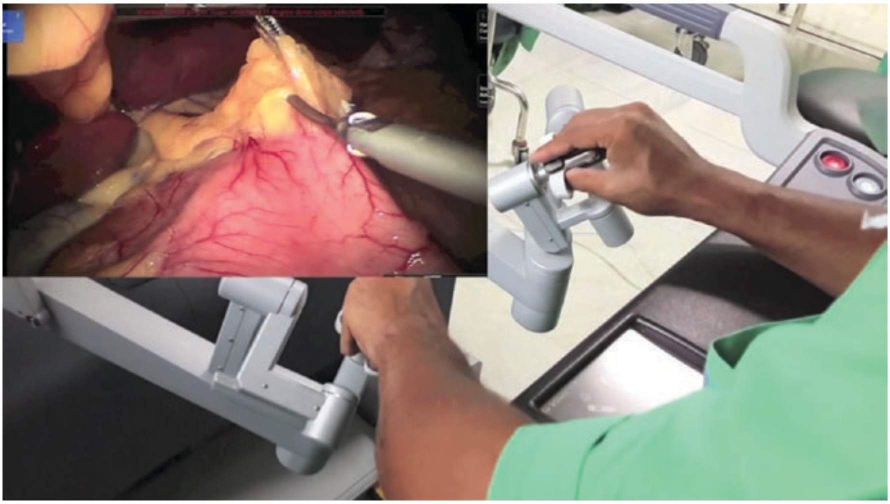

Fig. 20.5 Start of dissection above crow's foot

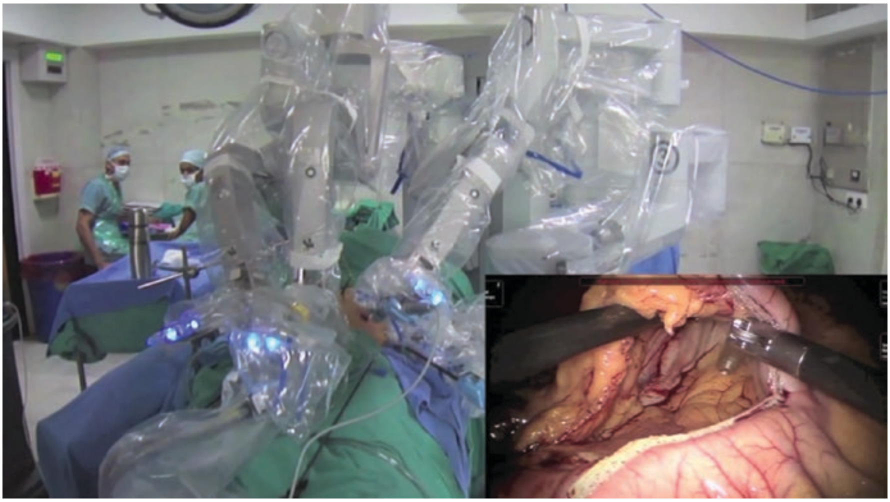

Fig. 20.6 Articulating instruments for retrogastric dissection

along it right to the gastroesophageal junction. Robotic instruments assist in creating the tunnel (Fig. 20.6) between pancreas and stomach until the angle of His (Fig. 20.7).

The transverse colon is lifted up with robotic arm 1 instrument, while arm 2 and 3 instruments trace the duodenojejunal junction. Then, 200 cm of the jejunum is measured. The jejunal loop is taken up ante-colic to the sleeved stomach tube. A side-to-side gastro-jejunostomy is done between the lower end of the sleeve and the jejunum. Initial cases were done using a stapler with sutured closure of the enterotomy. Subsequent cases have been done by a three-layered suturing technique (Figs. 20.8, 20.9, 20.10, and 20.11).

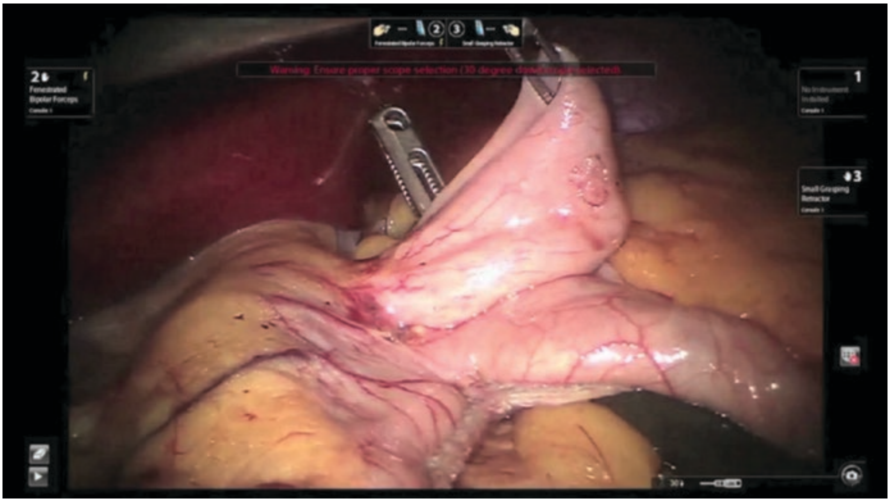

Fig. 20.7 Ease of dissection at crura

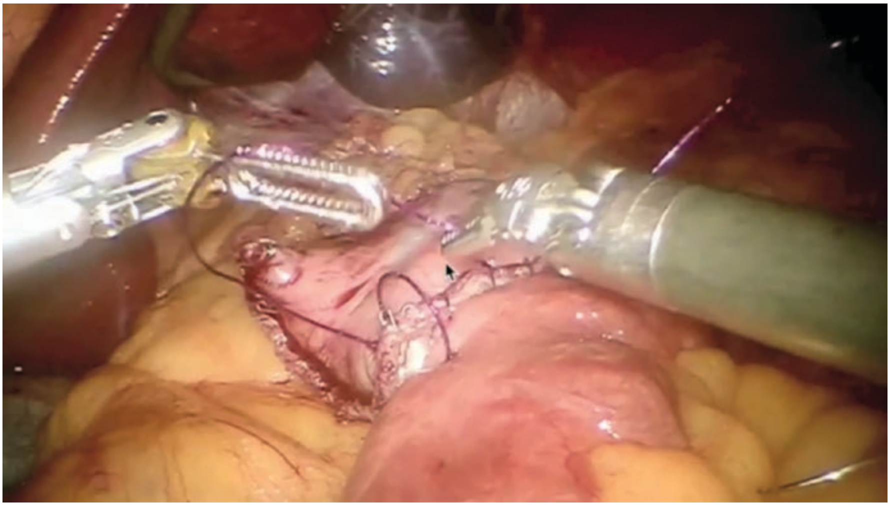

Fig. 20.8 First layer of gastro-jejunostomy suturing

20.3 Discussion

Laparoscopic bariatric surgery is one of the most challenging advanced laparoscopic procedures. It requires intracorporeal resection and anastomosis of stomach and intestines, double-handed tissue manipulation and use of angled telescopes. In addition, there is the increased cannula torque against a bulky abdominal wall and an awkward surgeon positioning that further adds to the difficulty level [5].

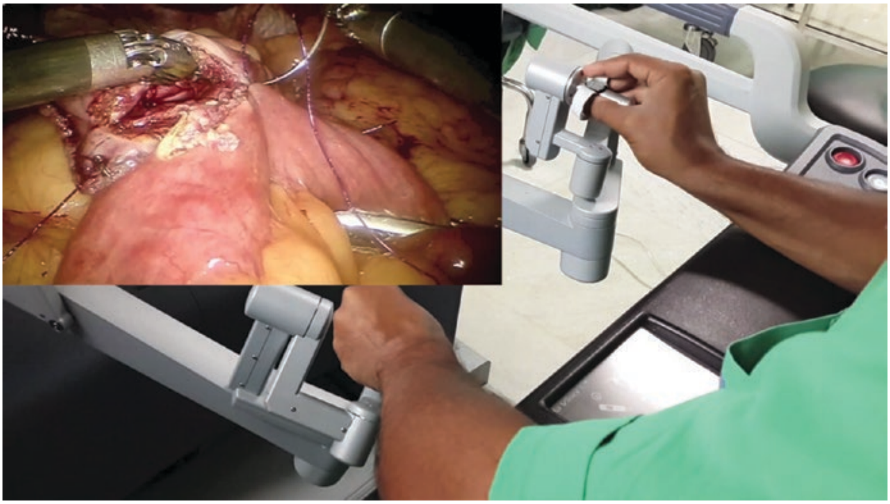

Fig. 20.9 Corner suture

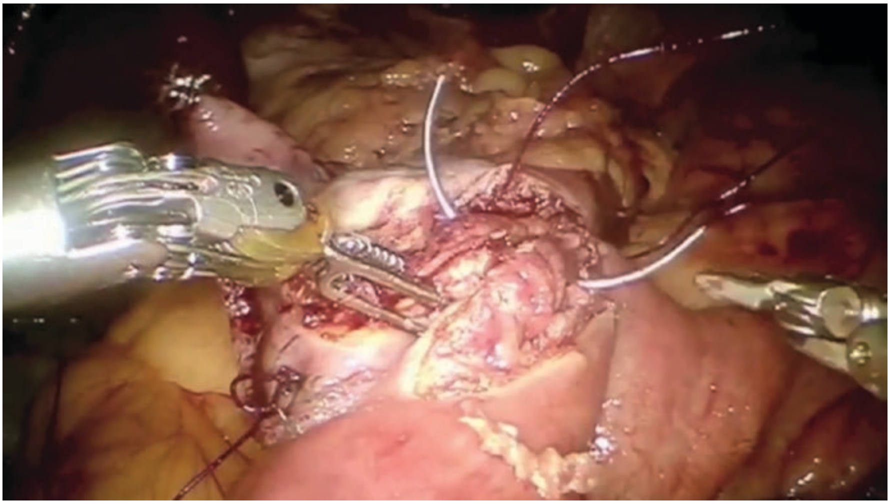

Fig. 20.10 Second layer of gastro-jejunostomy suturing

Use of the robot has to a certain extent reduced the ergonomic challenges of bariatric surgery. The robotically-controlled telescope is superior to a human-controlled telescope [15], and robotic suturing has been found to be easier and more accurate for gastrointestinal anastomosis, more so in the obliquely or vertically placed situations like gastro-jejunostomy [16]. Tissue manipulation and alignment are also made easy [17].

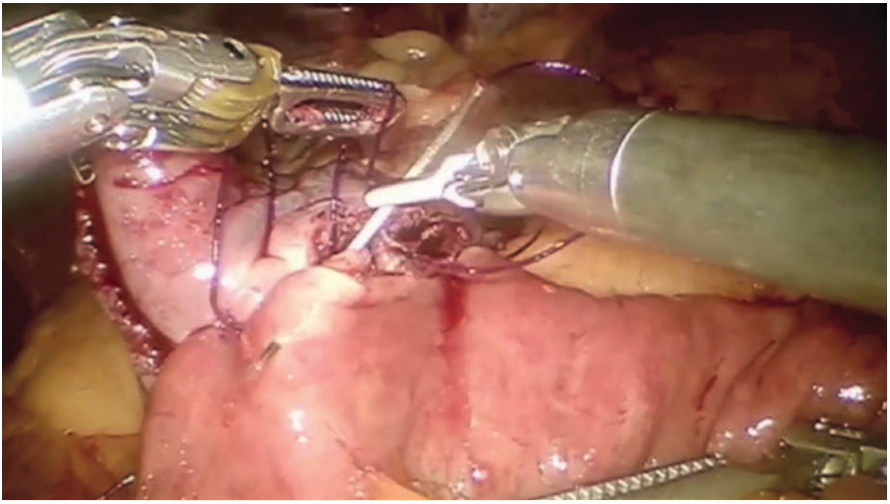

Fig. 20.11 Third layer of gastro-jejunostomy suturing

This procedure takes time that is comparable to its laparoscopic counterpart. In addition, it gives all the added benefits of the robotic technology to both the surgeon and the patient.

Conclusions

Robotic surgery is here to reduce the technical challenges that are faced during complex surgeries. Surgery in a morbidly obese patient can be difficult at times, and the availability of a robotic option can simplify some of the steps during MGB. This applies especially to the retro-gastric dissection around the crura and also the gastro-jejunostomy anastomosis, which can be safely and accurately performed by robotic suturing. Robotics is not a replacement for laparoscopy but should be used if available, to tackle difficult situations especially in the super-obese and during revision surgery.

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21 Absence of Gastric and Esophageal Carcinoma After MGB-OAGB

Mervyn Deitel

21.1 Introduction

There has been fear of cancer developing after MGB or OAGB in the gastric tube or esophagus, based on the presence of bile in the lower end of the gastric tube. However, it must be noted that after the Billroth II gastrectomy, where there is always bile passing through the lower stomach, very long-term studies showed an actual decrease in incidence of carcinoma [1–5]. Moreover, this was before it was realized that *Helicobacter pylori*, a cause of cancer in the stomach, was known and treated.

Furthermore, in the 1960s and 1970s, when peptic ulcer disease was common and was treated by vagotomy and pyloroplasty (Heinecke-Mikulicz, Finney, or Jaboulay), ensuing cancer of the stomach was not reported. Yet, postoperative gastroscopy (e.g. for abdominal pain such as cholecystitis), always saw bile in the lower stomach. Indeed, I had performed >1000 V&Ps, with no development of carcinoma on long-term follow-up.

Chronic bile in the stomach can cause gastritis, which is asymptomatic [6]. This was considered to cause symptoms occasionally after a Billrohth II. However, when a Roux-loop diversion was inserted, the symptoms were not reversed [6]. Any symptoms often resolved sponstaneously.

21.2 Studies in Laboratory

Studies by Frantz et al. [7], Proctor et al. [8] and Chandra et al. [9] found that application of concentrated bile or irritating chemicals in the rat stomach produced carcinoma only in the proximal two-thirds (rat "forestomach"). The proximal two-thirds

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of the rodent stomach has squamous cell mucosa, where hyperplasia and malignancy develop. In humans, these squamous cell changes have relevance to the sleeve gastrectomy (SG), where GE reflux and Barrett's esophagus occur [10]. The distal third of the rat stomach (beyond a tiny mucosal ridge) is *glandular mucosa*, which is similar to the *entire* human stomach. In the rodent's glandular stomach (distal third), bile or irritants do not cause neoplasia.

21.3 Cancers After Bariatric Operations

After bariatric surgery, there were a total of 36 carcinomas in the stomach or esophagus reported in collected literature in 2007 and 2013 by Karuba et al. [11] and Scozzari et al. [12], when overlapping cases are excluded. These two combined series contained four Mason horizontal loop gastric bypasses, fifteen RYGBs (two banded), ten VBGs, six Lap-bands, and one SG. Following this, case reports were no longer accepted for publication in the journals; however, three further CAs have been published: RYGB 2 and SG 1 [13–15]. SG is known to have a high-pressure tube with GE reflux [16], plus a future hazard from Barrett's (premalignant) [10, 17] and other problems [18].

GE reflux following SG (and gastric band and VBG) is common [19]. However, mini-gastric bypass (MGB) with the long vertical pouch to below the crow's foot has been effective in resolving GE reflux because of its low-pressure gastric tube and decreased GE pressure gradient [20].

21.4 Carcinoma After MGB-OAGB

Only one case of carcinoma in the stomach has been reported, 9 years after MGB, from Taiwan. This was *not* in the gastric tube or esophagus, but away in the bypassed stomach. In the Far East, carcinoma of the stomach remains a common cancer, although it had decreased remarkably in the rest of the world [21].

An online Survey-Monkey® questionnaire was undertaken by Dr. Kular of 147 experienced surgeons of the MGB-OAGB Club in 2016, representing ~49,000 MGB-OAGBs, many going back to the year 2000. None of the respondents had found a case of CA of stomach or esophagus after these operations.

Conclusion

It appears that carcinoma of the stomach after MGB or OAGB must be extremely rare.

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Revision of Lap-Band to MGB

22

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22.1 Introduction

Several surgical procedures can be considered to treat morbid obesity—each with their strengths and drawbacks. One of these techniques is gastric banding, which was largely used in the 1990s and early 2000s and showed satisfying initial results. Initially popularized by the American surgeon Lubomyr Kuzmak in 1986, the use of gastric banding grew substantially in the 1990s with the advent of laparoscopy [1]. Belgian surgeon Guy-Bernard Cadière then was the first to place a Lap-Band-type adjustable band in *perigastric* position [2]. The improvement of Forsell's technique involving the Swedish adjustable gastric band (SAGB) helped significantly to reduce the risk of band slippage by placing the band around the upper part of the stomach by the cardia (*pars flaccida* approach) [3]. However, given their relatively disappointing long-term results, adjustable gastric bands have progressively been replaced by gastric bypass and sleeve gastrectomy, now offered as primary surgery. Few studies have been published regarding the use of the min-gastric bypass (MGB) as a secondary procedure following failure or complications related to gastric bands [4, 5]. Yet, bariatric surgeons are more and more led to perform revisional surgery, considering the ever-increasing number of patients showing a gastric banding failure. The conversion of band to MGB is occupying a dominant position among the different techniques available. In this chapter, we will try to demonstrate the feasibility and effectiveness of converting a band to a MGB, and address some specific points regarding the MGB taken from our own experience.

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22.2 History of Bariatric Surgery Trends in France

22.2.1 Laparoscopic Adjustable Gastric Banding

Laparoscopic Adjustable Gastric Banding (LAGB) emerged as one of the most commonly performed bariatric procedures in the world. Between 2003 and 2008, France ranked third in numbers of bariatric procedures performed annually (n = 13,722), after the USA and Brazil [6]. This could be explained by a favorable policy context and unlimited access to bariatric surgery in France. As estimated in 2007, 87.3% of bariatric procedures performed in France were LAGB [7].

22.2.2 Sleeve Gastrectomy and Gastric Bypass

Since 2011, sleeve gastrectomy (SG) has become the most common bariatric procedure performed in France, while LAGB has progressively diminished until it became the least commonly used technique [8]. Czernichow et al. used the National Health Insurance database to evaluate the number of patients who underwent a bariatric procedure in France in 2013. A total of 41,648 bariatric procedures were recorded, 30.7% of which were gastric bypasses [8]. However, this database was unable to distinguish between Roux-en-Y gastric bypass (LRYGB) and MGB due to the lack of a specific code for this procedure. The current trend suggests that MGB represents half of the bypass procedures performed annually in France.

The number of bariatric procedures is also expected to increase as a growing number of patients will require a second or even a third procedure after weight regain or in a context of medical or surgical complications.

22.3 LAGB

22.3.1 Excess Weight Loss After LAGB: Disappointing Results

Revisional surgery after failed gastric banding is required in 20–60% of cases [9]. The most important reason for LAGB removal is weight loss failure and/or weight regain. Chevallier et al. published a prospective consecutive series in 2007 with short-term results at 2 years. The authors found that EWL was <50% at 1–2 years for the majority of the 1079 obese adults who had undergone a LAGB procedure [10]. In a meta-analysis by Buchwald et al. that included 1848 patients with LAGB (1995–2003), the EWL was 47.5% at >2 years [11]. This result was nearly identical to that of the current French SAGB study [12]. Suter et al. concluded that LAGB should no longer be considered as an operation of choice for obesity, with a 5-year failure rate of 40% (EWL < 50%) in their prospective cohort of 317 patients [13]. Better results seem to have been achieved by O'Brien et al. [14]. They described their long-term outcomes after LAGB in a single institution and showed good results with 47% EWL maintained up to 15 years. However, in this Australian prospective cohort of 3327 patients with LAGB, 46% of patients at 10 years and 76% at 15 years of follow-up underwent a surgical revision with replacement of the band.

22.3.2 High Incidence of Late Complications After LAGB

LAGB has a high incidence of complications requiring revisional surgery and/or band removal. However, the need for revision for gastric banding complications decreases as the technique evolves [14]. Band prolapse initially observed in a high incidence of cases (24%) (FDA Trial 2007) has fallen to 2–4% in more recent studies due to the pars flaccida approach [15]. Another common reason for LAGB removal is mega-esophagus and/or pouch dilatation that occur in almost 10% of cases [16, 17]. Pouch dilatation is usually associated with band slippage. The incidence of intragastric band migration is ~5% in recent literature [18–20]. Regarding functional troubles, almost one- third of patients have GERD and/or food intolerance after LAGB [18]. To these surgical complications, we must also add mechanical complications linked to the wear of the band. These complications, which occurred in 12% of patients in our experience, include band leaks and disconnection or malfunction of the band's port. Finally, Suter et al. stated that each additional year of follow-up added 3–4% of major complications leading to band removal [13]. The overall reoperation rate as a result of these complications ranges from 1.7% to as high as 66.7% in some studies [13–20].

22.4 Malabsorptive Procedures After Gastric Banding Failure: MGB or LRYGP?

22.4.1 Why Suggest Gastric Bypass?

Several revisional strategies have been suggested after gastric banding failure, but there is no consensus regarding the best surgical option [21]. Weight loss after revision of pure restrictive operations is significantly better than after revision of procedures with malabsorptive components [22]. Marin-Perez et al. compared the results of conversions of failed LAGB to either laparoscopic sleeve gastrectomy (SG) or LRYGB and found that for patients who had the band removed because of insufficient weight loss, the postoperative %EWL was superior after conversion to LRYGB [23].

22.4.2 MGB Vs. LRYGB

There are currently no studies that compare the results of MGB and LRYGB as revisional procedures after LAGB failure. Moreover, in the different series published, data regarding revisional MGB and primary procedures are confused. In a randomized controlled study comparing MGB and LRYGB at 2 years follow-up, Lee et al. concluded that MGB was comparable to LRYGB regarding EWL, co-morbidity resolution and quality of life [24]. The same authors, in a retrospective study, reported at 5 years a similar efficacy in excess weight loss (MGB 72.9 vs. RYGB 60.1%) [25]. Bruzzi et al. with MGB reported a %EBMI loss of >70% at 5 years which is consistent with the literature [26–30]. This trend of significant and sustained weight reduction was confirmed in the first meta-analysis published regarding MGB [31].

22.5 Revisional MGB (r-MGB)

22.5.1 Indications for Preoperative Evaluation

As suggested by several authors, a cut-off point of 50%EWL is considered as the threshold for success after a bariatric procedure. Revision to MGB (r-MGB) is proposed to the patients by the surgeon and multidisciplinary team after analyzing the main reason for revision. Weight loss failure after LAGB is usually explained by a progressive alimentary behavior modification with the switch to a hypercaloric liquid and semi-liquid diet ("sweet eaters"). Preoperative medical weight management (3–6 months) gives the patients an opportunity to learn the dietary and behavioral changes required for bariatric surgery. Understanding the specific nutritional demands of surgery is important, and a lack of understanding of these requirements or lack of willingness to change behavior in response to them, are considered contraindications for surgery [32]. On the contrary, reflux and other upper GI problems do not represent contraindication for r-MGB.

The band has to be completely emptied a few weeks before the surgical procedure. Upper gastrografin series are recommended to localize the band and to potentially diagnose complications such as band prolapse, pouch dilatation, mega-esophagus or hiatal hernia. As for primary MGB, upper endoscopy with systematic gastric biopsies is also required before r-MGB. In some cases, upper endoscopy allows intra-gastric migration diagnosis. Rarely, endoscopic band removal is feasible.

22.5.2 Surgery

The patient is placed in French position (supine with legs apart and arms in abduction), with the surgeon standing between his legs. The abdomen is insufflated with a Veress needle at Palmer's point to a pressure of 16 mmHg. When a one-stage procedure is performed, the port is removed at the beginning of the procedure. Some Lap-bands or latest generation SAGBs come with a case equipped with claws that facilitate parietal attachment but make them difficult to remove—sometimes causing fascia and muscular deterioration. In some cases, the band itself will be incorporated with the liver or even the spleen in the case of Forsell's initial technique, in which the clamping system is tilted towards it. The difficulty then lies in freeing the

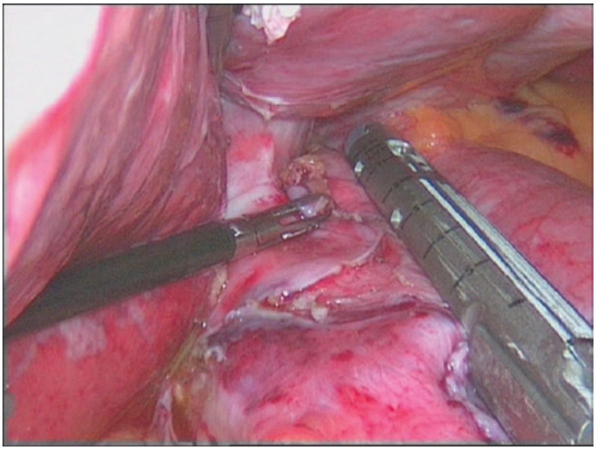

Fig. 22.1 Stapling while avoiding the band's shell and the rearranged fibrous tissue. (Figures 22.1–22.8 are reproduced with the permission of Dr. Antoine Soprani)

band without causing any traumatic lesion to the spleen. In most cases, however, the band is freed from adhesions with the liver and exposed by sectioning the gastro-gastric tunnel. The band is then removed. The fibrous band-shaped mark left by the band around the cardia can induce dysphagia, similar to when the band was in place, even after conversion to a MGB (in our experience, in 1.2% of cases). We think it is essential to cut this fibrous band or even to remove part of it during revisional surgery. The type of band (MidBand/LapBand/SAGB) does not predict such sort of complication. The fibrous capsule of the angle of His is then dissected in order to expose the left crus of the diaphragm.

Based on the judgment of the surgeon, a one stage or two-stage strategy is performed (i.e. proceeding directly with MGB or waiting for 3 months). During the creation of a long and narrow gastric tube, the stomach is transected with an EndoGia Tri-Staple, loaded with two "purple" and two or three "tan" cartridges, calibrated over a 36-F oro-gastric tube pressed along the lesser curvature. The last staple cartridge used can be "purple" or "black" depending on the presence of inflammatory tissue or the intention to use a buttressing material. Usually, bariatric surgeons recommend deviating the vertical gastric transection line towards the spleen to avoid inflammatory tissue and band fibrous capsule for the last staple-line (Fig. 22.1). We believe this to be a crucial point of the procedure, for two reasons:

1. Selecting the correct staple height for scar tissue does not completely eliminate the risk of leaks, but operating surgeons can take an active role in leak prevention by reducing bleeding and tissue ischemia [33]. We classified leaks after MGB based on their origin: from the gastric pouch (type 1) and from the gastrojejunal anastomosis (type 2). In MGB, the creation of a long and narrow gastric tube could increase the risk of staple disruption as seen in post-gastric sleeve leaks, especially during revisional procedures [34].
2. The deviation of the axis of the gastric tube transection towards the spleen in order to place staples in a safe area can promote the persistence of a posterior

fundus pouch, and theoretically lessen the efficacy of the r-MGB in terms of excess weight loss.

The bariatric surgeon must take these two parameters into account, in order to limit the risk of postoperative complications and create a gastric tube that is narrow enough to allow an acceptable dietary restriction following revisional surgery.

22.6 r-MGB: Weight Loss, Early and Late Postoperative Outcomes

22.6.1 EWL Results

Among bariatric procedures with malabsorptive components, revisional MGB is an effective method for patients showing inadequate weight loss after previous restrictive bariatric surgery [5]. Bruzzi et al. evaluated the outcomes of primary MGB and r-MGB performed for restrictive procedure failure (LAGB/SG/VBG) at 5 years after surgery, and did not find statistically significant differences between the two groups [35]. In the r-MGB group in particular, the mean %EBMIL was 66% at 5 years, comparing favorably with results reported in the literature for r-LRYGB [21, 36, 37].

22.6.2 A Safe Procedure (One-Step Or Two-Step Surgery)

In our 8-year (2005–2013) retrospective experience of over 2321 MGBs, overall postoperative morbidity after r-MGB (n = 875) was not different from primary MGB (p-MGB) (3.3 vs. 3.2%; p = 0.54). Complications included leaks r-MGB vs. p-MGB (16 vs. 19; p = 0.38), intra-abdominal bleeding (9 vs. 12; p = 0.65) and anastomotic stenosis. Among these patients, 700 underwent single stage removal of LAGB. Worni et al. used the Nationwide Inpatient Sample in the United States from 2005 to 2008 to compare short-term outcomes between primary RYGBP (n = 63,171) and revisional RYGBP performed concomitant with band removal (n = 3132). Patients who underwent a one-step r-RYGBP showed a higher rate of intra-operative complications (risk-adjusted OR: 2.3, p < 0.001) [38]. However, this study included heterogeneous centers with non-comparable bariatric surgery experience. Another study recently published used the ACS-NSQIP database for the time period between 2008 and 2014. Over these years, 64,866 patients had primary LRYGB and 1212 had one-step r-RYGBP, and no statistically significant differences were observed for the rate of postoperative mortality, sepsis and other postoperative complications between the two groups [39].

In our specialized center, one stage procedure r-MGB after gastric banding failure is safe and feasible, with acceptable complication rates comparable to primary

MGB. The average operative time was significantly longer for conversion procedures compared to p-MGB, but length of stay was comparable. As for r-LYGBP, r-MGB must be delayed in case of acute band slippage or gastric erosion [40].

22.7 Late Reoperation After r-MGB

22.7.1 High Incidence of Bile Reflux and Physiopathology

As for major late complications, in our single institution from 2005 to 2014, intractable bile reflux was significantly higher after r-MGB ($n = 879$) than after p-MGB ($n = 1440$) (2.8 vs. 0.4%; $p < 0.001$). The incidence of malnutrition requiring reversal procedures after r-MGB was comparable to p-MGB in our cohort (0.8 vs. 0.9%). According to the results of Bruzzi et al., patients in the r-MGB group had a significantly lower overall GIQLI score than patients in the p-MGB group [26]. LAGB before MGB seems to worsen the upper GI symptoms and probably promotes GE reflux disease. Facchiano et al. demonstrated that severe esophageal dyskinesia (pseudo-achalasia), although a rare complication, persists even after band removal [41]. Burton et al. explained the dyskinesia physiopathology with the increased frequency of esophageal contraction related to the level of band filling [42]. The repetitive contraction (secondary peristaltis) likely reflects some kind of esophageal reaction in an attempt to overcome the obstruction created by the LAGB. These repetitive contractions may induce esophageal shortening and lead to trans-hiatal enlargement [43–45]. This enlargement could lead to a progressive weakening of the esophageal musculature and the lower esophageal sphincter [46]. These non- specific upper symptoms appear to be reversible in most of cases [45, 46], but our findings attest that in a few cases, anatomic disruption of the esophagogastric junction promotes bile reflux after r-MGB.

22.7.2 Surgical Management of Intractable Bile Reflux: Roux-en-Y Conversion

Surgical management of intractable bile reflux after r-MGB is the Roux-en-Y conversion. In our cohort, patients were re-operated on after a mean delay of 22 months. The operative technique consisted in carrying out the second step of Lonroth LRYGB by preserving the gastrojejunal anastomosis (GJA) and the 2-m biliary limb (Figs. 22.2, 22.3, and 22.4). A 90-cm-long alimentary limb was created in order to limit the risk of malnutrition after conversion.

Some bariatric teams advocate the resection of the GJA and the restoration of the digestive tract with a linear side-to-side entero-entero-anastomosis. They perform a regular LRYGB by successively transecting the gastric pouch higher and by creating a 1.5 m long alimentary limb. The former surgical technique of conversion is a safe, easy to perform and effective procedure to cure bile reflux (Fig. 22.5). The latter has to be performed in a highly specialized institution.

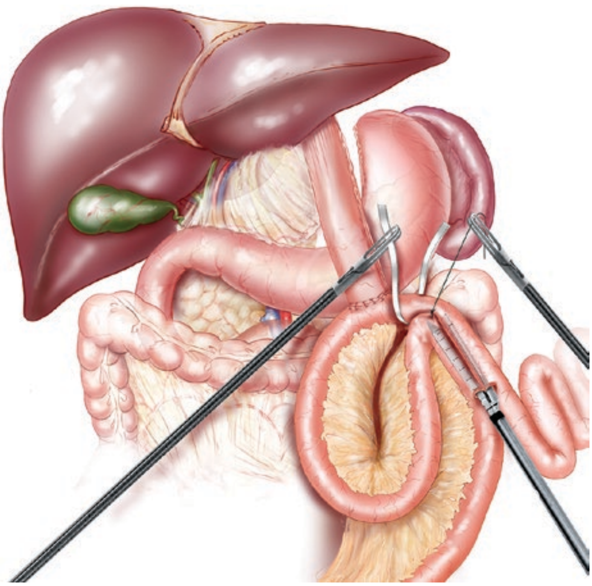

Fig. 22.2 Tying the afferent loop by the gastro-jejunal anastomosis. Creating the food loop (90 cm) from the efferent loop, then creating the foot of the Y-loop

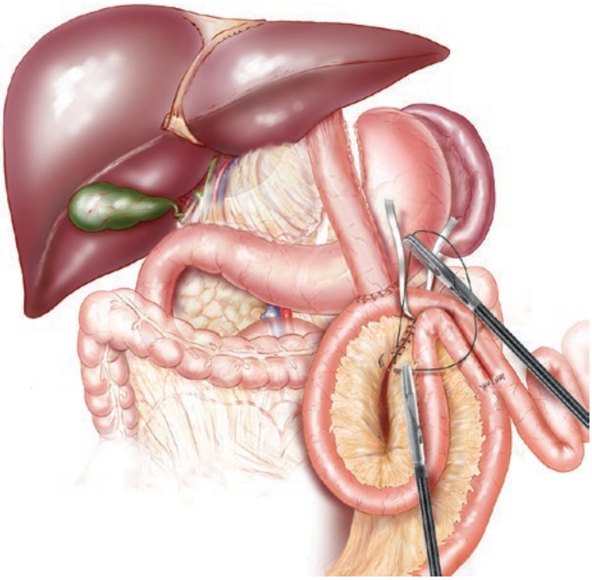

Fig. 22.3 Closing the mesenteric breach

22.8 Preventive Surgery to Avoid Bile Reflux After r-MGB

22.8.1 One Anastomosis Gastric Bypass

In 2004, Carbajo et al. described the One Anastomosis Gastric Bypass (OAGB) as a modification of the original MGB, to reduce the exposure of the gastric and esophageal mucosa to bilopancreatic secretions [47]. This procedure consists of

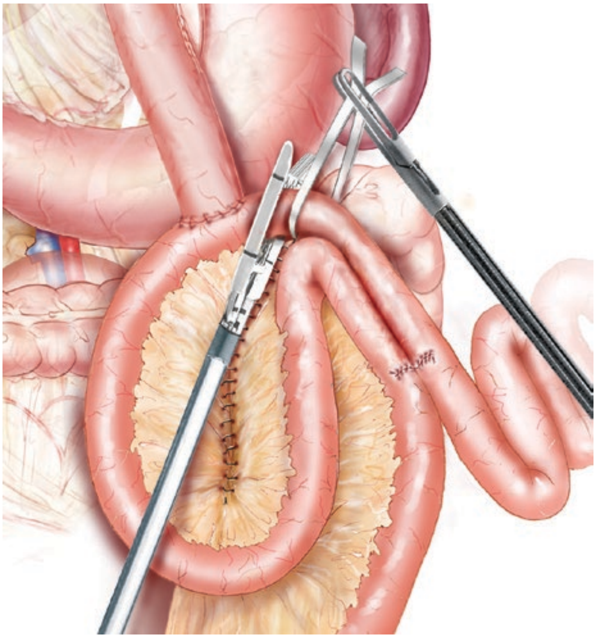

Fig. 22.4 Separating the two anastomoses

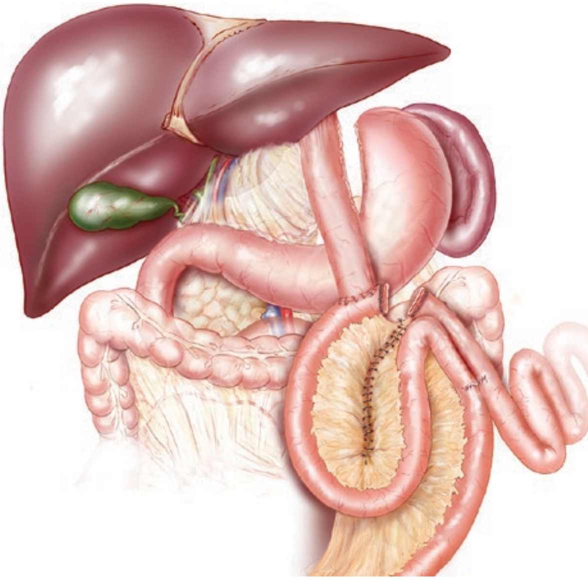

Fig. 22.5 Final aspect of the conversion from MGB to RYGB

creating a narrow latero-lateral gastro-jejunal anastomosis and fixing the jejunal loop some centimeters up to the anastomosis. In their last series [28], 27 patients had undergone revisional OAGB and no cases of bile reflux had occurred.

22.8.2 Nissen-Mini Bypass: Feasibility and Preliminary Results

High-resolution manometry (HRM) allows assessment of esophageal clearance [43], and could provide guidance for the choice between r-MGB and r-OAGB. However, this diagnostic procedure is not suggested routinely before revisional surgery. Sometimes, hiatal hernias are documented preoperatively by upper GI series and/or upper gastroscopy, challenging r-MBG indication.

We collected a series of 16 patients who underwent laparoscopic Nissen/MGB for large sliding hiatal hernia or paraesophageal hernia between 2013 and 2016. The surgery consisted of a standard MGB combined with crural repair (Figs. 22.6 and 22.7) and Nissen fundoplication using the remnant stomach as an anti reflux valve (Fig. 22.8). During this period, ten patients underwent Nissen/MGB after LAGB (seven two-stage and three one-stage procedures). None of these patients developed postoperative symptomatic bile reflux. This suggests the Nissen-MGB could be

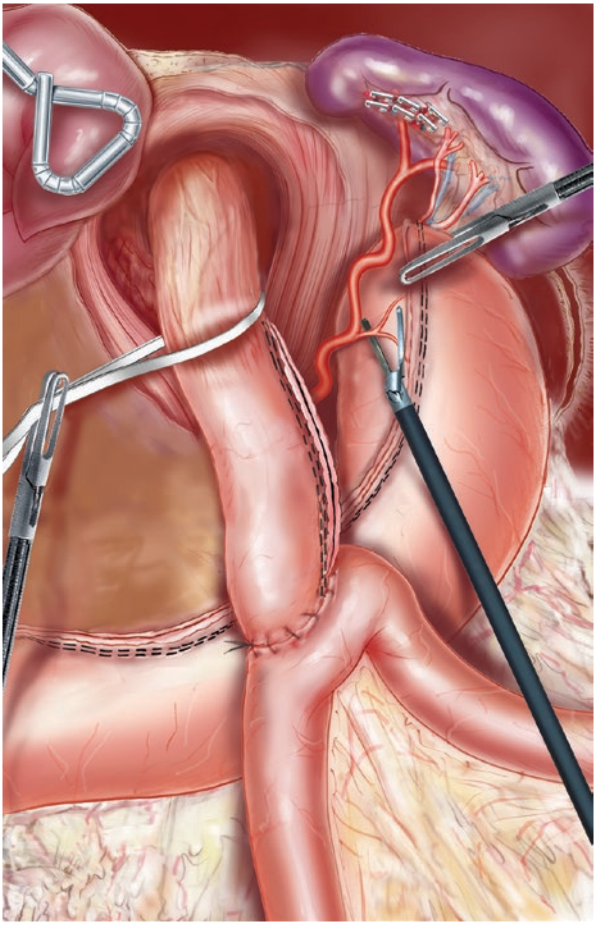

Fig. 22.6 Reduction of the hiatal hernia and resection of the hernial bag followed by the creation of a MGB. Liberation of the greater tuberosity of the excluded stomach by sectioning the remaining vessels and gastric pedicle

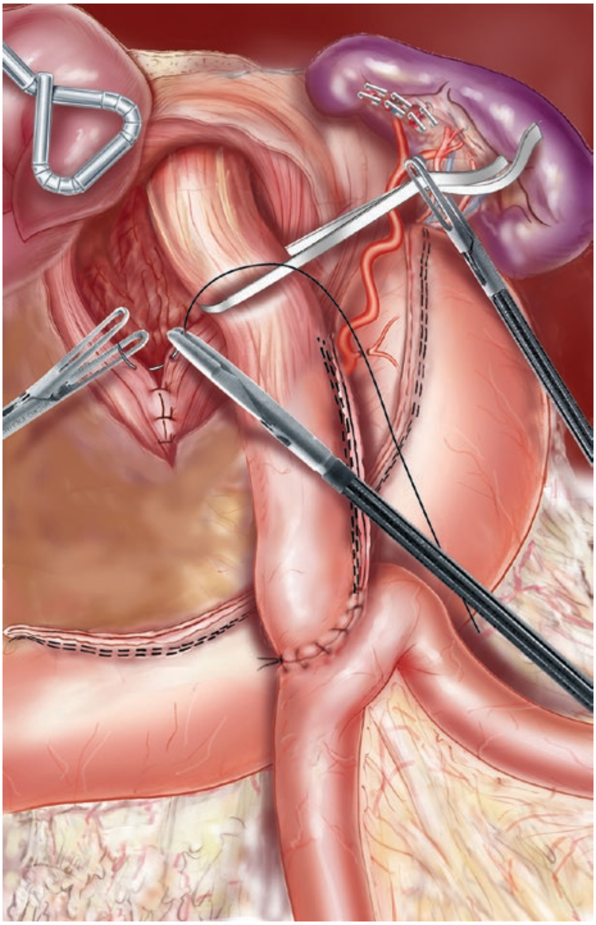

Fig. 22.7 Crural repair behind the esophagus

envisioned as an alternative to the standard MGB in order to better control bile reflux over time, in the presence of an anatomic esophagocardial disruption due to high pressure secondary to gastric banding.

Gastric banding as a way of treating morbid obesity is a procedure which is less and less carried out in France. In our experience, the risk of excess weight loss failure or weight regain is >80% at 10 years. The main reasons for this failure can be a progressive change in alimentary behavior, an intolerance to tightening leading to reflux, or complications with the band itself. To this must be added the numerous additional procedures due to the wear and tear or mechanical complications of the band. The MGB can be suggested as an alternative. This implies preparing the patient both at psychological and dietetic levels to increase the chances of success of this second bariatric surgery. In a great majority of cases, the removal of the band and the MGB procedure can be done at the same time without increasing the risk of postoperative complications, although this significantly increases surgical time. To this day, there is no contraindication to using the MGB as revisional surgery, and the

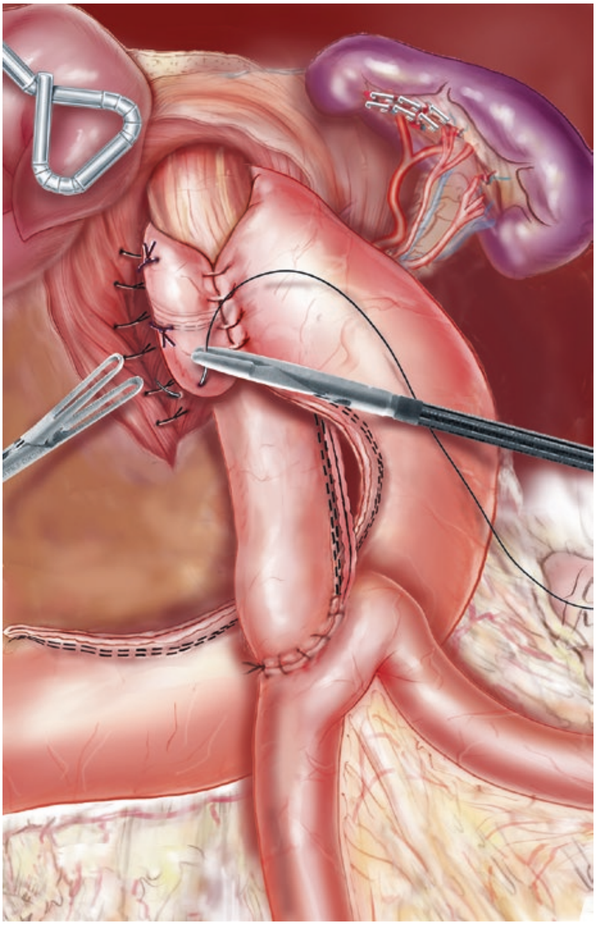

Fig. 22.8 Creation of an anti-reflux valve around the esophagus following Nissen's technique (360°)

results in terms of excess weight loss are comparable to the RYGB. The residual post-gastric band pseudo-achalasia could alter the functional outcome and the quality of life of patients with a MGB. Additional preoperative investigations which are not suggested routinely (esophageal manometry) would be necessary to identify patients at risk and decide on a better-suited procedure (OAGB or Nissen/MGB).

Conclusion

Laparoscopic gastric banding was a widely performed restrictive bariatric operation. However, weight loss failure frequently ensued, and gastric, esophageal, band, reflux, hiatal hernia, and maladaptive eating complications often occurred. This has led to revisions to SG and LRYGB, which occasionally required removal of the band as a prior separate operation, according to the surgeon's judgment. Removal of fibrous capsule was frequently indicated at the reoperation. For GE reflux, repair of hiatal hernia and Nissen fundoplication was occasionally needed. Revision to a MGB has been a relatively simple and successful method to obtain malabsorptive weight loss. With reflux, the one-anastomosis gastric bypass of Carbajo has been highly successful.

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23 Comparison of Results of Mini-Gastric Bypass to Sleeve Gastrectomy and Roux-en-Y Gastric Bypass. Technique of Conversion of Failed Sleeve Gastrectomy to MGB

Gurvinder S. Jammu

23.1 Introduction

Obesity is a leading preventable cause of death worldwide, and is a major public health problem in the twenty-first century [1]. Bariatric surgery is the best treatment for severe obesity, because it achieves better short- and long-term results, compared to medical management and behavioral approaches [2]. There is a continuous quest to find the most effective and safe bariatric procedures.

The mini-gastric bypass (MGB) is a mildly restrictive but importantly a malabsorptive operation, started in 1997 by Robert Rutledge [3]. It consists of a lesser curvature gastric tube from below the crow's foot, dividing proximally, and avoids dissection of the cardia. The long pouch has a wide anastomosis to an antecolic loop of jejunum about 200 cm (variable) distal to Treitz' ligament. The remainder of the stomach is left *in situ*. The anastomosis to the jejunal loop can be moved proximally or distally, depending on the need for weight loss (Fig. 23.1).

Laparoscopic sleeve gastrectomy (SG) is a restrictive and irreversible procedure, and consists of a lesser curvature sleeve, with resection of the greater curvature portion of the stomach down to the antrum (Fig. 23.2).

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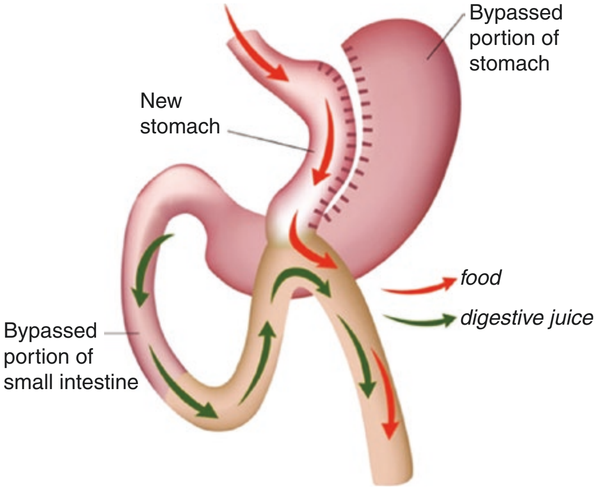

Fig. 23.1 MGB

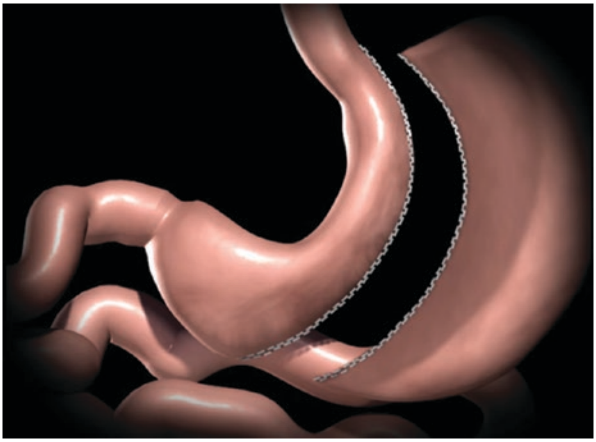

Fig. 23.2 SG

Roux-en-Y gastric bypass (RYGB) consists of a small gastric pouch anastomosed to a Roux-limb constructed from the distal end of divided jejunum. The proximal end of the divided jejunum is anastomosed to jejunum distal to the Roux-loop (Fig. 23.3).

Fig. 23.3 RYGB

23.2 Technical Aspects of Converting a SG to a MGB

(a) ***For a Non-Dilated Pouch:*** The sleeve is transected 2–4 cm proximal to pylorus and distal to the crow's foot, with a green 60-mm or purple 60-mm cartridge, followed by 200 cm (variable) of bilopancreatic bypass with an antecoic wide gastro-jejunostomy (GJ) of ~45 mm diameter (Fig. 23.4).

(b) ***For a Dilated Gastric Sleeve:*** A dilated sleeve should be refashioned, so as to make a long narrow gastric pouch; the dilated pouch is trimmed. Sometimes the pouch size is normal except for the fundal part; in that case, fundectomy may be done. Careful and meticulous dissection in a revision operation requires patience and expertise. The rest of the procedure is done as for the non-dilated pouch.

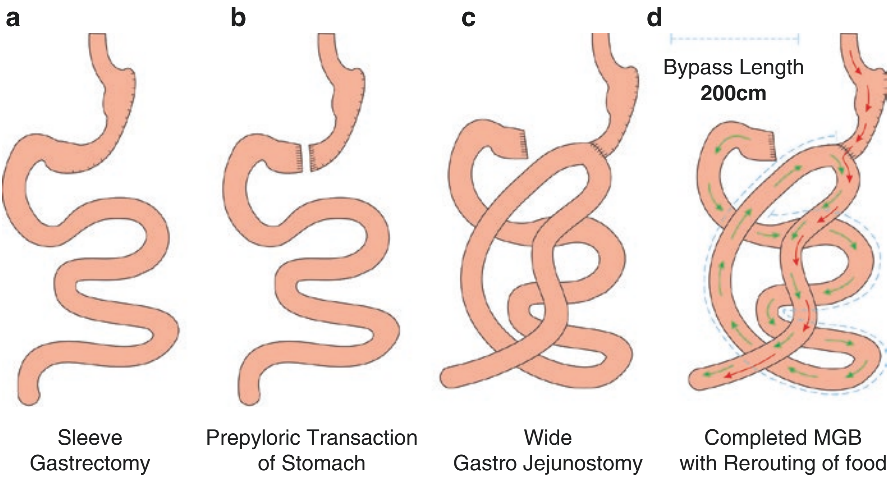

Fig. 23.4 Conversion of SG to MGB. (**a**) Sleeve gastrectomy. (**b**) Prepyloric transection of stomach. (**c**) Wide gastro-jejunostomy. (**d**) Completed MGB showing rerouting of food

23.3 Comparative Study of SG, RYGB and MGB

23.3.1 Data Collection

We performed an analysis of our prospectively-collected database of 473 MGBs, 339 SGs and 295 RYGBs from a single center (Jammu Hospital) from Jan. 2007 to Mar. 2014 [4]. The patients were categorized by age, gender, preoperative BMI and body weight.

A data collection system was used to monitor bariatric-specific longitudinal data on all patients. Data were analyzed for complications and benefits. For complications, data were further divided into life-threatening and non-life-threatening complications, and benefits were observed for %EWL and resolution of co-morbidities. For %EWL and resolution of co-morbidities, patients with mean follow-up of 53.5 months (maximum 87 and minimum 20 months) made up the patient material.

The data included immediate postoperative outcomes at 30 days, 3 months, 6 months, 1 year, and yearly thereafter.

23.4 Statistical Analyses

Analyses were performed using Chi-square tests for categorical data and t-test for continuous data. A p-value <0.05 was considered significant.

23.5 Results

The trend of each year's follow-up was: first year (94.7%), second year (90.8%), third year (81.1%), fourth year (75.1%), fifth year (72.2%), sixth year (68.9%) and seventh year 52.0%. For complications, the data comprised all 1107 patients. It included even those cases whose follow-up was <1 year; we assume that any major issue is always reported to the primary surgeon. The three operative groups were demographically comparable on the bases on age, sex and weight.

23.5.1 SG Cohort

The data included 339 (30.6%) SG cases of which 154 (45.4%) were female and 185 (54.6%) were male, with mean age 23 and mean BMI 35. The pre-existing co-morbidities in the SG group were T2D 83 (24.5%), hypertension 90 (26.5%) and dyslipidemia 79 (23.3%).

23.5.2 RYGB Cohort

There were 295 (26.5%) RYGB patients of which 210 (71.2%) were female and 85 (28.8%) were male, with mean age 38 and mean BMI 42.5. Pre-existing co-morbidities in the RYGB group were T2D 96 (32.5%), hypertension 113 (38.3%) and dyslipidemia 107 (36.3%).

23.5.3 MGB Cohort

There were 473 MGB cases of which 333 (70.4%) were female and 140 (29.6%) were male, with mean age 46.5 and mean BMI 56.5 (range 40–73). Pre-existing co-morbidities in the MGB group were T2D 359 (75.9%), hypertension 325 (68.7%) and dyslipidemia 287 (60.7%).

For %EWL and resolution of co-morbidities, the data comprised 782 patients of which 563 (72.0%) were female and 219 (28.0%) male. Complete follow-up information was achieved in 407 of the 782 patients (52.0%), and the mean duration of follow-up was 53.5 months (87 months maximum and 20 minimum). The 375 patients with incomplete follow-up were excluded from this study. This included 297 patients with follow-up <1 year. A total of 78 patients could not be contacted despite multiple attempts, because of change of contact numbers and addresses.

The 407 patients with complete data (52.0%) consisted of 225 (55.2%) females and 182 (44.8%) males. The SG group had 97 patients, of which 23 (23.7%) had T2D, 30 (30.9%) hypertension and 21 (21.6%) dyslipidemia. The RYGB group consisted of 143 cases, with pre-existing co-morbidities T2D 33 (23.1%), hypertension 47 (32.9%) and dyslipidemia 50 (35.0%). The MGB group with 167 patients

Table 23.1 Duration of operation (minutes) [4]

Procedure	LSG	RYGB	MGB	LSG to MGB
Duration (Mean)	60.0	160.5	57.5	75.0
Range	45–75	123–198	42–75	60–90

had as pre-existing co-morbidities T2D 62 (37.1%), hypertension 48 (28.7%) and dyslipidemia 45 (26.9%).

Of the SG patients, 11 were revised to a MGB due to weight regain and incomplete resolution of co-morbidities. In these 11 cases, one patient (9.0%) has HbA1c 8.5% at 3 years after the revision and %EWL <50%.

The mean time taken to perform SG was 60.0 min, RYGB 160.5 min, MGB 57.5 min, and 75 min for converting a SG to a MGB (Table 23.1).

23.6 Post-operative Complications and Changes

The incidence of leak was highest in SG (1.5%), followed by RYGB (0.3%), and there was no leak in the MGB group (Table 23.2). The incidence of hypoalbuminemia in MGB was 13.1%, of which 18 patients (3.8%) had severe hypoalbuminemia (<2.5 g/dL) and 44 cases (9.3%) had mild hypoalbuminemia (3.0–2.5 g/dL). Hypoalbuminemia occurred in 2.0% in RYGB and zero in SG (Table 23.2). The incidence of anemia was highest in MGB (4.9%), followed by RYGB (4.8%) and SG (3.5%) (Table 23.2). The incidence of pulmonary embolism and DVT was zero in MGB, 0.3% in LSG, and 0.3% in RYGB.

In our series, GERD was maximally seen after LSG (9.4%), followed by RYGB (1.7%), and lowest in MGB (0.6%) (Table 23.2). Bile reflux was seen in 0.4% of MGB patients and was nil in SG and RYGB. One patient (0.4%) after SG had persistent vomiting which progressed to Wernicke's encephalopathy. One patient (0.3%) after RYGB had marginal ulceration within 30 days of surgery; this patient was a smoker and improved with conservative methods. Three patients (0.6%) after MGB had a marginal ulcer, which occurred at the GJ, and all three responded to conservative management—PPI, yoghurt, and cessation of cigarettes, NSAIDs and alcohol. One patient (0.3%) after RYGB presented with persistent vomiting 1 year after surgery; upper GI endoscopy revealed stenosis at the GJ which responded to endoscopic dilation. There was no incidence of internal hernia after SG and MGB, but it occurred in 2.0% after RYGB.

There was no case of dumping found with SG, but it was reported in 2.7–5.9% after RYGB and MGB respectively (Table 23.2).

No mortality occurred in the MGB series, but 2.1% occurred in SG and 0.3% in RYGB (Table 23.2).

Regarding the target weight, less %EWL was maximum after SG (13.3%), followed by RYGB (6.4%) and nil after MGB. In our series, all MGB patients had EWL >90%, while EWL after RYGB and SG were 72% and 53% respectively. The incidence of weight regain was seen in two procedures—14.2% after SG and 8.5% after RYGB, but nil after MGB (Table 23.2).

Table 23.2 Comparative complications between procedures [4]

Procedure	LSG	RYGB	MGB
Number performed	339	295	473
Number of leaks	5	1	0
Hypoalbuminemia mild (3.5–2.5 g/dL)	0	6	44
Hypoalbuminemia severe (<2.5 g/dL)	0	0	18
Anemia	12	14	23
GERD	32	5	3
Internal hernia	0	6	0
Dumping	0	8	28
Mortality	7	1	0
Less of excess weight loss (%EWL <50%)	45	19	0
Weight regain	48	25	0

Table 23.3 Resolution of co-morbitities by operation [4]

Cases	LSG	RYGB	MGB
Total no. of T2D patients	23	33	62
No. of patients achieving remission	13	25	59
Percentage	56.5%	75.8%	95.1%
Total no. of hypertensive patients	30	47	48
No. of patients achieving remission	14	34	41
Percentage	46.7%	72.3%	85.4%
Total no. of patients with dyslipidemia	21	50	45
No. of patients achieving remission	11	37	42
Percentage	52.4%	74.0%	93.3%
Only obese (without co-morbidities)	23	13	12
No. of patients achieving remission	14	7	12
Percentage	60.9%	53.8%	100.0%

No case of external bleeding occurred in the SG patients, but external bleeding occurred with RYGB in 0.3% and with MGB in 0.6%. There was no case of internal bleeding with SG, but it occurred in 0.3% with RYGB and 0.4% with MGB. There was no incidence of respiratory failure in RYGB and MGB, but 0.4% with SG.

The reported cases of nausea were highest in SG, followed by RYGB and MGB—8.3%, 7.1% and 4.7% respectively. In this series, constipation was seen after all three operations—2.6%, 2.7% and 1.1% in SG, RYGB and MGB respectively. Hair loss was a common problem after all three procedures—highest after MGB (10.1%), followed by RYGB (8.5%) and SG (8.0%). Occurrence of gallstones has been highest in the MGB group (8.3%), followed by RYGB (7.1%) and least after LSG (4.1%).

In this series, the %EWL was maximal after MGB, followed by RYGB and LSG—92.2%, 72.3% and 53.6% respectively (significant at $p < 0.05$). For resolution of co-morbidities, dyslipidemia, hypertension and T2D were considered (Table 23.3). After SG, 55.8% of patients were rid of their elevated lipid levels, after RYGB 75.0% of patients had normal lipid levels, and after MGB 93.4% of

Table 23.4 Revision of SG to MGB: result after 1 year

No. of patients converted	Conversion causes	Results
11	Weight regain	8 patient %EWL >75% 3 patient %EWL >50%
1	Increased HbA1c	<6

dyslipidemia was cured. With pre-existing hypertension, again MGB resolved the most cases. In resolution of T2D, MGB showed spectacular results—94.4% of patients stopped their regular T2D medications a few weeks after MGB, while after RYGB, 76.2% and after LSG, 59.4% of diabetic patients had resolution of T2D. This result was significant ($p < 0.05$).

After revision of failed SG to MGB, 72.2% (8) patients achieved %EWL >75% and 27.2% (3) patients achieved %EWL >50% after 12 months following revision. Elevated HbA1c became <6 in one patient (9%) after 6 months of revision surgery (Table 23.4).

23.7 Discussion

SG and RYGB are currently the most commonly performed bariatric operations, but MGB is increasing [5–7], especially in India [8].

The incidence of leak in our series was highest in SG, similar to the experience of others [9]. The higher incidence of leaks and reflux in SG is due to high intraluminal pressure [10, 11], which can make the stomach give way at its weakest point, i.e. near the EG junction. Leaks may sometimes occur immediately, i.e. within 2–3 days of surgery or late when the patient is already discharged. Leaks increase the hospital stay and mortality [12, 13].

In the MGB patients, there were no leaks, due to the long and wide gastric tube with a wide GJ (~45 mm), leading to a low intraluminal pressure and low incidence of GE reflux [11]. These results match those of Kular et al. who also found an extremely low incidence of leaks in their MGB patients [14]. RYGB was called the "gold-standard" technique, but MGB is an attractive alternative, with shorter operating time, easier performance, and less complications and mortality. Another advantage is the single anastomosis in good view, reducing the possibility of leaks [14, 15].

However, hypoalbuminemia has occasionally developed, especially after MGB. Mild hypoalbuminemia (serum albumin 3.5–2.5 g/dL) may have symptoms of fatigue and weakness. Severe hypoalbuminemia (<2.5 g/dL) may have ankle edema, with or without ascites. An increased incidence of mild hypoalbuminemia was seen in those patients with MGB where length of the bypass was >230 cm [4]. In all cases of MGB where the length of bypass was 200 cm, no hypoalbuminemia resulted except in one patient with diabetic nephropathy. Severe hypoalbuminemia was maximal in the MGB group with longer bypasses, i.e. >250 cm (done in our early experience, often for super-obesity), which caused increased protein malabsorption [4]. With RYGB, Faintuch et al. and Skroubis et al. found that longer bypasses led to more macronutrient deficiency [16, 17]. When length of bypass in

MGB is planned for >250 cm, we recommend that the whole length of the small intestine be measured, making sure that the length of the common channel is at least 300 cm.

The incidence of hypoalbuminemia was more frequent in vegetarians, diabetic nephropathy, and alcoholic and non-alcoholic liver disease. Severe hypoalbuminemia was treated by reversal of the MGB: the GJ was taken down with a single 60-mm Echelon Green and a gastro-gastric anastomosis was performed. During the reversal in two cases of MGB, the entire length of small intestine was measured and found to be 7 m and 6.8 m; it is proposed that with this length of small intestine a > 200 cm bypass be avoided. Our patients who required reversal of MGB (3.2%) are the ones with persistent hypoalbuminemia (<2.5 g/dL), with ankle edema, and who were non-responsive to a conservative approach. The length of the bypasses in these two cases had been 270–300 cm.

Hypoalbuminemia usually responded to good nutritional supplementation in the form of high protein diet and Creon® (pancreolipase). Long bypasses should be avoided with liver disease, length of small intestine <8 m, and in nephropathy patients. As of now, most of our MGB patients undergo a 200 cm bypass, except in super-obese with length of small intestine >8 m, who may undergo a bypass up to 250 cm. Vegetarians are protected by yoghurt, milk, tofu-soy, legumes (lentils, beans, chick peas, peanuts, etc.), barley, buckwheat, quinoa, brown rice, and if necessary a liquid protein (whey).

All patients undergoing the bariatric operations followed the same protocol of DVT prophylaxis [18]. This consisted of 40 units (60 units for super-obese) of low molecular weight heparin (LMWH) subcutaneously 8 h before surgery, then 40 units (60 units for super obese) of LMWH 8 h after surgery [19], and then once daily for 15 days. All patients were subjected to intermittent pneumatic leg compression devices until they were completely mobile. Early ambulation was encouraged. Then, patients were given elastic stockings to be worn for 2 months.

Occurrence of anemia after RYGB and MGB may result from malabsorption. Maximum absorption of iron occurs in duodenum which is bypassed in MGB and RYGB. A higher incidence of anemia was seen in menstruating women [20]. Nutritional deficiencies can be prevented by surveillance by the multidisciplinary team [21]. Oral iron supplementation with Proferrin® (iron heme peptide, which is intestinally absorbed) rarely fails, but if it does, IV iron therapy may be necessary [22, 23]. Blood transfusion is rarely required [24]. In our series [4], blood transfusion was required in one RYGB patient and three MGB patients.

The increased incidence of GERD in SG in our series is attributed to the high intragastric pressure [25] and slow exit of food through the pylorus [26]. Cases of hiatus hernia in LSG require crural repair to prevent GERD [27].

GERD was rare after MGB because of the long wide gastric tube and wide GJ [11]. If bile GE reflux does occur (usually transient) after MGB and does not respond to conservative management, there is the option for a Braun side-to-side jejuno-jejunostomy, although this has never been required at our center.

Wernicke's encephalopathy has been reported after SG [28] and RYGB [29]. Our one case (after SG) required hospitalization with parenteral nutrition and immediate I.V. replacement of vitamin B_1.

Of the four casesof marginal ulcer in our audit, one was a smoker and three were non-smokers. Marginal ulcer was confirmed endoscopically where erythema was seen at the anastomotic site [30]. These patients responded to I.V. cefotaxime, tinidazole and pantoprazole therapy. This I.V. therapy was stopped after 5 days, and proton pump inhibitor was given orally for 6 months.

Internal hernia is one of the many complications rep0rted after RYGB by Higa et al. [31]. Although we had closed the mesenteric defects, this complication after RYGB resulted in persistent abdominal pain. These patients were diagnosed by CT scan, and were treated by re-laparoscopy, the hernia reduced, and the defects closed.

The increased incidence of dumping in MGB results from bypass of jejunum so that simple carbohydrate foods enter the small intestine early. The wide GJ also leads to early gastric emptying. In MGB, dumping causes an awareness for volume-eating patients. We experienced no intractable hypoglycemia. Severe dumping if ever a problem is in MGB can easily have the length of bypass shortened, whereas in RYGB shortening of the bypass is a complex procedure [32]. However, no shortening has been done in our MGB patients, because the dumping could be managed through conservative methods.

The low incidence of mortality in MGB may be attributed to the short, technically easy operation, as also found by Kular et al. [14]. The less anesthesia time leads to early ambulation. The low mortality in MGB is also attributed to the low incidence of leaks and low incidence of internal hernia [33]. Although the incidence of hypoalbuminemia and anemia was high in MGB compared to SG and RYGB, both were manageable. With MGB, if conservative methods for nutritional deficiency fail, reversal is easy [32, 34]. The incidence of mortality 2.1% (n = 7) in SG consisted of three leaks (all the leaks occurred after discharge within 30 days), one pulmonary embolism after 30 days, one death due to hepatic encephalopathy, one death due to choking, and one patient died after 7 months of surgery with no identifiable cause. Although pulmonary embolism can occur after the other two procedures, in this audit it was seen only in the SG group.

The less %EWL in SG and RYGB relates to the fact that both are mainly restrictive, although RYGB is a combination but with less malabsorption. After bariatric surgery, one of the main concerns is weight regain. In our study, the increased regain in SG is attributed to dilatation of the sleeve after some time, leading to more intake of food [35]. In the RYGB, the gastric pouch and outlet can eventually dilate, leading to increasing food intake and late weight regain [36]. In our MGB group, the EWL was >75% after 6 years, and similar results has been reported by others [16].

We believe that maximal resolution of T2D in the MGB group was due to the combined effect of some restriction of intake, significant rapid transit (incretin effect) and more fat malabsorption, compared to SG [37–42]. MGB is proving to be a boon for India, because India is only second to China in the population with T2D [43, 44].

Problems with the MGB are prevented by: (1) division to left of the angle of His, (2) constructing the long gastric tube adequately wide, (3) making the stoma of the GJ wide, and (4) altering the length of the bypass cautiously according to nutritional implications, age and BMI. MGB can be revised easily if ever required, whereas SG or RYGB are not easily revisable or reversible, which, when advantages and disadvantages are considered, makes MGB our favored operation.

Conclusion

In our series, the mortality was highest with SG, followed by RYGB, and was zero with MGB. Leaks were highest in SG, followed by RYGB and none in MGB. Persistent vomiting occurred in SG only. Weight regain was maximal in SG, followed by RYGB, and zero in MGB. Hypoalbuminemia was minimal after SG and maximal after MGB, but now does not occur with the usual MGB bypass being ≤200 cm. Resolution of dyslipidemia, T2D and hypertension was greatest after MGB, as was %EWL. MGB was technically easier to perform and in less time compared to SG and RYGB.

Conversion of SG to MGB is feasible, safe and effective, and results in significant additional weight loss. We believe that MGB is the operation of choice for morbidly obese patients who are compliant in taking calcium and iron supplements. SG may be performed in evaluated non-compliant patients who may accept weight regain. RYGB and MGB both act via the principle of restriction and malabsorption, but MGB superseded RYGB in its simpler technique, efficacy, reversibility and revisibility.

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24 Anti-Reflux One-Anastomosis Gastric Bypass (OAGB)—(Spanish BAGUA): Step-By-Step Technique, Rationale and Bowel Lengths

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Abbreviations

BMI	Body mass index
BP	Biliopancreatic
CCh	Common Channel
EGJ	Esophago-gastric junction
FU	Follow-up
GERD	Gastroesophageal reflux disease
MGB	Mini-gastric bypass
OAGB	One-anastomosis gastric bypass
RLQ	Right Lower Quadrant
RYGB	Roux-en-Y gastric bypass
SB	Small bowel
ST	Surgical Table
WL	Weight loss

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24.1 Introduction

The enormous contributions made by Professor Mervyn Deitel in the fields of bariatric and metabolic surgery are unquestionable. During the last 15 years, his efforts have been crucial for the dissemination and international recognition initially of the Mini-Gastric Bypass (MGB), and later, of the One Anastomosis Gastric Bypass (OAGB -*BAGUA in Spanish*). His dedication and commitment have led to the progressive appreciation and acceptance of these operations, which are becoming mainstream in the bariatric and metabolic surgery repertoire. With an immeasurable gratitude we are deeply indebted and proud for his invitation to participate and expose our ideas and arguments, in order to contribute to the scientific development of this book which arose under Professor Deitel's thoughtful initiative.

OAGB started its development in 2002 by Dr. M. Carbajo at the *Center of Excellence for the Study and Treatment of Obesity and Diabetes* in Valladolid (Spain); the operation emerged as a modification of the original technique that Dr. R. Rutledge proposed in 1997 and published for the first time in 2001 under the name MGB [1]. Essentially, the philosophical concept of both procedures is similar, and it is to avoid the alimentary (Roux) limb and two anastomoses (characteristic of the Roux-en-Y Gastric Bypass (RYGB)) by performing only one (loop) anastomosis; differentiation from the old Mason's loop [2] is based primarily on the long, vertically oriented gastric pouch. Moreover, OAGB has progressively introduced a series of modifications which have turned the procedure into a technique with differentiated characteristics of its own and whose initial results were published in 2005 [3].

Those early years of standardization and dissemination of the technique were characterized by great skepticism and the same critical hardness initially launched against the MGB by the international bariatric community. Instead of backing down, this led us to be persistent and tenacious, with the conviction that OAGB was providing excellent outcomes for our patients, and that our critics lacked scientific arguments; in this manner, we were able to witness the progressive acceptance of the procedure and the incorporation of an increasing number of surgeons performing it [4, 5]. As others, we had experienced in our bariatric practice with RYGB, a high percentage of perioperative complications, as well as controversial and nebulous outcomes, especially in the medium- and long-term follow-up (FU). These observations were later confirmed in the literature [6], and gave us increasing confidence that we were on the right track in spite of misunderstandings, unfounded criticisms and constant restraints to the scientific divulgation of OAGB.

The progressive experience acquired and recent publication of long-term outcomes have validated our technique [7]. Moreover, in 2015 a transcendental event and qualitative leap occurred for those of us who have stood up and supported this valuable alternative in bariatric and metabolic surgery: under the direction of Professor Deitel, during the IFSO World Congress in Vienna, we were able to constitute and establish the *"MGB-OAGB International Club"* [8] as an independent organization that will drive and lead the two techniques addressed thoroughly in this book into the future. The Consensus Conferences held in London—2016 [9] and Naples—2017 [10], and the forthcoming ones in Valladolid (2018) and Berlin (2019), represent important steps in the consolidation and internationalization of these operations.

24.2 Preoperative Preparation

For years we have advocated that all patients who will undergo obesity surgery through OAGB must be submitted not only to the usual clinical, biochemical and radiological tests, but also to a protocol of moderate physical activity and preoperative weight loss (WL), ranging from 10% to 20% of their excess body weight (according to ideal weight, based on the Metropolitan Life Insurance Company 1983 height/weight Tables [11]). The main objectives are to reduce cardiovascular risk, as well as to facilitate anesthetic intubation, minimize anesthetic risks, reduce hepatic fat content, improve comorbidities, minimize blood loss, reduce operative time and hasten a 24-hour length of stay; these benefits were demonstrated in a prospective randomized study we conducted with this aim [12].

Preoperative preparation is an essential aspect that has a great influence on patient outcomes and should be performed by a multidisciplinary team in a sequential fashion. Endoscopy and other ancillary tests are done selectively in case of hiatal hernia, gastro-esophageal reflux disease (GERD), reflux esophagitis or history of peptic ulcer disease; detection and treatment of *Helicobacter pylori* in case of positivity, is necessary. Antibiotic and thromboembolic prophylaxis are also required, as well as specific monitoring in case of prior anticoagulation or psychiatric treatment. Furthermore, eradication of smoking and preoperative respiratory physiotherapy are indicated for a period of 3–6 months prior to surgery. Patients with previous significant alcohol intake or some type of drug addiction that are not considered a surgical contraindication by the multidisciplinary team, must be followed carefully.

24.3 How OAGB Works: Ten Key Steps to Perform the Standard OAGB Technique

24.3.1 Positioning of the Patient

Compression stockings and devices in the lower extremities of the patient, are imperative to prevent thrombosis. Also, firm and secure fastening of the patient to the surgical Table (ST) is essential in order to allow safe performance of all the different intraoperative movements of the latter; these are a fundamental characteristic of the technique (see below). After anesthetic intubation, the ST is initially placed either in a slight anti-Trendelenburg or horizontal position to prepare the operative sterile field and begin the operation.

24.3.2 Trocar Placement

Inadequate trocar positioning may lead to severe difficulties and add unnecessary risks to the procedure. It is important to note that the number and layout of trocars in OAGB, is not the same as in MGB; it is thus worthwhile to recognize this difference and plan their correct placement. The procedure starts with the surgeon standing between the patient's legs, surgical assistants on both sides and scrub nurse behind the surgeon, with the ST in a slight anti-Trendelenburg position to facilitate adequate introduction of the trocars (Fig. 24.1). A long-lasting local anesthetic (Bupivacaine 0.5%, 10 mL) is infiltrated subcutaneously into the pre-peritoneal space before incising all sites where trocars will be introduced; we advise this practice as it has been demonstrated to reduce pain in the immediate postoperative period [13]. After the stomach is decompressed with an oro-gastric tube, pneumoperitoneum is created through a Veress needle which is inserted ~3 cm below the left costal margin on the midclavicular line (Palmer's point); this has been described as a site with minimal risk of abdominal injury (Fig. 24.2). Initial insufflation is calibrated between 14 and 17 mmHg, according to patient characteristics.

A 10-mm optical trocar is placed ~20 cm below the xiphoid process in the midline above or at the umbilical level. Since this is a trocar which is introduced blindly and where severe visceral and vascular lesions have been described, we recommend atraumatic models such as reusable trocars (Karl Storz, Germany) which

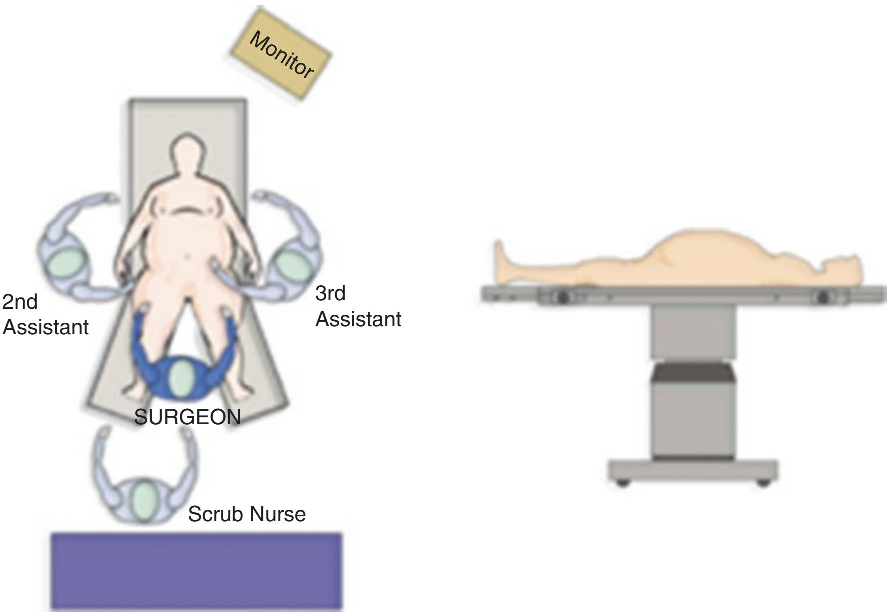

Fig. 24.1 Initial positioning of the patient and surgical team

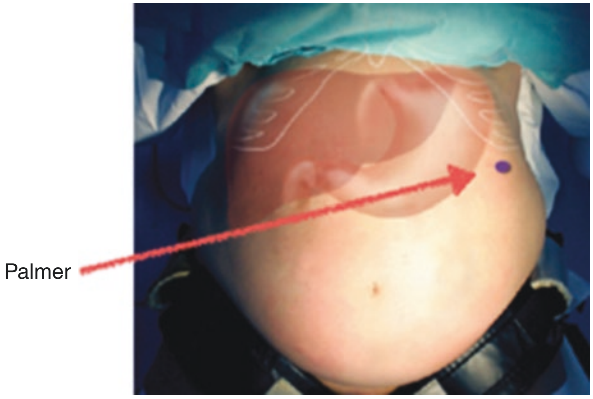

Fig. 24.2 Palmer's point (site for insertion of Veress needle)

Fig. 24.3 Final layout of all trocars

penetrate through manual spiral rotation, dissecting tissues without cutting and with less damage. Disposable optical bladeless atraumatic trocars (Medtronic, USA) may also be used. Once optical abdominal access with a 30° endoscope is gained, two extra-large working trocars (12-mm) for the surgeon and for insertion of endostaplers are placed on both sides of the abdomen, at the midclavicular level, equidistant for ~12–14 cm and in a (horizontal) plane slightly above the optical trocar. Three other 5-mm trocars are placed at different locations and for various functions: (a) At Palmer's point (where initial Veress needle was inserted), for stomach retraction and use by the surgical assistant, (b) At the right subcostal space (for liver retraction and drainage placement at the end of the procedure), (c) At the right lower quadrant (RLQ), a trocar which is essential for complete measurement of the SB. Besides SB estimation, this trocar also helps us with other maneuvers such as complete total exploration of the abdominal cavity (including the pelvic area). Through all this information we are able to determine the degree of malabsorption assigned for each patient; this represents an important contribution of OAGB compared to MGB or RYGB. Final layout of all trocars is shown in (Fig. 24.3).

24.3.3 Complete SB Measurement and Estimation of Biliopancreatic (BP) Limb and Common Channel (CCh) Lengths—Degree of Malabsorption

Measurement of the entire SB represents one of the main differences introduced by the OAGB. We believe knowledge of the total length of the small intestine constitutes an essential part of any malabsorptive bariatric technique. Unawareness of this information may lead to severe mistakes and consequences in the designation of both the BP limb and CCh. These latter range from insufficient SB bypassing and inadequate WL or even weight regain, to severe nutritional deficiencies as was recently published [14]. Counting the whole SB is actually the first part of the operation and must be done before any gastric intervention, since it will provide important facts in regard to the steps to follow. Besides total length data, running the whole SB also provides critical knowledge in relation to mesenteric characteristics such as thickness, length, consistency and pattern of vascular flow, which may prove quite valuable in the selection of the SB loop to be anastomosed and which should be easily moved upward above the supra-mesocolic area without tension.

Successful measurement of all SB requires the previously mentioned 5-mm trocar placed in the RLQ above the iliac fossa (surgeon's right hand), parallel to the right subcostal 5-mm trocar (surgeon's left hand), and with optical positioning inside the right midclavicular 12-mm trocar. In this manner, all infra-mesocolic maneuvers are performed with the surgeon and camera operator standing on the right side of the patient (Fig. 24.4), with slight anti-Trendelenburg tilting of the ST for proximal (jejunal) manipulation, and slight Trendelenburg for distal (ileal) counting. Atraumatic intestinal clamps (K. Storz, Germany) are indispensable for these maneuvers in order to decrease the risk of enteric lesions which may be easy to produce, especially in the ileum and where thin bowel walls are encountered.

The counting process starts at the ligament of Treitz, ends at the ileocecal valve and is completed in ~5–10 min; due to the amount and type of information obtained, this definitely is time well invested. Along with body mass index (BMI), total SB length is the main parameter with which we adjust limb lengths and ultimately degree of malabsorption. Other important patient characteristics to add into the equation include: age, type of obesity, co-morbidities, dietary habits and socio-cultural (economic) status. Thereby, from a metabolic standpoint there are important differences between a younger from an older patient, an obese from a super-obese, a male with truncal (apple-shaped, central) obesity from a female with gynecoid (pear-shaped) obesity, a patient with severe metabolic syndrome from another with few co-morbidities, a patient submitted to a pure metabolic surgery from another undergoing the procedure for morbid obesity, and the list goes on.

Running the whole SB also allows us to identify and treat enteric pathology such as Meckel's diverticula (Fig. 24.5). Also, direct visualization of inguinal and pelvic (genital) areas may be achieved; pathology in these locations is not infrequent among obese patients. Finally, many patients undergoing bariatric operations have had prior abdomino-pelvic operations for diverse pathologies (especially appendiceal and gynecologic), leading to potential adhesions; adhesiolysis is mandatory

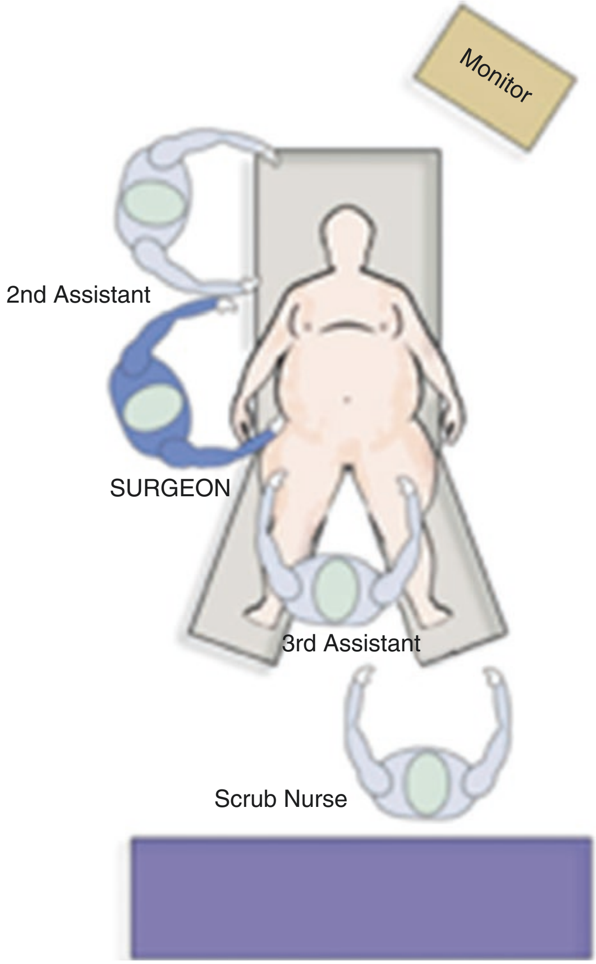

Fig. 24.4 Surgeon and camera operator working on the right side of the patient for complete small bowel measurement

and much safer and easier when done from the right of the patient (with the same set-up as for SB measurement). Moreover, simultaneous abdominal wall hernia repair may also be performed with efficacy from the right side (in the same direction of the camera), avoiding well-known catastrophic consequences of SB incarceration.

Proper complete SB measurement starts by lifting the gastro-colic omentum above the transverse colon in order to locate Treitz' ligament (Fig. 24.6). Jejunal counting is done by grasping and running segments of 10 cm sequentially; initially it is advisable to introduce a measuring tape of some sort, in order to gain visual experience of what 10 cm really are. Measuring continues up to a pre-designated point where the assistant grasps the mesenteric fat as an indicator. This point varies in each patient, but usually ranges between 200 and 350 cm (Fig. 24.7). The ST is then tilted in a slight Trendelenburg position in order to continue running the ileum distally and down to the ileocecal valve; this segment will be the CCh and is also

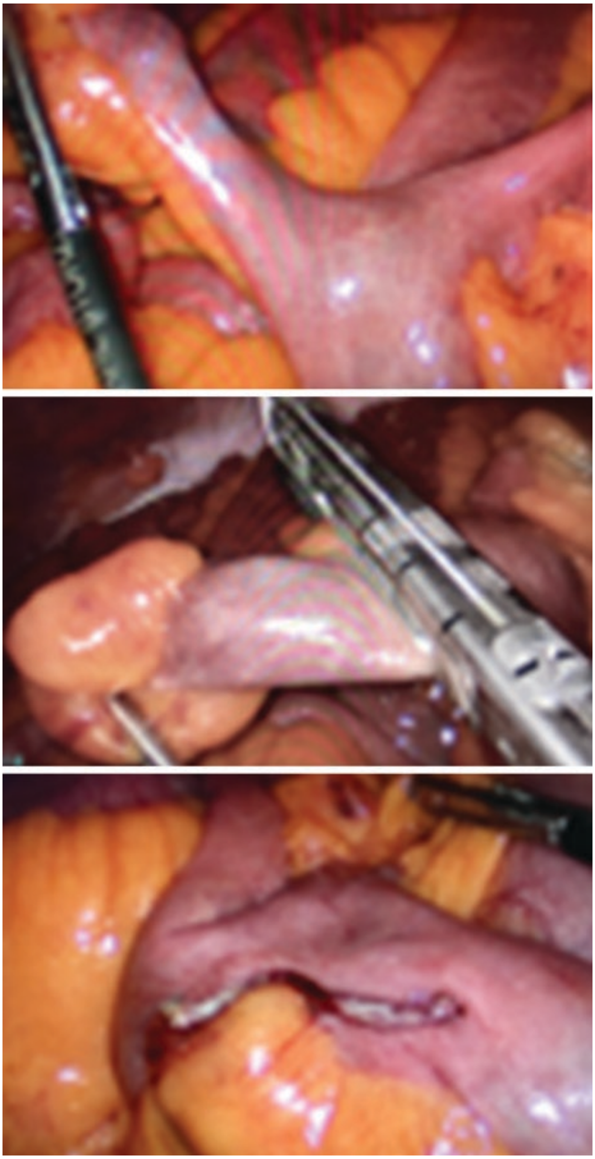

Fig. 24.5 Meckel's diverticulum identified and resected during intestinal counting

variable in each individual patient, ranging from 200 to 350 cm. When total SB measurement is completed, and with knowledge of total SB length, final BP limb and CCh lengths are recalculated if necessary, in order to adjust proper degree of malabsorption for each particular patient. Once the final SB loop to be anastomosed is decided upon, it is encircled by a soft rubber drain which is inserted across the mesentery (Fig. 24.8) and fixed with a grasper introduced into the RLQ trocar and left in place until the gastro-enteric anastomosis is done. This ends the

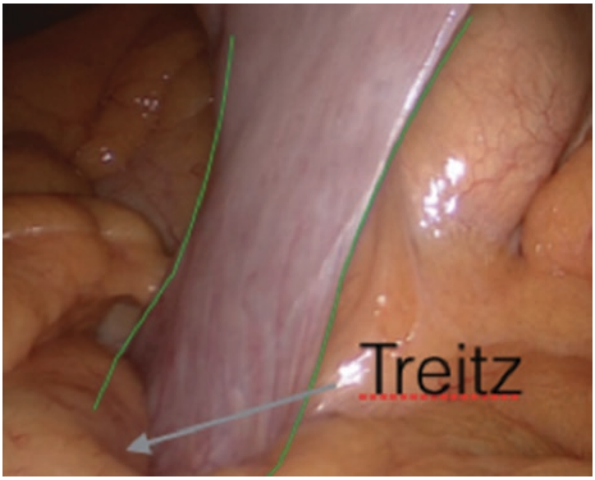

Fig. 24.6 Treitz' ligament identified after lifting the gastro-colic omentum

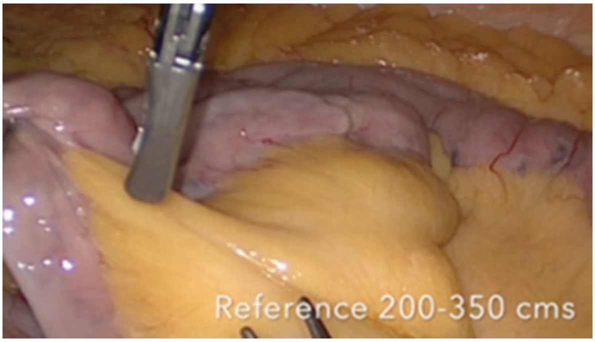

Fig. 24.7 Grasper at mesenteric fat, indicating enteric reference between 200 and 350 cm from Treitz' ligament

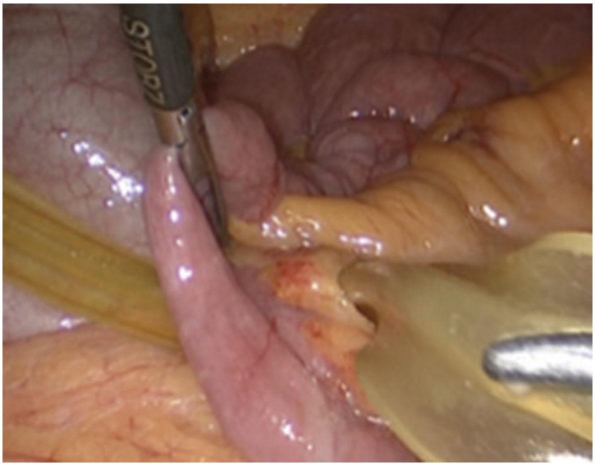

Fig. 24.8 Soft rubber inserted through the mesentery and encircling small bowel to be anastomosed

infra-mesocolic stage of the operation (which is completely different to that performed in MGB); the rest of the procedure will be completely done in the supramesocolic area with no need of going back to the previous (infra-mesocolic) space.

24.3.4 Special Note on SB Limb Lengths

A transcendental and decisive feature of the OAGB operation that will determine the outcome and future of the patient, is our estimation of BP (afferent) limb and CCh (efferent limb) lengths. We have repeatedly emphasized the relevance of measuring complete SB length (from Treitz ligament to ileocecal valve), and definitely do not share the point of view of those performing a standard MGB (with fixed 150–200 cm BP limbs, measured from Treitz' ligament downward [1, 15]), or SADI's (with fixed 200–250 cm CCh, measured from ileocecal valve upward [16]). These practices clearly do not provide all the information needed in order to assess limb lengths, and ultimately, the degree of malabsorption.

Since weight and metabolic characteristics vary markedly among patients, fixed limb lengths are not the answer for all. No single patient is equal to another: thus, "tailoring" malabsorption according to the different parameters that we have mentioned previously, seems a more reasonable option. Obesity has been recognized as a chronic, inflammatory, progressive and relentless disease [17]. Most operations report reasonable outcomes in the short- and medium-term, but many fail the test of time [18]. Therefore, treatments should aim at long-term outcomes of at least >10 years. Our experience after >15 years has indicated that bypassing <200 cm of jejunum may prove insufficient for most patients after long-term FU; this is especially true in Caucasian patients in developed countries (which represent most of our cases).

Average total SB length in our series ranges from 500 to 550 cm. Depending on degree and type of obesity, we advise BP limbs of 200–350 cm for young patients with these characteristics. This group constitutes the vast majority of our patients and we have found that when the ileocecal valve and large bowel are present and untouched, even a CCh as short as 200–250 cm will maintain them nutritionally intact if they follow our intestinal adaptation program strictly. This "aggressive" approach has provided substantial, durable WL with sustained metabolic benefits traduced in a high index of enduring remission of co-morbidities [7]. A different story is that of older patients (>65 years) or those diabetics with low BMI in whom a metabolic operation is being pursued. A conservative strategy with CCh of at least 300–350 cm is a more prudent alternative in these cases.

A recent study by our group evaluated the different lengths of BP limb and CCh performed in 320 consecutive patients undergoing OAGB, analyzing the obtained 1-year postoperative weight loss. Establishing as a success an obtained BMI of 25 kg/m^2, a cut-off point for each bowel length and the ratios (BP limb/total SB length) and (CCh/Total SB length) was investigated. At 12 months after surgery, BP limb and BP limb/Total SB ratio directly correlated with weight loss and EWL. CCh and CCh/Total SB ratio inversely correlated with weight loss and EWL. Ideal cut-off point to obtain a BMI ≤25 kg/m^2 was calculated with area under the curve (AUC) for all the measures, being statistically significant for the CCh length (AUC 0.640; CI 95% (0.571–0.709); $p < 0.001$) and for the CCh/Total SB ratio (AUC 0.687; CI 95% (0.621–0.753); $p < 0.001$). For the CCh, cut-off point was established for 220 cm with 75% sensitivity and 65% specificity. A CCh length of 180 cm achieved a BMI <25 kg/m^2 in 100% of the cases. For the CCh/Total SB ratio, the cut-off point was established at 0.44 with 78% sensitivity and 68% specificity. A CCh/Total SB ratio of <0.37 achieved a BMI <25 kg/m^2 in 100% of the cases (data not yet published).

Given these results, we can affirm that CCh/Total SB ratio is the best determination to predict the weight loss success of OAGB. We recommend a ratio between 0.37 and 0.44 and the CCH length must range between 180 and 220 cm.

24.3.5 Division of the Omentum

Another technical proposal advocated by the OAGB is complete opening (bivalving) of the gastro-colic omentum. This is performed selectively in super-obese patients, those with truncal (visceral, central) obesity and especially in those cases when after selecting the SB loop to be anastomosed, tension is found when lifting it upwards to the figured anastomotic site. Note that as more SB is bypassed (larger BP limb), more anastomotic tension may be placed. Thus, in standard MGB where fixed BP limbs between 150 and 200 cm are used, omental division is usually not required [1, 15]. When indicated, bivalving of the gastro-colic omentum is done from the right side of the patient (before finishing the infra-mesocolic stage of the operation), so as to be able to re-test that no tension will be placed when the selected SB loop is brought above the transverse colon and up to the gastric incisura angularis (usual anastomotic site), after the omentum has been divided.

24.3.6 Dissection and "Opening" of the His Angle

The ST is now placed in a steep anti-Trendelenburg position so that intra-abdominal contents fall considerably and allow a comfortable and easy access to the angle of His. The surgeon returns to what will be a definitive position for him throughout the operation between the patient's legs, and assistants are positioned at both sides of the ST. The camera is returned from the right-sided trocar to its central position, and the 36-Fr oro-gastric tube is pulled out of the stomach into the esophagus.

Opposed to what is advocated in classic MGB of avoiding the angle of His in order to prevent devascularization at this site [1, 15], we advise to explicitly dissect and "open" the angle of His completely. A thick fat pad usually surrounds the esophago-gastric junction (EGJ). Thus, we start by sectioning the phreno-esophageal membrane with an ultrasonic dissection device (Sonicision®- Medtronic, USA) until the left crus of the diaphragm is completely free and visualized (Fig. 24.9) and extend this dissection all the way to the posterior aspect of the spleen. These

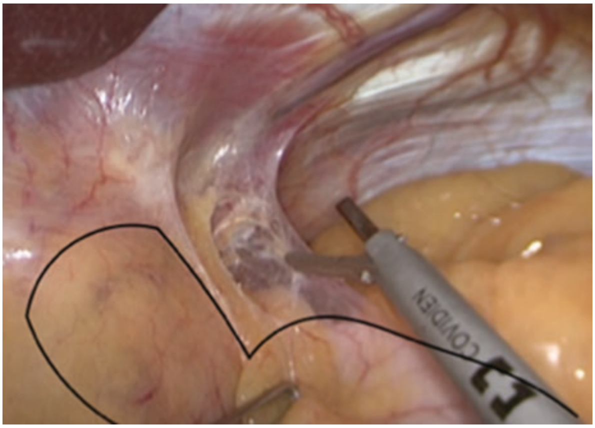

Fig. 24.9 Initial view prior to sectioning the phreno-esophageal membrane in order to dissect and "open" the angle of His

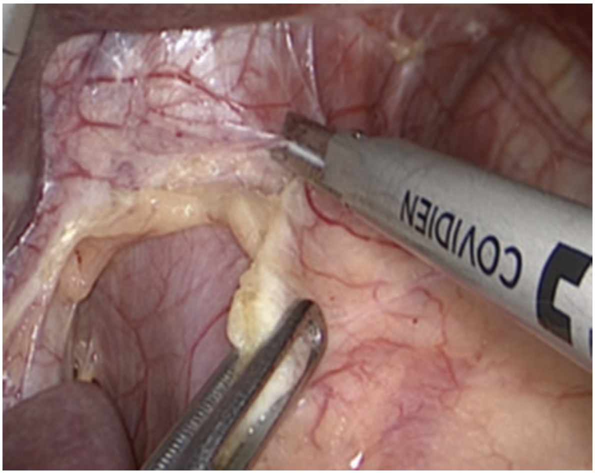

Fig. 24.10 Dissection of the gastro-hepatic ligament (lesser omentum) up to the right side of the phreno-esophageal membrane

measures allow us to reduce the EGJ, avoid splenic lesions, hasten wide aperture of the retrogastric window (leaving less fibrous and fatty tissue), and favor optimal endostapler positioning at this critical location. The gastro-hepatic ligament is then dissected, freeing all adhesions to the right diaphragmatic crus, as well as what remains of the (right) phreno-esophageal membrane (Fig. 24.10). This facilitates maximal reduction of the EGJ, returning the distal esophagus to the abdominal cavity; these actions will ultimately lengthen the gastric pouch and diminish anastomotic tension. At this point, hiatal closure is performed selectively (when marked enlargement is found). The fat layer which is always covering the angle of His is then sectioned until gastric serosa is reached (Fig. 24.11). This maneuver is rather important, since this is the precise site where the last cartridge will be fired and it will allow the six staple-lines (3 in the pouch—medially, and 3 in the excluded stomach—laterally) to penetrate entirely in the gastric wall, diminishing risk of leaks at one of the most common locations for this complication. This type of leak

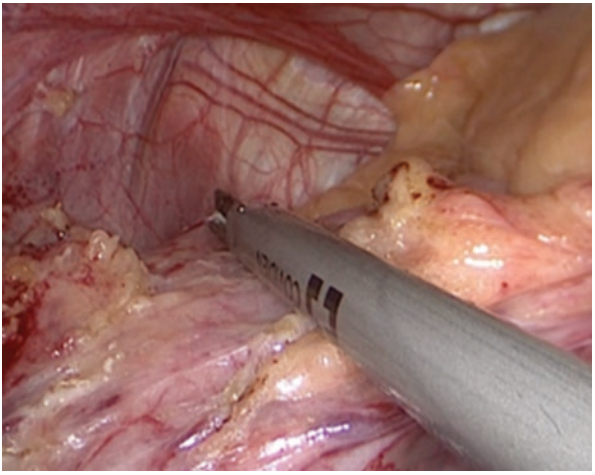

Fig. 24.11 Sectioning of fat tissue lying over the angle of His prepares the path for the endostapler

may be more common after MGB and especially after sleeve gastrectomy where this area is explicitly avoided [19]; fat, which is rather thick at this location (particularly in patients with truncal obesity), may prevent the external staple-line from penetrating the gastric wall completely and actually remain in the fatty tissue [20].

Classic MGB teaches to maintain integrity of all EGJ and avoid sectioning fibrous and fatty adhesions in order to avoid devascularization and leaks at the last staple-line [1, 15]. In regards to hiatal hernias, classic MGB teaches to avoid reducing and/or repairing them, and when necessary to do so at another time, once weight loss has been achieved [1, 15]. We share neither of these concepts. Regarding the former, we do not know of any leak originated at the end of the last staple-line (angle of His), after thousands of OAGBs performed worldwide; in all of them, the angle of His is opened extensively as we previously described. Vascularization at the EGJ does not come from the fat layers, but from cephalic branches of the left gastric artery and inferior phrenic arteries [21]; these obviously are preserved in its entirety. In regard to the latter, we have already described the benefits of sectioning the phreno-esophageal membrane and reducing the EGJ. Both of these maneuvers also aid in the identification and (selective) management of large hernias which is a relevant issue since GERD and hiatal hernias of various degrees are commonly associated with obesity [22].

24.3.7 Construction of the Gastric Reservoir

For this step of the procedure, the steep anti-Trendelenburg position in the ST is changed to a slighter one of around 30º which will be maintained until the gastro-enteric anastomosis is finished. An automated camera-holding system (Lap Man®-Medsys, Belgium) is then installed and operated through a laser remote control (Lapstick®-Medsys, Belgium) by the first assistant. This allows both surgeon and assistants to work comfortably seated, without disruptions or need for camera

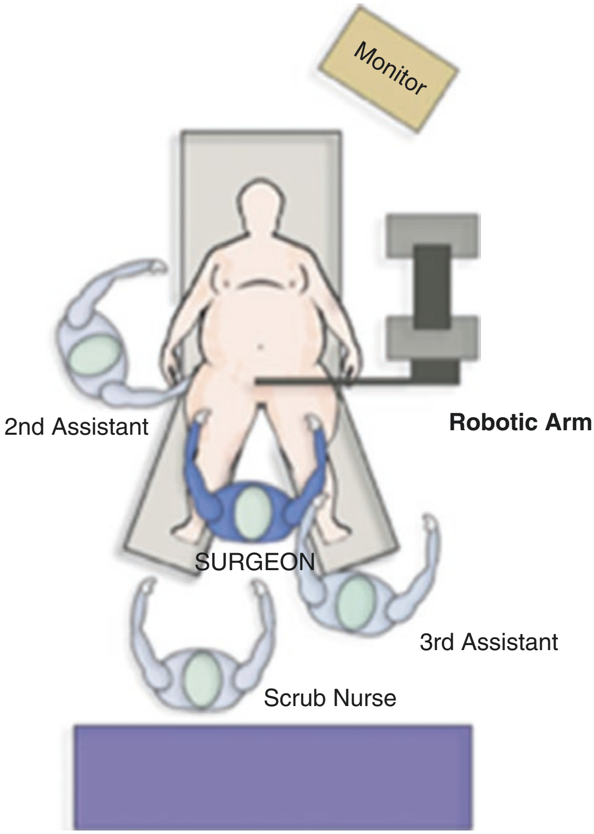

Fig. 24.12 Position of the surgical team after the robotic arm is installed

cleansing (Fig. 24.12). If such a robotic arm is not available, optical layout would be the same, but with manual assistance (as is usual).

First, both pylorus and crow's foot, near the incisura angularis, are identified; the ideal point to begin the dissection in the gastric lesser curvature is the mid-point between the crow´s foot and the pylorus. The ultrasonic dissection device is again used to continue opening a gastro-hepatic window and to section the lesser gastric curvature's fat and blood vessels at the chosen site below crow's foot, in order to open a retrogastric window and gain access into the lesser sac (Fig. 24.13). Our aim in performing a meticulous dissection of all perigastric fat is that the first (horizontal) firing of the endostapler achieves optimal penetration into the gastric serosa, leading also to free entrance into the lesser sac. This first endoscopic stapler (Endo-GIA®, or preferably iDrive® Ultra Powered Stapling System-Medtronic, USA) is loaded with a 45-mm/3 to 4-mm purple cartridge (Tri-Staple®-Medtronic, USA) and introduced through the right working trocar. It is then inserted through the created opening in the lesser omentum and completely articulated (tip in a podalic direction); in a simultaneous maneuver, the gastric body is grasped and pulled in a cephalic direction (surgeon's right hand) and the endostapler is applied, closed and fired (surgeon's left hand), so that the stomach is sectioned horizontally in the more distal (antral) gastric region (Fig. 24.14).

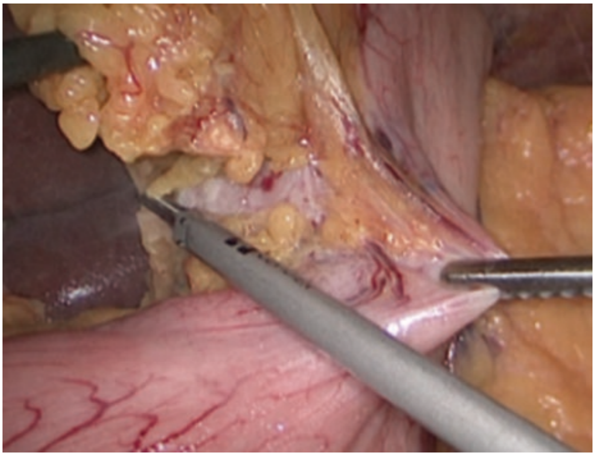

Fig. 24.13 Sectioning of fat and blood vessels in the lesser gastric curvature to open a retrogastric window and gain access into the lesser sac

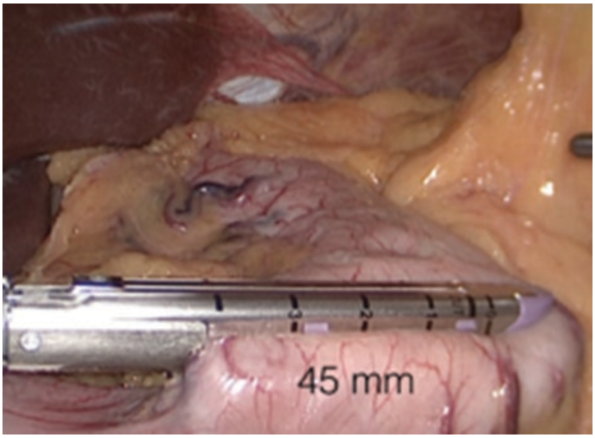

Fig. 24.14 First endoscopic stapler inserted through the retrogastric window is applied and closed horizontally in the more distal (antral) gastric region

After this gastric partitioning, we are now in the lesser sac and able to dissect and section all potential congenital and fibrous adhesions and fatty tissue which sometimes attaches the posterior gastric wall to the pancreas. Care must be taken not to extend this dissection medially into the posterior lesser curvature, where important vascular structures (left gastric artery and branches) are located and which will be the main blood supply to the gastric reservoir. Vertical sectioning of the stomach is next. The endoscopic stapler loaded with a 60-mm/3 to 4-mm purple cartridge (Tri-Staple®- Medtronic, USA) is now introduced through the left working trocar. A 36-Fr double-lumen oro-gastric tube (Ref 340.36®, Vygon, France) is then inserted between the gastric lesser curvature and endostapler to calibrate the gastric reservoir (Fig. 24.15). The endostapler is adjusted as near to the calibrating tube as possible, and closed. Before firing, the anesthesiologist pulls the tube to make sure it is not caught within the endostapler, and then reinserts it all the way to the tip of the pre-formed gastric pouch. After firing and removing the endostapler, "migratory"

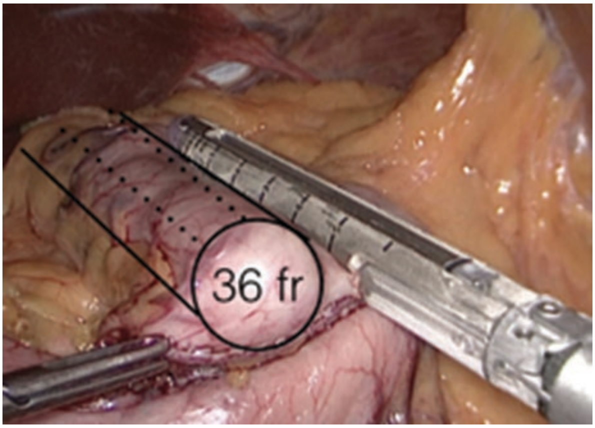

Fig. 24.15 Initial vertical gastric sectioning is done after inserting a 36-Fr calibrating oro-gastric tube between the gastric lesser curvature and the endostapler

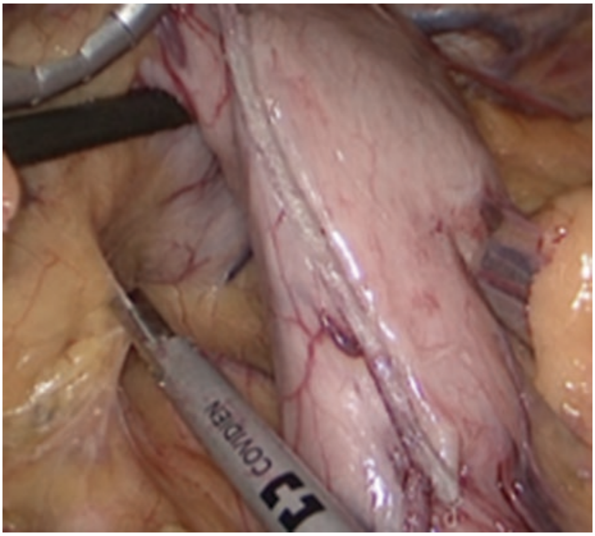

Fig. 24.16 Section of fatty tissue, and lysis of congenital and fibrous adhesions which may attach the posterior gastric wall to the pancreas

staples should be looked for and removed, in order to prevent misfiring of the next cartridges and potential staple-line leaks [20]. Dissection of posterior adhesions and fatty tissue continues if necessary after each vertical sectioning of the stomach; these latter allow the progressive visualization of the more cephalic areas of the lesser sac (Fig. 24.16). A second 60-mm cartridge is again adjusted close to the calibrating tube and fired. At this point. it is usually possible to dissect all adhesions and fatty tissue up to the (posterior) angle of His; following the pancreatic anterior-superior border facilitates reaching an avascular plane at this site. Care should be taken not to injure splenic vessels (especially the splenic artery), which are usually evident in this more cephalic retrogastric area. If a Snowden-Pencer® (or similar) liver retractor is being used, the first assistant may be able to retract the pre-formed gastric pouch medially and aid with the dissection process (Fig. 24.17).

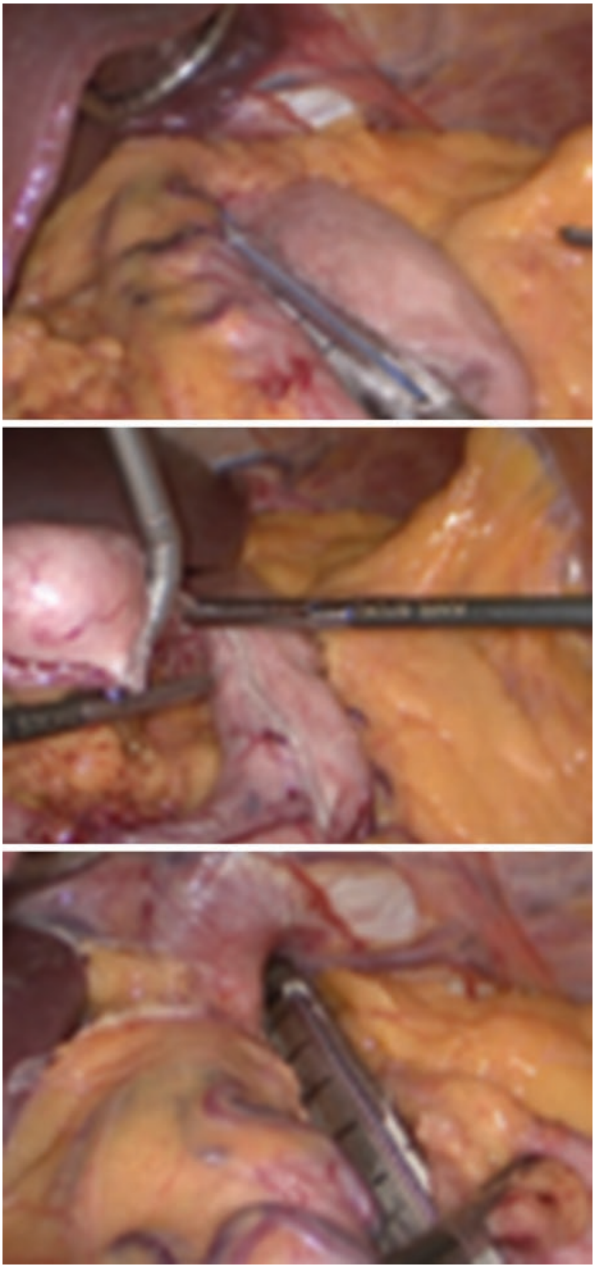

Fig. 24.17 Completion of the vertical dissection and sectioning to construct the gastric pouch under direct vision

Ultimately, connection with the anterior dissection that we had previously done at the angle of His is possible, in order to open a wide retrogastric window and completely visualize the diaphragmatic left crus. All these measures will allow sectioning the angle of His under maximum visualization and with almost nil risks. We

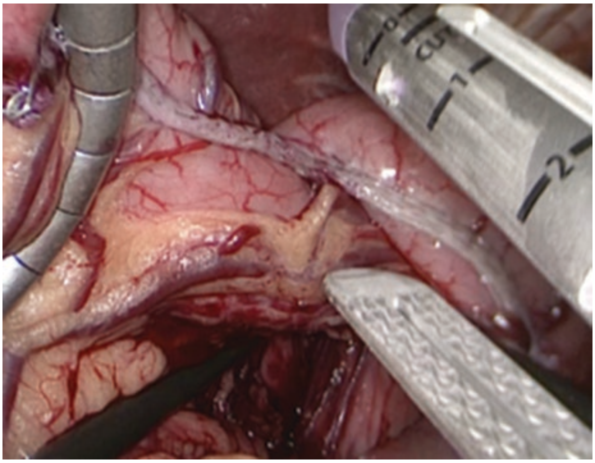

Fig. 24.18 Connection of posterior and anterior dissection of the angle of His to allow its section under maximum visualization

are completely against "blind" dissections and staple firings to gain access to the anterior angle of His from its posterior counterpart, as we have sometimes seen in some classic MGB or sleeve gastrectomy operations. This stresses the importance of the wide initial anterior dissection at this area (see above), and complete dissection and opening of the lesser sac, which will allow broad access, under direct visualization and with much less risk of injury to adjacent organs. From this position our third 60-mm cartridge is directly applied over the angle of His at a point where fatty tissue was previously sectioned (Fig. 24.18), and by performing a (double) caudal traction from the perigastric fat (surgeon's left hand) and gastric fundus (second assistant); the aim is that the endostapler is introduced as far as possible in our chosen site, and that it is positioned between the left crus and superior splenic pole, sectioning at the level of the EGJ. At this point, it is of utmost importance to verify that complete (vertical) gastric transection has been achieved; it is usually necessary to use another firing (cartridge ranging from 30- to 60-mm, according to final pouch length), to finish dividing the gastric pouch from the excluded stomach entirely and safely. Once the last stapling device is removed, the calibration tube is pulled to the esophagus and bleeding at the staple-line is controlled with the tip of the ultrasonic dissector and/or clips. Construction of the gastric reservoir is now finished. The latter should be long (ideally ~15–18 cm), narrow, well vascularized, and easy to move caudally; it usually lies over the gastric antrum with its tip at the level of the transverse colon (Fig. 24.19).

24.3.8 Creation of the "Anti-reflux Mechanism"

Bile reflux has been the major criticism ever since the MGB was first presented [23]. One of the most important contributions and adjustments that the OAGB proposed shortly after, was its "anti-reflux mechanism". This was partially conceived and designed from our own previous experience with the RYGB as described by Capella in which the Roux limb is sutured in a latero-lateral fashion to the vertical

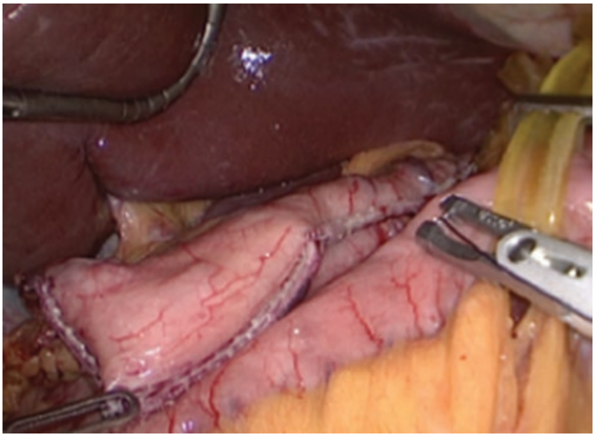

Fig. 24.19 Long, narrow, well vascularized gastric reservoir, which is easy to move caudally

staple-line of the gastric pouch, with the gastro-enteric anastomosis being performed at the distal end of the latter [24].

Similarly, in OAGB the selected SB loop which was encircled with a soft rubber drain (held with a grasper introduced in the RLQ 5-mm trocar—see above), is brought in a cephalic direction and above the transverse colon. At this point, the grasper is replaced by another introduced in the 5-mm left subcostal trocar. While the SB loop is being held upwards with this grasper (surgeon's right hand), both the afferent (BP) limb and efferent limb (CCh) are brought up and arranged (surgeon's left hand) so that the SB loop itself is widely placed over the transverse colon, reaching the gastric reservoir with no tension whatsoever; SB and its mesentery should end up as a large and wide fan-shaped arch without breaches. This configuration diminishes risk of internal hernia markedly; actually, although very few have been reported after MGB [25], we do not know of any internal hernias after OAGB. We again stress the importance of using atraumatic intestinal clamps when manipulating the SB at this stage, in order to avoid lesions.

The SB loop must lay very close and parallel to the gastric pouch without tension for at least 8–10 cm; this can be aided by caudal traction of the latter. A continuous reabsorbable no. 2-0 suture (Polisorb®, Endo Stitch®-Medtronic, USA) is sewn in a latero-lateral position between the anti-mesenteric SB border and the staple-line of the gastric pouch, beginning between the first and second 60-mm vertical firings (Fig. 24.20); this suture is extended ideally along ~8–10 cm all the way down to the junction with the (first) horizontal staple-line of the gastric pouch, aligning and securing the SB loop to the gastric reservoir's staple-line (Fig. 24.21). This configuration brings about several advantages: (a) Solid fixation between SB and gastric pouch unloads anastomotic tension, (b) Permanent posterior anastomotic suture, (c) Prevention of gastric pouch twisting, (d) Avoidance of potential gaps and openings; and thus internal hernias, (e) Perfect alignment of the two structures to be anastomosed and the anastomotic site (Fig. 24.22). This is part of what we have called "anti-reflux mechanism"; the ascending direction BP secretion must follow, along with a moderately wide latero-lateral anastomosis, plus the gravity force exerted, diminishes the possibility of free entrance into the gastric pouch, abating the

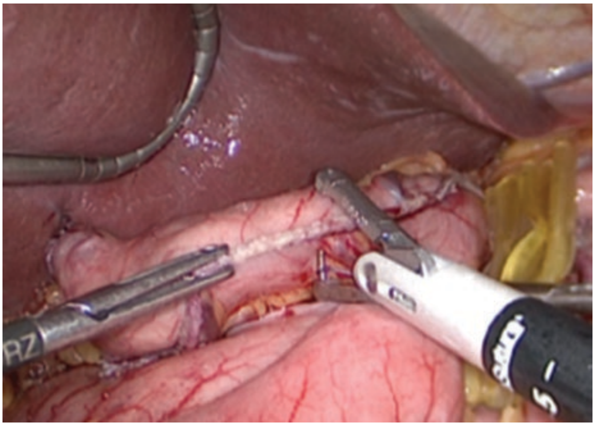

Fig. 24.20 Construction of the "anti-reflux system" starts by a continuous latero-lateral suture between the small bowel loop (anti-mesenteric border, close to the soft rubber drain) and staple-line of the gastric pouch (between 1st and 2nd 60 mm vertical staple firings)

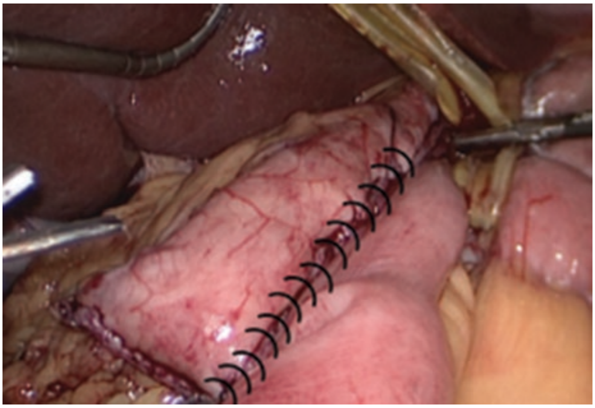

Fig. 24.21 Continuous suture is extended caudally for 8–10 cm until the tip of the gastric pouch is reached; note optimal alignment between the structures

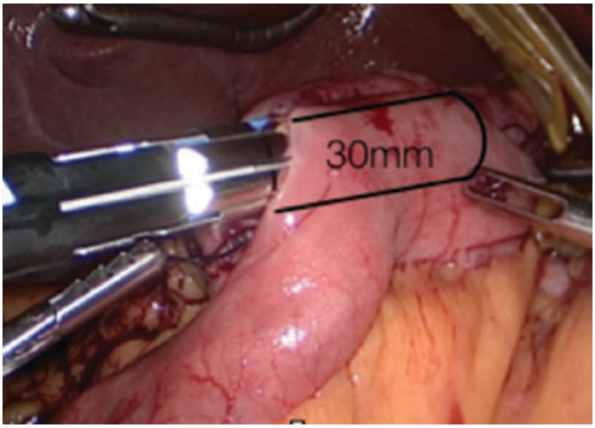

Fig. 24.22 Endostapler loaded with a 30-mm blue cartridge is partly inserted and applied latero-laterally creating a gastro-enteric anastomosis 2.5 cm long

possibility of postoperative gastro-esophageal bile reflux markedly. This is in contrast to the MGB where its very wide, termino-lateral low anastomosis does not exert the same theoretical principles.

24.3.9 Construction of the Gastro-intestinal Anastomosis

After both, gastric pouch and SB loop are securely fixed side-by-side, the first assistant pulls the gastric pouch in a caudal and slight medial direction with a grasper introduced through the RLQ 5-mm trocar, which holds the end of the previously performed continuous suture. The surgeon then introduces the ultrasonic dissection device or a diathermic hook through the right subcostal working trocar, in order to perform small parallel apertures in both the anterior side of the distal gastric pouch (5 mm) and SB (3 mm); in both cases confirmation of adequate entrance and aspiration of intraluminal contents is done. An endoscopic stapler loaded with a 30-mm/3.5-mm blue cartridge (Endo-GIA®-Medtronic, USA) is partially inserted (~75%) and applied between both structures; it is then fired over their anterior side in a latero-lateral fashion, thus creating a gastro-enteric anastomosis 2.5 cm long (Fig. 24.22). After its withdrawal, hematic content is aspirated and the inside of the anastomosis is inspected to corroborate the integrity of the posterior mechanical suture, as well as hemostasis. In case of even slight bleeding, we suggest use of clips over the involved staple-line.

Incisions on the anterior anastomotic wall are sutured with reabsorbable no. 2-0 (Polisorb®-Covidien, USA) interrupted stitches. This begins by closing the lower angle with two stitches which start on the enteric side (outside-inside), pass through the final border of the anastomotic staple-line and end on the gastric side (inside-outside) (Fig. 24.23); also, the end of the posterior continuous suture is invaginated within these stitches. A third full-thickness stitch including enteric and gastric walls completely seals the lower anastomotic angle. We then close the superior angle with another interrupted stitch and proceed to complete the "anti-reflux mechanism". This is done by fixing the apex of the afferent SB loop in an upward direction to the excluded stomach with one or two interrupted stitches (Fig. 24.24). These measures further unload anastomotic tension, improve its orientation, and reinforce the "antireflux mechanism". If the excluded stomach ends up being extremely displaced, especially in a horizontal position, these sutures may be omitted due to potential undue tension. Closure of the midportion of the anastomosis is finally done with 2–3 interrupted stitches, and this is the last part of this step of the procedure (Fig. 24.25). For this latter, we also prefer reabsorbable interrupted stitches using the Endo Stitch® (Medtronic, USA), because we feel that a better control in anastomotic closure without harm in vasculature of its edges is achieved; however, other OAGB surgeons have reported closure with both interrupted and continuous sutures using conventional needle holders, with equally good results.

Construction of the gastro-intestinal anastomosis is both controversial and key, in order to obtain good patient outcomes. Classic MGB anastomosis is performed in

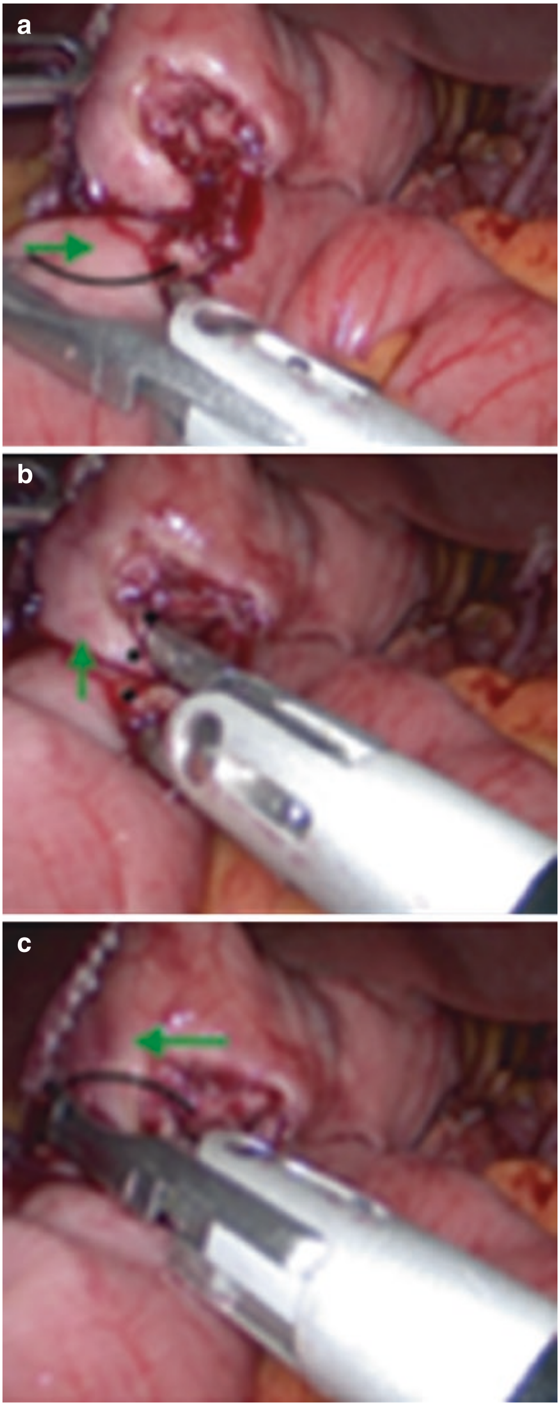

Fig. 24.23 Aperture in the anterior anastomotic wall is closed with interrupted stitches beginning in the lower angle in three steps: (**a**) enteric side (outside-inside), (**b**) through anastomotic staple-line, (**c**) gastric side (inside-outside)

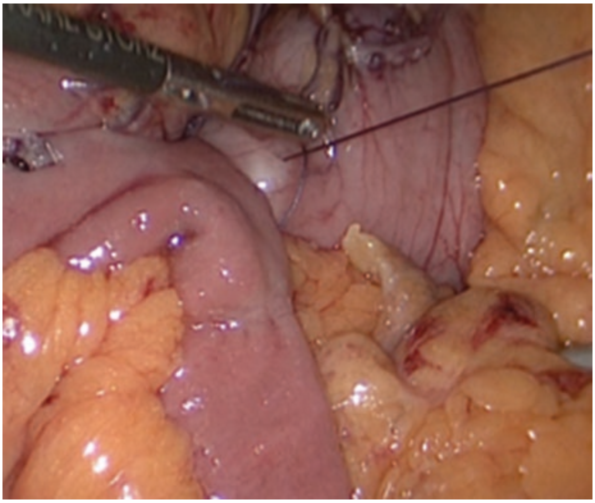

Fig. 24.24 "Anti-reflux mechanism" is reinforced with one or two interrupted stitches sewing the highest point of the biliopancreatic limb (afferent loop) in an upward orientation to the excluded stomach

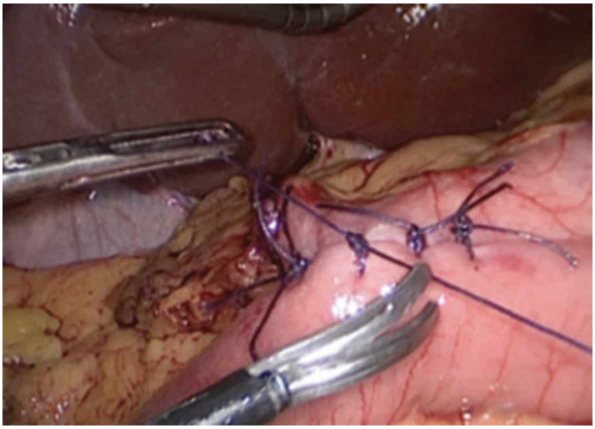

Fig. 24.25 Gastro-enteric anastomosis is completed with 2 or 3 interrupted stitches sealing its midportion

a termino-lateral fashion with a wide opening (~5–6 cm). This configuration promotes abrupt passage and pressure of food onto the underlying bowel wall, eventually leading to its dilatation, making it behave like an authentic newly-formed bowel pouch; moreover, this also facilitates entrance of food in an almost equal distribution to each side of the anastomosis, which may increase possibility of reflux and marginal ulcer. In contrast, OAGB has a latero-lateral anastomosis which according to the physical laws of LaPlace and Poisseulle (studied and applied in his time by Capella [24]), makes gravity effect, load distribution and bowel peristalsis itself, decreases anastomotic tension and produces a more harmonic movement of the food bolus in an isoperistaltic pattern. This mechanical effect is further reinforced by the long continuous suture between the gastric pouch and SB loop through which weight of the SB and mesentery is distributed along a large surface area, which

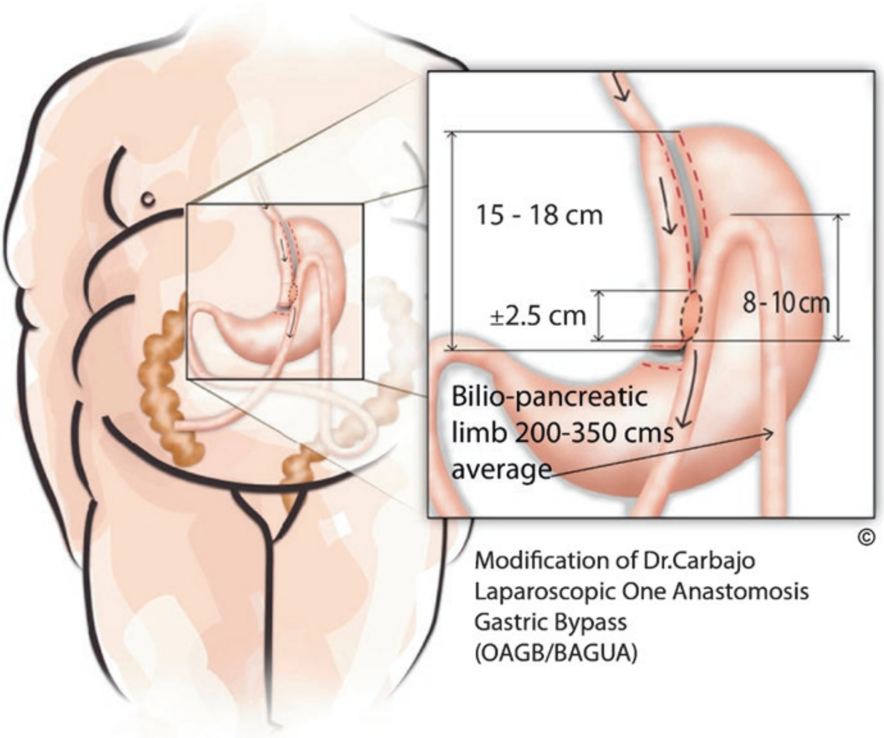

Fig. 24.26 Schematic representations of the One-Anastomosis Gastric Bypass

favors load distribution. Also in contrast to MGB, anastomotic width is less (~2.5), and also BP secretions have a higher downward effect into the CCh (due to the effect of gravity itself); these factors minimize the possibility of biliary reflux and marginal ulcer, as has been described in the literature comparing large series with or without the use of the "anti-reflux mechanism" associated with different anastomotic models [26]. All these physical and mechanical aspects, in addition to a proper suturing technique, make OAGB's latero-lateral anastomosis an extremely robust alternative, which is well vascularized, tension-free, and with an almost nil risk of leaks, stenosis or other complications. To facilitate comprehension of the complete standardization of the procedure, a graph is depicted in Fig. 24.26.

24.3.10 Leak Test and Completion of the Procedure

The ST is moved to a steep Trendelenburg position in order to verify anastomosis integrity with a pneumatic test. The anastomotic region is covered with saline, and while the surgeon uses atraumatic clamps to close the afferent and efferent SB limbs (right and left hand, respectively), the anesthesiologist insuflates ~20 cc of

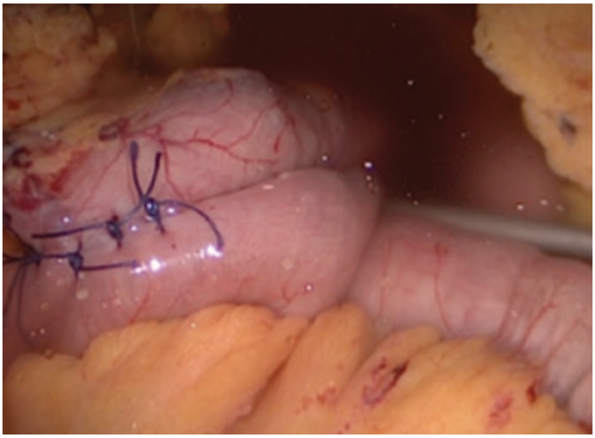

Fig. 24.27 Pneumatic test to confirm anastomosis integrity and to rule out obstruction at this level

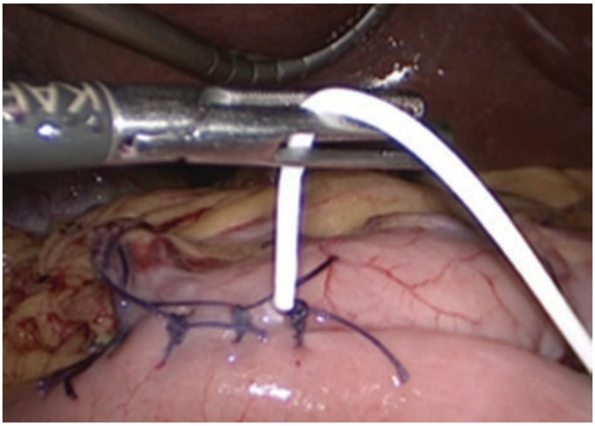

Fig. 24.28 Fibrin or chemical glue is applied to the anastomotic surface and stapled regions of the gastric pouch and remnant

air through the calibration tube (tip positioned proximal to anastomosis). Besides checking for leaks, this test also assures adequate passage of air through both limbs, ruling out obstruction at this level (Fig. 24.27). Air is then aspirated and the calibration tube is pulled all the way out. Intra-abdominal fluid is carefully aspirated and the ST is turned again to its usual position. Potential bleeding sites are all inspected, and if necessary, hemostasis is done with titanium clips. Fibrin glue (Tissucol®-Baxter, USA) or chemical glue (Ethibond®, France) is applied to the anastomotic surface and stapled regions of the gastric reservoir and remnant (Fig. 24.28), and the greater omentum is tucked and adhered to them (Fig. 24.29). A penrose drain is positioned from the left sub-diaphragmatic space, running under the left and right hepatic lobes and brought out through the 5-mm right subcostal incision; this leaves all the drain in the supra-mesocolic space so that in case of a leak, such space is blocked limiting intra-abdominal dissemination and its dreaded

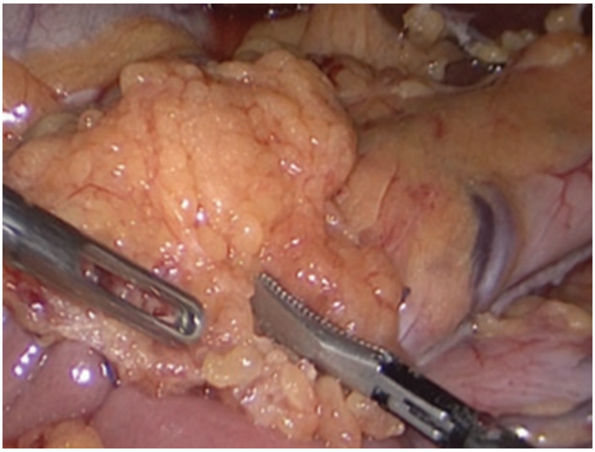

Fig. 24.29 Portions of greater and/or lesser omentum stuck as a patch on the anastomotic surface

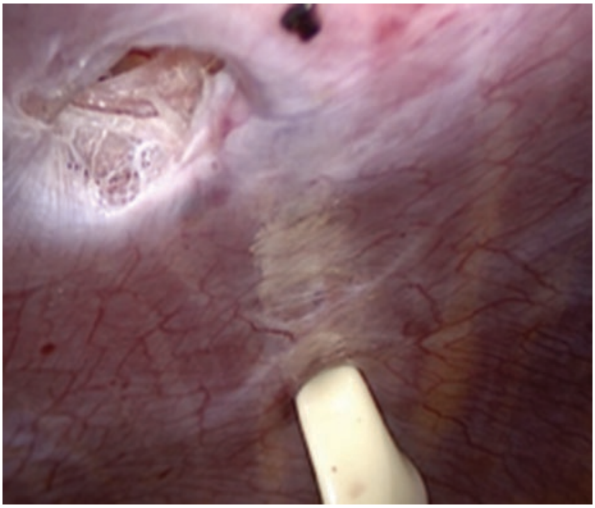

Fig. 24.30 Trocars are pulled out under direct vision to seek for bleeding at these sites

consequences. Lastly, trocars are pulled out under direct vision (Fig. 24.30), so that if bleeding is found, it can be taken care of with v diathermy or trans-parietal sutures. Use of atraumatic, bladeless trocars (as previously described) that penetrate through muscular dissection, rather than cutting, has made this possibility virtually impossible.

24.4 Postoperative Management

Trocar incisions are re-infiltrated with 0.5% bupivacaine and closed with staples; skin sutures are used in cases of bleeding or extreme obesity. Average operative time is 90 min; it can be extended ~30 min in cases of truncal (central) obesity and/or when other simultaneous procedures are performed (i.e cholecystectomy, hiatal hernia repair, extensive adhesiolysis, etc.). OAGB as a revisional operation takes the longest time (~180 min).

Patients are extubated in the operating room and taken directly to the surgical ward. Intravenous analgesics and anti-emetics are given through a pump during the first postoperative hours, and regulated according to patient's progress and pain sensitivity. Twelve hours after the operation, the patient starts walking and an upper gastrointestinal hydrosoluble contrast swallow (Gastrografin®- Bracco Diagnostics, Canada) is routinely performed to verify patency, rule out leaks, and provide a baseline postoperative map (Fig. 24.31). The urine catheter is then removed and the patient is more actively mobilized. A clear liquid diet is then started with swallows of 30 mL every 15 min. Patients usually tolerate this regimen well, their drain is removed, and they are discharged ~24 h postoperatively with specific indications regarding diet, activities, and medications. The drain is left in place and removed at the first office visit only in patients with unusual operative bleeding, a higher risk for postoperative bleeding (i.e., liver failure), and complex operative cases (i.e., re-operations and revisional cases).

Our initial postoperative ambulatory clinical evaluation is done two days later. The drain is removed (if it was not done prior to hospital discharge). Nutritional assessment and our complete protocol of dietary guidelines to follow during the next months, as well as the list of supplements, vitamins and minerals to be strictly taken, are given. Finally, scheduling for the next clinical and biochemical evaluations (at 3, 6, 12, 18, 24 months, and then annually for life) is discussed with patient and family.

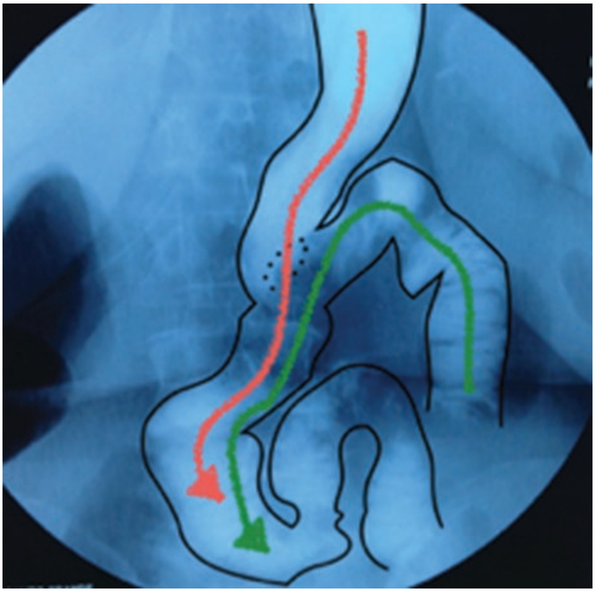

Fig. 24.31 Upper GI hydrosoluble contrast swallow to verify patency, rule out leaks, and provide a baseline postoperative map. Anastomotic opening is shown as a dotted circle, orange arrow indicates flow from gastric pouch to common channel (efferent limb), green arrow points out flow from bilio-pancreatic limb (afferent limb) to common channel (efferent limb)

Conclusions

Among all bariatric and metabolic operative techniques described until today, during the past 15 years and after thousands of procedures performed worldwide, OAGB has been demonstrated to be a robust, safe and efficacious alternative which does provide an important and long-lasting restrictive component, but especially a decisive malabsorptive element, particularly to fatty foods and complex carbohydrates, which upholds and magnifies its excellent results in the long-term.

OAGB has a shorter and simpler learning curve than other complex procedures. It leads to lower perioperative morbidity, and greater, durable weight loss and metabolic results, when compared to either purely restrictive or standard mixed procedures, providing patients with a long-term outstanding quality of life. OAGB may be comparable to the more complex, purely malabsorptive techniques in its weight loss and metabolic benefits, but definitely not in their technical difficulty, long learning curve, dramatic collateral effects, and rate of complications and revisions.

Complete SB measurement, tailoring degree of malabsorption to overall characteristics of each patient, and our "anti-reflux mechanism" with its particular configuration of latero-lateral anastomosis are among the differentiating factors that are progressively making OAGB play a superior role in present and future bariatric and metabolic surgery.

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Results of the One-Anastomosis Gastric Bypass (OAGB): Safety, Nutritional Considerations and Effects on Weight, Co-Morbidities, Diabetes and Quality of Life

25

Enrique Luque-de-León and Miguel A. Carbajo

Abbreviations

BMI	Body mass index
BP	Biliopancreatic
BR	Bile reflux
BS	Bariatric surgery
EAC	European accreditation council
EG	Esophago-gastric
EW	Excess weight
EWL	Excess weight loss
FU	Follow-up
GERD	Gastroesophageal reflux disease
GI	Gastrointestinal
HP	Helicobacter pylori
IFSO	International Federation for the Surgery of Obesity and Metabolic Disorders
IWQoL	Impact of weight on quality of life
LAGB	Laparoscopic adjustable gastric banding
LOS	Lenght of stay
LSG	Laparoscopic sleeve gastrectomy

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LSML	Left subcostal mini-laparotomy
MGB	Mini-gastric bypass
MO	Morbid obesity
MU	Marginal ulcers
NPO	Nil per os
OAGB	One anastomosis gastric bypass
PPI's	Proton pump inhibitors
QoL	Quality of life
RYGB	Roux-Y gastric bypass
SB	Small bowel
SBO	Small bowel obstruction
TPN	Total parenteral nutrition
WL	Weight loss
WR	Weight regain

25.1 Introduction

Obesity is a multifactorial predominantly metabolic disease with an exponential and alarming increase in its incidence worldwide [1]. Besides its devastating effects on health, the chronic, progressive and disabling nature of the illness, also causes countless personal, economic and social losses [2, 3]. Surgical treatment is currently the only available option to achieve substantial and durable excess weight loss (EWL), as well as remission and/or improvement of its life threatening comorbidities, and a greater life expectancy [4–6].

Besides its clear benefits, bariatric surgery (BS) has also provided some insight in regard to the pathophysiology of obesity as a human metabolic condition [7]. Thus, in spite of the (technical) involvement of the gastrointestinal (GI) tract, BS should be considered metabolic in essence (rather than digestive), since its main goal is to control a severe metabolic disorder. In this sense, the "ideal" operation should focus on achieving the greatest efficacy through the least aggression; among other reasons, this is in order to prevent appearance of new problems (particularly digestive).

In recent years, there has been a boost in the practice of bariatric and metabolic surgery (especially after laparoscopy entered this arena). There are now many techniques and many surgeons trying to find the "golden pond" [8]. The current spectrum varies from "simple" restrictive operations to "complex" procedures that completely alter digestive structure and function. Although some techniques have clearly set apart from others, increasing types of procedures for morbid obesity (MO) indicate there is still no "ideal" bariatric operation. In its search, besides widely known and used parameters like morbidity, mortality and long-term outcomes, several more specific variables need to be considered, such as steepness of learning curves (and their consequences), rates of conversions, re-admissions and re-operations, among others.

After Mini-gastric bypass (MGB) was first presented and later reported [9], we assessed the possibility of changing from the Roux-en-Y gastric bypass (RYGB) which was being performed at that time in our Centre, to perform an operation with all the advantages of a mixed procedure and presumably less complexity and potential complications. As many others, we were disturbed by the possibility of alkaline reflux and its inherent consequences; thereby, we devised an anti-reflux mechanism. Through time, other adjustments to the technique have been devised in order to improve its safety, durability of EWL and outcomes (*see* Chap. 24). In our original publication [10] the term "One Anastomosis Gastric Bypass (OAGB)" was coined for this modified procedure. We were quite positively impressed with our initial results, and since 2002 have adopted OAGB as our main procedure for almost all kinds of patients being submitted both to primary and most revisional operations.

This chapter describes our results and long-term outcomes and is primarily based on our sequential published series and presentations, last one of which comprises a total of 3000 patients [10–13]. Comparative results with other common bariatric operations based on the International Federation for the Surgery of Obesity and Metabolic Disorders (IFSO) European Accreditation Council (EAC) in BS Registry, are also included in a summarized fashion.

25.2 Follow-Up at Our Center of Excellence

Optimal follow-up (FU) is essential for well-founded outcome reporting. It also serves as a tool to assess how rigorously patients are carrying on specific and sequential indications regarding diet, activities, medications and supplements to be consumed at different postoperative stages. Moreover, objective unbiased FU indeed serves as a method for self-auditing.

At our Center, postoperative FU office visits for clinical and biochemical evaluation are scheduled 3, 6, 12, 18, and 24 months after surgery, and yearly thereafter. Endoscopic (control) studies are usually planned for all patients completing a 5-year FU, as well as for those referring persistent upper GI symptoms (including esophageal reflux). Other ancillary studies are ordered as needed. Along with preoperative psychological analyses, a quality of life (QoL) baseline assessment is applied using the Impact of Weight on QoL (IWQoL) survey [14]; this latter is repeated at periodic postoperative office evaluations and data entered into a specific program for monitoring purposes.

Most of our patients come from different regions of our nation, and more recently some have been referred from other countries as well. In order to complement direct in-office consultation, which may be difficult to fully accomplish with this referral pattern, we have established mechanisms to keep close contact with our patients and referring physicians through telephone and/or electronic means. When unable to attend, we ask patients to respond questionnaires and send their biochemical tests periodically; the electronic FU report is as objective as possible and includes all data to be assessed during an in-office visit. Moreover, a dedicated web page which contains a blog and forum is continuously being updated; here patients can retrieve all kinds of information, and maintain communication with any member of our team, and with other patients as well. Validation of our methods has come from the meticulous and increasing requirements for re-certification by the IFSO's EAC-BS as a Centre of Excellence which also consistently lead us in our quest to improve overall FU.

25.3 Perioperative Data and Outcomes: Demographics and Operative Data

Although mean age in our patients has been similar through time (41–43 years old), we have progressively operated more patients at the extremes of life (12–74 year-old patients). Long-term FU has demonstrated the safety and efficacy of OAGB even in patients just entering their adolescence [15]. In regard to gender, an important shift was seen in female to male ratios from 4/1 to 1.5/1 starting around the year 2004. This is rather uncommon in large series and perhaps demonstrates the good outcomes OAGB has led to in this type of more difficult patients.

Mean body mass index (BMI) and excess weight (EW) have also been similar, with a large percentage of patients with super-obesity (BMI > 50 kg/m^2) and a top value of 86 in BMI and 220 kg in EW. Although we do not endorse step management in these latter patients (i.e. use of intragastric balloon or sleeve gastrectomy prior to OAGB), a thorough preoperative preparation is mandatory. This includes a reduction of at least 20% of their EW prior to surgery. Most of our patients successfully achieve this through a specifically designed diet protocol which includes an 800 calorie/day pure high-protein diet with micronutrients and vitamins *(Vegefast-Complet®-Vegenat,Spain)*, and a complete liquid diet starting 5–7 days prior to the operation [16].

At the initial part of our series patient inclusion was according to criteria proposed by the National Institutes of Health Development Panel [17]; these included a BMI > 40 kg/m^2 or a BMI > 35 kg/m^2 with severe related co-morbidity (range in BMI was 39–86). However, in accordance with current recommendations [18], more patients with Class I obesity and metabolic comorbidities have progressively been included (our BMI range is currently 31–86).

Our cohort of patients has been composed by different subgroups which includes: (A) Primary OAGB (patients with no previous or simultaneous abdominal operations), ranging through time from 50% to 60%, (B) Patients with prior open abdominal operations (that required adhesiolysis of variable complexity), and those who had abdominal operations performed simultaneously (particularly gallbladder removal and/or hiatal or ventral hernia repairs), totalling 40–45% of the group, and (C) Patients in whom laparoscopic OAGB was performed as a revision of other (failed) bariatric restrictive procedure, initially including laparoscopic adjustable and non adjustable gastric bands, as well as open vertical banded gastroplasties, and more recently after sleeve gastrectomies; this subgroup has been progressively increasing over time to a total of 3–4%.

In spite that OAGB unquestionably provides reduced difficulty when compared to other complex procedures, we have emphasized it should not be promoted as a very simple, easy and rapid operation. As would be expected, our operative time varies for each subgroup of patients and did improve during the learning experience [10–13]. It is now rather stable and similar to that reported by many others [19], but definitely falls short when compared to the original MGB's *"thirty minute case"* [9, 20]. Besides the fact that speediness is not among our goals, there are several modifications in OAGB which have been clearly explained in Chap. 24 and prove time consuming. On the other hand, mastering and performing standard techniques is directly related to better outcomes; overall, both MGB and OAGB have proven to be highly reproducible techniques associated with shorter learning curves in contrast with RYGB and other more intricate mixed or purely malabsorptive procedures [21–23].

25.4 Perioperative Outcomes

Soon after the operation, patients are able to stand and walk for progressively longer intervals. Passage of GI gasses is also rapid, and besides some use of intravenous analgesics during initial postoperative hours, there is almost no need for further pain medications; recovery is thus normally quick and uneventful. As a consequence, length of stay (LOS) is short, and has decreased from a mean of 36 h. for uncomplicated patients (95%) at the beginning of our series [10], to a current mean of 24 h. for patients without morbidity (now almost 99% of the whole group); this LOS is one of the shortest reported so far after either MGB or OAGB [19, 24]. Although we recommend relative rest at home during 5–7 days, most patients report being able to engage in almost all normal activities shortly after being discharged.

25.5 Morbidity and Mortality

In order to better describe adverse events after OAGB we have listed all early and late complications and side effects as was recently published after our long-term FU with 1200 patients [11] in Table 25.1. Most of them occurred during the initial part of our experience; thus, few changes have been added in our recent analyses of our whole series with 2600 [12], and more recently 3000 patients [13]; these latter will rightfully be emphasized when appropriate. Furthermore, the section on *early* complications starts with a chronologic assessment of adverse events and how they were managed, and finishes with a breakdown and thorough analysis of each subgroup of complications. Evaluation of *late* complications on the other hand is done in an integrated fashion.

Table 25.1 Complications and side effects following laparoscopic one anastomosis gastric bypass (OAGB) in 3000 morbidly obese patients

	n (%)	Treatment/Comments
Intraoperative complications requiring conversion to open surgery	**4 (0.13)**	
Intra-abdominal bleeding	2 (0.07)	LSML
EG junction perforation (calibration tube)	1 (0.03)	LSML (conversion to distal RYGB)
Incorrect gastric transection	1 (0.03)	LSML (conversion to distal RYGB)
Immediate postoperative complications resolved by open re-operations	**6 (0.2)**	
Intra-abdominal bleeding	2 (0.07)	LSML
Leaks (anastomotic/gastric reservoir)	2 (0.07)	LSML/One with prosthesis (placed radiologically)
Small bowel obstruction	1 (0.03)	LSML/Afferent limb torsion
Partial necrosis of excluded stomach	1 (0.03)	LSML/Patient died with nosocomial neumonia
Immediate postoperative complications resolved by re-laparoscopy	**17 (0.57)**	
Intra-abdominal bleeding	10 (0.3)	Solved laparoscopically
Leak (anastomotic/gastric reservoir)	2 (0.07)	Solved laparoscopically/Prosthesis (placed endoscopically)
Small bowel obstruction	3 (0.1)	Solved laparoscopically/Adhesion (trocar incision—efferent limb)/NO internal hernias
Acute dilation excluded stomach	2 (0.07)	Solved laparoscopically
Early postoperative complications resolved conservatively	**12 (0.4)**	
Leaks (anastomotic/gastric reservoir)	10 (0.3)	Medical treatment (NPO and TPN)/ Endoscopic prostheses placed in two
Acute (postoperative) pancreatitis	1 (0.03)	Submitted to laparoscopic OAGB and cholecystectomy
Infected hematoma	1 (0.03)	Percutaneous drainage
Major late complications	**39 (1.3)**	
Gastro-enteric (stomal) stenosis	9 (0.3)	Pneumatic endoscopic dilation (7), endoscopic coated prosthesis (2)
Anastomotic or marginal ulcer	30 (1)	Medical treatment & one operation/Acute UGI bleed or chronic persistent pain All had risk factors
Other complications and side effects		
Espohageal clinical reflux	~2%	Medical treatment
Malnutrition (protein)	29 (0.97)	Medical treatment/Some readmitted for IV supplementation/One revisional operation
Severe iron deficiency anemia	40 (1.33)	Medical treatment (parenteral iron)

Table 25.1 (continued)

	n (%)	Treatment/Comments
Mild iron deficiency anemia	Up to 30%	Medical treatment (oral iron)
Nausea/Vomiting	15 (0.5)	Early readmission and medical treatment
Hair loss/Iron/Folate/B12 deficiencies	Variable	Medical treatment/Improvement after intestinal adaptation
Diarrhea/bad fecal odor	Variable	Medical treatment/Improvement after intestinal adaptation

LSML left subcostal mini-laparotomy, *RYGB* Roux-en-Y gastric bypass, *EG* esophago-gastric, *NPO* nil per os, *TPN* total parenteral nutrition, *UGI* upper gastrointestinal, *IV* intravenous

25.6 Early Complications—Description

Intraoperative complications requiring conversion to an open approach have occurred in only four patients (0.1%). Intra-abdominal hemorrhage could not be controlled laparoscopically in two cases, esophago-gastric (EG) junction was perforated by the calibration tube in one patient, and one incorrect gastric transection in a patient with severe inflammation of the cardio-oesophageal region happened in another; the latter two required conversion to distal RYGB with esophago-ileal anastomosis. Noteworthy is the fact that these few cases occurred during our initial experience, and no conversions to an open approach have been required thereafter. Moreover, all were done through a left subcostal mini-laparotomy (LSML); this approach has been described previously [25], and was utilized by our group routinely in the open bariatric era [26].

Early major complications requiring reoperations increased slightly in total number, but decreased in percentage from 16 (1.3%) in our published long-term FU [11] to 23 (0.76%) in our whole series analysis [13]. Numbers in this latter included intra-abdominal bleeding in 12 (2 solved through LSML and 10 through laparoscopic means) and leaks in 4 (2 solved by LSML and 2 by re-laparoscopy; some required temporary coated prostheses). Also, early small bowel obstruction (SBO) developed in 4 patients. One of them had a long history of severe constipation with chronic use of multiple aggressive laxatives, suffered afferent limb torsion and was treated by LSML; the other three patients were treated through a laparoscopic approach. Internal hernias were not found as a cause of SBO in any of these cases.

Rare complications included partial necrosis of the excluded anterior gastric wall of unknown cause in one patient and acute dilation of the excluded stomach in two others. The former occurred very early in our series [10] in a patient with a BMI > 70 who required a traqueostomy for intubation. The tube was displaced and severe abdominal pain developed a few hours after the operation, re-laparoscopy disclosed extensive necrosis of the excluded stomach (predominantly body and antrum) which was resected through LSML. We hypothesized genetic absence and/or operative lesion (embolism) of the right gastric artery may have contributed in this case. This patient eventually died due to nosocomial neumonia. In the other two patients, the excluded stomach and afferent limb were completely filled with several liters of bilio-pancreatic secretion. Through re-laparoscopy, SBO was ruled out and anastomosis integrity verified. Decompression was obtained through a nasogastric tube positioned into the afferent loop and a tube gastrostomy; the former was removed upon discharge (48 hours later). These patients had an uneventful course and gastrostomies were removed on an ambulatory basis.

Successful conservative treatment of early major complications was achieved in 12 patients (0.4%). This number did not change at all between our published long-term FU [11] and our whole series analysis [13]. Leaks occurred in 10 and were treated with nil per os (NPO) and total parenteral nutrition (TPN); an endoscopic prosthesis was placed in two of them. Another patient submitted to laparoscopic cholecystectomy and OAGB developed acute (post-operative) pancreatitis. A further patient had an infected hematoma which was solved by percutaneous drainage under radiological guidance.

25.7 Early Complications—Integrated Analysis

25.7.1 Leaks

Leaks represent a dreadful complication inherent to BS. Besides several well-known patient risk factors, there are various procedure related ones which may determine their incidence and outcomes. OAGB entails no enteric sectioning and all the intestinal vascular arcade supplies the peri-anastomotic area; thus, blood flow in OAGB (compared to RYGB), may be higher and hasten tissue healing. Furthermore, this avoidance of enteric sectioning along with a much longer pouch provides less mesenteric and vascular traction. OAGB's antireflux mechanism further decreases tension (*see* Chap. 24). As a result, even though leaks were one of our most common complications initially, our leak rate has always been within range or even lower than most other MGB/OAGB [19, 24, 27], RYGB [28] and laparoscopic sleeve gastrectomy (LSG) series [29]. Going beyond the learning curve was noted by a decrease from 1.9% in our first 209 patients [10] to 0.5% in those operated thereafter [11–13].

Remarkably, most leaks could be managed conservatively. OAGB's previously described anatomic features may lead to better outcomes with non-operative treatment. This is in contrast to other procedures where several authors state leaks may be hard to manage and increase mortality rates [28, 30–32]. Although some allege leaks after MGB/OAGB are more difficult to control due to presence of biliopancreatic (BP) secretion in the anastomotic region [33, 34], we have not experienced these troubles. We systematically only follow conservatively patients that are clinically stable without systemic and/or intra-abdominal manifestations. Effluent of these leaks must be adequately drained and should be localized only in the supramesocolic compartment. Management includes NPO, and in some cases TPN; successful non-operative management usually starts with low and progressively decreasing outputs. Routine closure confirmation is done both fluoroscopically and with methylene blue tests.

Incidence and management of leaks vary among MGB/OAGB surgeons. Rutledge [20] reported a 1.08% leak rate and opted for a less conservative approach; when suspected early after operation, all patients were re-explored through laparoscopy. Also, Chevalier, et al. [35] had six leaks (0.6%); three were anastomotic, and all were reoperated. In contrast, Musella et al. [36] had 10 leaks (1%) and classified them according to origin; all five gastric pouch leaks required operative treatment, but two gastric remnant and 2 out of 3 anastomotic leaks were treated conservatively. Lowest leak rate has been reported by Kular, et al. (0.1%) [37]; treatment was not described in their article.

25.7.2 Bleeding

Although intra-abdominal bleeding was the second most common complication, overall our rate (0.46%) compares positively with other MGB/OAGB series [19, 24]. This problem ocurred in 4 cases (1.9%) during our learning curve and lead to conversion to an open approach in 2 (representing half of all our conversions throughout the whole series), and 2 early open re-operations [10]. Thereafter, as more experience with the procedure was gained, we have had only 10 cases (0.35%), which have all been solved through re-laparoscopy.

Hemodynamically stable patients in whom hemoperitoneum is suspected, may be managed expectantly; staple lines are frequently the origin, and bleeding stops spontaneously [38]. When operated, active bleeding is frequently not identified, but reoperations do help with removal of multiple blood clots which may cause symptoms or get contaminated; as previously described, an infected hematoma eventually happened to one of our patients.

25.7.3 Small Bowel Obstruction

Far below these complications, there were four cases (0.1%) of SBO in our whole series. All presented early and required reoperations (LSML in one and re-laparoscopy in the others). In contrast to SBO after Laparoscopic RYGB which is usually associated with internal hernias [39], these latter were not the cause in any of our cases. Their absence has also been reported in most other MGB/OAGB series [19–24, 27, 35–38].

Since small bowel (SB) is not transected, there are no mesenteric defects to close after OAGB. Furthermore, although there is a slight controversy, most MGB/OAGB surgeons (including us), believe there is no need to close Petersen's space [19–24, 27, 35–38]. Thus, in spite of not closing mesenteric defects or spaces, there were no internal hernias in our experience; this has also been reported in most other MGB/OAGB series [19–24, 27, 35–38]. An almost nil incidence of internal hernias represents a great advantage compared to laparoscopic RYGB, where these have been found in up to 16% of patients [40]. Moreover, although their clinical presentation may be varied, some may present many years after the operation with symptoms that range from simple chronic abdominal pain to frank bowel necrosis and lead to difficulties for a timely diagnosis and sometimes even fatal outcomes [39–42].

25.7.4 Other Early Complications

Other rare early complications were present. Technical difficulty during our learning curve led to an EG perforation by the calibration tube in one patient, and an incorrect gastric transection in another. Also, the excluded stomach suffered partial necrosis in one more case, and acute dilation in another. This latter complication has been found more commonly after RYGB as a result of closed-loop BP limb obstruction which may end up with catastrophic outcomes [43]. The only other case reported after MGB [44] was related to gastric remnant outlet obstruction due to marked narrowing at the incisura angularis caused by wrong positioning of the first transverse stapler; after excluding SBO, it was successfully managed by decompression through image-guided placement of a gastrostomy tube. In our case we ruled out SBO and placed a tube gastrostomy through re-laparoscopy. Finally, we had one case of postoperative acute pancreatitis, and one infected hematoma; both were successfully treated non-operatively.

25.8 Late Complications—Description and Integrated Analysis

25.8.1 Anastomotic Stenosis

Although the number of stomal stenosis increased slightly (from 6 to 9), overall percentage decreased from 0.5% to 0.3%. Most of them occurred during the initial part of our series when anastomotic size ranged from 1.5 to 2 cm [9]. We then changed to a 2.5–3 cm stoma, and have decreased this problem significantly. As is usual, most of these patients (~80%) were successfully treated through endoscopic dilation; only two required further endoscopic placement of a temporary prosthesis due to failed treatments. We came to know of another patient (lost to FU) who was submitted at another hospital to repeated endoscopic dilations, and eventually suffered a perforation that required urgent operative treatment.

Risk factors for gastroenteric (stomal) stenosis include anastomotic tension, ischemia and subclinical leaks; our overall rate is within range and even lower than other MGB/OAGB series, and much better than most RYGB series where strictures may complicate >25% of patients [45]. A potential culprit for this higher rate is the restrictive nature of standard RYGB which includes a narrower (~1.2 cm) anastomosis [45]. A further problem is that although most are initially treated with endoscopic dilations, up to a third may end up needing a reoperation and its attendant problems [46].

25.8.2 Marginal Ulcer

In our initial long-term FU [11], 6 patients (0.5%) developed anastomotic or marginal ulcers (MU). These increased in number (to 30) and doubled in percentage (to 1%) in our most recent analysis with 3000 patients [13]. Most have appeared acutely with upper GI bleeding and without previous signs or symptoms; a few have presented in a more chronic fashion with persistent epigastric pain. Risk factors which have been found in our patients include presence of helicobacter pylori (HP), chronic oral ingestion of aggressive medications (without adequate gastric protection), as well as important alcohol and tobacco consumption; these latter three despite our continuous specific written and verbal recommendations and warnings. Noteworthy is the fact that most have recovered with medical treatment, and only recently did we have the need for operative treatment in the management of one patient.

An initial argument against MGB-OAGB was its potential higher rate for MU and lower response to their medical management [34]. Systematic reviews have found a 0.6–4% incidence for large series [19, 24, 27]; this is lower to MU rates after RYGB which have a wide range, but may affect as much as 25% of patients [47]. Other risk factors which are not related to bile reflux (BR) have been described such as type of suture materials, gastric pouch position and use of anti-inflammatory drugs [47]. Furthermore, an increment in acid production in an oversized pouch has been proposed as another potential cause; we and others hypothesized peri-anastomotic bile in MGB/OAGB may actually buffer acid's ulcerogenic effect and have a protective role [11, 35].

Our current MU rate of (1%) is one of the lowest reported for any type of gastric bypass. Besides the type of procedure, perhaps our scrupulous and detailed explanation of risk factors and ways to avoid them, has had an effect to this end. Whether our anti-reflux mechanism has further benefits, is difficult to ascertain. Moreover, besides the low rate of MU, all our patients, and those in most other MGB/OAGB series [19–24, 27, 35–38] have demonstrated a good overall response to medical treatment, responding to proton pump inhibitors (PPI's), sucralfate and HP eradication when needed.

25.8.3 Bile Reflux

Incidence of occasional esophageal clinical reflux has been reported at a stable figure of ~2% in all our evaluations. Patients usually report symptoms are sporadic and include a bitter and/or sour sensation, unfrequently reaching the throat; these episodes are associated with dietary transgressions, occur most commonly at night and after a short interval between dinner and bedtime.

When performed, endoscopic studies in these patients may reveal presence of some bile in the peri-anastomotic area with mild to moderate pouch gastritis in some, but no bile in the esophagus and/or esophagitis whatsoever. Dietary recommendations are emphasized, and sucralfate and PPI's are prescribed; this usually solves the problem, and we have had no patient with persistent problems of reflux symptoms. To the best of our knowledge no patient of ours has been re-operated elsewhere due to "intractable" BR. Moreover, at completion of a 5 year FU, regardless of symptomatic status, we program control endoscopic studies for all patients. Most of them contend they are completely asymptomatic and refuse to have the study done. Thus, we have been able to comply with our plan in only ~20% of our patients. Endoscopic reports have usually included no significant findings; importantly, there have been no cases of esophageal reflux and/or esophagitis, signs of acute or chronic stomal or MU, or worrisome histological changes. Mild to moderate pouch gastritis was found in ~10%, and presence of HP in ~3–4%. These patients are treated accordingly.

BR was the main reason that led to abandon the old Mason's loop [48]. Since MGB and OAGB have been confused with this latter procedure, increased gastroesophageal exposure to bile, and its potential consequences have been the main criticism against MGB/OAGB from the time they were first proposed and presented. MGB's anatomical configuration make esophageal BR highly improbable. Our OAGB (antireflux technique) takes this a step further (*see* Chap. 24). BR to the stomach on the other hand, is found both physiologically [49] and after some GI operations [50, 51]; MGB and OAGB are no exception. However, symptomatic, endoscopic and histologic deleterious effects arising from the presence of bile in the stomach have not been clinically relevant or conclusively proven [52]. Overall most series report symptomatic gastric and/or esophageal BR after MGB/OAGB has been rare. When present, most identify specific triggers and agree it is easily treated medically [19–24, 27, 35–38].

Ancillary studies have been carried out by other MGB/OAGB surgeons. Chevallier, et al. [53] found very few peptic ulcers and follicular hyperplasia, but no esophageal changes or other significant findings in asymptomatic patients enrolled in a postoperative endoscopic screening program similar to ours. Musella, et al. [36] performed postoperative endoscopies in 26 (3%) symptomatic patients with prolonged dyspepsia, epigastric pain, heartburn and vomiting; they found MU (1.7%) and biliary gastritis (0.9%), but no other significant finding; all responded to medical therapy. Moreover, Tolone, et al. [54] evaluated the potential effects on EG junction function preoperatively and one year postoperatively through clinical assessment, endoscopy, high resolution impedance manometry, and 24-hour pH-impedance monitoring; results were compared with a group of patients submitted to LSG. After MGB, there was no heartburn or regurgitation, esophagitis, biliary gastritis or presence of bile; also, manometric patterns did not vary (from preoperative). Intragastric pressure, gastroesophageal pressure gradient and reflux events (acid, weakly acid and even weakly alkaline), all significantly diminished. In contrast, due to the pylorus (which represents a functional obstruction), LSG led to a significant elevation in all these latter parameters, demonstrating a significant increase especially in esophageal acid exposure. This observation has also been found in several studies, making gastro-esophageal reflux disease (GERD) and/or Barrett's esophagus a contraindication for LSG [55, 56]. Reoperations for intractable GERD after LSG are not infrequent [57]. On the other hand, the unjust fame for increased esophageal BR has led bariatric surgeons and even some MGB-OAGB supporters to contraindicate the procedure in obese patients with GERD for fear of worsening the condition [35]. We believe this in essence is wrong since OAGB has in fact demonstrated to relieve or improve symptoms of GERD in most patients *(see below)*.

Although extremely rare, some patients have required reoperations due to "intractable" BR [35, 58]. Among MGB/OAGB groups this has ranged from 0% (most series) to 0.7%. Detractors have also reported reoperations due to BR [34]. However, this is in a collection of complications, and as they accept, the denominator in their series is not known. Besides, "intractability" is not described precisely. Patients with postoperative GI symptoms should be classified and categorized appropriately. OAGB poses a distinct course and phases of GI adaptation which should always be considered so as not to blame BR as the culprit of any dyspeptic symptom. A recent definition of BR after MGB included bilious vomiting and/or documented bile in the esophagus on upper GI endoscopy with presence of GERD-like symptoms [37]; the authors proposed differentiating BR from vague symptoms that characterize "dyspepsia". Before considering a reoperation due to "intractability", objective and clear definitions must be made in regard to symptoms, diagnostic approach and appropriate sufficient medical treatment. When needed, these few reoperations are usually performed in patients who have already achieved significant EWL and metabolic benefits, and are thus often times technically not demanding and very effective. Alternatives have included conversion to RYGB (with or without gastric pouch shortening) and Braun entero-enterostomy [34, 35, 58].

Finally, when reoperations due to "intractable" BR are carried out, preoperative (endoscopic) and operative findings are often times not reported [34]. This information is essential because operations resembling the old Mason's loop are erroneously being labeled as MGB or OAGB. They are characterized by short gastric reservoirs and/or short SB bypassing, which place undiluted BP secretion in the vicinity of the esophagus and promote harmful symptomatic esophageal BR [59, 60]. We have previously emphasized the importance of performing standard operative techniques in order to optimize outcomes and elude the need for reoperations [61].

25.8.4 Bile Reflux and Gastro-Esophageal Cancer

Although gastric BR after Billroth II gastrectomy has been associated with stomach cancer [62], this concept has not been conclusively proven and is not shared by many authors [63]. More recent systematic studies portend there are several potential risk factors for the development of gastric cancer besides BR [64]; furthermore, they all may act as confounding variables which would have to be isolated through multivariate analyses in order to reach valid conclusions. HP was not considered in older studies [65], and current research indicate it may well be one of the most significant factors. This data underscores the importance of its timely identification and treatment, not only in patients considered for OAGB, but for all other bariatric procedures as well.

In regard to the esophagus, in-vitro studies have shown bile can stimulate production of inflammatory mediators and lead to changes in the genetic expression to intestinal metaplasia [66]. However, there seems to be no association between gastric bile and Barrett's esophagus [67]. Also, in patients with GERD, the correlation of bile in the distal esophagus with Barrett's esophagus is not as important as that of acid reflux [68].

Cancer development has not been found in our group of patients or in any other large MGB/OAGB series [19–24, 27, 35–38]. The only case of cancer reported thus far, originated in the excluded stomach (unrelated to BR) in an asian patient 9 years after MGB [69]. However, since gastro-esophageal cancer may appear 20–30 years postoperatively [70], this evidence may not seem strong enough. Nevertheless, data from the highly criticized and abandoned old Mason's loop can be used to complement ours. In spite of its proven BR, this procedure has not been associated with esophageal cancer, and there is only one case of gastric pouch cancer 26 years after [71]. The only other 3 reports of cancer after Mason's loop were in the bypassed stomach, but these of course were not related to BR, and they have also been found after other bariatric operations as well [72].

Overall, cancer arising in the gastric pouch or distal esophagus has been reported after several bariatric operations including LSG and RYGB [72]. It seems unfair that in spite that LSG has unequivocally been associated with de novo or exacerbation of GERD [73, 74], and GERD has been demonstrated to lead to Barrett's esophagus and cancer [75], it has been MGB/OAGB (and not LSG), the procedure that has been under meticulous investigations for a potential cancer risk, which has so far not been found.

25.8.5 Malabsorption/Malnutrition

In the beginning we followed the original MGB in regard to limb lengths (fixed 200 cm of BP limb [9]). Overtime, we have progressively increased to a range of 2.5–3.5 m, based primarily on total SB length and BMI, but also on other parameters as well (*see* Chap. 24). Tailoring extent of bypassed SB has also been performed by other MGB/OAGB surgeons [76–78]. Our OAGB technique must currently be considered a malabsortive procedure. In theory, increased malabsorption could lead to more side effects and malnutrition, however, this has not been the case in our series. A few patients have experienced excessive weight loss (WL) and/or subtle protein deficiencies (especially between the sixth and twenty-fourth month), but most have been successfully controlled and managed on an ambulatory basis with dietary recommendations, particularly once intestinal adaptation is achieved.

In all our assessments only ~1% of our patients have required further ambulatory treatment based mainly on high-protein enteral supplements and pancreatic enzymes (Kreon®-*Abbott,Germany)* 10,000–25,000 IU with each meal during 3–6 months; hardly any of them (~15% of this subgroup) went on to be readmitted in order to receive parenteral supplementation. This rate is comparable and even slightly lower to that reported in other MGB [19–24, 27, 35–38] and even RYGB series [40]. Our strict postoperative regimen may have contributed to these figures; not surprisingly, all those with protein malnutrition confessed not following our program carefully. The only case of revisional surgery for malnutrition in our series (0.03%) came recently. The patient was originally a super-obese female with multiple autoimmune disorders, who we had to reoperate due to recurrent bouts of malnutrition. Common channel lengthening from 150 to 260 cm was performed keeping the original anastomosis intact; the operation has thus far normalized her nutritional status. Experience from other MGB-OAGB surgeons includes that of Chevallier et al. [35], who at the time had not reversed any patient, but reported malnutrition in 2 (0.2%) which were with TPN under evaluation for a reoperation. They also noted deficiency problems always involved noncompliant patients. In the very few cases of reoperations reported by others, alternatives have included reversal to a normal anatomy or conversion to LSG. In his larger report, Rutledge and Walsh [20] reported excessive WL in 1% of their patients; they selected gastroplasty (gastrojejunostomy division and gastro-gastrostomy) as their reoperation of choice. Lee et al. [58] revised 23 of 1322 patients (1.7%). The most common cause was malnutrition in 9 (0.7%). Based on their results, they recommended conversion to LSG due to the efficacy in improving malnutrition without regaining the body weight. Kular, et al. [37], also had to reoperate 2 (0.2%) patients. They attributed malnutrition to the longer bypass (> 300 cm) these two super-obese patients originally underwent. Noun et al. [38], reported excessive WL in 4 (0.4%) patients with reversal in 2 and conversion to LSG in the other 2. The italian group [36] submitted 7 of 818 patients (0.8%) to late reoperations; the indication was EWL > 100% in only one (0.1%). All these groups agree a laparoscopic approach with its attendant benefits in this kind of reoperations was feasible and technically not demanding.

In their highly critical article Johnson, et al. [34] reported severe malnourishment in 8 patients (unknown denominator), who were either planned to or converted to RYGB. They also pointed out that some patients had a very distal MGB (30 to 100 cm from the ileocecal valve!!). Dang, et al. [79] also reported this finding; the patient in their case report had an 80 cm common channel. BMI went from 59 to 25 (post distal MGB), to 32 (after conversion to proximal RYGB). Prior to reoperation, enteral nutrition was given through a gastrostomy tube placed laparoscopically. Regrettably, a more recent case did not make it to revisional surgery and died of severe protein malnutrition and liver failure; at autopsy, an even shorter common channel was found [80]. This very aggressive malabsorption has never been described in either the MGB or OAGB operative technique and only stresses the importance of knowing and following standard procedures [61]. Variations from original techniques can be found in any bariatric operation and should not automatically discredit original versions. Interestingly, these non MGB/OAGB surgeons converted their cases to proximal RYGB which is yet another revisional alternative.

25.8.6 Other Late Nutritional Complications and Side-Effects

During preoperative work-up nutritional deficits may be found in MO. In our series, notable ones have included iron (~10%), vitamin D (~15%) and calcium (~5%). We recommend supplementation before submitting patients to surgery. Postoperatively, a few patients may develop excessive WL and/or nutrient deficits. We recently detailed the percentage of patients with individual deficiencies in our long-term FU with 1200 patients [11]; it is worthwhile to clarify these represented laboratory values below normal range and not necessarily their clinical manifestation; thus, even subtle subclinical deficits were included. Most of them were successfully managed with dietary modifications, and insisting on compliance with our usual supplementation until intestinal adaptation was achieved.

Slight iron deficiency may be common during the first two postoperative years. Oral iron supplementation is routinely given, however, up to 30% of our patients may need it even after intestinal adaptation usually occurs. A stable figure of around 1% of our patients have required parenteral iron as part of their treatment. As would be expected, this deficit is usually more common in premenopausal women with abundant menstrual bleeding. Deficit in vitamin D was important among liposoluble vitamins; more than half of our patients were deficient at 3 years, and a third in the longer term. Many of our patients come from the Basque Country where sunshine is scarce throughout the year. To a much lower degree (<2%), vitamins A and K were deficient at 3 years, but resolved in the longer term. In regard to hydrosoluble vitamins, deficits were practically only seen in B_9 and B_{12}; it reached ~20% at 2 years, but decreased significantly to <3% at 10 years. Calcium deficit reached 8% and decreased thereafter to ~2%; supplementation was especially suggested to postmenopausal women. Other deficits were quite infrequent; signs including hair loss, dry skin and brittle nails have been usually mild and temporary. They usually resolve with intestinal adaptation and WL stabilization.

Manifestations of malabsorption such as soft stools, increased flatulence and a bad fecal odor are expressed in various degrees in most patients. They are all magnified in patients consuming processed carbohydrates and fatty foods; female patients tend to complain more. Bismuth salts, activated carbon and simeticone may help control symptoms; these usually improve in a progressive fashion as intestinal adaptation is being gained.

25.9 Readmissions and Mortality

Thirty-day readmission rate has been around 1% in our evaluations. Causes have been varied and include SBO, persistent nausea and vomiting, bleeding stress ulcers and even abstinence syndrome from psychiatric medication in patients with extreme anxiety. Although some cases have required reoperations (especially for SBO – *see above*), most problems have been solved with conservative measures. Late readmissions have seldom been required for ~1% of patients for late complications including stomal stenosis, GI bleeding due to MU, and malnourishment *(see above)*.

Our original report of OAGB [10] included mortality in two patients early in our series (0.9%); besides having super-obesity, both of them had multiple co-morbidities and risk factors. One had an uneventful early postoperative course and suffered an unexpected pulmonary thromboembolism 3 days after surgery. The other patient developed postoperative necrosis of the gastric wall, was re-operated and developed refractory nosocomial pneumonia. Many years went by and a third death was added in the most recent evaluation of our experience with 3000 patients [13]. This latter death was related to disseminated intravascular coagulation in a patient submitted to conversion to OAGB from a previous failed laparoscopic gastric band. Our current overall mortality rate (0.1%) is well within that of other large MGB/OAGB series [19–24, 27, 35–38] and other bariatric procedures as well [4].

25.10 Long-Term Outcomes—Effects on Weight, Co-Morbidities and Quality of Life

25.10.1 Follow-up

Overall, during the initial part of our series, we were able to complete in office FU in 95%, 85%, 75% and 65% of our patients, 1, 2, 3, and 5 years after surgery, respectively. These figures improved markedly by adding FU through electronic means *(see above)* to 98%, 95%, 91%, and 89% at those same intervals. As time goes by it is usual for large series to have a gradual decrease in the number of patients available for FU. Nevertheless, for our (published) long-term FU [11] we had at least 50% of those patients operated >12 years ago being followed up, and we were in contact and had information from 7 out of 10 (cumulative FU) among the whole group of 1200 patients (Table 25.2). We have recorded a total of 15 patients who have died from unrelated causes during this FU period.

Table 25.2 Weight loss evolution after one anastomosis gastric bypass (OAGB) in 1200 morbidly obese patients (published long-term FU) and final %EWL at 15 year

Yrs of FU (Yr operation)	Cumulative FU No. of patients (%)	Weight (kg)[a]	BMI (kg/m^2)[a]	%EBMIL[a]	%EWL[a]
Preoperative		124 (82–308)	46 (33–86)		
6 yr (2008)	233 (87%)	68	28.54	83.09%	77
7 yr (2007)	447 (84%)	69	28.74	82.89%	76
8 yr (2006)	607 (74%)	71	29.32	79.38%	73
9 yr (2005)	704 (73%)	72	29.64	77.85%	72
10yr (2004)	759 (72%)	73	29.89	76.60%	70
11yr (2003)	810 (71%)	73	29.89	76.60%	70
12 yr (2002)	839 (70%)	73	29.95	76.30%	70
15 yr					70 (40–98)

[a]Mean

FU follow up, *BMI* body mass index, *%EBMIL* percentage excess BMI lost, *%EWL* percentage excess weight lost

25.11 Weight Loss After OAGB

The most significant WL is achieved during the first six postoperative months. Although highly related to their initial (preoperative) EW, patients usually loose a mean of ~15–20 kg during the first month and ~30–40 kg at the end of the first trimester. Almost half of this EW (~15–20 kg) is then lost during the second trimester. Thereafter, depending on remaining EW, patients usually loose from 1 to 3 kg per month. Lowest BMI is usually reached between the eighteenth and twenty-fourth postoperative month, after which a few patients experience a slight weight increase (leading to a small change in our figures), which is not significant clinically.

From our long-term FU [11], Table 25.2 outlines the evolution of WL expressed in various forms and at different point intervals. Number and percentage of patients followed up at each time interval is also included; noteworthy is the fact that taking into account all types of FU, only from 13% (at 6 years) to 30% (at 12 years) of our cumulative number of patients were lost for FU. Since most of our patients have been able to maintain their EWL, based on Reinhold's Criteria [81] our results can be classified from good (EWL > 50%) to excellent (EWL > 75%); in terms of WL, a long-term successful treatment (EWL > 50%) has been achieved in almost all patients.

As previously stated, OAGB is more malabsorptive than either RYGB and standard MGB. This leads to a greater WL compared to any purely restrictive operation [4, 30, 73], standard RYGB [4, 30, 40] and even some series of MGB [19, 24]. Results are comparable in efficacy to those obtained with BP diversion or duodenal switch which are more complex malabsorptive techniques [4, 30]; WL curves are more pronounced and frequently reach ideal weight.

Furthermore, WL durability has proven to be another benefit. Once WL stabilizes, it is usually maintained in most patients; after 2 years, slight weight increments are experienced by a few patients, which are not clinically relevant. In fact, considerable weight regain (WR) requiring a reoperation was not seen until recently when a patient complained of progressive substantial increase in body weight; he was originally operated in 2002, during the initial part of the series [10], when a fixed BP limb of 200 cm was done for all patients (*see* Chap. 24). Thus, after almost 3000 cases and more than 12 years after initial operation, we had to reoperate in our first patient for failure. While keeping the original anastomosis intact, BP limb lengthening from 200 to 400 cm was done; this patient has eventually lost 45 kg and has had a good outcome.

Most procedures provide acceptable EWL during the first 12–24 postoperative months. As time goes by, many fail in sustaining it. Overall, inadequate EWL and/or considerable WR is especially seen in a significant proportion of patients submitted to purely restrictive techniques [4, 30, 73]. Even RYGB series with a long term FU have reported inadequate EWL in ~35% and appreciable WR in up to ~20% of patients [40, 82]. This has led to proposals of modifications to the original technique such as banded RYGB [83] and distal RYGB [84] in order to optimize EWL and its longevity. Considering WL as an endpoint, studies have compared the MGB-OAGB concept to other procedures. The former has shown better results than the purely restrictive LSG [85, 86], and also similar or greater WL when compared to RYGB [22, 23, 87]. Interestingly, even though OAGB is not based on a restrictive component, most patients do report permanent restriction. Favorably, due to characteristics of the gastric reservoir and anastomosis, this restriction is described and sensed as a non-obstructive one, and provides quite reasonable digestive comfort.

25.12 Improvement and Remission of Co-morbidities After OAGB

Obesity-related diseases can be broadly divided into metabolic and mechanical. In regard to the former, OAGB incorporates key features which are characteristic in metabolic surgery. These include some form of restriction, and a unique very long BP limb which bypasses the proximal gut and places food in the initial part of the ileum [88].

Patients in our series have experienced exceptional metabolic beneficial effects after OAGB, which are similar or better than those obtained by other MGB-OAGB surgeons [19–24, 27, 35–38]. Co-morbidities from the metabolic syndrome improve shortly after the operation and most remit during the following weeks. This has been confirmed clinically and biochemically during our FU and was explicitly shown in our long-term FU with 1200 patients [11]. Severe metabolic co-morbidities such as type II diabetes mellitus, insulin resistance, hypertension, and sleep apnea either totally resolve or substantially improve in all affected patients. Most of these changes start immediately after surgery. Remission (or at least improvement) is also demonstrated for other metabolic conditions like hyperlipidemia and liver steatosis when the first biochemical tests are ordered at the third postoperative month. Our most recent evaluation of the whole series with 3000 patients after 15 years [13] has shown a slight to moderate decrease in the percentage of full remission in patients with type II diabetes mellitus (from 94% to 90%), hypertension (from 94% to 87%), and dyslipidemia (from 96% to 86%); anyhow, most of these patients have continued to have improvement from their preoperative state in these illnesses (Table 25.3).

We recently published results from 415 patients included in the IFSO - EAC for Centers of Excellence Registry from January 2010 to May 2012 [89]. A total of 79

Table 25.3 Evolution of outcomes of one anastomosis gastric bypass (OAGB) on comorbid conditions in 3000 morbidly obese patients after 15 years

Comorbidity	Remission (%) at 2 yr	Remission (%) at 15 yr
Type II diabetes mellitus	94	90
Fasting glucose impairment	100	100
Hypertension	98	87
Hyperlipidemia	98	86
Gastro-esophageal reflux disease	92	90
Shortness of breath on exertion	100	100
Fatty liver	100	100

(19%) had either insulin resistance or type 2 DM. After a 12 month FU, BMI went from 42.73 ± 7.32 to 23.8 ± 3.05, and from 43.19 ± 6.21 to 25.59 ± 3.78, respectively. All achieved full remission from their metabolic condition. Likewise, a group of 150 patients from the IFSO—EAC Registry with MO and dyslipidemia, were studied during a 2-year FU. OAGB led to substantial WL and significant improvement in their lipid profiles in all patients; these changes (in theory) translate into cardiovascular risk benefits [90]. Overall, comparative studies and controlled trials favor MGB-OAGB over purely restrictive operations and are similar or better than RYGB in their beneficial results in regard to the metabolic syndrome [22, 23, 85, 86, 91].

As far as other "mechanical" related co-morbidities, they also improved or were abated in a more progressive manner, and in close relationship to pace and magnitude of WL. These complications included osteoarthritis, urinary incontinence and respiratory insufficiency. Moreover, incidence of GERD increases with obesity and should also be considered a co-morbidity. The unjustified reputation for increased esophageal BR has led even some MGB/OAGB supporters to contraindicate the procedure in obese patients with GERD for fear of worsening the condition [35]. However, OAGB has in fact demonstrated to relieve or improve symptoms of GERD in most patients. Through our assessments we have documented more than 50% of our patients had the condition preoperatively, and remission or (at least) improvement has been obtained in all (Table 25.3). Many others have corroborated MGB/OAGB's anti-reflux effects with clinical improvement in ~90% of affected patients [20, 37].

25.13 Quality of Life After OAGB

Our previous assessments have shown significant improvement in QoL and in all but one IWQoL survey parameters 3 months after surgery. The item *"comfort with food"* also improved markedly but takes longer (~6 months after surgery); problems with it are usually referred as *"insignificant"* at the 1-year office visit. At this time, most patients do not report food intolerance of any kind. This improvement in QoL has really remained through time.

25.14 Other Favorable Qualities

Both MGB and OAGB have also proven to be easy to revise, convert to another procedure or reverse to normal anatomy. Technically it seems logically easier to reoperate a gastric bypass with only one anastomosis [92]. Although there have been reports of patients needing this type of procedures [35, 58], until recently we had no patient in our long-term series needing such an operation [11, 12] . During the last year, we had to revise one patient for WR, and another for malnutrition *(see above)*. The best scenario for those patients requiring a reoperation is to have them done at their original center [58], or at a Center of Excellence with vast experience in bariatric and revisional surgery; not infrequently, general surgeons without knowledge and skill in this type of reoperations end up with more problems and even catastrophes. Since there has been skepticism towards MGB/OAGB by some groups [34, 79], we advise them to objectively assess the real need for each reoperation. As some of them have stated, revisional surgery may lead to increased risks and even mortality, as well as added costs which sometimes delay adequate treatment for financial reasons [34]. However, in contrast to their opinion, large series of MGB/OAGB seldom report a need for revisional surgery [19, 24, 27]. Closer attention should be given to other procedures which due to their nature seem to carry much higher probabilities of needing such reinterventions [73]; LSG for example, originated as a first (of a two step) procedure and oftentimes requires reoperations due to inadequate WL and/or WR [30]. On the other hand, MGB or OAGB are great alternatives especially after failed restrictive operations [92–96]. In our whole series, 75 patients (~3%) were submitted to laparoscopic OAGB as a conversion from unsuccessful restrictive bariatric procedures. Although operative time was longer, overall results in terms of safety and efficacy were similar to those of the rest of our patients. Regrettably, when the "gold-standard" RYGB fails it cannot be converted to OAGB. An alternative should be sought according to the indication for the reoperation.

25.15 OAGB vs Other Common Operations—IFSO-EAC Registry

Centers of Excellence from the EAC of IFSO periodically report their results to a common Registry. The following is a comparative analysis between OAGB (performed at our Centre) and the most common procedures in this audit. These were performed from January 2010 to January 2017 and included: OAGB (n = 938), RYGB (n = 14,161), LSG (n = 16,225), and laparoscopic adjustable gastric banding (LAGB) (n = 2542). Perioperative characteristics included a similar BMI distribution amongst all groups. Almost all patients in the OAGB group (99%) had at least one co-morbidity, compared to 79%, 66% and 59% in the RYGB, LSG and LAGB, respectively. Mean LOS recorded for OAGB (1 day) was lower, compared to 4.6, 3.7, and 2.5 days, for the other groups.

In regard to morbidity, bleeding was the most common intraoperative complication and was higher after RYGB (0.53%) and LSG (0.39%); OAGB and LAGB had the lowest rates (0.22% and 0.20%, respectively). Overall extremely low rates of GI perforation, liver failure, vascular and splenic injuries occurred during RYGB, LSG and LAGB, but none of these intraoperative complications were recorded after OAGB. The only intraoperative death which has been recorded was during a RYGB. As far as postoperative complications bleeding was also the most common event and was again higher after RYGB (1.4%) and LSG (0.85%), than after OAGB (0.2%) and LAGB (0.1%). Leaks were considerably higher after RYGB (0.55%) than after LSG (0.18%) and OAGB (0.12%). Concerning esophageal complications, as expected, dilatations occurred more frequently after LAGB and very rarely after RYGB and LSG; none were found after OAGB. Postoperative vomiting occurred more often after RYGB (0.2%), and then after LSG and LAGB (0.1%); it did not seem to be a problem after OAGB. As has been extensively described throughout this chapter, OAGB has been criticized for its potential to lead to BR and its consequent GERD and esophagitis. However, in this Registry these latter have only been recorded after LSG (2.1%), and less frequently after RYGB and LAGB (0.40%); this data is congruent with other reports in the literature. MU and SBO were only recorded after RYGB (0.48% and 0.14%, respectively); anastomotic strictures were higher after RYGB than OAGB (0.36% vs. 0.22%). OAGB is more malabsorptive than any of the other procedures and protein deficiency was recorded in 0.34%; patients after RYGB and LSG did develop this deficit but in lower frequency (0.19% and 0.09%, respectively).

Figures 25.1 and 25.2 illustrate the evolution of WL expressed as %EWL and %EBMIL, respectively. OAGB has shown the greatest WL at all different point intervals. Depending on preoperative EW, lowest BMI was usually attained between the 12th and 24th postoperative month and was kept at the 5 year FU. RYGB demonstrated good efficacy and a stable WL curve, but always >20 points below OAGB. LGS had an acceptable WL tendency during the first 2–3 years, but was not maintained during the longer term FU when they displayed the worst %EWL and %EBMIL, which were even below LAGB. In summary, OAGB had the quickest postoperative recovery (mean LOS of 24 h.), and displayed the safest profile (comparable to that of LAGB). It also exhibited the greatest efficacy in terms of %EWL and %BMI lost from the beginning and up to the 5 year FU.

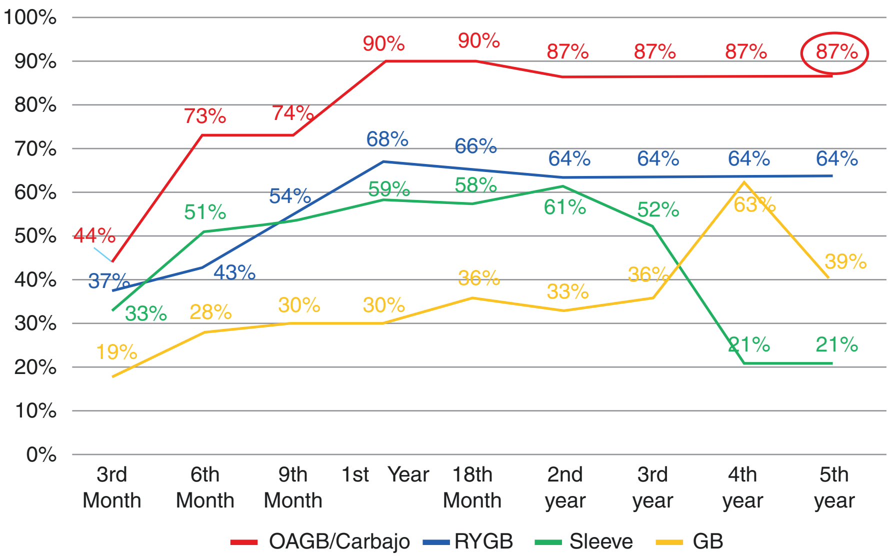

Fig. 25.1 Comparative analysis between four common operations from the IFSO-EAC Registry. Lines represent %EWL at different point intervals during a 5 year FU. *OAGB one-anastomosis gastric bypass, RYGB Roux-Y-gastric bypass, Sleeve laparoscopic sleeve gastrectomy, GB Laparoscopic adjustable gastric banding*

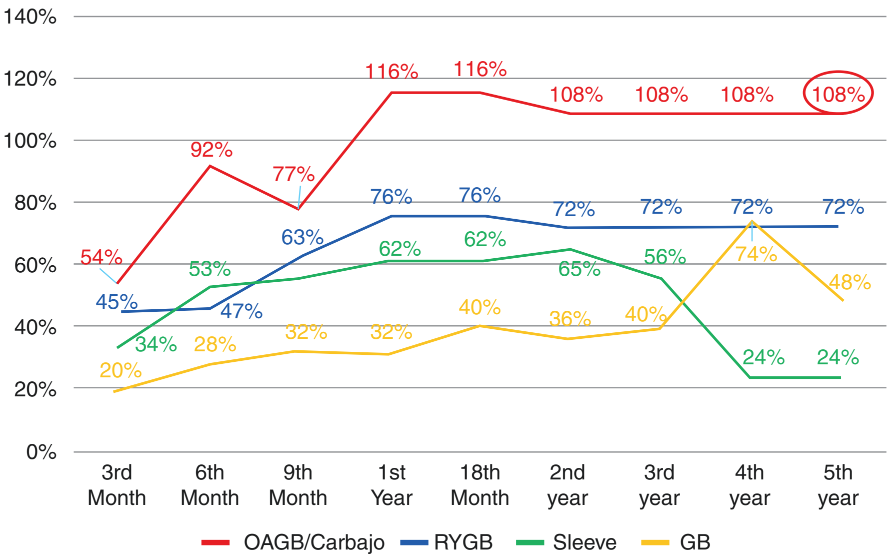

Fig. 25.2 Comparative analysis between four common operations from the IFSO-EAC Registry. Lines represent %EBMIL at different point intervals during a 5 year FU. *OAGB one-anastomosis gastric bypass, RYGB Roux-Y-gastric bypass, Sleeve laparoscopic sleeve gastrectomy, GB Laparoscopic adjustable gastric banding*

Conclusions

Although OAGB was developed as a modification of MGB, it portrays a distinct conceptual and technical framework. This chapter reviews the latest information from our series of 3000 patients during a 15 year period. As such, this group represents the original largest series, and with longest FU of patients submitted to a procedure for which we "coined" the term OAGB or BAGUA *(bypass gástrico de una anastomosis—in Spanish)*.

OAGB has a short learning curve, and provides reduced difficulty and operating time compared to other complex procedures. Complications mostly occurred at the beginning of our series, and overall morbidity has been low and largely manageable through laparoscopic, endoscopic or conservative means. Clinical alkaline reflux is very infrequent, mild and treatable. When performed (either as a screening program or in symptomatic patients), endoscopic findings have not been worrisome. Concerns regarding BR and its potential consequences have now proven to be unsubstantiated. Development of subsequent cancer has not been reported.

Long-term substantial, durable EWL, remission of comorbidities through its metabolic benefits and degree of satisfaction are similar to the best results obtained with more aggressive and complex operations. OAGB is a powerful, robust operation which has established itself as one of the safest and more effective alternatives, and is becoming mainstream in bariatric surgery.

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Results of the OAGB in Adolescents

26

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26.1 Introduction

Obesity has generally been considered as an adult disease. However, worldwide childhood obesity has increased greatly in recent years, reaching 8–16% of the pediatric population (BMI >120% of the 95th percentile) and is not only limited to developed countries. Currently, 4.4 million children and adolescents have been diagnosed with severe obesity in the USA, with few effective available treatments to date. With this, obesity-related co-morbidities, eg. type 2 diabetes (T2D), insulin resistance, hypertension, dyslipidemia, obstructive sleep apnea syndrome (OSAS) and non-alcoholic steatohepatitis (NASH) have been demonstrated in adolescents and children [1, 2].

Obesity is one of the most common metabolic disorders worldwide. In the USA, 31% of the adults and 16% of adolescents currently meet criteria for obesity. Childhood obesity has also risen significantly. Obesity in adolescence is multifactorial and may be the result of genetic, environmental, social and cultural factors. The short- and medium-term consequences include insulin resistance and T2D, OSAS, hypertension, acanthosis nigricans, NASH, polycystic ovary syndrome and pain in

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weight-bearing joints. In the long-term, premature risk of death increases (which is estimated to decrease life expectancy 5–20 years, due to cardiovascular and oncological diseases including colon cancer, and no less important psychological disorders as a result of bullying, isolation and discrimination [3].

26.2 Definitions

Adiposity is easily predictable with children and adolescents by their BMI. Children who are within The WHO Child Growth Standards at the 85th–94th percentile are defined as overweight, and those above the 95th percentile as obese. Statistics for 2010 report that 31.8% of 2–9 year old children are above the 85th percentile, 16.9% above the 95th and 12.3% above the 97th. According to the WHO, the prevalence of overweight, obesity and severe obesity in the different age groups of children and adolescents are 23.1%, 9.3% and 2%, respectively [4].

In the last three decades, adolescent obesity prevalence has tripled. It is estimated that 17–25% of adolescents and children have abnormal glucose tolerance curves, whereas prevalence of T2D is 4–6%. Therefore, both insulin resistance and T2D have increased. Recently, it has been documented that half of adolescents with morbid obesity meet the criteria for metabolic syndrome [5].

Sleep related breathing disorders such as hoarseness, sleep apnea and hypopnea are highly associated with obesity in adolescents. OSAS leads to chronic fatigue, poor academic performance and development, hypertension and ventricular dysfunction [6].

NASH is more likely to be observed in obese children than those who are normal weight. Liver steatosis has been found in 38% of obese children, unlike 5% in the non-obese, and NASH has been documented in 9% of obese children compared to 1% of non-obese children [7].

There is a psychological and psychiatric consequence with negative impact on quality of life due to depressive disorder. Although, major depression has been reported in 53% of obese children and adolescents, only 30% of this population has mentioned the condition by patients themselves, and mothers disclosed another 45% in these obese patients.

Obese children and adolescents have a higher propensity to remain obese in their adult years. A BMI above the 99th percentile in children is linked to a BMI >30 when they become adults in 80% of cases [8, 9]. The association between obesity, morbidity and mortality has led us to seek a more effective treatment for obesity in adolescents. Current medical care and lifestyle changes (diet, exercise and counseling for severe childhood obesity) rarely have adequate and sustained results to improve healthy outcomes [1, 10, 11]. Recent literature reported that obese adolescents who undergo a conservative medical care (non-surgical treatment) do not have adequate weight loss, and it is not maintained for more than 2 years follow-up [12]. A recent Cochrane review shows a maximum of 1.7 kg/m^2 of BMI lost after a healthy lifestyle modification [13].

Bariatric surgery is the only effective weight loss intervention in adults for the long-term, with decrease in co-morbidities and mortality. In adolescents, the use of bariatric surgery has increased markedly throughout the world because of these favorable outcomes. In USA, the number of bariatric operations in adolescents has increased to about 1500 cases a year. While adolescent operations have good long-term weight loss, they experience improvements in mental health in terms of depression, anxiety, self-esteem, and quality of life. Bariatric surgery should be considered as an effective treatment in severely obese adolescents who have not responded to conservative medical treatment.

Adolescents undergoing bariatric surgery require major and unique support, which is stricter than adult programs. Minimally invasive laparoscopic techniques are widely used with excellent safety results.

There is not enough data to describe the optimal learning curve and experience for adolescent bariatric surgery. However, as demonstrated in both Teen-LABS (Teen Longitudinal Assessment of Bariatric Surgery) and in several institutions that gather information special multidisciplinary team, including management by specialists of pediatric patients combined with the multidisciplinary and follow-up team suggested for the management of adult patients.

T2D remission has been shown in multiple literature studies following weight loss surgery and is related to the patient's age and illness progression; which has a greater opportunity for cure or remission if recently diagnosed. Early intervention has greater reduction or full resolution of co-morbidities [14, 15].

26.3 Multidisciplinary Team

An ideal multidisciplinary team must have at least 4–5 members experienced in management of obese pediatric patients—a bariatric pediatrician, a bariatric surgeon with experience with young patients, a pediatric nutritionist, a psychologist pediatrician with experience in family pathologies and eating disorders, and a nurse or social worker coordinator who maintains contact between the patient and family. The multidisciplinary team provides adequate follow-up. Other members that are suitable are a hepatologist and pediatric endocrinologist (Table 26.1).

Table 26.1 Adolescent bariatric surgery multidisciplinary team

Indispensable	• Pediatrician with obesity experience • Bariatric surgeon with experience with young patients • Pediatric nutritionist • Psychologist pediatrician • Nurse of social worker
Ideal	• Pediatric endocrinologist • Pediatric hepatologist

26.4 Indications for Surgery

A proper selection of candidates for bariatric surgery in adolescents and children is vital for long-term positive results. The following criteria are published in clinical practice guidelines:

26.4.1 BMI

A BMI >35 with major co-morbidities, such as T2D, OSAS (AHI > 15), pseudotumor cerebri, non-alcoholic fatty liver, BMI >40 with minor co-morbidities such as OSAS (AHI > 5), insulin resistance, impaired fasting glucose test, hypertension and dyslipidemia.

26.4.2 Weight Loss Failure

Psychological therapy and nutritional weight loss program with poor outcome or failure for 6 months in addition to no benefit in their health are candidates for bariatric surgery.

26.4.3 Tanner Stage and Skeletal Maturity

Candidates must have reached adequate maturity by Tanner stage IV–V and have reached 95% of adult height. Skeletal maturity has to be demonstrated radiologically.

26.4.4 An Understanding of Lifestyle Changes

The patient has to show interest and an understanding of lifestyle changes, which include exercise and dietary habits before and after the surgical procedure for candidates to achieve sustained weight loss and to avoid complications.

26.4.5 Psychosocial Compatibility

Multiple psychosocial aspects should be evaluated before the final decision. Patients need maturity in decision-making with an understanding of risks and benefits of the surgery, as well as a real expectation regarding weight loss. A positive outcome will be reflected by support of family and friends. Compliance with pre-operative plan and postoperative lifestyle must be shown. Any psychological alteration will require treatment and has to be resolved before surgery.

Regarding contraindications, candidates excluded are those who demonstrate a correctable medical cause of obesity, substance abuse, medical or psychological alterations that are incompatible with post-operative care, and pregnancy or pregnancy plans for 12–18 months after surgery [4].

Bariatric surgery in adolescents is indicated with hypertension, dyslipidemia, metabolic syndrome, polycystic ovarian syndrome, urinary incontinence, difficulty with activities of daily living, NASH, arthralgia, gastroesophageal reflux disease (GERD) and psychosocial distress. Psychological management is important for preparation; the barriers and strengths that will help the post-operative results must be identified.

During the interview, to solve any psychological problem, it is necessary to explore the patient's family and social interactions. The three basic components of psychosocial management are:

1. evaluation of current family environment;
2. understanding of surgery recommendations, and evaluation of emotional maturity and cognitive function;
3. Peri-operative diet and social changes [16].

Nutritional management should start 6 months before the surgical event, with structured dietary plans that include the whole family. It is crucial that the family provides an encouraging and supportive environment for adherence to dietary recommendations. Calorie restriction to liquid 1000 Kcal/day with limited carbohydrate for 10 days before the surgical procedure will decrease the size of the liver, facilitating the laparoscopic operation.

26.5 Decision for Type of Procedure and Surgical Advice

Final decision regarding the operation has to be made by a surgeon and pediatrician, according to each patient's characteristics and the surgeon's experience. Worldwide experience is limited in adolescents. However, it has been proven that bariatric operations used in adults have similar effectiveness, and are even better in adolescents. There are a few bariatric surgery publications where a minimum age is considered adequate and only three publications specify minimum age: the first states that the patient must be at least 11 years old [17], the second only stipulates for those >13 [18], and the third stipulates for patients to be >15 (or 14 years old in exceptional circumstances) [19].

26.6 Informed Consent

Risks, benefits and a follow-up plan should be explained to both family and patient in a very understandable and clear manner. Every effort must be made to avoid any misunderstanding. Surgical options should be discussed in detail.

26.7 Selection of Surgical Procedure

We perform the laparoscopic *One Anastomosis Gastric Bypass* (OAGB) for adolescent patients. Dr. Miguel A. Carbajo of Valladolid, Spain in 2001, after having performed Roux-en-Y gastric bypass (RYGB) for >10 years, created the OAGB or *Bypass Gástrico de Una Anastomosis* (BAGUA). He has shown less morbidity and better results with long-term follow-up, as reported in >1200 patients, which include a number of adolescent patients [20]. Intra-operative complications occurred in 0.3%, peri-operative complications in 1.3% (90% of which resolved conservatively), 1% had long-term complications, and there was a 0.16% mortality rate. Average excess weight loss was 88% (after 2 years), 77% (after 6 years) and 70% (after 12 years). Median BMI decreased from 46.0 to 26.6.

Laparoscopic OAGB (Fig. 26.1) is a safe and effective procedure, which reduces technical difficulty, operative time, and early and late complications, compared to other procedures currently considered as effective, such as the RYGB. Long-term weight loss, resolution of co-morbidities and degree of satisfaction are similar to the results obtained with more aggressive and complex operations, which makes OAGB a powerful and safe alternative for bariatric surgery [20].

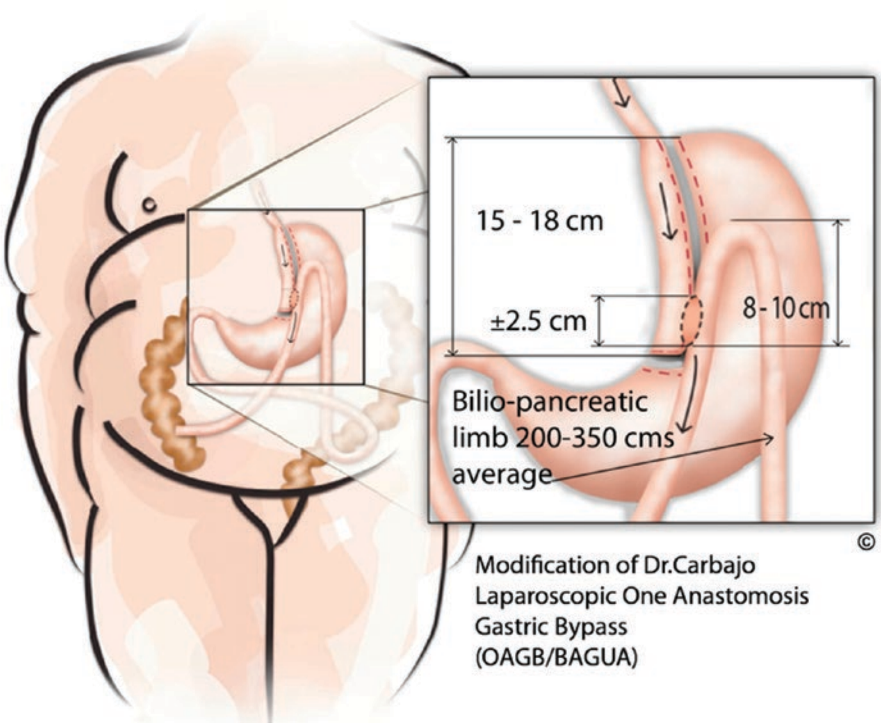

Fig. 26.1 Diagram of the OAGB

The Adjustable Gastric Band has not shown favorable results in adolescents, with failure in up to 40% [21] and average BMI loss of 11.6 kg/m^2. During follow-up, 10.5% developed band-related complications and 14.7% required re-intervention surgery. Vitamin deficiency occurred in 0.5–36% and resolution of co-morbidities 22.9%. Regarding quality of life, 75% of the adolescents show post-operative abnormalities in the Pediatric Quality of Life Inventory [13].

RYGB has an average BMI loss of 16.6 and peri-operative complications including anastomotic leakage, bleeding and conversions in 5.1%, and surgical site infection in 6.2% of patients. Late complications include intestinal obstruction, internal hernias, marginal ulcers and incisional hernia in 20.2% of patients, vitamin deficiencies in 4–56%, and re-intervention in 17.1% of patients. Resolution of co-morbidities has occurred for hypertension in 61–100%, dyslipidemia 62%, and resolution of T2D in 79–100%. The depression scale was significantly lower after the surgery [13].

Sleeve gastrectomy (SG) has had average BMI loss of 14.1. Resolutions of hypertension are reported in 75–100%, dyslipidemia in 58–70%, and T2D in 50–93.8% [13]. However, serious post-operative leaks, development of Barrett's esophagus and weight regain have been reported after SG.

OAGB has given better long-term results than RYGB and SG, less complications, and thus is more convenient for adolescent patients. Carbajo and co-workers [22] reported a laparoscopic OAGB in a 12-year old massively super-obese adolescent, with spectacular results and resolution.

26.8 Nutritional Concerns after Bariatric Surgery

Close attention to nutritional indices after adolescent bariatric surgery is mandatory, because of potential metabolic imbalance and subsequent growth disorders. Macro- and micronutrients are insufficiently absorbed by the reduction in intake and by the decreased absorption in malabsorptive procedures. Post-operatively, nutritional protocols (including supplemental medication) should ensure the sufficiency of these macro- and micronutrients. After adolescent bariatric surgery, dehydration and protein deficiency should be avoided.

26.9 Results of OAGB in Adolescents: Follow-Up to 5 Years

In the City of Zacatecas, Mexico, after adequate scrutiny and with the indications mentioned above, the multidisciplinary group called "Adios a la Obesidad" (Goodbye to Obesity) performed laparoscopic OAGB in five severely obese adolescents, ages 12–17. Biochemical parameters, weight loss, resolution of co-morbidities and quality of life were assessed in order to evaluate 5-year results. Pre-operative weights ranged from 95 to 205 kg, with BMI 38–65. All the adolescents had >95% of their parents' average size at the time of the surgery. All had major co-morbidities (Table 26.2). One was in a rehabilitation program for drug addiction; the

Table 26.2 OAGB for severely obese children and adolescents

Case	Co-morbidites
1	T2D, asthma, OSAS, dyslipidemia, GERD, Barrett's esophagus, NASH
2	T2D, NASH, asthma, depression
3	T2D, NASH, depression, severe psychosocial distress
4	Drugs addiction, alcoholism, depression, gallstones, severe psychosocial distress
5	T2D, OSAS, super-super obesity, NASH

multidisciplinary team and social worker agreed that the OAGB would be part of his rehabilitation and society adaptation.

Average time for the OAGB operation was 100 min (90–110 min). Median follow-up was 36 months (16–64 months). The entire small bowel was measured in all patients, with average intestinal length 616 cm (600–640 cm). The bypassed loop was selected with an average 336 cm length (320–360 cm). At 24 hours after the OAGB, a radiologic study with fluoroscopy was obtained, to observe liquid contrast passing appropriately through the anastomosis of the gastric pouch to the small bowel loop.

Average weight loss defined by BMI has been 21 kg/m^2 (13–36 kg/m^2). The excess weight lost was 90% (74%–105%). The longest follow-up patient has maintained an excess weight loss of 91% at 5 years. Hemoglobin levels in all patients have remained within normal levels. All patients were given multivitamins and iron supplements. Four of the adolescents pre-operatively had T2D. Serum glucose levels after 18 months were all normal; every case had resolution of T2D. Glycosylated hemoglobin measured every 6 months normalized in all.

Serum iron levels remained within normal range in all cases. On liver function tests, ALT levels increased in three patients considered as a non-alcoholic steatohepatitis, which resolved without any medication. None of the cases has developed hypoproteinemia or hypoalbuminemia. Most of the adolescents had had dyslipidemia, but resolution of cholesterol and triglycerides to normal levels was observed in all cases (Figs. 26.2, 26.3, 26.4 and 26.5).

OAGB has better results in adolescents than in adults. Although adolescent patients were close to their adult height or even taller than expected for their age, their longitudinal growth did not stop; they increased in size in an expected way without any interruption. We believe that the benefits resulted from early intervention in adolescents with associated severe co-morbidities. Late intervention could lead to irreversible organ damage, with loss in life expectancy. Improvement in quality of life was observed by patients and their families.

Fig. 26.2 14-year-old before surgery

Fig. 26.3 14-year-old during his bariatric surgery

Fig. 26.4 14-year-old 24 h after the OAGB

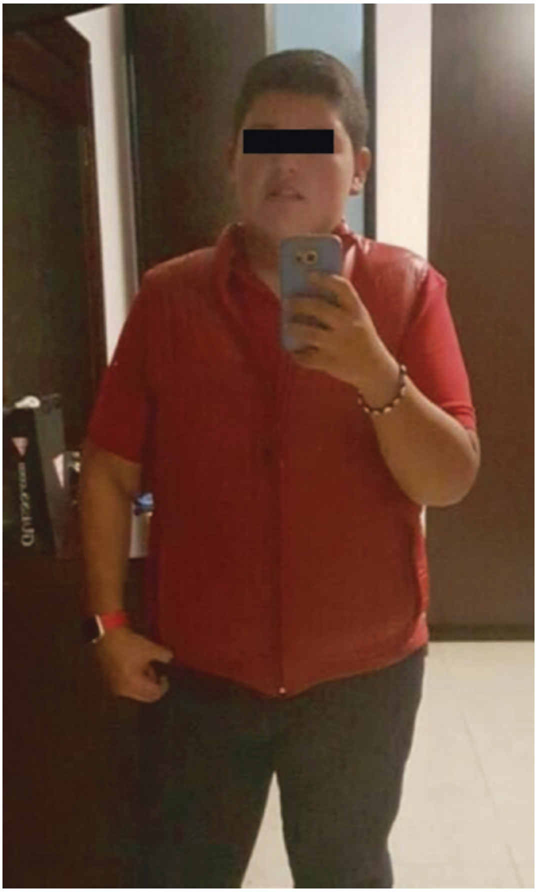

Fig. 26.5 Same adolescent at 48 months after the OAGB. Evolution of weight loss, growth and development

Conclusions

OAGB/BAGUA is a safe and effective surgical option in adolescents for permanent management of obesity and its co-morbidities, with improvement in quality of life, health in general, and psychosocial environment.

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Physical Principles Applied to the OAGB

27

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27.1 Physical Principles

The word physical comes from the Greek word *physis* which means *nature*. It is the science that studies the properties of the bodies and the laws that govern the transformations that affect its state and its movement, without altering its nature [1]. That is to say, the science responsible for analyzing physical transformations or phenomena is a science applicable to all biological processes [1]. The tissues undergo changes before each surgical re-procedure, and the scar tissue has different quality and exerts more traction on the anatomical structures [2]. Every surgical change made with suture materials involves a redistribution of forces that affect tissues and thereby physiological processes. This situation is little taken into account; however, it is extremely important as it actively participates in the outcome of surgery.

Distribution of forces may result in the presence of dehiscence of sutures, ischemia, tissue twisting, elongations and many other physical changes on the tissues, affecting the evolution of patients. When going through the magnifying glass of physics, some physiological process is important to take up different definitions common in physics that are necessary to analyze processes; these definitions are applicable to all materials, including human body tissues such as mass, force, gravity, friction, weight, vector, detente, elasticity, content, and continent [1]. Here, the important thing is to substitute or apply each definition to the surgical procedure

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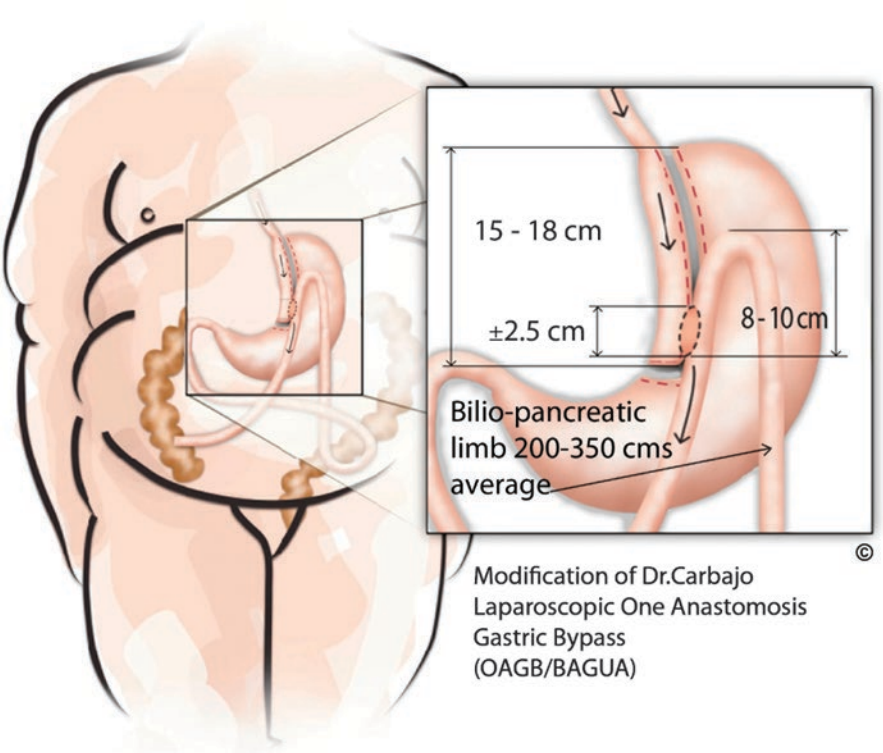
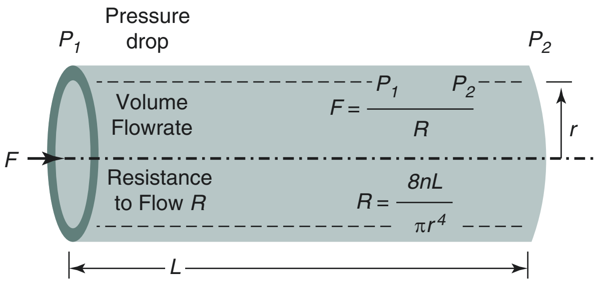


Fig. 27.1 OAGB

Fig. 27.2 Law of Hagen-Poiseulle



that we are reviewing. In this case, we apply these physical concepts to the one anastomosis gastric bypass (OAGB) [3]—Fig. 27.1.

The law of Hagen-Poiseuille [4, 5], is a law that allows determination of the laminar flow of a fluid which is uniformly viscous (also denominated Newtonian fluid) through a cylindrical tube. The law is formulated as in Fig. 27.2.

This law evaluates the volume of liquid that circulates in the unit of time (velocity) along a cylindrical tube, where the flow velocity of the liquid inside is affected by three factors: the internal radius of the tube, the viscosity and the cylinder length [6, 7].

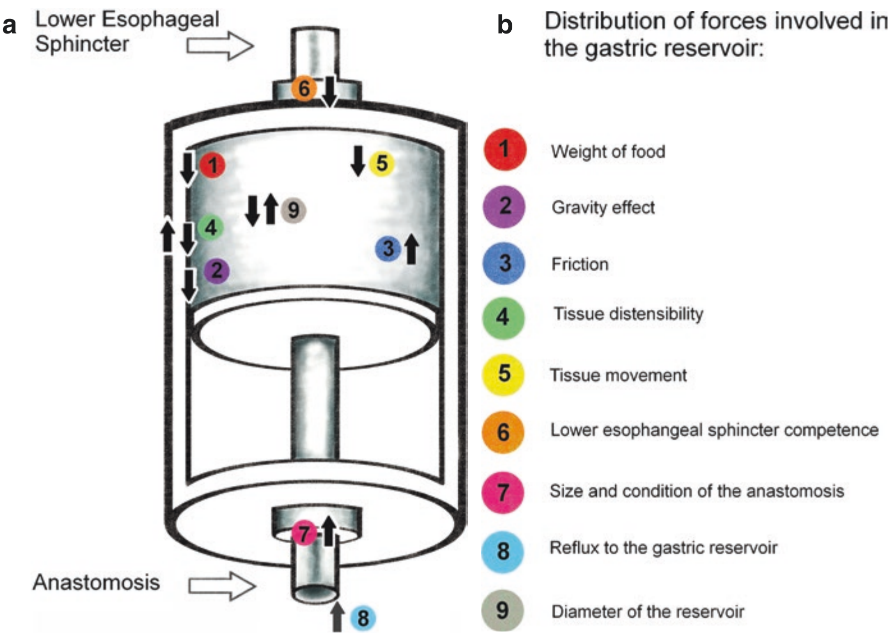


Fig. 27.3 Factors in favor of the flow of liquid or food inside the reservoir

This law is very useful, because it evaluates the behavior of the liquid in cylindrical structures. However, we now establish our model based on the cylinder that we generate when doing a gastric bypass of one anastomosis, and we see the differences. The model that we describe below is based on the analysis of the physical forces involved in OAGB.

If one considers the gastric pouch of the OAGB, it is seen that it is effectively a cylindrical structure in which there are factors in favor of the flow and others that oppose the flow of the liquid or food inside (Fig. 27.3).

Factors in favor of the flow of liquid or food inside the reservoir:

- Imperfect torsion (tissue movement)
- Weight of food
- Lower esophageal sphincter competence
- Diameter of the reservoir
- Size and condition of the anastomosis
- Distensibility of the tissues
- Gravity effect

Factors that oppose the flow of the liquid or food inside the reservoir:

- Roughness of the mucosa in the reservoir (friction)—line of cut and row of staples (friction)

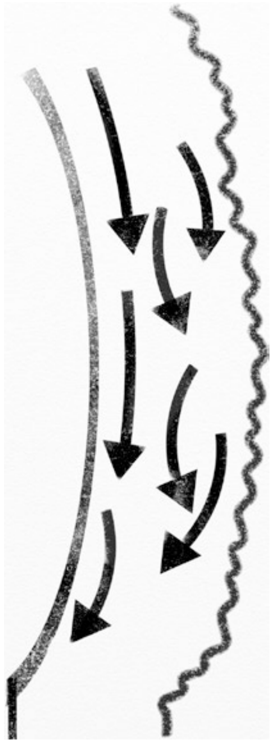


Fig. 27.4 Passage through OAGB tube

- Diameter of the reservoir
- Tissue distensibility
- Size of the anastomosis
- Reflux to the gastric reservoir

If we review the two models, we see that it was necessary to make some adjustments to the law of Hagen-Poiseuille. Hagen's law was established to analyze the behavior of liquids called perfect, liquids in which the molecular cohesion is uniform such as water or viscid liquids such as oil [6, 7]. Although it is true that water is an element that participates in our model (OAGB), we see that the rest of the food does not represent perfect liquids with uniform molecular cohesion, which, because of their consistency, generate greater turbulence in their passage through our cylinder model in the OAGB, establishing the first difference (Fig. 27.4).

Another factor to consider is that the law of Hagen-Poiseuille was described in perfect cylinders, i.e. cylinders with smooth walls. In our model, it is very important to consider that it is a cylinder of rough walls, represented by the roughness of the gastric mucosa and the staple-line, the lesser curvature, besides being a geometrically uneven structure which undoubtedly generates more turbulence to the passage of liquids and foods in general, affecting the speed of the flow [4, 5].

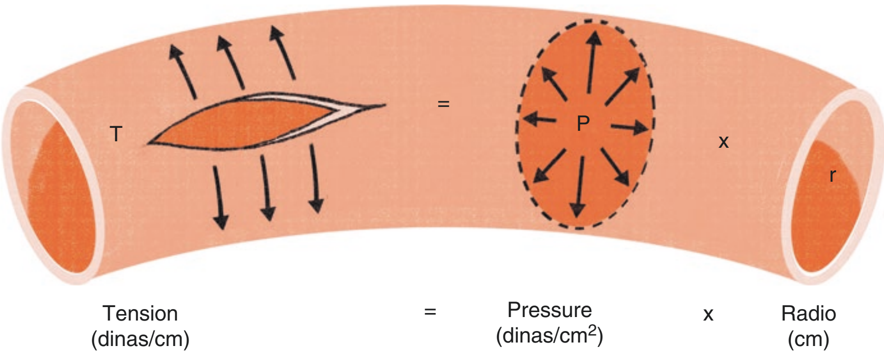


Fig. 27.5 Laplace's law

The law of Hagen was described in metal cylinders without distention or elasticity. In our model, the radius of the cylinder is changing, because it is affected by the capacity of the reservoir to distend with the passage of the food. Here, another physical law (already described) participates: the law of Laplace [7] (Fig. 27.5), that if applied to our cylindrical model of the gastric reservoir, this law establishes that the parietal tension (T) is proportional directly to the transmural pressure (P) and to the radius of the cylinder (gastric reservoir) and is inversely proportional to the thickness of the gastric wall (w): $T = Pr/w$.

Parietal tension can be defined as the force that tends to separate the myofibrils in centimeters (cm). The parietal tension depends directly on the pressure and the intraluminal radius (intragastric) and inversely on the thickness of the wall (gastric). This means that the greater the liquid (or food) in the gastric reservoir, the greater the cylinder radius and the pressure in the reservoir wall, as the fiber in the reservoir is not uniform [5, 6]. Because it depends on the thickness of the same, this point has different repercussions and reflects the transcendence of making a cylindrical long. As already stated, in the arrangement of the cylinder (gastric reservoir), the thickness of the wall is greater in the lower part when compared to the upper part near the gastro-esophageal junction. Here we must mention another applicable physical law that will allow us to reinforce why the cylinder must be long—the law of Pascal, which establishes that the pressure applied to the liquid contained in a cylinder is uniform in all the points of the cylinder [4] in such a way that, when applying pressure to the pair (reservoir) by ingestion of liquid or food, this pressure will be transmitted uniformly for each cm of the reservoir.

Figure 27.6 on the left side exemplifies the law of Pascal as described; on the right side the cylindrical model of the gastric reservoir shows two flow velocities: in the higher part there is greater flow due to lower pressure of the wall, compared to the lower part where the thickness of the reservoir wall is greater.

However, if the principle of Laplace [4] is applied, the pressure that supports the cylinder wall is directly related to the thickness of it, so that when applying these two physical laws (Pascal and Laplace), we see that the passage of food by the cylinder (reservoir) generates a constant pressure in a reservoir of walls with different thicknesses—thinner in the upper part than in the lower—with the possibility of

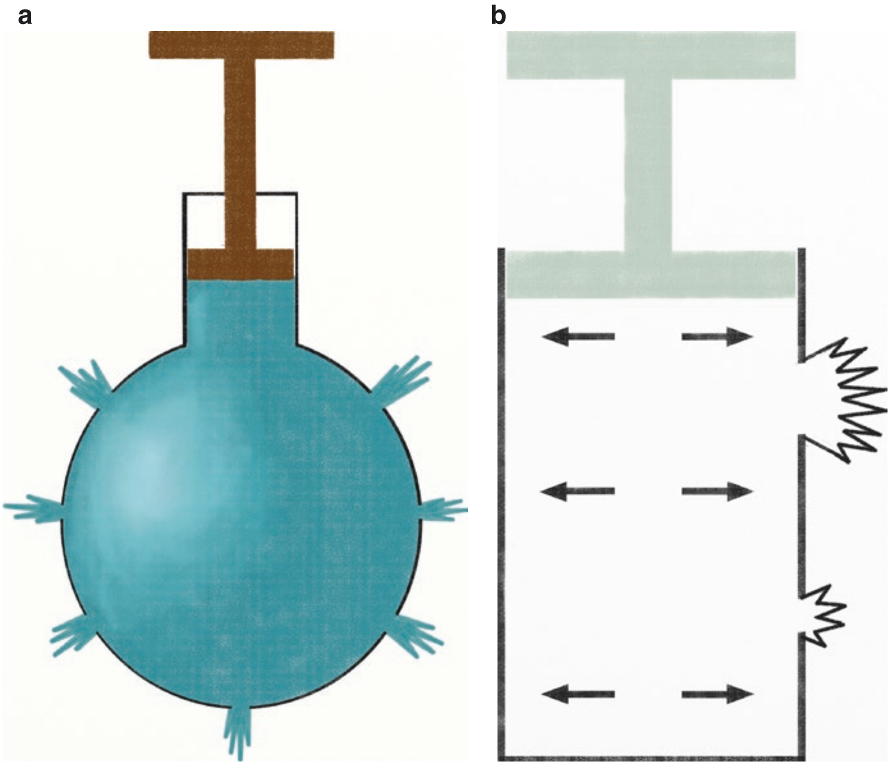


Fig. 27.6 Left, Pascal's law. Right, two flow velocities due to wall thickness

producing permanent transverse elongation or compliance of this zone, creating a new gastric reservoir. This information is perfectly in accord with the observations in re-operation of gastric sleeves, where this space of the gastric reservoir is elongated—a condition that is also reported in Roux-en-Y gastric bypass (RYGB) (Fig. 27.7) where the main technical cause for weight regain is loss of restriction due to enlargement of the gastric pouch [7].

There are other factors in our model that affect the flow of liquid and food through the cylinder, that are not described in Hagen's law but which we describe in our model. In a normal stomach without surgery, the disposition of the muscle fibers generates an effective propulsive movement from top to bottom and from left to right, which brings the food to the small intestine. In our model, we consider that in the new stomach as a long and narrow cylinder, the partial section of the fibers can make this natural propulsive motion an "imperfect torsion"; the torsion is the effect produced by applying parallel forces of equal magnitude in opposite directions [8]. However, in our model the application of forces is not uniform, and is given by movement of the gastric fibers that still remain in the reservoir. Therefore, the torsion is not perfect (Fig. 27.8). This photo exemplifies the movement called imperfect twisting—a movement made by the muscle fibers remaining in the gastric reservoir, which occurs from top to bottom and from left to right.

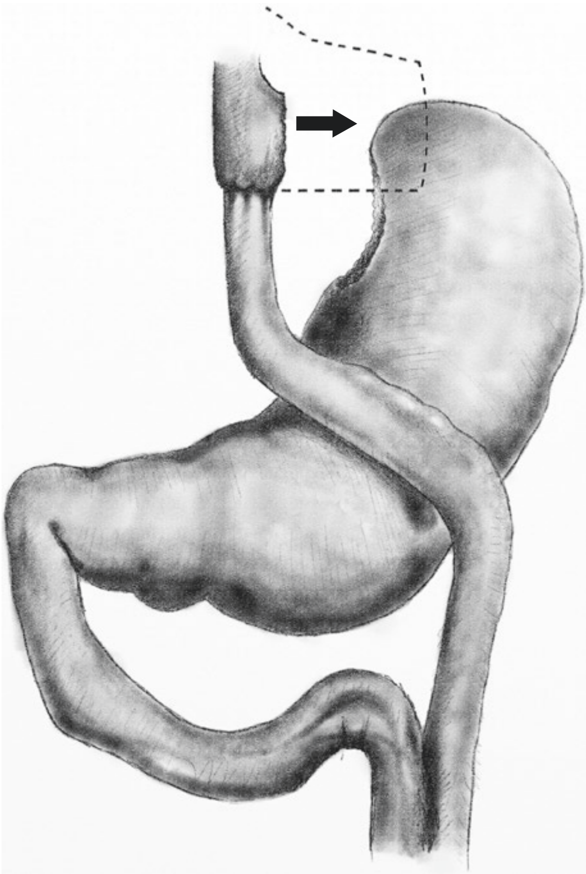


Fig. 27.7 Arrangement of the muscle fibers in the RYGB, according to a physical interpretation, allows horizontal elongation of the muscle fibers, as shown by the arrow

Finally, the diameter of the anastomosis should be considered, since there is no uniformity in the dimensions of it. The size of the anastomosis is related inversely to the passage of food and the increase in pressure in the cylinder (reservoir). This means that the smaller the diameter of the anastomosis, the greater the resistance to the passage of food into the intestine, which would result in accelerated filling of the cylinder from the bottom upwards (Fig. 27.9). The size of the anastomosis is directly related to the fill rate of the reservoir and the smaller the size of the cylinder. The arrows exemplify how the cylinder is filled by transmitting the force vector to the upper part of the reservoir.

Another factor that was not considered by Hagen and which we add to his equation is gravity. His model is designed for predominantly horizontal tubes. In the OAGB, gravity aligns the gastric spar and the common handle. The effect of gravity is a factor that must also be considered as a participating physical force.

Therefore, our model replaced by Hagen's law is what we consider is the model most attached to the reality of the OAGB. If we review lateral anastomosis, we can

Fig. 27.8 "Imperfect torsion"

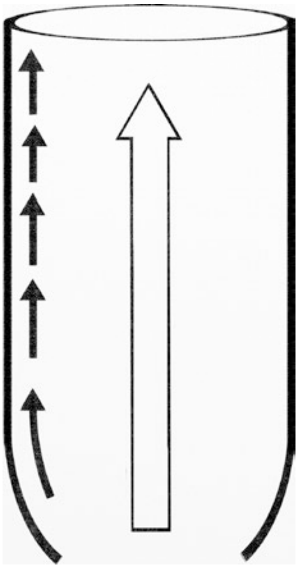


Fig. 27.9 Filling of reservoir

realize that the continuous emergence that occurs as a posterior plane and joining the gastric reservoir with the intestinal segment representing the biliopancreatic handle, splints the gastric reservoir and allows a much more vertical food fall towards the handle. This verticalization of the common handle attenuates maximally the possibility of direct contact with the intestinal wall, with the possibility of general compliance or intestinal dilatation. This is a new term that we use to describe the chronic effect of the weight of the food on a fixed tissue, and is the term that in physics is known as "plasticity"; this means that the over-distention has caused the expiration of the elasticity, thereby causing loss of the capacity of recoil of the fibers to their original form.

Another virtue of the loop and reservoir alignment in the OAGB is the fall of the food directly into the intestinal loop, which results in a minimal food fall in the biliary loop. This attenuates much of the peristalsis of the biliopancreatic segment, and tends to return the food and biliopancreatic secretion to their natural course (Fig. 27.10). The alignment of the gastric reservoir with the intestinal loop allows the verticalization of both structures and a more natural fall of the alimentary segment to the intestine, thus reducing the possibility of compliance and reflux from the biliopanceatic loop.

The theory of compliance is based on Hooke's law [1, 8], which states that the elongation of a spring is directly proportional to the force applied to it, provided that said spring is not permanently deformed.

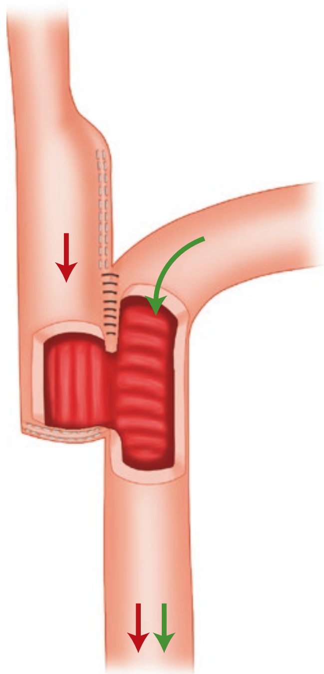


Fig. 27.10 Alignment of gastric reservor and Intestinal loop

$$\mathbf{F} = \mathbf{k}\left(\mathbf{x} - \mathbf{x0}\right)$$

where:

F is the modulus of force applied to the spring. (In our model, this is represented by the intestinal handles fixed in lateral form).

K is the elastic constant of the spring, which relates strength and elongation. (In our model, this is represented by the elasticity of the intestine and the gastric reservoir). The greater its value, the more work the spring will cost.

X0 is the length of the spring without applying force. (Ability to stretch from the reservoir and intestine).

X is the length of the spring with the applied force. (Stretching of the tissue).

If we review the Fig. 27.11 that represents a gastric bypass with a lateral end-anastomosis, we see how the arrows exemplify the fall of the food on a fixed intestine. This exemplifies how the food falls directly on the wall of the intestine. The weight of the food falls on a tissue that offers greater capacity for distention in relation to the stomach.

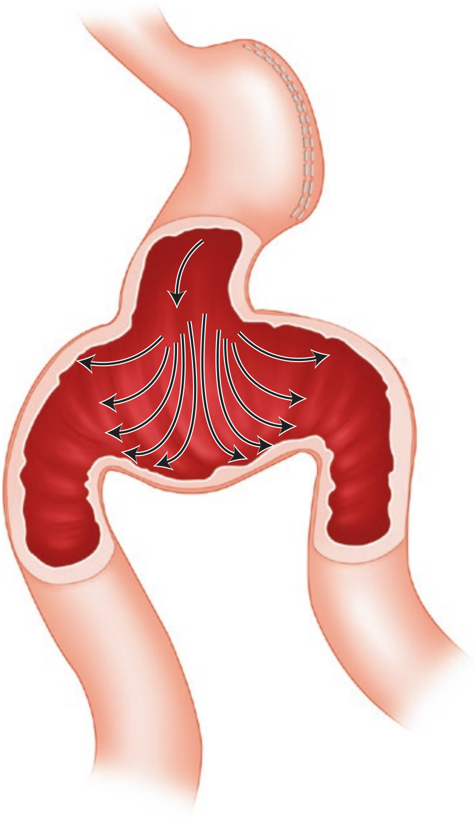


Fig. 27.11 Arrows indicate the distribution of the force vectors by the weight of the food against the intestine, leading to elongation

With time, the soft intestinal tissues can permanently elongate. The arrows illustrate how the food weight falls on the wall of the fixed intestinal reservoir, giving rise to "compliance", which is elongation of the intestinal tissue just in the place where it falls directly. In a chronic manner, permanent dilatation of the intestine is generated in this lateral ended model.

Analyzing the distribution of the loads in the OAGB, the continuous sutures generate the uniform distribution in a larger site of the tension forces. The weight of the intestine, mesentery, omentum and other structures fall, suspended in this continuous surge, leaving the anastomosis without tension; this can be seen in Fig. 27.12, where (1) exemplifies the site of the posterior continuous suturing on which the tension is distributed and (2) the anastomosis free of tension.

The total diameter of the gastric reservoir, whether calibrated with a bougie of greater or smaller size is a factor that is related in an inverse way to the flow of the food, to a greater diameter smaller. Resistance and smaller size will be the friction and the resistance, according to Hagen's law and our model, which may be manifested as a greater sensation of postprandial fullness or true satiety. The greater the

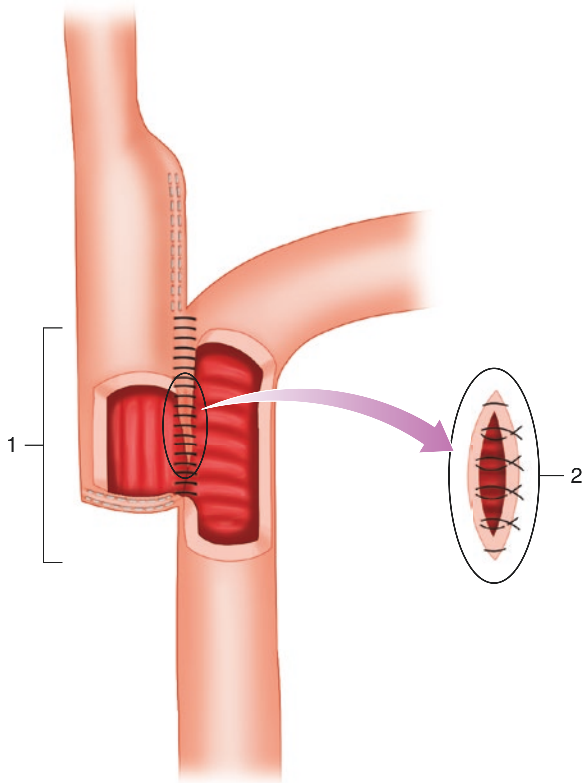


Fig. 27.12 1 = site of posterior continuous suture. 2 = anastomosis free of tension

length of the cylinder or reservoir, the greater will be the resistance to the flow of food, which could contribute with the first point and be part of the sensation of true satiety.

Conclusion

Physics is a basic science applicable to all natural phenomena, including surgical procedures. In the gastric bypass of an anastomosis to generate a long and narrow reservoir, the most widely used laws and physical principles study the behavior of the cylinders and their contents, as are the laws of Hagen-Poiseuille, Pascal, Laplace, and other laws that evaluate the elasticity of materials such as Hooke's law and the law of torsion. In the OAGB, the alignment of the small intestine and the cylindrical gastric reservoir according to the application of the physical principles has several meanings. On the one hand, the latero-lateral anastomosis allows the distribution of the traction vectors on this posterior suture-line, leaving the anastomosis free of tension; on the other hand, this allows the verticalization and alignment of both structures so that the fall of the food into the intestine is more physiological, without generating compliance or fall of the food towards the bilopancreatic handle. This is a more physiological technique.

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Method of Revision of Sleeve Gastrectomy to OAGB

28

José Sergio Verboonen Sotelo
and Vicente Lopez Kavanagh

28.1 Introduction

Bariatric surgery, regardless of type, is the therapeutic option that offers the best results for the treatment of obesity and its co-morbidities [1]. It was estimated that in 2014 in countries with associations affiliated with IFSO, 579,517 bariatric operations were performed, which only represented 0.02% of the population, showing that there is an immense growth opportunity for these procedures. Until 2013, the most performed surgery worldwide was the Roux-en-Y gastric bypass (RYGB), but the upward trend in sleeve gastrectomy (SG) since its introduction in 2003, made it the most performed bariatric surgery in 2014 (45.9%), followed by the RYGB (39.6%) and thirdly the adjustable gastric band (7.4%), leaving the one anastomosis gastric bypass in 4th place with 1.8%, and the biliopancreatic diversion (BPD/DS) as the least performed surgery [2, 3]. This substantial increase (9%) in the number of SGs may be due to several factors, one of the most important being its relative technical simplicity, which has allowed a great number of surgeons to have their first approaches to bariatric surgery through learning this technique; on the other hand, it is a procedure that can provide good results at least in the short-term, very similar results to the nowadays "gold standard", the RYGB.

28.2 Why does the SG fail?

There are many discrepancies related to results reported in the long-term regarding the effectiveness of the SG—few studies evaluate >8 years and it is common to find low numbers of follow-up. Arman et al. (2016) reported outcomes of 110 patients who underwent SG between 2001 and 2003 in two European hospitals; only 65

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patients (59.1%) were available to obtain information, and it was found that the average percent of excess of weight lost (%EWL) after 11 years of follow-up was 62.5%; however, 28% of the patients had required revision surgery due to weight regain, gastroesophageal reflux disease (GERD), or failure to resolve co-morbidities [4]. Diamantis et al. (2014) performed a review of 16 studies in which 492 patients were analyzed, with follow-up at 5, 6, 7 or >8 years, and found that the %EWL was 62.3%, 53.8%, 43% and 54.8% respectively, very encouraging results without taking into account that the follow-up rates were low for longer term studies [5]. It is also frequent to observe that the SG is associated with a variable rate of resolution of long-term co-morbidities. Gadiot et al. [6] found that at 5 years, the SG had resolution of type 2 diabetes (T2D) of 68%, hypertension 53%, dyslipidemia 25%, obstructive sleep apnea 89% and GERD 95%. Successful resolution of co-morbidities seems to be associated with maintenance of the loss of excess weight over time, and in turn, to different factors such as care and follow-up by a multidisciplinary team that promotes changes in lifestyle of patients, but also to factors related to the technique used in the shape of the SG.

In this sense, the correlation between the diameter of the sleeve and the risk of regaining weight is one of the most documented. Weigner et al. (2007) analyzed the postoperative evolution in 120 patients scheduled for LBPD-DS and who underwent SG as first stage with different calibration bougies: 44Fr, 32 Fr, and without a calibration probe; they found that the loss of excess weight after 2 years was significantly greater in those patients in whom a calibration bougie had been used, compared with those in whom it had not been used; among the groups in which it was used, the 32 Fr group had the best results; They also concluded that resecting a gastric volume < 500 ml appeared to be a predictor of treatment failure and an increased risk of weight regain [7, 8].

28.3 Indications for a Revision Surgery

As the years pass since the appearance of the SG as a single therapeutic option, there will be a greater number of patients with problems to solve secondary to this procedure. A large percentage of these patients get a consultation due to regaining weight, but there is another group that will require a revision of this operation because of symptoms, such as GERD who do not respond to medical therapy, patients with sleeve stenosis, and those who have not improved their co-morbidities sufficiently as in the case of T2D.

28.4 Preoperative Assessment

New preoperative laboratory tests, imaging, and assessments by the multidisciplinary team are vital. In the case of regain or failure in weight loss, anamnesis and a good clinical history become more relevant. If the patient had a significant weight loss, but after several months presented weight regain, we may be faced with two circumstances: a change in their eating habits towards carbohydrates and liquid calories, or an increase in the overall volume of gastric sleeve; both situations can be expected, especially when the patient does not have a support by the nutrition and psychology team. In such cases, it is imperative that the patient adhere to a multidisciplinary care program. An esophago-gastro-duodenal series will be the study that will allow us to confirm the dilatation of the gastric sleeve.

When patients present symptoms of GERD or chronic epigastric pain, an esophago-gastro-duodenal series and endoscopy are essential, in order to determine if there are anatomical alterations that favor the symptomatology. Complications such as stricture of the sleeve, esophageal dilatation, esophageal dysmotility, or preexisting alterations such as a Schatzki's ring or hiatal hernia should be kept in mind. Endoscopy will allow evaluation of the presence of gastric ulcers, esophagitis or exposed suture material. It is important to biopsy, because many patients with dyspeptic symptoms may be carriers of *Helicobacter pylori.*

Although the vast majority of gastric sleeves are performed by laparoscopy, and it is rare for this technique to produce generalized adhesions, it is important to investigate whether the candidates for revision had any complications in their initial surgery, such as bleeding, residual abscesses, fistulae, or if they have been subjected to other attempts at revision, since this increases the possibility of a difficult surgical scenario in which dissection and exposure are even more risky. With this background, we should contemplate the possibility that a conversion to a bypass withan anastomosis is not possible or safe, and inform the patient.

28.5 What Options can be Offered?

One of the questions that the surgeon faces when confronted by a patient with a history of SG and failure in weight loss is: what is the best procedure that can be offered? The answer depends on several factors, but one of the most important is the technical ability and experience of the surgeon and his team. We must never forget that revision surgery will always be presented in a scenario that, if not difficult, is at least special, where frequently adhesions with different degrees of complexity are found; in these cases, the support of a surgeon with a lot of experience in revision surgery will improve the chances of successful surgery. Regardless of our operation of choice for a sleeve revision, time has taught us that the final decision about which surgery to perform can be taken only after having achieved a laparoscopic inspection and dissection, to allow for safe surgery. We will avoid at all costs excessive dissections that lead to high risk of perforation or vascular lesions; we must always remember the basic principle of performing an anastomosis free of tension and the best vascularization possible.

There are two broad groups of possibilities when choosing the best option: perform a restrictive procedure such as a re-calibration of the sleeve or the application of an adjustable band, or perform a technique that adds malabsorption such as gastric bypass or a BPD/DS. To date, there are few studies that demonstrate advantages of any particular technique.

Salman AlSabah (2016) performed a retrospective study comparing the outcomes, after 1 year, of two groups of patients undergoing SG revision; one group was submitted to laparoscopic RYGB (n = 12) and the other was a re-calibrated SG (n = 24). The indications for such revisions were insufficient weight loss, with an EWL of 37.9% and 43% for RYBG and re-SG respectively. In this study we found that the mean EWL% was 61.3% and 57% for LRYGB and LSG respectively at 12 months follow-up, but the difference between both groups was not significant (p = 0.097) [9].

Langer et al. reported in 2010 their results of SG revision surgeries—8 cases of 73 patients whose indication was GERD (n = 3) and weight regain (n = 5). They subjected the patients to RYGB. The three cases with GERD managed to control symptoms on medication after 18 months of follow-up, and in the cases with weight regain achieved an average weight loss of 15.2 kg ± 8 kg with a follow-up range of 1–52 months without complications in only eight cases [10].

Homan et al. [10] compared outcomes obtained in two SG revision techniques incorporating malabsorption: BPD/DS (n = 25) vs. RYGB (n = 18). They found that the %EWL was higher for BPD/DS 59% (15–113%) than RYGB 23% (49–84%)—p = 0.008. All patients who had GERD or dysphagia improved after RYGB. In this study, short-term reported complications were greater with BPD/DS due to anastomosis leakage (n = 1), closed loop occlusion (n = 1), bleeding (n = 1); in both techniques, interventions for internal hernias were required—four in each group [11]).

28.6 Why One-Anastomosis Gastric Bypass (OAGB)?

We consider that the mechanism that allowed a patient to regain weight after a purely restrictive procedure will reappear over time if we offer a revision technique such as re-calibrating the sleeve or the application of a band. Thus, we opt for one that offers malabsorption. However, one of the objectives of the revision is to offer a solution with the lowest risk possible. The history of BPD/DS make us also rule it out as the first choice, because of the risk of early complications and being a highly demanding procedure. That is why we consider bypass as the best alternative.

Very little has been written about one-anastomosis gastric bypass (OAGB) as an alternative for SG conversion; however, it is a technique that offers excellent long-term results as primary surgery, with a very good index of correction of co-morbidities, with results comparable to those of RYGB and with a lower rate of complications [12, 13]. It is a controversial technique because much has been debated whether the flow of bile through the gastric reservoir increases the risk of marginal ulcers or increases the risk of cancer, but to date no evidence has been found [14–16]. OAGB offers advantages, because performing only one anastomosis and not requiring closure of mesenteric gaps, makes it less demanding and with a shorter surgical time. These are the reasons why the OAGB is our first choice for revision of SG. Our technique of conversion uses a MGB of Rutledge but with the anastomosis latero-lateral as Carbajo.

28.7 Surgical Technique

In the French position and under general anesthesia, three 12-mm laparoscopic ports and one 5-mm port in V–position and, if necessary an automatic liver retractor, are placed. A general laparoscopy is performed to evaluate the state of the adhesions (Fig. 28.1).

It starts with dissection of omentum, which is often again found adherent to the greater curvature of the sleeve. This procedure is performed with the Harmonic energy to avoid bleeding (Fig. 28.2).

The lesser omentum is then dissected below the level of the crow's foot, and the distal stomach is transected with endo-stapler 60-mm to leave the prepared gastric reservoir (Figs. 28.3 and 28.4).

If the sleeve is significanty dilated, it is possible to reshape the pouch with a continuous suture of 2-0 Prolene, always calibrating on a bougie. Then, the Treitz angle is located, and the small intestine is measured up to the ileocecal valve. After

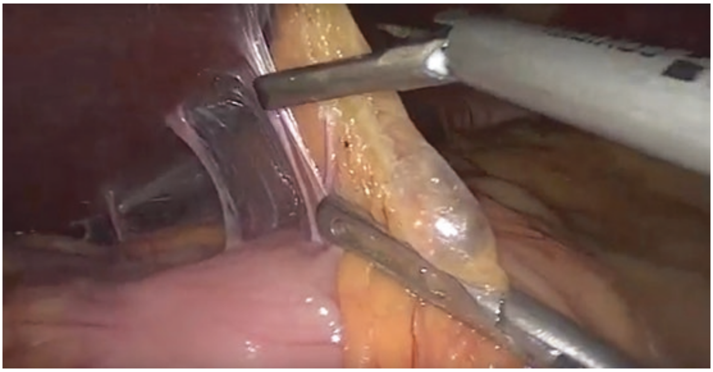

Fig. 28.1 Adhesions of liver to omentum

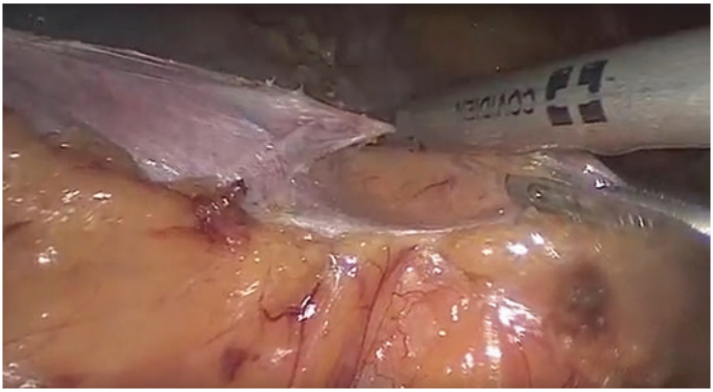

Fig. 28.2 Dissection of greater curvature

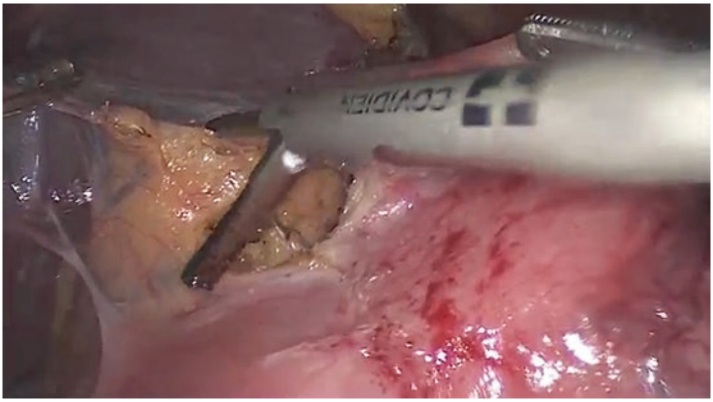

Fig. 28.3 Opening lesser omentum

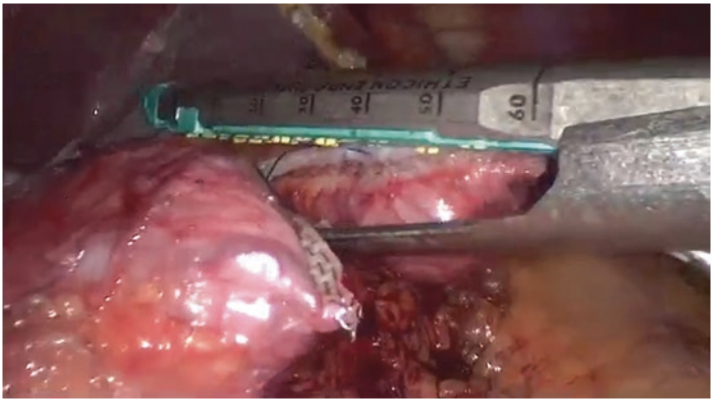

Fig. 28.4 The distal stomach is separated from the pouch with a 60-mm stapler. The initial surgical suture is exposed

that, the level of the bypass is decided. When the patient has a BMI of 40–45 kg/m^2, it is performed at 250 cm, with a BMI of 45–50 it is performed at 300 cm, and with BMI 50–60, we exclude 350 cm of jejunum. However, when the small intestine is larger than 8 meters in total, up to 400 cm of intestine can be excluded for adequate weight loss. To lift the loop to the gastric reservoir, an incision is made with electrocautery in the gastric tube and the calibration probe is visualized (Fig. 28.5).

The small intestine is incised, and a purple 30-mm triple line stapler (Covidien) or a 45-mm gold stapler (Ethicon) is inserted, and only two shots are performed. The stapler is removed and the inside of the anastomosis is checked; in case of bleeding, intraluminal titanium endoclips or soft electrocautery can be applied (Figs. 28.6 and 28.7).

The anastomosis is closed with 2-0 monocryl with continuous suture, and the anterior border of the anastomosis is reinforced with an invaginating second plane

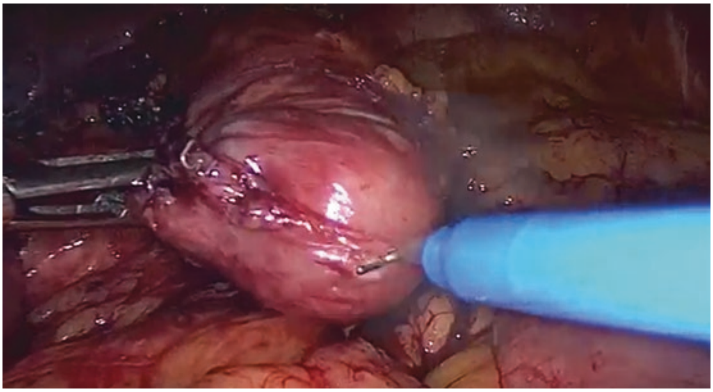

Fig. 28.5 The anastomosis is calibrated with a 34-Fr probe. It is incised by electrocautery

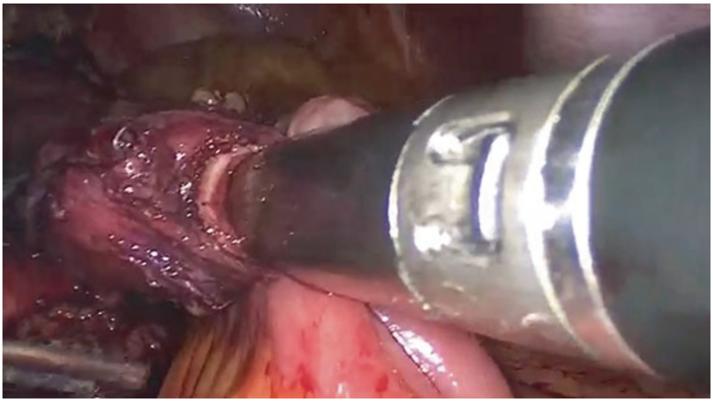

Fig. 28.6 Anastomosis performed with a linear stapler

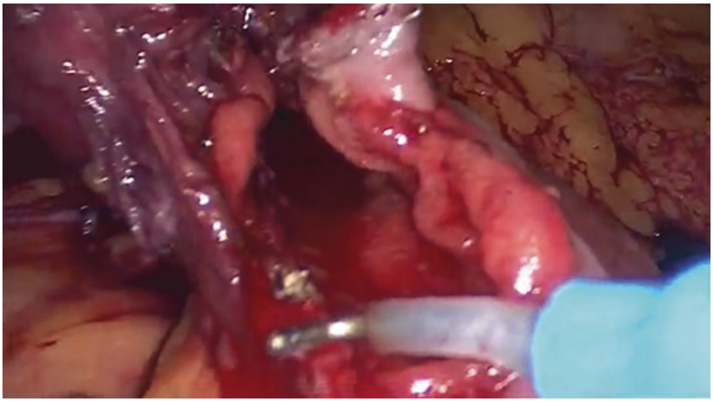

Fig. 28.7 Hemostasis of the border with electrocautery

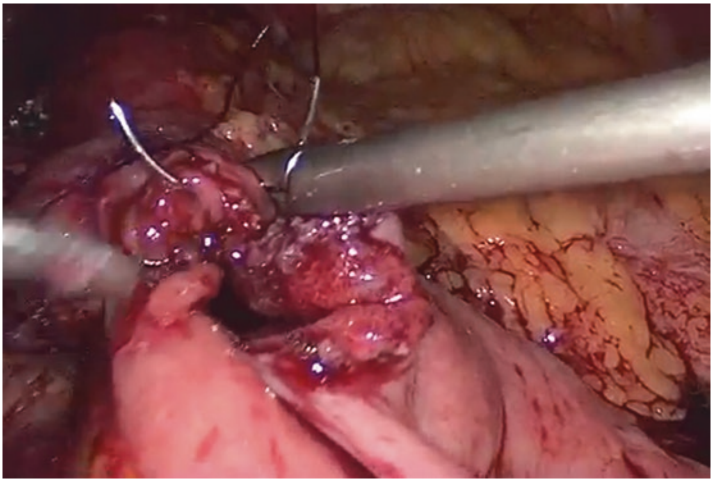

Fig. 28.8 Double hand-sewing of the edge

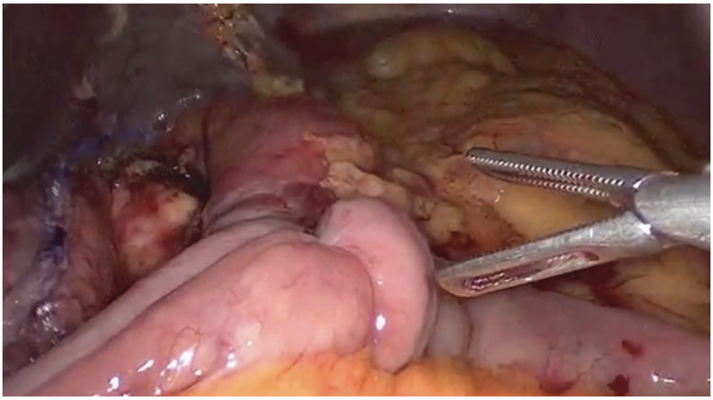

Fig. 28.9 Test of tightness. The final position of the OAGB is observed. The afferent gut is not fixed above the anastomosis

with the same suture material. Finally, a tightness test with methylene blue and air is performed, flooding the anastomotic site with saline solution (rim test). The anastomosis is performed in a side-to-side arrangement; the application of stitches above the anastomosis, from reservoir to afferent loop, is not necessary and even has the risk of tearing. When this is completed, a closed drainage type Blake or Jackson-Pratt is placed, the wounds are closed, and the drain tube is fixed (Figs. 28.8 and 28.9).

28.8 Our Experience

From May 2014 to December 2016, 107 SG revision operations were performed due to insufficient weight loss or weight regain. Of these, 65 were women and 42 men, with mean BMI 40.2 and mean %EWL 31.1 (13–55%). Of these, 24 patients had T2D and 32 hypertensive before the procedure. After surgical revision, mean BMI was 37.0, 35.3, 32.1, 30.3 and 29.85 kg/m^2 at 3, 12, 18 and 24 months follow-up. There were three non-fatal complications, and one reoperation due to omental hemorrhage. In all cases of T2D, there was control of the disease in use of medications and a significant improvement in the control of hypertension.

Frozen peritoneal cavities have been encountered in rare cases, where complete mobilization of the small bowel is not possible. The surgeon should always maintain an open mind, and even consider not performing any further surgery.

Conclusion

This revision technique to MGB-OAGB has given excellent results in patients with a past SG who had weight regain or failure to correct co-morbidities.

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29 The Ileal Food Diversion Operation: Technique, Rationale and Results

Francesco Greco, Laura Pedretti, Antonio Vilardi, Giulia Deretti, and Edoardo Matteo Rosso

29.1 Introduction

Since its birth, bariatric surgery underwent a cyclic alternation of malabsorptive and restrictive procedures. The proponents of the former, being detractors of the latter—and vice versa, have always tended to see the glass “half empty”: in other words, they focused on the risks and potential complications of certain procedures rather than on their advantages.

When speaking about malabsorptive procedures in Italy, it is impossible for us not to mention the Biliopancreatic Diversion (BPD), developed by Nicola Scopinaro in the late 1970s. Although BPD, as confirmed by Scopinaro himself, was an intervention that had always been reserved to an elite number of patients and surgeons (done by a few, and for a few), in view of the resulting nutritional and socio-economic implications (in Italy, at the peak of its success, the technique represented no more than 10–15% of all bariatric procedures). It is also true that to date no other bariatric intervention can boast the follow-up of BPD and a similar profound understanding of its mechanisms of action.

In the beginning of my experience as a bariatric surgeon, BPD was reserved for the so-called “eating” patients, i.e. for those who rejected the restrictions imposed by gastric band surgery (GB) and then by the Roux-en-Y gastric bypass (RYGB). The dietary and socio-economic history were clearly pivotal in the selection of this type of intervention. A second group of patients in whom BPD was preferentially indicated consisted in all those subjects with a primary or acquired (iatrogenic) anomaly of the gastro-esophageal junction, such as those with large hiatal hernias or previous restrictive interventions (vertical gastroplasty, gastric band). The

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motivation was the need to minimize unexpected intraoperative events, to shorten surgical times and consequently morbidity, and to minimize risks while still ensuring an important result in terms of weight loss. The rationale was to revise to malabsorption if restriction had failed, a logic of unquestionable value still today, in spite of it being often ignored.

29.2 Development of an Hybrid Procedure: Ileal Food Diversion

The first version of Ileal Food Diversion (IFD) consisted in the transverse resection of the stomach at the level of the gastric body and the execution of a Billroth II anastomosis on the posterior wall, transversally and parallel to the division line and distanced about 250 cm from the ileocecal valve (ICV). This procedure was performed in 2007 in four consecutive cases in collaboration with Roberto Tacchino [1]. Compared to the traditional BPD of Scopinaro, such approach differed by preservation of the gastric antrum and presence of a single anastomosis. The procedures were carried out laparoscopically, with four ports and without complications. In terms of weight loss, the results were encouraging and overlapping with those expected with a traditional BPD. One of the patients who underwent the procedure gave birth to a child, just over 3 years later after a normal pregnancy. After 2 years and in two separate centres, the two authors became aware of the goodness of such a concept, also driven by the need of put alongside the mini-gastric bypass (MGB) a real non-restrictive procedure, so as to satisfy those patients who longed for weight loss without food-eating restrictions.

29.3 Rationale of Ileal Food Diversion

In reviewing the possibility of performing a BPD with a single-anastomosis, some doubts persisted: first regarding pouch and anastomosis technicalities, and second about the potentially increased incidence of anastomotic ulcers due to the larger pouch and the retained antrum.

In classic BPD surgery, the stomach is resected horizontally; hence in case of marked visceral obesity, the anastomosis may have to be made under tension and with some difficulty, with an increased risk of fistulae, stenosis and ulceration. In addition, such a big pouch often dilated in early postoperative days, because of delayed empting, which explains why a preventive nasogastric tube is often necessary after surgery. The Mason-loop bypass, i.e. the first version of the single-anastomosis gastric bypass surgery performed in the 1970s, consisted of a pouch obtained by transecting the stomach transversely below the cardias, along its entire length, therefore including a portion of the gastric fundus. Technically easy to perform, it was however characterized by a short pouch, with the consequent risk of bile reflux into the esophagus. This result forced the abandonment of the technique.

The MGB consists of a long and narrow pouch on the lesser gastric curvature; notwithstanding a capacity of about 70–100 cc, it does not have a reservoir function and actually acts as an artificial esophageal extension which empties food into the bowel at about 2 m distal to the duodenal-jejunal flexure. From a technical and anatomical point of view, the advantages of MGB's long pouch are considerable whenever the anastomosis is completed without tension and the bile reflux is far from the esophago-gastric (EG) junction. This makes the use of a nasogastric tube unnecessary as well as any delay before oral liquid feeding. In addition, the optimal vascularisation provided by the left gastric artery reduces the risk of ischemia and of anastomotic fistulae.

The IFD pouch (Fig. 29.1) was designed to combine the advantages of the long and vertical MGB pouch with those of the BPD pouch that is an easy anastomosis in more complex cases and an easy way out in case of a large hiatal hernia or previous surgery at the EG junction. The pouch consists of a long and narrow vertical portion cut out on the lesser curvature, similar to the pouch described for MGB. However, the upper portion of the pouch in the IFDs opens up funnel-like in the direction of the pole of the spleen. Vascularization and innervation of the gastric fundus are preserved; hence, no areas of relative ischemia are present, and pouch vascularization is no longer solely dependent on the left gastric artery but receives blood from the posterior gastric vessels coming from the splenic artery and the short gastric vessels. The capacity of such a pouch averages about 250–350 cc at medium filling, sufficient to ensure a regular meal, as the gastric fundus is elastic and capable of distending to accommodate food. Consequently, the pouch no longer acts solely as an artificial extension of the esophagus; it in fact retains part of its reservoir function, dilating with meals, and then gradually emptying: the amount of food that can be ingested by the patient with a single meal is therefore much greater and the stomach emptying is much slower.

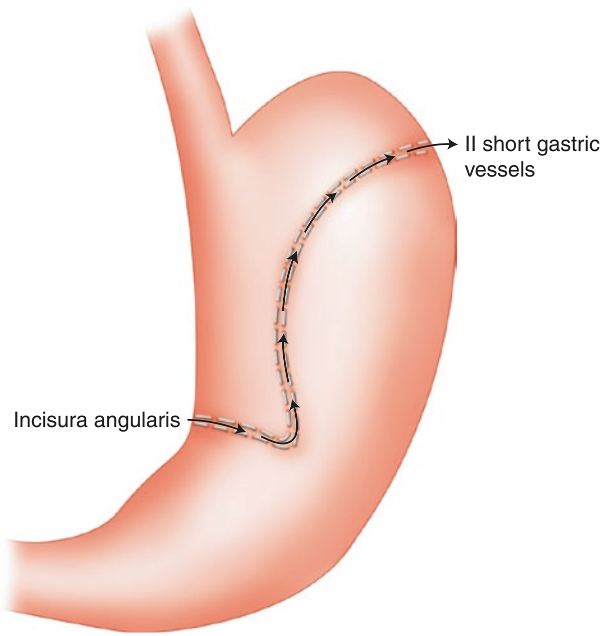

Fig. 29.1 Author's diagram. The pouch of IFD combines the advantages of the long and vertical MGB pouch (no tension anastomosis) with those of the BPD pouch (eliminates the risk of EG junction dissection)

29.4 Technique of the Ileal Food Diversion

The patient is placed in a standard supine, lithotomy position, with legs joined and the right arm extended, available for the anesthesiologist for venous access, and with the left arm along the body. The monitor is placed above the patient's left shoulder, with the surgeon on the right, using a small 10-cm elevation platform. The surgical nurse attends the surgeon on the left of the patient; the surgical equipment table is on the left of the patient's feet (Fig. 29.2). Preoperative trichotomy and intestinal preparation are not performed. A pure single surgeon procedure is performed with three ports, assisted by the nurse and by the scope retaining arm. The procedure starts with induction of pneumoperitoneum by means of a Verres needle into the epigastrium. Needle insertion is made by taking the xiphoid process as a landmark and by using the open left hand as a compass (the middle finger points towards the xiphoid process); the thumb (using the middle finger as a hinge) is rotated slightly counterclockwise for about 10–15°. Once the Verres needle is removed, the needle entry point is used for the insertion of the first 5-mm (or 3-mm trocar), that will be used for the 30° scope. The pneumoperitoneum is set at 12–15 mm Hg and the flow at the maximum rate (ideally equal to or greater than

Fig. 29.2 The patient is placed in a standard lithotomy position. The monitor is placed above the patient's left shoulder, with the surgeon on the right, using a small 10-cm elevation platform. The surgical nurse attends the surgeon on the left of the patient. and the surgical equipment table is on the left of the patient's feet

40 L/min). By rotating the thumb counterclockwise by an additional 45–60°, the second trocar is inserted in the left subcostal area at the level of the midclavicular line, at a variable distance from the rib cage of 3–4 fingers. This trocar will accommodate the radiofrequency dissection system, the mechanical stapler and the Endostitch suture system, and will therefore require a 12-mm gauge. The third and last port is just below the right costal arch, about 2 cm to the left of the median line. This 5-(or 3-) mm trocar is inserted by directing the tip towards the angularis of the stomach and through the falciform ligament.

The first step of the procedure consists of the introduction of a 40-Fr orogastric tube; the tube is advanced forward along the greater curvature, in order to exert traction on the stomach downward and to the right of the screen; this manoeuvre exposes the angularis and the pars flaccida by bringing them outside of the shadow of the left lobe of the liver. Liver retraction is never required. The pars flaccida is grasped with the EndoClinch™, with the left hand, and exposed vertically; the window is then opened and access is established to the epiploon retrocavity. At times, the retrocavity may be closed due to adhesions between pancreas and posterior gastric wall. In such cases, the opening on the lesser omentum does not allow access nor the release of the lesser curvature. In such cases, perigastric dissection becomes mandatory: this surgical step can be done with a progressive perigastric dissection, grasping the fat of the lesser omentum and progressively rotating the margin of the lesser curvature, exposing the inner side; maximum attention must be paid in order to avoid damage to the pancreas and the transverse colon-superior duodenal flexure, which are easily pulled upward in the attempt to gain access to the epiploon retrocavity. Dissection begins just under the region of the crow's foot: once the retrocavity is opened, the opening is extended downwards, releasing the margin of the lesser curvature for a length of about 3 cm, up to a distance of about 5–6 cm from the pylorus. The redundant vascularization of the gastric wall at this site does not allow for blunt dissection through the fat, as it would almost inevitably result in the onset of bleeding, which is sometimes difficult to control because of the low visibility and abundance of fat. It is better, in our opinion, to exploit the full coagulating power of the radiofrequency scalpel (Ligasure™) and to dwell in the dissection always a little more than what is apparently necessary, in order to then have a large window, with an accurate preparation of the anterior and posterior wall of the stomach. The transverse resection of the stomach to create the base of the pouch should be done gaining as much tissue as possible, well below the angularis, in order to have a pouch as long as possible, allowing for a tensionless anastomosis and protection against bile reflux into the esophagus.

In our technique, the resection is performed with a special articulation and rotation manoeuvre of the stapler, which enters from the right subcostal trocar, instead of what is usually described with the stapler inserted from the left of the screen. Such an approach limits the use of 12-mm access, thereby reducing pain and the incidence of incisional hernias. Once the stapler is articulated at 60°, the stomach is rotated counterclockwise by 30° and the resulting 90° angle is ideal for the resection. At this point the stomach is pulled upward to gain centimeters of tissue downwards, and the resection line is moved as distally as possible. The vertical resection

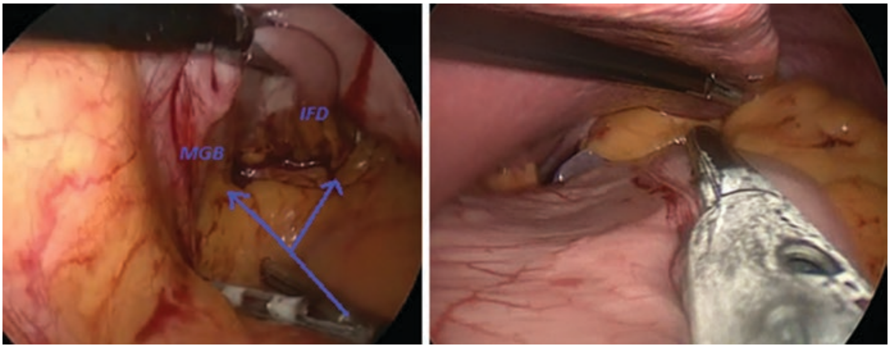

Fig. 29.3 Left: The pancreas is visualized below, the gastric artery to the left, the greater curvature with the short vessels on the back right, the gastroesophageal junction in front. Right: After evaluating the size of the gastric fundus, the resection is continued by rotating the stapler by 45° to the right of the screen in the direction of the splenic hylum

of the gastric pouch is thus continued, under guidance of the orogastric tube: the 60-mm stapler (Tri-Staple Purple Medtronic) is used twice vertically, remaining a few millimetres from the tube. The EndoClinch™, from the left, raises the pouch with the tube within, and allows an extensive exposure of the retrocavity (Fig. 29.3): the pancreas is visualized below, the gastric artery to the left, the greater curvature with the short vessels on the back right, the gastro-esophageal junction in front. After evaluating the size of the gastric fundus, the resection is continued by rotating the stapler by 45° to the right of the screen in the direction of the splenic hilum. Two or three Tristaple™ 60-mm Purple Cartridges are necessary to reach the greater curvature, which is resected between the first and second or between the second and third short vessel in an avascular area.

The resulting pouch resembles a funnel, flared upwards and narrow below, functionally replicating what occurs naturally in the passage between the stomach and the duodenum; in this case, food will no longer reach the jejunum, as physiologically happens, but will instead be *diverted* to the ileum (Fig. 29.4). The pouch's mean filling capacity is 250–350 cc, enough to accommodate a regular medium-sized meal. Gastrotomy is opened with scissor and coagulation on the lower anterior face of the pouch (where the horizontal and vertical staple-line cross each other) and then stretched a little with a small bowel clamp.

The second part of the intervention involves measuring the entire small intestine. This manoeuvre requires 5–10 min, although in difficult cases it may be complex and not void of risks. The surgeon moves to the patient's left shoulder and the patient is now rotated on his left side and placed in a slight Trendelenburg tilt, in order to approximate the ileocecal valve to the surgeon (Fig. 29.5). The camera remains within the epigastric trocar; two fenestrated graspers are used to identify the cecum and the last ileal loop and a 300-cm tract is measured proximally; a landmark is placed at this level (usually a large clip on both sides of the intestinal mesentery, so that it can later be readily visualized).

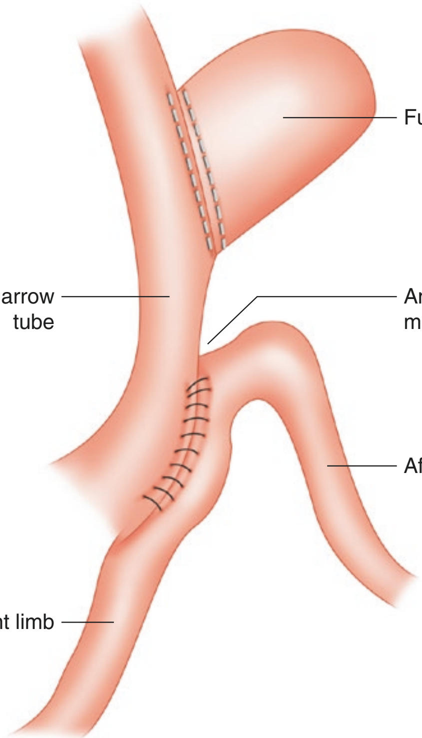

Fig. 29.4 Author's diagram. The resulting pouch resembles a funnel, flared upwards and narrow below. In this case, food will accommodate in the fundus and is then *diverted* to the ileum. The pouch's mean filling capacity is 250–350 cc, enough to accommodate a regular medium-sized meal

Fig. 29.5 The second part of the intervention involves measuring the entire small intestine. The surgeon moves to the patient's left shoulder, and the patient is rotated on his/her left side and placed in a slight Trendelenburg tilt in order to approximate the ileocecal valve to the surgeon. The camera remains within the epigastric trocar

The surgeon now returns to his original position to the right of the patient, who is now positioned on a plane slightly rotated to the right. An Endoclinch™ is used in the left hand and a fenestrated grasper in the right hand: the greater omentum is lifted gently with a combined manoeuvre of the two hands exposing the transverse colon. In an almost horizontal position, the surgeon performs the measurement of the bowel that is progressively moved upward, keeping the inferior pole of the spleen as a target. The mesocolon is put under tension by pulling on an epiploic appendix in proximity of the left colic flexure, where it is thin enough and relaxed enough to allow easy exposure of the ligament of Treitz. The biliary limb is measured starting from Treitz' ligament up to the mark placed at 300 cm from the ileo-cecal valve, thereby completing the measurement of the entire small bowel. If the total limb lenght is <7 m, the measurement continues until 250 cm from the ileo-cecal valve, in order to elongate as much as possible the biliary tract.

After the enterotomy is done, a Tristaple™ 45 purple reload is introduced into the bowel and directed proximally. The bowel is rolled 180/270° with rotation on the major axis of the stapler to spread the tension on the intestinal wall and with a counter-clockwise translation, the limb is approximated to the gastric pouch (Fig. 29.6). While the patient was placed in the reverse Trendelenburg position, the pouch was pulled down, and the gastro-ileal anastomosis is performed on the anterior wall of the pouch ~1 cm from the vertical staple-line. The service opening is closed with a hand-sewn double layer barbed suture (V loc™) performed with EndoStitch™. The last step of the procedure is the creation of an anti-reflux mechanism: 5–6 cm of the afferent loop are sutured to the pouch and reinforce the vertical staple-line, reducing the tension on the anastomosis and providing a preferential way for food and liquid travelling toward the alimentary/efferent limb, minimizing the risk of reflux of food (Fig. 29.7). The patency and the tightness of the gastro-enteral anastomosis in general are not tested with methylene blue. No drain is left in place, and no nasogastric tube is necessary. The operation ends with the instillation of Carbocaine along the staple-line. The abdominal fascia is never closed.

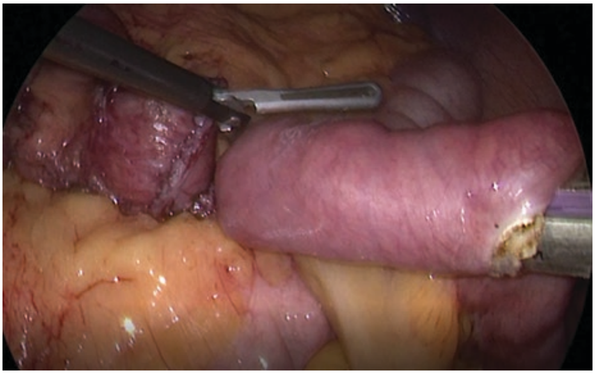

Fig. 29.6 Tristaple Endogia™ is introduced within the enterotomy, and the bowel is rolled 270° with a movement of rotation on the major axis of the stapler to spread the tension on the intestinal wall. With a counter-clockwise translation, the limb is approximated to the gastric pouch in order to perform the anastomosis

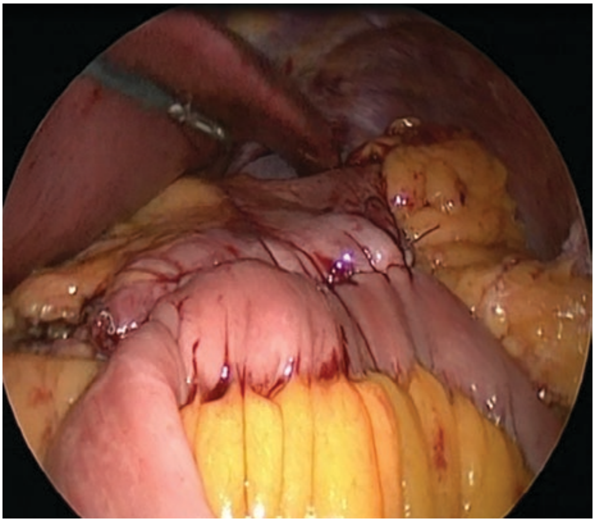

Fig. 29.7 Intraoperative view at the end of the procedure: 5–6 cm of the afferent limb are sutured to the pouch vertically to reinforce the vertical staple-line, reduce the tension on the anastomosis and provide a preferential way for food and liquid travelling toward the alimentary/efferent limb

29.5 Results

We performed a total of 216 (104 male) IFDs from Sept. 2012 to Dec. 2016. In the last 3 years, the IFD represented our second procedure after MGB and 35% of all bariatric interventions that we performed; 12.9% (28) were re-do surgery after failed gastric band (18), open vertical banded gastroplasty (3), laparoscopic vertical sleeve gastrectomy (6) and transoral gastroplasty (1). Average preoperative BMI was 44.26 SD ± 5.78 (range 31.3–63.9) and average weight was 126.12 kg SD ± 22.2 (range 75.2–209.0). We start a very low-calorie diet (600–800 Kcal/day) 10–30 days before surgery according to the degree of obesity and fat distribution, in order to reduce liver volume and visceral fat. Cefazoline (2 g) was administered preoperatively, and Enoxaparine 4000 I.U. postoperatively was used as prophylaxis. Patients are encouraged to stand and walk 2 h after the end of the operation and start oral liquid diet after 5–6 h. No routine contrast x-ray is done. Perfusions are interrupted after 24 h and patients are discharged the morning of the second postoperative day.

Supplementation with oral multivitamins, ursodeoxycholic acid and high-dose PPI are prescribed. High parenteral doses of vitamin D and vitamin A are prescribed according to blood test findings at 2, 6 and 12 months follow-up.

IFD in our experience is a very fast and secure procedure, even in difficult cases: mean operating time was 72 SD ± 17 min ranging from 25 to 220 min. Revisional surgeries last longer (average 113 min SD ± 19). In all cases, we perform a single surgeon procedures by a 3-trocar laparoscopy. Major perioperative adverse events were reported in 3.2% of procedures (2 leaks from the staple-line that were reoperated by laparoscopy and sutured, 4 stenosis of the anastomosis, two of which required reintervention, 1 pulmonary embolism). Minor adverse events consisted of one patient who developed ab-ingestis pulmonitis, three patients required insertion of a nasogastric tube because of delayed gastric empting, and one respiratory

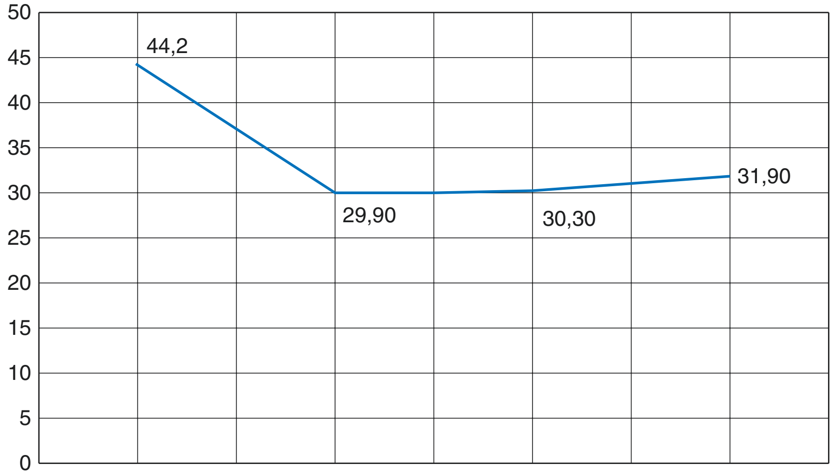

Fig. 29.8 57% of patients reached 1 year follow-up and 25% completed 3 years follow-up. The values reported in the graph represent the preoperative mean BMI, BMI at 1, 2 and 3 years follow-up respectively

insufficiency. One case of peripancreatic collection presented 7 days after discharge with abdominal pain and leukocytosis, which resolved with conservative treatment. This was the only adverse event reported among revisional surgeries procedures.

Fifty-seven percent of patients reached 1-year follow-up, and 25% completed 3 years follow-up: mean BMI decreased from 44.2 to 29.9 (SD ± 4.48) after 12 months; at 2–3 years follow-up, BMI was respectively 30.3 (SD ± 5.4) and 31.5 (SD ± 6.2) (Fig. 29.8). Two patients (0.9%) experienced excessive weight loss that resolved with conservative treatment after 1 year postoperatively; 4 patients (1.8%) underwent revision for inadequate weight loss: in two cases, we performed a tubularization of the pouch with anastomosis of the fundus to the excluded stomach. The others two patients received endoplication of the fundus by Overstitch™. In all those cases, we achieved a good result in terms of weight loss and patient satisfaction with low-risk revision strategy. Late complications consisted of three patients who developed ulcers: one of them required laparoscopy and suture. In terms of resolution of co-morbidities, we experienced very good results, that were coupled with unexpected very good outcome in nutritional profile. Albumin level which preoperatively was 4.6 g/dL (SD ± 0.4), decreased to 4.0 g/dL (SD ± 0.37) at 1 year follow-up and stabilized at 2 years (4.0 g/dl SD ± 0.36) (Fig. 29.9). No protein malnutrion was found at follow-up. Hemoglobin level was preoperatively 141.2 g/dL (SD ± 1.41), after 1 year 13.38 g/dL (SD ± 1.97), and at 2 years 13.5 g/dL (SD ± 1.90).

Preoperatively, 63 patients had elevated blood glucose (>110 mg/dL) and 24 were in treatment for diabetes with insulin and/or oral antidiabetics. Diabetes resolution, defined as withdrawal of insulin/oral antidiabetic, was accomplished in 20 patients (83%) after 1 year, while 4 patients improved and reduced the insulin dose dramatically.

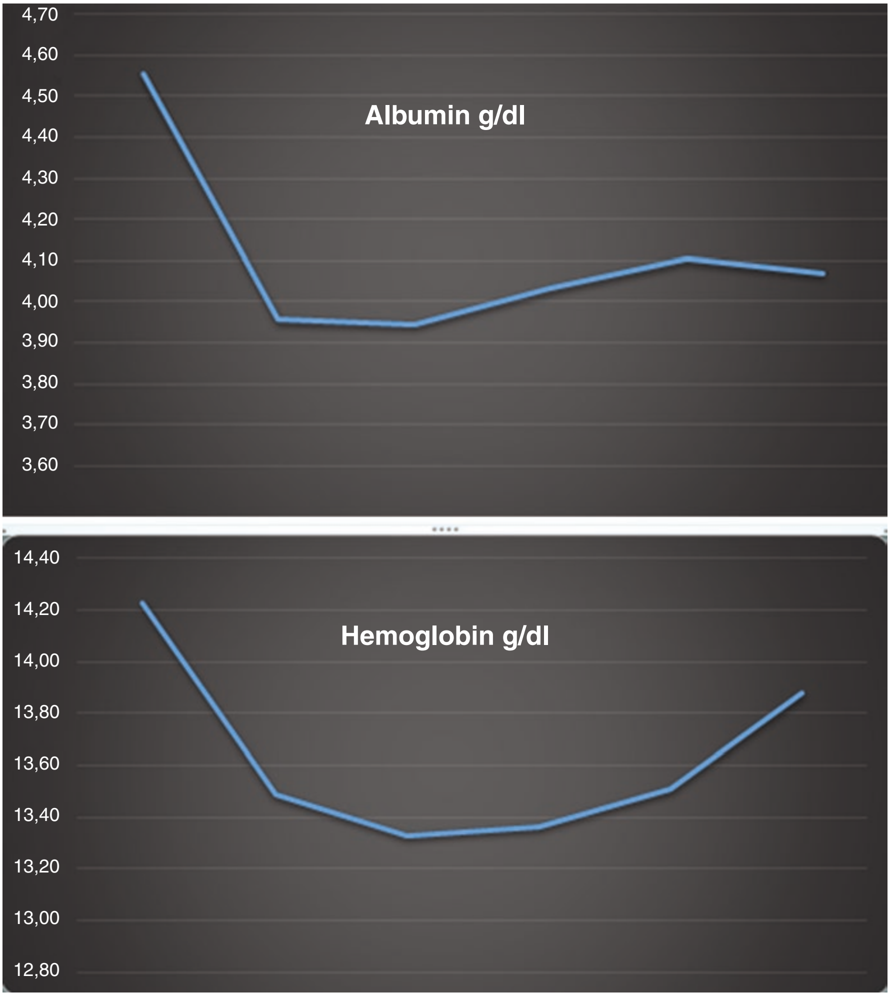

Fig. 29.9 IFD patients maintain excellent nutritional status despite weight loss. This probably reflects a better quality of nutrient absorption after Billroth II (IFD) recontruction than Roux-en-Y (BPD)

The preoperative mean cholesterol level was of 196.6 mg/dL (SD ± 40.3); it decreased to 156.1 (SD ± 33.9) at 1 year, and was of 161.5 (SD ± 33.7) at 2-year follow-up.

The preoperative mean triglyceride level decreased from 140.8 mg/dL (SD ± 76.6) to 96.8 mg/dL (SD ± 36.8) after 1 year and was of 103.1 mg/dL (SD ± 49.6) at the 2-year follow-up (Fig. 29.10).

Patients reported excellent quality of life. Symptoms related to Roux-syndrome, such as nausea and vomiting described in the first months after BPD and RYGB, disappeared rapidly with great improvement in quality of life. Bowel movements

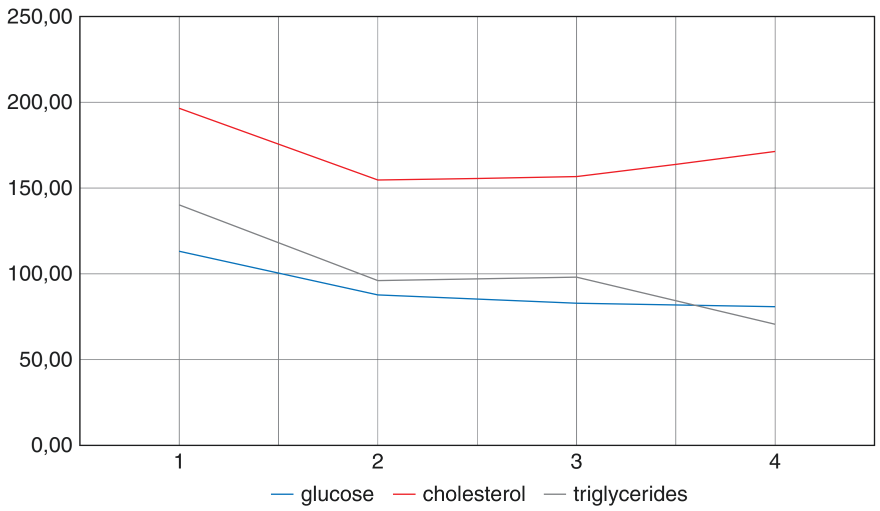

Fig. 29.10 Modification of glucose, cholesterol and triglycerides blood values from pre-op and after 1, 2 and 3 years from intervention

and signs of malabsorption were similar but milder than those described after Scopinaro's BPD: 2–5 bowel movements per day were reported with no restrictions but only some food limitations, allowing standard medium-sized meals 3–5 times a day.

29.6 Discussion

29.6.1 Reduced Absorption and Limb Lengths in IFD

The introduction of the Mini-Gastric Bypass in 2005, as an alternative procedure to RYGB, triggered a philosophical revision of indications for bariatric surgery. It was immediately apparent that this technique was not simply a technical variant of traditional bypass surgery but, indeed, a truly "mixed" procedure, combining restriction and malabsorption in a new, simple and effective way; it also disproved some of the classic principles underlying obesity surgery, arousing a new interest in the pathophysiology of malabsorption that was at the time erroneously considered beyond dispute.

The superior MGB perioperative outcome in terms of patient recovery and discharge (i.e. in terms of mini-invasiveness), shown by its routine use, and its excellent results over time, allowed the procedure to "take away" an ever-increasing number of interventions from RYGB and BPD. The possibility of performing the intervention in less than an hour, with only three ports (or with just one), without the need for a naso-gastric tube and abdominal drainage, made the postoperative course much faster and anticipated patient discharge. Also, the non-removal of the antrum made the complete restoration of the anatomy and the duodenal transit anatomically possible, while reducing surgical trauma and preventing the potentially fatal risk of duodenal stump fistulae.

Scopinaro's principle of not adding *restriction* to *malabsorption*—in view of the high incidence of long-term malnutrition [2]—was shaken by the evidence of the results obtained with MGB. His principle maintains instead its validity when considering Roux-type reconstruction, i.e. with a long, isolated and *defunctionalised* alimentary loop, deprived of the physiological passage of biliodigestive juices, as in the classic BPD approach. In the latest and more diffuse version of Scopinaro's BPD, the alimentary limb is 250 cm, but on various occasions, they have published different combinations of stomach volume and intestinal lengths. Also, as explained by the author himself, pancreatic enzyme must be reabsorbed in the biliopancreatic limb and pancreatic digestion did not occur in the common limb. Protein and starch absorption occur through the enzymatic activity of the intestinal brush border of the entire intestinal segment comprised between the gastroenterostomy and the ileocecal valve (ICV) [2].

The scenario is totally different with the Billroth II reconstruction: in this case, having bypassed the upstream tract, rather than the diversion of biliopancreatic juices, we should instead refer to *food diversion* to a distal tract of the intestine. Semantics, in this case, reflect important and partially not yet studied pathophysiologic consequences: in short, it can be said that compared to classic Roux-en-Y recontruction, gastric bypass with single anastomosis has shown that malabsorption is modulated not only quantitatively but also in term of quality.

The data from our case series allows us to state that the probability of calorie-protein malnutrition after IFD is rare and, so far, not reported, and that blood albumin levels remain constantly elevated at 2–3 years (Fig. 29.9) even in the presence of considerable weight loss. A similar consideration can be made with regards to the development of iron-deficiency anemia: at follow-up, a lower incidence of iron deficiency has been found in IFD patients compared to MGB patients. The likely explanation is that the greater amount of food consumed can better compensate for reduced iron absorption. However, the data are not comparable, because the male population, which is less likely to develop anemia, is over-represented in the IFD group. In any case, when compared to the data in the literature of Scopinaro himself, the outcomes are quite different from the protein malnutrition in 11.9% of patients at 18-years follow-up after BPD and anemia in 33% of patients at 2-years follow-up [3].

The variation in intestinal length in humans is controversial: no real standard measurement method or standard bowel limb length has been reported and almost no bariatric surgeons measure the entire bowel length. We intraoperatively measured the total small-bowel length by stretching the bowel with a clamp marked at 5 cm: Fig. 29.11 reports values from >100 intraoperative findings. We found an average total limb length of 687 cm (SD ± 129.2), with mean alimentary limb length of 285 cm (SD ± 29.7) and a mean biliopancreatic limb length of 385.7 cm (SD ± 102.8). The first thing to emphacize is that a consistent number of patients have >8 and <6 m of total small-bowel length. This is in accordance with other findings in the

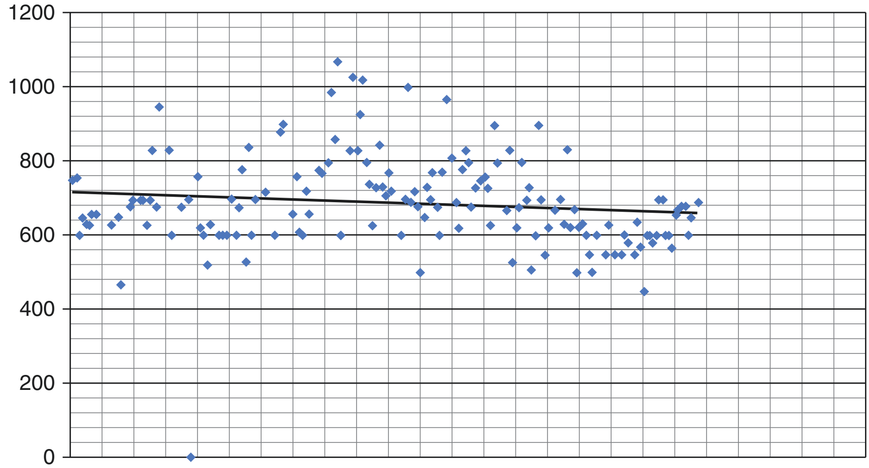

Fig. 29.11 Intraoperative measurement of small bowel length. Average total limb length was found to be 687 cm (SD ± 129.2). A consistent number of patients were found to have >8 and <6 m of total small-bowel length

literature [4] that report a significant number of subjects (3% of females and 2% of males) with a small bowel <400 cm and in 15% of males and 5% of females a small bowel >800 cm. From a practical point of view, the reduced absorption can be modulated depending on the length of the biliary tract bypass; however, the length of the biliary tract is influenced by the overall length of the entire intestinal tract, and the anthropometric variability of each patient must be considered especially when—as in this case—restriction is limited or absent in order for the patient not to present the signs and symptoms of protein-calorie malnutrition.

Nutrient absorption depends on the residual absorption capacity: this in turn depends on the length of the common/alimentary tract and on the patient's residual enzymatic capacity that decreases by increasing the biliary tract length and the food transit rate. Should the hypothesis be considered that the enzymatic flow through the alimentary tract is constant over time, there will be a maximum absorption threshold beyond which there will be no more absorption [2]. The absorption level is therefore determined by the rate at which food transits through the common/alimentary tract: in other words, with an equal residual enzymatic capacity at low transit speed, the threshold will not be reached or will in any case be minimally exceeded; should plenty of food transit rapidly within the lumen, the non-absorbed percentage will instead be higher. This could explain signs of malabsorption (steatorrhoea, oily stools, meteorism, flatulence) in many MGB patients with a 2-meter biliary tract. In a retrospective analysis of the first 70 patients in which the anastomosis was invariably made at 300 cm from the ileocecal valve (and hence the length of the biliary tract was the only variable), it was clearly evident that in the presence of a pouch of around 250–350 cc, the best results were obtained when the biliary tract was >4 m (Fig. 29.12). With 3 m or less, the resulting physiological adaptation

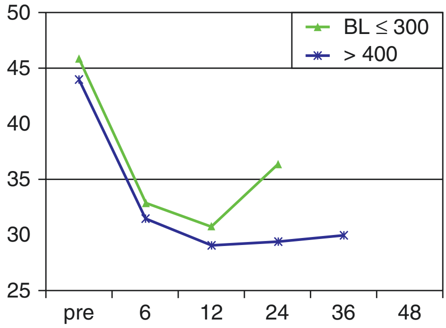

Fig. 29.12 This chart is referred to the first 60 cases with a fixed 300 cm common channel and different outcome depending solely on the length of the bilopancreatic tract: with 3 m or less, the resulting physiological adaptation occurring approximately 1 year after the procedure was able to significantly compensate for reduced absorption with consequent weight regain and significant reduction of steatorrhea

occurring approximately 1 year after the procedure (in parallel with the loss of the initial transient restriction), was able to significantly compensate for reduced absorption with consequent weight regain and significant reduction of steatorrhea. The relatively modest modification of the gastric pouch volume in IFD allows for a much slower food transit and a progressive emptying of the pouch, thus allowing for a progressive and non-immediate transit through the alimentary loop. The consequence is an improved use of the residual absorption capacity of the downstream intestinal tract (common/alimentary tract). To achieve a satisfactory weight loss with a gastric pouch volume that increases from 100-150 to 250-300 cc, a much longer bypass is required, compared to the 2-meter standard described for MGB.

29.6.2 Preservation of the Antrum, Size of the Gastric Pouch and Risk of Ulcers

Marginal ulcer is one of the most fearsome complications of gastric bypass and of all gastroentero-anastomosis procedures; although being reported more frequently in smokers and in patients using NSAIDs, with an incidence ranging from 0.5% to 3%, no strong evidence exists concerning what their real cause is. Classical theories about the ulcerogenic potential of the antrum, which is believed to be responsible for hypergastrinemia, as well as the excessive acid production directly proportional to the size of the gastric pouch, have lost part of their validity in the era of proton pump inhibitors. BPD itself as reported by Scopinaro has a risk of marginal ulcer of about 5% in the first year and the variants with retained antrum, such as Resa's BPD or Vassallo's BPD, did not appear to present higher incidences [5, 6]. Marginal ulcers are equally frequent following vertical gastrectomy and Roux type loop reconstruction (BPD-DS), as well as after RYGB. Confirmed predisposing factors, independent of the shape and size of the gastric pouch and type of reconstruction, are loco-regional microischemia (iatrogenic or diabetic) and anastomotic tension [7]. In our case-series of IFD, the incidence of marginal ulcers is slightly above 1% (similarly to that of MGB), despite the volume of the gastric pouch being considerably greater vs conventional gastric bypass and contemporary antrum retention. It may be hypothesized that the optimal vascularization of the IFD pouch (which as previously mentioned receives blood from both the left gastric artery and from the posterior branches originating from the splenic artery and the short gastric vessels), as well as the absence of anastomotic tension - guaranteed by the long vertical segment - are protective factors with regards to ulcer development.

29.6.3 Advantages of the IFD in Revisional Surgeries and in Particular Cases

Complex situations are commonly present in clinical practice, and bariatric surgeons must be able to manage them by minimizing as much as possible perioperative risks and potential long-term complications. In recent years in bariatric surgery, revisional surgery following sleeve gastrectomy has become a hot topic; however, revisions after gastric band surgery are also numerous. Less frequent, but even more complex, are failures following vertical banded gastroplasty.

In the above-mentioned cases, Ileal Food Diversion is our procedure of choice. Following sleeve gastrectomy, a dilated or poorly prepared gastric pouch is a frequent finding, with part of the gastric fundus preserved for either technical difficulty (i.e. a previous gastric band) or unskilfulness. In such cases, the pouch is very similar to the one that we deliberately create in our modified gastric bypass with single anastomosis. The sleeve's gastric pouch is therefore not cut out, and the anastomosis is made at about 250–350 cm from the ileocecal valve after measuring all the bowel. This avoids re-resecting an area at high risk for perforation or on pre-existing scars. We have also published a functional variant of this conversion method [8] (Fig. 29.13), which involves the use of a ring instead of transecting the pouch horizontally detaching it from the antrum. This easily performed variant has the additional benefit of simple reversibility and the possibility of exploring the antrum and the biliary tract.

In revisions following VBG (vertical banded gastroplasty), the philosophy remains unchanged, i.e. avoid dissection in dangerous areas and resections on thickened tissues. The restoration of the normal anatomy is thus accomplished without removing the band (which often adheres to the liver and is difficult if not impossible to remove) and instead by anastomosing with a 60-mm cartridge the gastroplasty pouch—which is often dilated above the neo-pylorus—with the excluded fundic part of the stomach that results small and defunctionalized. Such anastomosis is easily performed and relatively risk-free. At this stage, the usual ileal food diversion pouch can be made by resecting the stomach transversely below the crow's foot and continuing vertically with one or two 60-mm cartridges upwards and then to the right moving away from the band and from the previous gastroplasty suture-line (Fig. 29.14). The gastro-ileal anastomosis is then performed as usual at 250–300 cm from the ICV, based on the overall intestinal length. To date, we have converted

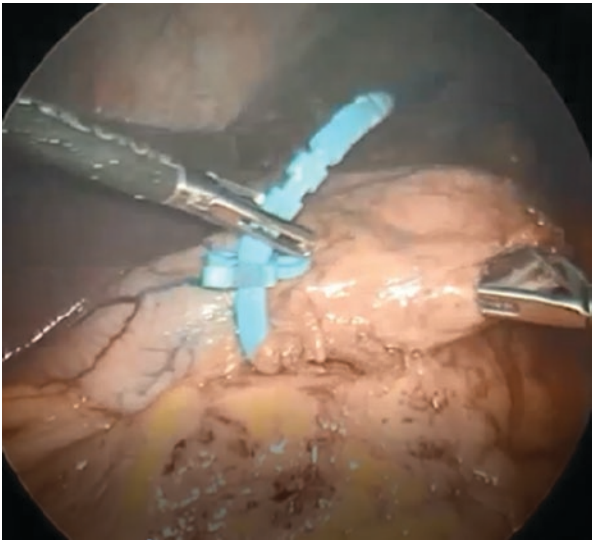

Fig. 29.13 Conversion of sleeve gastrectomy into functional bypass which involves the use of a ring instead of transecting the pouch. This easy variant has the additional benefit of simple reversibility and the possibility of exploring the antrum and the biliary tract

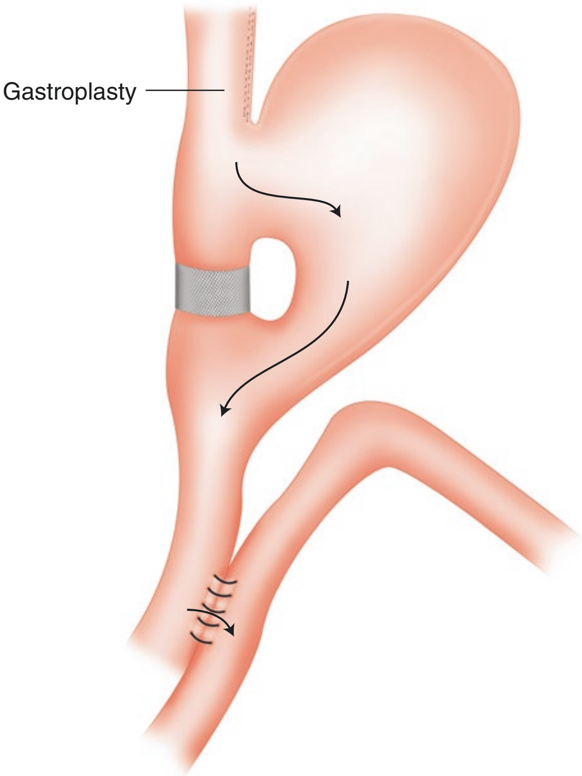

Fig. 29.14 Author's diagram. In revisions following VBG, restoration of the normal anatomy is by anastomosing with a 60-mm cartridge the gastroplasty pouch with the excluded fundic part of the stomach. The gastro-ileal anastomosis is then performed 250–300 cm from the ICV, based on the overall intestinal length

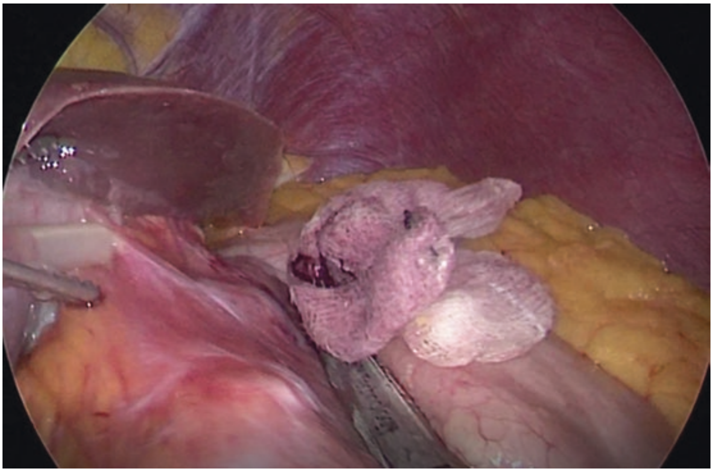

Fig. 29.15 It is always possible to guarantee to the patient the removal of the band and the execution of the IFD in a single surgical procedure, because the area at risk (the band capsule and adhesions) are not involved in the intervention. The gastric band may be left in place until the intervention is completed

three cases with the technique described above, without perioperative complications and with excellent results in quality of life and weight loss.

In revisions following gastric band surgery, the preparation of the IFD pouch allows for a simple, safe and effective surgery, as in primary surgery (Fig. 29.15). With this technique it is always possible to guarantee for the patient the removal of the band and the execution of the bypass in a single surgical step, as the area at risk where the band capsule and adhesions persist are not involved in the intervention. The gastric band may be left in place until the intervention is completed, removing it only at the end, so as to allow for a clean operative field during the execution of the bypass. The anastomosis is at 250–300 cm from the ileocecal valve, exploiting once again the malabsorbtive component of the intervention.

The reasoning behind the limited use of malabsorbitive procedures includes fear of long-term complications such as protein-calorie malnutrition, vitamin deficiencies, osteopenia and the fact that laparoscopic BPD and other technique demands a high level of technical skill. On the other hand, a purely restrictive procedure has its own limitations, eg. older patients would likely have unsatisfactory results in quality of life because of scarce adherences to diet and less powerful action on metabolic syndrome. In those cases, our policy is to elongate the alimentary limb to 350–400 cm, thus improving the degree of absorption and reducing the risks of deficiencies while still preserving a good effect on weight and metabolic syndrome. The same is done in diabetic patients with low BMI where the main goal is the glycemic control that is achieved with the delivery of food to the distal small bowel and bypassing the proximal one, despite a free diet and with low risk of protein malnutrition.

Conclusion

Ileal Food Diversion is a modified Mini-Gastric Bypass that works by diverting food into the distal small bowel, shortens food transit through the intestine, and thus produce a reduced absorption of nutrients.

Regarding the surgical technique, the Ileal Food Diversion is a single-surgeon, single anastomosis, three trocar procedure, where every step is standardize to be simple, less traumatic and fast. Dissection of the esophagogastric junction is not necessary, abolishing the risk of damage in that critical zone. This procedure is a secure and effective way-out in many complex cases such as super-obesity, patients with giant hiatal hernia, revisional surgeries, lower BMI patients or the aged with metabolic syndrome and, obviously, in all patients requesting a non-restrictive procedure.

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Diverted MGB: A New Procedure

30

Rui Ribeiro, Anabela Guerra, and Octávio Viveiros

30.1 Introduction

Since the introduction by Mason and Ito in 1966 [1] of the loop gastric bypass, subsequently modified to the Roux-en-Y gastric bypass (RYGB), this procedure has proved for years as the most consistently successful treatment for the greatest number of patients. RYGB is also the most well researched bariatric operation, with >7780 peer-reviewed publications in 2013 [2]. RYGB has been, for many years, the most effective and well balanced metabolic/bariatric surgical technique, with >50% excess weight loss (%EWL) maintained beyond 10 years [3].

Yet, RYGB patients may contend with significant complications, such as internal hernias, marginal ulcers or hyperinsulinemic hypoglycemias. Intermediate-term weight regain is also a very serious concern. Christou et al. demonstrated that both morbidly obese and super-obese RYGB patients experienced significant weight regain from the nadir to 5 years and again from 5 to 10 years [4]. Some researchers report that weight regain following RYGB may be as high as 50% of weight lost [5].

Weight regain contributes to the overall failure rate of a particular bariatric procedure, as defined by the percentage of patients that do not achieve or maintain 50% EWL at follow-up [6]. Yet, the long-term failure rate for RYGB has been calculated at ~20% [4, 7]. This rate can be as high as 40–60% for super-obese patients undergoing RYGB [8].

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30.2 Rationale of the dMGB

From 2002 up to 2010, RYGB had been our main operation for obese patients, and we were able to see failures in about 10% of our patients—the ones who completed a follow-up >5 years. In 2% of additional cases, clinically significant complaints of hyperinsulinemic hypoglycemia presented. Such events pushed us to find a better solution, with less weight regain and hypoglycemia.

With experience and personal support by Miguel Angel Carbajo and Manoel Garcia Caballero, plus Wei-Jei Lee prospective data [9], we began another technique to provide better long-term weight loss and much less hypoglycemic complaints. With technical instruction from Robert Rutledge in our operating-room, we became MGB-OAGB practitioners for about 60% of our operations. We found it a simpler safe technique with a better clinical course and weight loss in the vast majority of the primary patients.

However, like Noun [10], we were still facing a high rate of revisional surgery for failure or complications from the thousands of gastric bands used before in our country. In our global series, one-third of the cases were failed gastric bands, and we embraced the MGB-OAGB as a salvage technique, where the anastomosis was far from the after-effects of the band presence (inflammation, scar and devascularization).

We tried the OAGB and MGB variants, and decided to standardize an intermediate technique incorporating steps from both, the one we are performing as a main part of the *diverted MGB*, which we will describe later. The only significant clinical issue when we evaluated the first 200 cases of OAGB-MGB, was a rate of 4% of non-acid reflux, which we had to revise.

There is still a controversy about the incidence and importance of so-called "biliary reflux" after OAGB-MGB [11, 12]. This kind of gastro-esophageal reflux (GER), many times with an acid component which allows a good response to proton pump inhibitors (PPI), could be more properly designed as "enterobiliar and acid reflux" (EBAR).

The OAGB has surgical steps to avoid GER, the so-called anti-reflux mechanism, and very low rates (2%) of biliary reflux are reported after the OAGB [13]. However, the pure MGB surgeons using a long pouch from below crow's foot, report approximately 1% of biliary reflux [14]. Musella, presented experiences with higher rates, mainly after revisions for failed gastric bands [15].

In our patients who had a severe non-acid reflux, we revised them and added a Roux-en-Y diversion to the previous MGB, using the "simplified gastric bypass" or "double loop" technique [16] that we had used before in the classic RYGB. In this technique, we measure 100 cm in the efferent limb, from proximal to distal, and we move that place enough to be in parallel with the afferent loop, immediately before the gastro-ileostomy. In other words, we create a new side-to-side ileo-ileostomy and we apply one endostapler cutting between the two anastomoses (Fig. 30.1). We perform a hernia repair (cruroplasty) whenever it is present and bigger than 2 cm.

These patients obtain a very good clinical condition, solving completely the reflux episodes and keeping their weight low as before. Therefore, we decided to perform this technique in obese patients prone to significant reflux in the future,

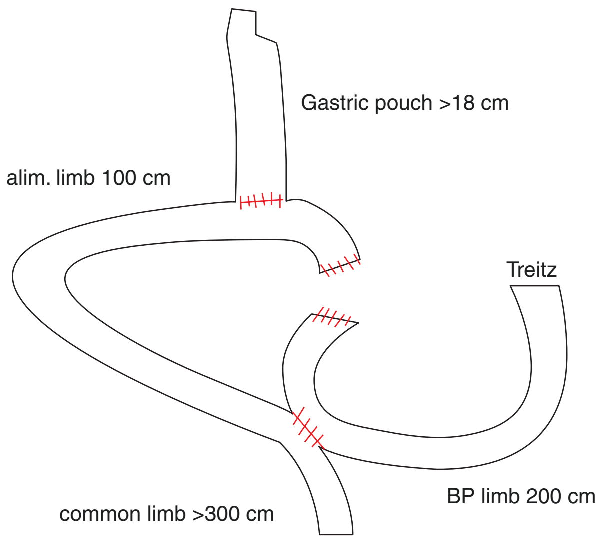


Fig. 30.1 Schematic diagram of diverted mini-gastric bypass (dMGB)

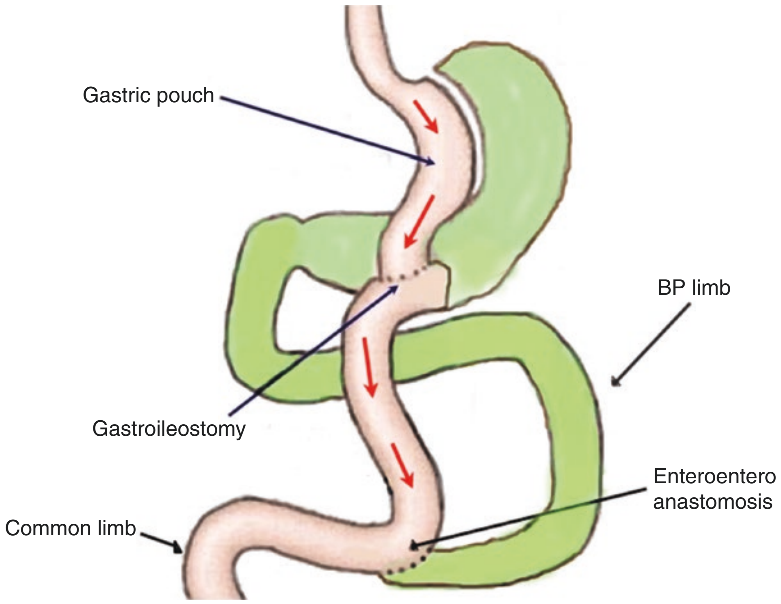


Fig. 30.2 Food flow in dMGB

typically the patients after removing a gastric band or in presence of a big hiatus hernia. Then, we standardized this procedure and called it "*sleeved gastric bypass*" because of the long and thin pouch, resembling the "sleeve gastrectomy" (Fig. 30.2) in the upper GI series that we perform routinely 1 year after the operation (Fig. 30.3). After a suggestion from Mervyn Deitel, we changed the name to *diverted MGB*—"dMGB", which is the technique we will describe in this chapter.

Fig. 30.3 Gastric pouch and gastro-ileostomy at upper GI series

This concept involves the “OAGB-MGB” with the Roux-en-Y diversion on the top of a long pouch with a non-calibrated anastomosis. People often get confused and understand this technical drawing as a RYGB, but it is closer to the OAGB-MGB concept because it has a long and narrow pouch and a wide anastomosis, resulting in mild restriction. Also, the biliopancreatic limb is long (usually 200 cm or more), providing some fat malabsorption that, in contrast to the RYGB, lasts for the future.

In all the aspects, except in the reduction of the daily bowel movements, we found dMGB similar to MGB-OAGB regarding morbi-mortality, post-operative course, weight loss and metabolic control. The only concern is about the inter-mesenteric spaces which need to be closed (unlike in OAGB-MGB), to avoid complications from bowel obstruction due to internal hernias.

30.3 Surgical Management

30.3.1 Pre-operative Course

All the primary patients were pre-operatively submitted to a complete multidisciplinary approach with endocrinological, psychological, nutritional and psychiatric evaluation. This was also done in the revisional cases, and in these, we consider it mandatory to include an endoscopic and imaging assessment before the reoperation.

In the pre-operative management, all the patients were given a hypocaloric pre-operative diet (1000 Kcal/day) for a minimum of 7 days). The significant co-morbidities like anemia, diabetes, hypothyroidism, sleep apnea or nutritional deficits received specialized treatment and support, especially anemia or hypoproteinemia. The patients also received some prophylactic treatments like assisted respiratory kinestherapy with incentive spirometry, and vitamin and mineral supplementation. Women are counseled to stop contraceptive pills. All patients on anticoagulant drugs or anti-aggregant agents stopped them accordingly to our protocol. Included in the pre-operative protocol are prophylactic antibiotherapy (cefazoline) and the thromboembolism prevention (subcutaneous enoxaparin and intraoperative intermittent pneumatic compression).

30.3.2 Surgical Technique

In our operating set up, we use the French position (Fig. 30.4) with a 30° reverse Trendelenburg tilt, the surgeon between the legs. We use two monitors, one on each side of the patient's head (Fig. 30.5).

For pneumoperitoneum, we use the closed method with a Veress needle introduced in the Palmer point. The first trocar (10–12 mm) is introduced in the midline, usually in the division between the upper two-thirds and the inferior third of the xipho-umbilical line. The other two 12-mm trocars are positioned beside the first one, at a slightly superior level, with a minimum of 8 cm distance to avoid instrumental clashing and obtain a nice triangulation. Another 5-mm left subcostal trocar, 6 cm from the left 12-mm, is introduced and used by one assistant to support the surgeon right-hand maneuvers. A Nathanson liver retractor is introduced (no trocar needed) in the subxiphoid space, supported by a left side positioned Murdoch arm (Fig. 30.6).

The instruments used consists of a 30° optical lens, 3 fenestrated graspers (one of them long), 1 dissector, 1 hook, 1 scissors, 1 needle-holder, and 1 Babcock (12 mm).

Fig. 30.4 Lithotomy position

Fig. 30.5 Team position

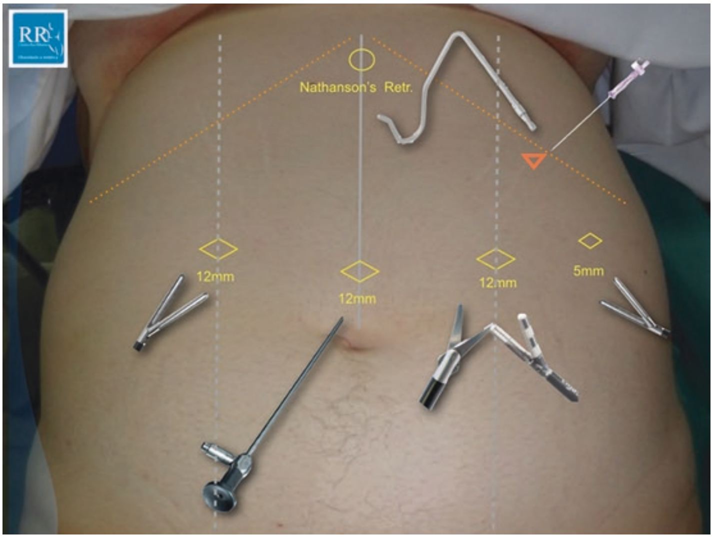


Fig. 30.6 Ports and instruments distribution and usage

After an abdominal exploration, the bowel is evaluated to check that it is free enough to perform the bypass.

We begin the procedure by dissecting partially the phrenogastric ligament in the area of the last short gastric vessels. In the case of a hiatus hernia (unsuspected or previously known), we go through the pars flaccida and dissect the right crus to evaluate the hiatus and perform an esophageal dissection and cruroplasty, if a hernia is bigger than 2 cm.

Then, we go to the incisura angularis and cut the two inferior vessels (Fig. 30.7) with a sealing device (Ligasure® 5-mm or Ultracision®, sometimes using only the hook) and get access to the retrogastric space. We build a long gastric pouch with an endostapler (Endogia™ Tristaple™) over a 36- French boogie (Fig. 30.8).

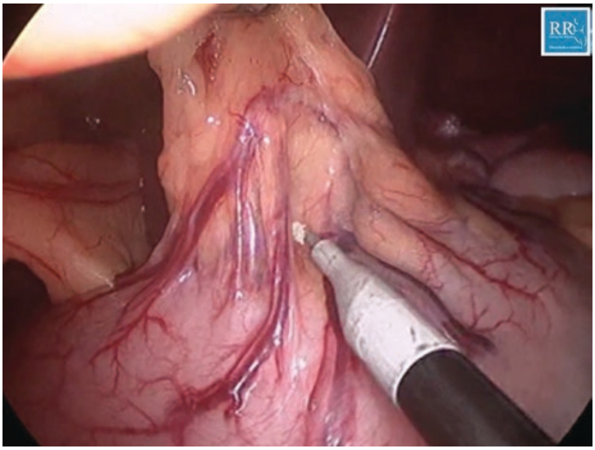


Fig. 30.7 Incisura angularis approach

Fig. 30.8 Pouch construction

According to the gastric wall thickness, we choose the staple height, Tristaple™ 45-mm, purple or black in the first application, purple or tan in the following ones up to the top. The boogie is inserted after the second stapling moment. It is important to fire the cartridges, keeping the pouch in a straight and stretched position to avoid torsions. Pushing the pouch tip with the boogie and maintaining the gastric walls' symmetry with a grasper is essential. Dissection of retrogastric adhesions of the stomach to the pancreas is done.

If some bleeding spots appear in the staple-line, we control them by touching the stapled oozing point with the electrocautery (using the hook or the dissector) in a very brief and localized manner.

Retracting the omentum upwards, we find the angle of Treitz and begin to run and measure the bowel distally up to the place where we want to perform the gastroenteric anastomosis. A very important detail during measurement is to keep the bowel loop with distal bowel in the patient's right side and the proximal in the left one; otherwise, we take the risk of a future torsion of the anastomosis we intend to perform. The omentum does not have to be cut, because the anastomotic level is low enough to avoid any tension on the bowel.

The proximal bowel segment will be the biliopancreatic limb (BP limb). Usually 200 cm long, we tailor this length making it longer (250 or 300 cm) in the case of diabetic or super-obese patients, or even more with BMI >60 kg/m². It will be shorter (180 or 150 cm) in patients with BMI <40 or 35 kg/m², or in patients >60 years old. Afterward, we try to measure all remaining bowel. In the case of short mesenteries or heavy intestine, this may be dangerous because some tearing or even perforation may occur. If this is the case, it is enough to count on, at least, 4 m of bowel down, which means 1 m for the future alimentary limb and 3 m for the future common limb. If this is not possible, the BP limb length will be decreased as much as needed to accomplish this rule.

At the selected point to construct the anastomosis, we make an antimesenteric hole, using the hook, in the bowel and another in the anterior face of the inferior top of the pouch. We introduce an articulated 30-mm Tristaple™ cartridge into the bowel and the fixed anvil into the stomach (Fig. 30.9), as close as possible to the gastric staple-line. The device is fired and the anastomosis is done; we check the inner surface of the new stape-line for bleeding and push the bougie to the distal bowel. The resulting hole is closed in a hand suture manner in a running invaginating technique, using a 2/0 Vicryl® or similar (Fig. 30.10).

Pulling the bougie tip back to the stomach and clamping the bowel on both sides of the gastro-enterostomy, we introduce diluted methylene blue through the bougie to exclude any leaks. A silk single stitch in the corner between the pouch staple-line and the bowel is done ("neo angle of sorrow"), as this is a site prone to leaks, because of some eventual localized tension on the anastomotic staple-line.

Measuring the bowel distally, we make another hole 1 meter far from the gastro-enterostomy. We do the same in the afferent limb (Fig. 30.11), 10 cm before the gastro-enterostomy and, using the previously described technique (Fig. 30.12), we create another side-to-side anastomosis (ileo-ileostomy), with an articulated 60 mm Tristaple™ cartridge. The hole is closed as before, and the Roux-en-Y diversion is matured by cutting the bowel between the two

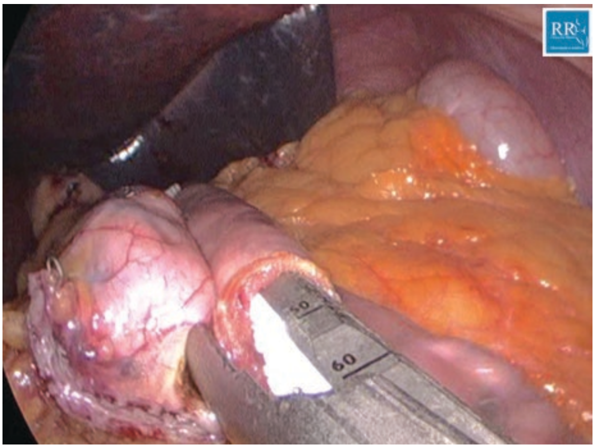


Fig. 30.9 Linear mechanical gastro-ileostomy (G-I)

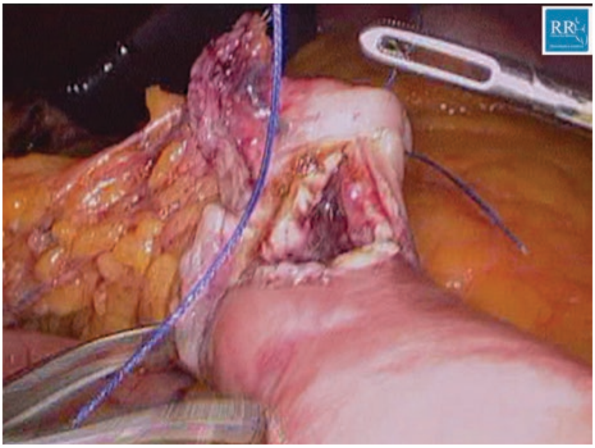


Fig. 30.10 Manual suture closing the G-I hole

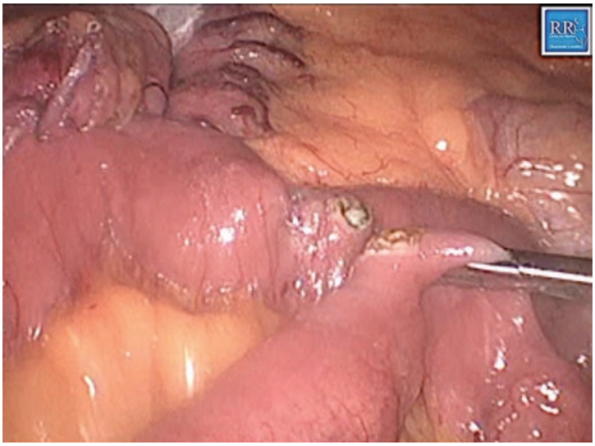


Fig. 30.11 Bowel openings for ileo-ileostomy (I-I)

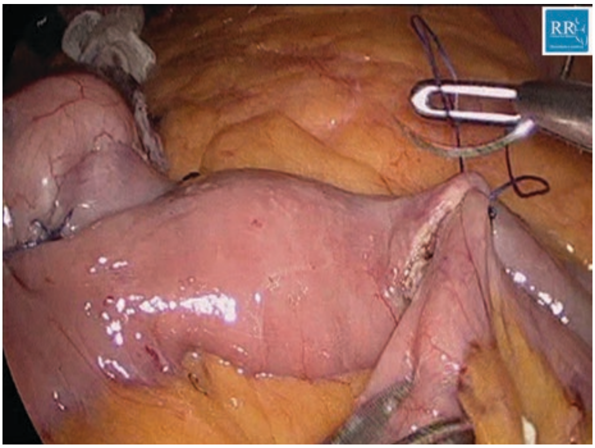


Fig. 30.12 Manual suture closing the I-I hole

Fig. 30.13 Roux-en-Y maturation

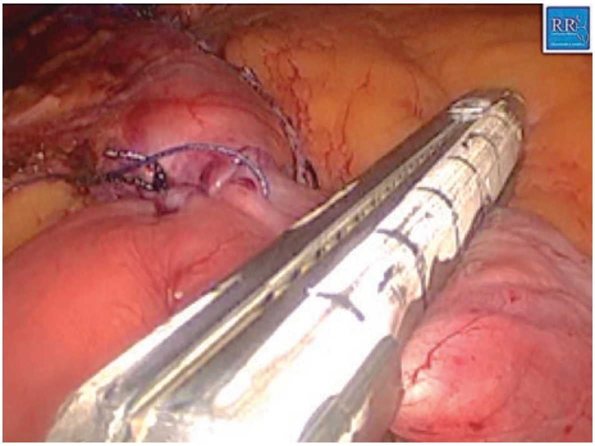
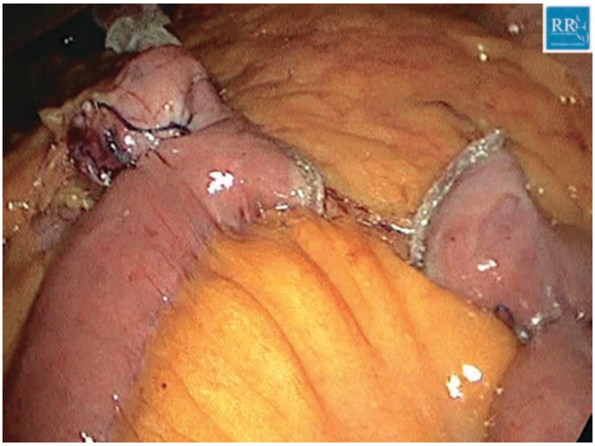


Fig. 30.14 Alimentary limb (left side) and BP and common limb (right side)



anastomoses using another 60-mm Tristaple™ cartridge (Fig. 30.13), and defining the alimentary limb on the left and the BP and common limb on the right of the image (Fig. 30.14).

For closing both the intermesenteric and the Petersen space, we use purse-string sutures with 2/0 silk or barbed non-absorbable sutures. The last step consists in the application of a spray of fibrin glue (Tisseel® 4 cc) on the staple-lines and anastomosis. We suture the aponeurosis of ports created by larger than 11-mm trocars.

We use drains selectively accordingly to a number of possible bleeding spots and the quality of the tissues and anastomosis. The boogie is removed and no nasogastric tube or urinary catheter is left.

30.3.3 Post-operative Course

The patients should leave the bed the same day of the surgery, and we introduce liquids in small portions (20 cc each 20 min) 12 h after the end of the operation. We administrate a proton pump inhibitor drug (PPI), an antibiotic, an analgesic, and enoxaparin. The patient is usually discharged on the second post-operative day. He/she will continue the PPI 6 months in women and 12 months in men and the enoxaparin for 7 days. Ursodeoxycholic acid will be administered twice a day for 3 months. Oral multivitamin and vitamin D are administrated to all patients and iron, vitamin A, B_9 or B_{12} when the lab-tests show deficits in those elements.

The protocol includes visits to the team every 3 months in the first year, every 6 months in the second, and then one time each year. Once a year, we check for *Helicobacter pylori* (and eradicate it if positive) and ask for an ultrasound to detect biliary stones. Usually, we perform an upper GI series at the end of the first post-operative year and an endoscopy if the patient has complaints suggesting esophago-gastric pathology.

30.4 Outcomes

The dMGB was introduced in our practice in 2013 as a primary approach to patients with risk factors for development of esophageal reflux, whether acid or non-acid. As a rescue surgery for failed gastric bands or sleeve gastrectomies, it became a safe and effective procedure.

We analyzed the outcomes of our first 300 dMGB operations, with follow-up from 6 to 48 months. This experience included 131 revisional cases (104 conversions from failed bands – 35 previously removed, and 27 failed sleevel gastrectomies).

The average age was 45.8 years (range 16–70), and the average BMI was 41.3 (range 27.8–56.9). Associated operations were 69 band removals, 73 hiatoplasties, 20 cholecystectomies, and 8 other procedures.

All the operations were completed by laparoscopy with no conversions. The mean operating time was 65 minutes (range 45–195).

The weight loss of the 300 patients went from a pre-operative mean weight of 111.2 kg (BMI 41.3) to 76.9 kg (BMI 29.6) in the patients who had 4 years of follow-up. The % excess BMI loss (%EBMIL) was 81.6% at 1 year, 81.0% at 2 years, 80.2% at 3 years and 76.8% at 4 years follow-up (Fig. 30.15).

When we differentiated between the primary (169) and revisional (131) cases, we found a difference in favor of the primary cases who had %EBMIL of 87.0% at 1 year (74.3% in revisional), 88.5% at 2 years (71.3% in revisional), 88.7% at 3 years (68.6% in revisional), and 82.9% at 4 years (68.8% in revisional) (Fig. 30.16). Statistical analysis of the %EBMIL of primary and revisional cases (Student t-test) found significance $p < 0.05$ at 1, 2 and 3 years post-operatively. Another important observation was that only three patients (1%) had some weight regain and none had excessive weight loss.

Co-morbidities showed resolution in the associated diseases, especially type 2 diabetes (80.2%), high blood pressure (70%), dyslipidemia (54%), hyperuricemia (60%), degenerative joint disease (55%), and obstructive sleep apnea—OSA (67%). Importantly, 54% of diabetics, 44% of high blood pressure, 42% of dyslipidemias and 49% of joint disease patients were off medications. OSA patients were free of treatment in 63% (Table 30.1).

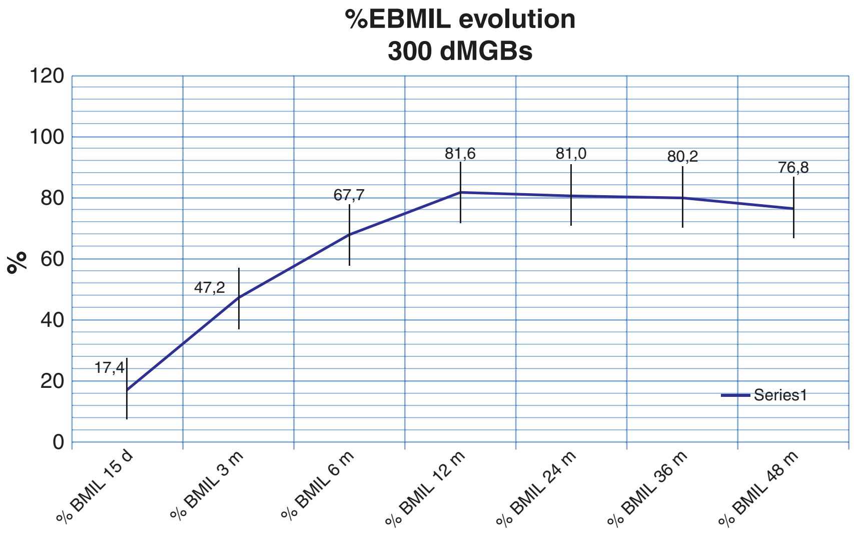


Fig. 30.15 % excess BMI loss (%EBMIL) after 48 months

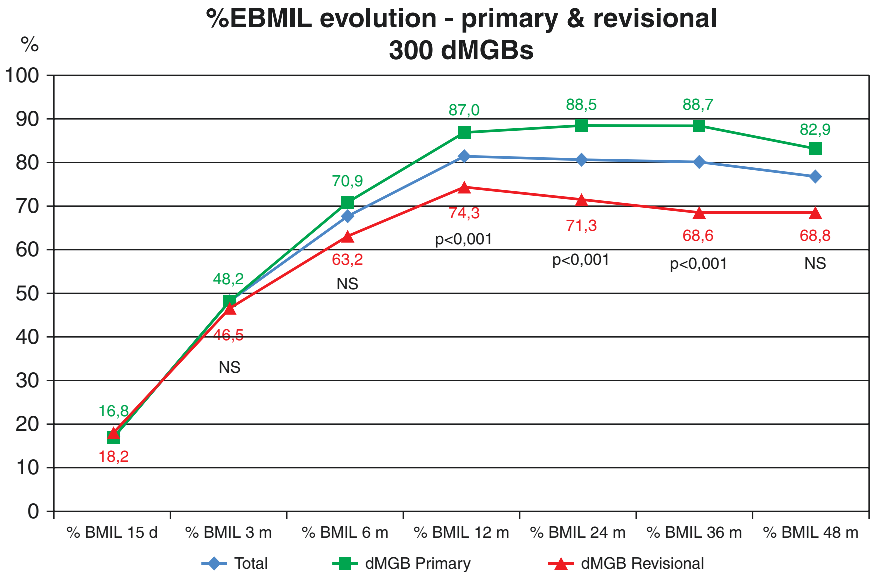


Fig. 30.16 %EBMIL in primay and revisional cases after 48 months

Although there may be some bias in the selection criteria for dMGB (all cases were prone to have GE reflux symptoms), 41.7% had clinical evidence of GERD. Of these, 63% were free of symptoms after dMGB, 4% improved, 2% became clinically stable and only two patients (0.7%) got worse GERD. No *de novo* cases were found.

Table 30.1 Resolution of co-morbidities after dMGB

	T2D (%)	HBP (%)	Dyslip (%)	URICEMIA (%)	DJD (%)	OSA (%)	GER (%)	Depression (%)	Varices (%)
Remission – No medication	54	44	42	27	49	63	63	20	5
Improved – With medication	26	26	12	33	6	4	4	14	2
Stable	2	1	2	–	3		2	8	32
Worse	–	–	–	–	–	–	1	–	–
New disease	–	–	3	7	–	–	–	3	–

T2D type 2 diabetes, *HBP* high blood pressure, *Dyslip* dyslipidemia, *DJD* degenerative joint disease, *OSA* obstructive sleep apnea, *GER* gastro-esophageal reflux

In our database, we have 2.6% of *de novo* GERD symptoms after MGB-OAGB in an evaluation of 650 patients. dMGB performed better avoiding *de novo* GERD.

30.5 Complications

Our series includes 131 (46%) cases of conversion: from 69 patients with a gastric band (23%), from 35 patients who had a prior band (12%), and from 27 with sleeve gastrectomy (9%). Complications in laparoscopic bariatric surgery are more frequent in revisional surgery [17, 18]. The adhesions, the scars and modifications of the normal vascularization of the tissues are main factors for an increase in complications [19]. Good outcomes and acceptable risk may be accomplished [19, 20], depending on the pre-operative study to define the risk of any proposed revisional intervention [20] and on the experience of the surgical team. A conversion to open surgery is more likely due to the increased difficulties that a surgeon faces in revisional surgery [21]. In our series, we had no conversions to open surgery.

We had 6 intra-operative complications (2%): bowel loop perforations (2), bowel ischemia (2), gastro-enterostomy torsion (1) and hepatic contusion (1).

Post-operative complications occurred in 30 patients (9.9%), 17 (5.6%) early and 13 (4.3%) late. We performed 17 reoperations (5.6%) in this group – 10 (3.3%) in the early period and 7 (2.3%) >30 days after the initial operation (Table 30.2). There was no mortality.

Table 30.2 Post-operative complications after dMGB

Post-operative complications		
Early	*"n"*	*Reoperations*
Hemoperitoneum	2	2
Intra-abdominal infection	2	2
Pouch leak (His angle)	1	1
Ileo-ileal anastomotic leak	1	1
Bowel perforation	1	1
Wound infection	3	–
Abdominal wall hematoma	2	1
Port-site hernia	3	2
Hematochezia	1	–
Pleural effusion	1	–
Sum	17 (5.6%)	10 (3.3%)
Late	*"n"*	*Reoperations*
Alimentary intolerance	3	2
GERD	3	2
Marginal ulcer	3	1
Steatorrhea	1	–
Port-site hernia	1	–
Cholelithiasis	2	2
Sum	13 (4.3%)	7 (2.3%)
Total morbidity	30 (9.9%)	17 (5.6%)

Conclusion

MGB-OAGB provides better outcomes and fewer complications compared to RYGB. It solved the two problems we have had with the RYGB – weight regain and hyperinsulinemic hypoglycemia. However, biliary or non-acid reflux can occur, although with a low incidence.

However, the dMGB appears to be as effective as the MGB and reduces the incidence of GER. It avoids bile in the esophagus and its potential consequences. dMGB combines the advantages of the MGB-OAGB (mild restriction and moderate malabsorption) with the anti-reflux effect of the Roux-en-Y diversion. The dMGB is also a convenient and effective solution for failed sleeve gastrectomy from weight regain or GERD. Also, from a technical point of view, MGB-OAGB or RYGB surgeons can reproduce the dMGB easily and safely.

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31 Comparison of MGB with SADI-S: Revision of Sleeve Gastrectomy to MGB or Single Anastomosis Duodeno-Ileostomy (SADI)

Arun Prasad

31.1 Introduction

Single anastomosis duodeno-ileal bypass with sleeve gastrectomy (SADI-S) is a simplified biliopancreatic diversion with duodenal switch. In SADI-S, after a sleeve gastrectomy (SG), the proximal duodenum is anastomosed end-to-side to the ileum 250 cm proximal to the ileocecal valve [1] (Fig. 31.1). Like the MGB, SADI-S is mainly malabsorptive. Patient follow-up is mandatory, especially for potential malnutrition. MGB and SADI-S have very beneficial effects on type 2 diabetes (T2D) [2–4].

At the MGB IFSO Course in Montreal, the SADI-S and MGB were discussed by surgeons who had had experience with both operations. The SADI-S is a longer procedure, has the possibility of leak from the top of the sleeve, mobilization of duodenum was necessary in the right gutter, there may be difficulty with bowel measurement, bowel obstruction has been reported [5], and SADI-S is more difficult to revise. Both MGB and SADI-S produce excellent resolution of co-morbidities, and no comparative study has been done of the two operations.

SG is currently the most common bariatric operation worldwide. Weight loss after SG has been satisfactory for many patients. However, some patients do not lose enough weight [6, 7], and some regain weight [8], even after a "properly" done SG. Proposed causes of weight regain include initial sleeve size, sleeve dilation, retention of fundus, increased ghrelin levels, inadequate follow-up support, and maladaptive eating behavior.

Most SG failures are offered a 'revision bariatric operation'. This revision is done in an attempt to lose more weight and make that weight loss permanent. Revision of SG to MGB, which is increasing, is discussed in Chap. 23 in this book.

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https://doi.org/10.1007/978-3-319-76177-0_31

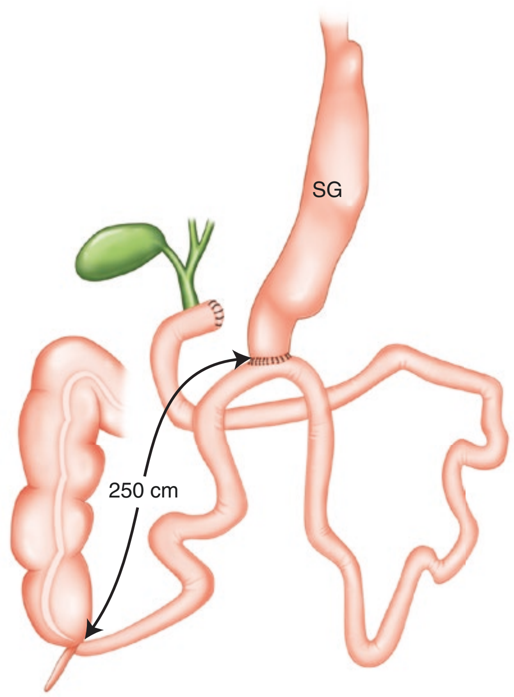

Fig. 31.1 SADI-S: SG followed by proximal duodenal division and antecolic isoperistaltic loop duodeno-ileal anastomosis, with 250-cm efferent limb

SADI and MGB are two metabolic procedures which can be offered as revision to patients who have inadequate weight loss or weight regain after a SG [9].

31.2 Study

We did a small series comparing short-term (2-year follow-up) results. From 2013, 22 patients have been followed-up: 13 patients underwent MGB and 9 patients SADI. Patients were given a choice of the two procedures, and after informed consent they underwent surgery. Of 5 patients with inadequate weight loss, 3 underwent MGB and 2 SADI; of 17 patients with weight regain, 10 underwent MGB and 7 SADI. Table 31.1 gives patient details.

31.3 Technique

SADI was done by division of the second part of the duodenum followed by a side-to-side anastomosis with the ileum, measured 250 cm proximal to the ileo-cecal junction (Figs. 31.2 and 31.3).

Table 31.1 Patient demography

Serial no	Gender	Age at primary surgery	BMI at primary surgery	Date of primary surgery	Type of primary bariatric surgery	Weight loss in kg after primary surgery	Cause for revision surgery inadequate weight loss	Cause for revision surgery weight regain	Choice of revisional procedure	Weight loss in kg after revision
1	M	36	40	2005	Band	16	y		MGB	14
2	F	33	52	2006	Band	22		y	SADI	19
3	F	42	47	2006	Sleeve	21	y		MGB	14
4	F	34	44	2006	Sleeve	15	y		SADI	13
5	M	25	38	2006	Band	17	y		MGB	13
6	F	27	47	2007	Sleeve	19	y		SADI	12
7	F	44	43	2007	Sleeve	28		y	MGB	22
8	F	34	43	2007	Sleeve	21	y		MGB	13
9	F	31	42	2007	Sleeve	17	y		SADI	14
10	M	55	39	2008	Sleeve	22	y		SADI	17
11	F	43	41	2008	Sleeve	17	y		SADI	18
12	F	32	43	2008	Sleeve	15	y		MGB	17
13	M	35	36	2008	Sleeve	20	y		MGB	20
14	M	26	35	2008	Sleeve	19	y		SADI	18
15	F	28	46	2008	Bypass	20	y		MGB	17
16	F	21	52	2009	Sleeve	27		y	MGB	19
17	F	33	43	2009	Sleeve	17	y		MGB	21
18	F	26	46	2009	Sleeve	21	y		SADI	17
19	M	31	42	2009	Sleeve	23	y		MGB	22
20	M	38	47	2010	Sleeve	29		y	SADI	17
21	F	33	49	2010	Sleeve	30		y	MGB	26
22	M	25	40	2010	Sleeve	17	y		MGB	19

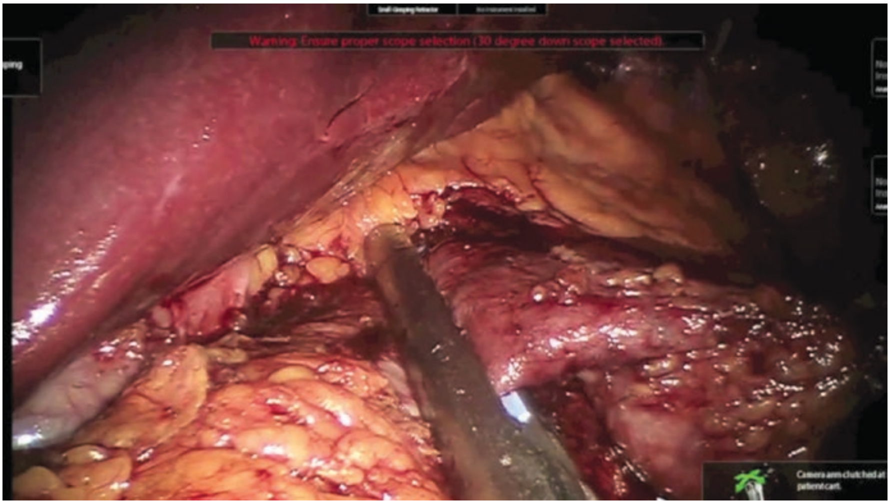

Fig. 31.2 Transection of second part of duodenum

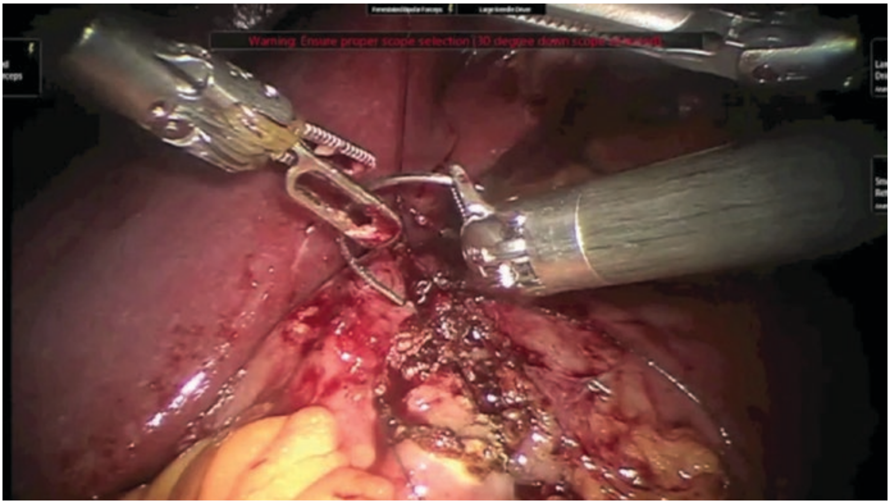

Fig. 31.3 Duodeno-ileal anastomosis

MGB was done by creation of a long gastric tube from distal to the crow's foot and dividing proximally, after retrogastric dissection from the greater curve side of the stomach. Gastrojejunostomy was done at 200 cm distal to the duodeno-jejunal junction (Figs. 31.4 and 31.5).

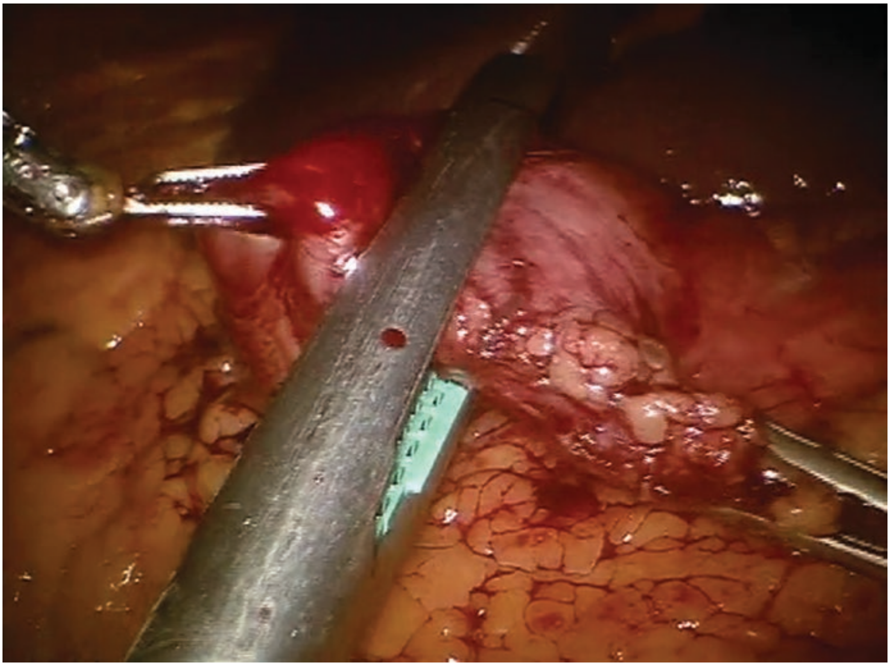

Fig. 31.4 Transection of antrum of stomach

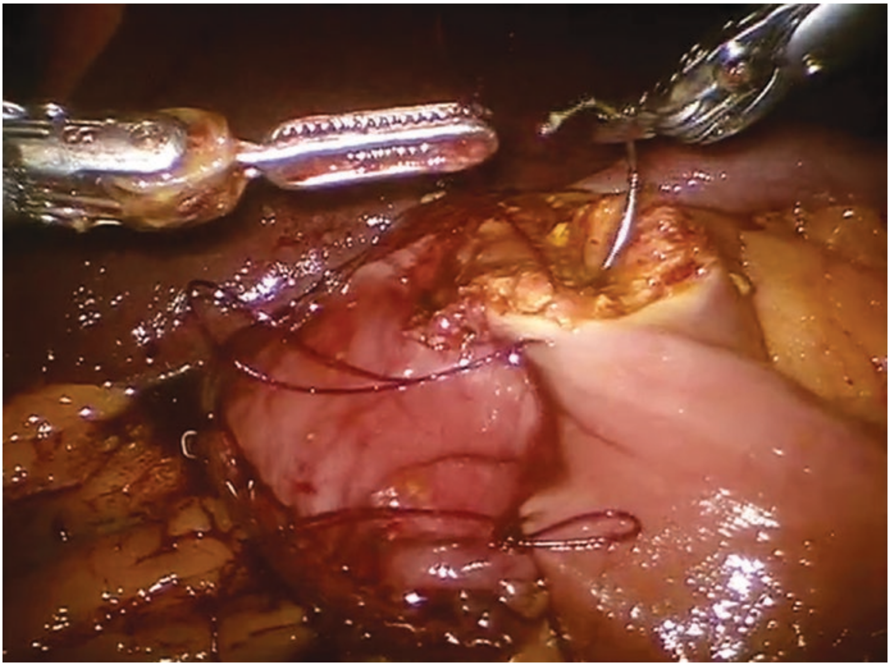

Fig. 31.5 Gastrojejunostomy

31.4 Results

The weight loss was higher in the SADI group during the first 9 months after surgery. However, by the end of 2 years, the MGB group showed comparable and a slightly higher weight loss (Fig. 31.6).

Total operating time was lower in the MGB group compared to the SADI group (Fig. 31.7).

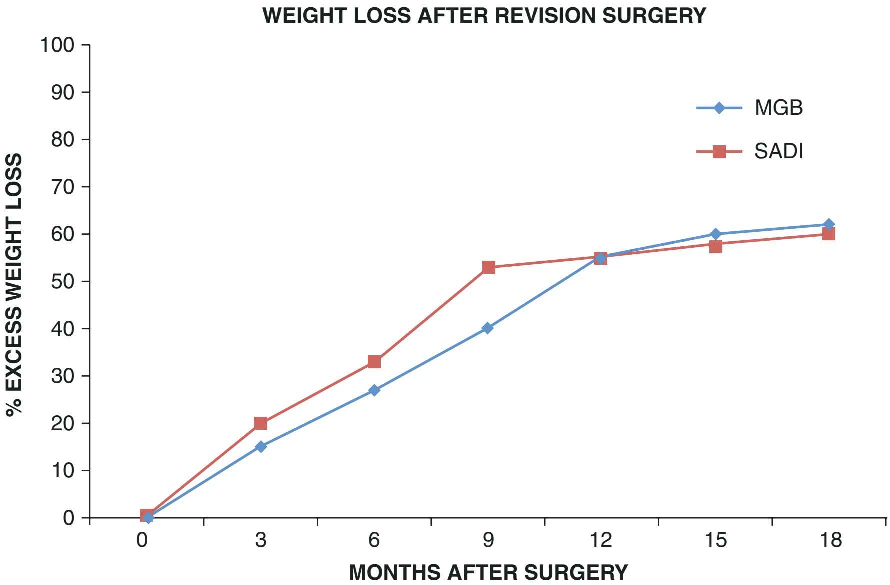

Fig. 31.6 Weight loss after surgery

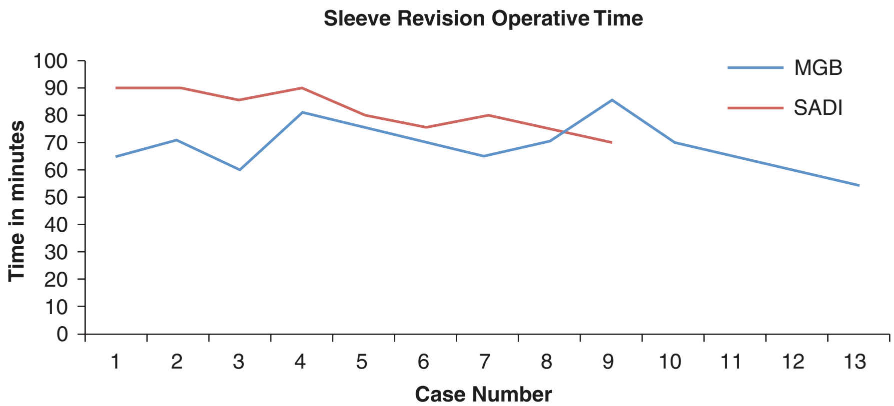

Fig. 31.7 Time taken for surgery

31.5 Complications

In the MGB group, one patient had deep vein thrombosis, which was treated medically. In the SADI group, there was one anastomotic leak (which was surgically repaired) and one port-site infection.

31.6 Nutritional Status

Deficiencies were higher in the SADI group (Table 31.2).

31.7 Gastrointestinal Symptoms

Gastrointestinal Symptom Rating Scale (GSRS) [4] was used to evaluate patient symptoms. There was a higher dissatisfaction in the SADI group (Table 31.3).

31.8 Discussion

Inadequate weight loss and weight regain after SG is seen in a substantial number of patients. Reasons are multifactorial and may be due to initial surgical technique, dilatation of the stomach pouch, poor patient compliance with high liquid calorie intake, adaptation of hormonal status and gut microbiota. Some of these patients

Table 31.2 Nutritional deficiencies

	Patients with deficiency		
	SADI = 9	MGB = 13	P value
Albumin	4	4	0.394
B12	5	5	0.055
Vitamin D	6	4	<0.001
Iron	6	4	<0.001
Ferritin	5	5	0.055
Hemoglobin	5	5	0.055

Table 31.3 Gastrointestinal Symptom Rating Scale

	SADI (n = 9)	MGB (n = 13)	p Value
GSRS abdominal pain	2.13	2.01	0.60
GSRS constipation	1.09	1.13	0.90
GSRS diarrhea	3.66	1.19	0.002
GSRS indigestion	2.76	2.36	0.14
GSRS reflux	1.45	1.40	0.83
Total GSRS score	11.10	8.81	

seek a revision operation. Both SADI and MGB have been offered, because they are technically easier in a patient who has had a past SG.

SADI was found to have a higher incidence of deficiencies and gastrointestinal symptoms in our group of revision surgery when compared to MGB. The weight loss was similar in both cases, although less than what is seen in primary procedures.

Conclusion

MGB is a technically simpler revision operation for SG compared to SADI. It avoids duodenal anastomosis which has a higher theoretical risk of leak due to to the poor vascularity in the area. Weight loss is similar in both cases. However, with a lower incidence of nutritional and gastrointestinal issues, MGB should be the preferred mode of treatment.

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Single Anastomosis Gastro-Ileal Bypass (SAGI)

32

Chetan D. Parmar

32.1 Introduction

MGB-OAGB are being increasingly performed internationally as bariatric/metabolic operations [1]. They are technically simple, safe, and effective, with satisfactory weight loss outcomes and co-morbidity resolution [2–6]. Potential malabsorptive complications and ideal limb lengths are discussed in this book. To control the malabsorptive aspect of the MGB, De Luca et al. constructed the gastro-intestinal anastomosis at a fixed distance of 300 cm proximal to the ileocecal junction (ICJ), and named the procedure *Single Anastomosis Gastro-Ileal (SAGI)* bypass [7] (Fig. 32.1). The biliopancreatic limb is variable in each patient, depending on the total length of the small bowel.

Operative technique includes steps similar to the MGB for construction of a long, lesser curve based gastric pouch alongside a 36-F orogastric tube. The pouch begins with horizontal entry just below crow's foot. The next step includes measuring the entire small bowel length starting from ICJ, for which the operating surgeon moves to the left side of the patient from the original position between the legs. The 300 cm proximal to ICJ is marked, and the operator moves back to the original position and performs a stapled (45-mm) gastro-ileal anastomosis. The enterotomy is closed with a reasonable monofilament. To prevent tension, 2–3 sutures are placed between the afferent intestinal loop and the bypassed stomach, and a second suture is inserted between the efferent limb and the remnant gastric antrum.

Between July 2015 and February 2016, seven non-diabetic patients with preoperative mean BMI 42.1 and a mean age 45 years (range 28–61) underwent SAGI. Three patients were primary and four patients were conversion for failed sleeve gastrectomy [7]. Mean operative time was 116 min (88–141), which was longer than that quoted for MGB-OAGB in the literature [3, 4, 6]. There were no

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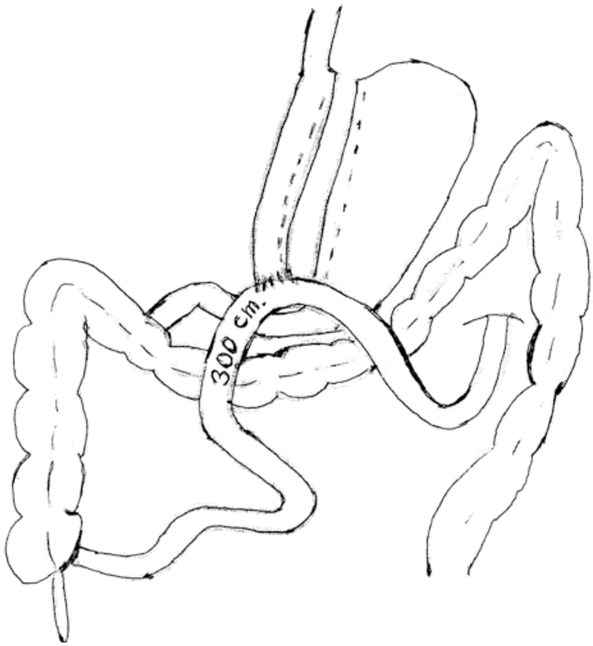

Fig. 32.1 Diagrammatic representation of the SAGI, with GI anastomosis 300 cm proximal to ileocecal valve

intra-operative complications including leak or bleeding. Seven patients at 3 months follow-up had mean excess weight loss (EWL) 55.1%, and at 6 months mean EWL 82.1% (n = 2). No patients have developed diarrhea, anemia, hypoproteinemia or reflux. One patient (14%) who according to the authors had low food intake developed low serum albumin of 2.9 g/dL (normal 3.5–5.5 g/dL) at 6 months. There was no mortality. Limitations of this data include small series with short follow-up. Final conclusions regarding weight loss, co-morbidity resolution and long-term complications (including marginal ulcer, reflux, malnutrition and reoperations) are awaited.

32.2 Discussion

SAGI has the advantages of MGB-OAGB of being technically easier, safer, having a single anastomosis and being easily reversible. SAGI bypass has the Scopinaro principle of not exceeding a safe level of malabsorption, using a fixed common channel of 300 cm [8]. The authors note that single-anastomosis-duodeno-ileal bypass with sleeve gastrectomy (SADI-S) with its common channel of 200 cm, appears to be safe in mid-term follow-up [9]. Based on this, they have designed their common channel (the part of the intestine where bile and pancreatic fluids from the biliopancreatic channel and food from the alimentary channel mix) to be fixed at 300 cm. In SAGI, they avoid the difficult steps of SADI-S: dissection of bile duct, pancreas and major blood vessels, transection of duodenum and anastomosis to duodenum. They suggest that combining principles of MGB-OAGB and SADI-S creates a safer operation.

The authors presented unpublished data at the IFSO London 2017 Congress of 68 SAGI bypasses now performed, with 37 patients having 1 year follow-up. The indications for SAGI were insufficient weight loss or weight regain after gastric banding and sleeve gastrectomy, insufficient weight loss or weight regain after MGB-OAGB, and primary surgery for MGB-OAGB candidates with short small bowel.

They describe a further modification called Single Anastomosis Jejuno-ileal (SAJI) bypass in patients who had previous failed RYGB needing revision. They transect alimentary limb 20–25 cm distal to the gastro-jejunal anastomosis. Small bowel is measured 300 cm from the ICJ, and jejuno-ileal anastomosis is performed.

Conclusion

SAGI is an interesting variation of MGB-OAGB which incorporates principles of SADI-S. It is a mixed restrictive and malabsorptive procedure, but mainly malabsorptive. Fixed common channel with variable biliopancreatic limb does have potential to make it more malabsorptive than standard MGB-OAGB. Long-term results are awaited.

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The MGB-OAGB International Club®

33

Roger C. Luciani

33.1 Origins

In 1987, Dr. Robert Rutledge who was a trauma and critical care surgeon at the University of North Carolina was asked to join the bariatric team at his hospital. Thereafter, he gained experience performing bariatric surgery for years, and was the first surgeon there to perfom a laparoscopic Roux-en-Y gastric bypass (LRYGB). However, this procedure was considered complex and technically demanding, with a high complication rate and many side-effects.

One night in 1997 while he was on duty, he operated on a patient with severe abdominal gunshot injuries, requiring partial pancreatectomy, intestine and antrum resection, gastrojejunostomy and duodenal exclusion, using a Billroth II-type reconstruction, with excellent post-operative course.

Following this, Dr. Rutledge decided to modify the technique and perform laparoscopically a similar operation and reconstruction as a simpler gastric bypass on a consenting morbidly obese patient. He made a *long* lesser curvature channel from below the crow's foot, with an ante-colic gastrojejunostomy. The post-operative period was uneventful. This was the birth of the mini-gastric bypass (MGB).

This technique was quite different from the failed old Mason horizontal loop gastric bypass where the Billroth II loop was placed adjacent to the esophagus, which could lead to bile reflux [1]. The MGB placed the Billroth II loop as a long gastric pouch 3 cm distal to the crow's foot.

Using a laparoscopic approach for this novel minimally invasive procedure, Rutledge named it *Mini-Gastric Bypass* or MGB [2]. This was in keeping with comparable new terms—mini-invasive, mini-laparotomy, mini-laparoscopy (for reduced

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ports), etc. This new procedure was easier, safer, more effective, with excellent results for durable weight loss and co-morbidities, and good quality of life.

33.2 From Dark Days to Golden Dawn

At the ASBS annual meeting in 2000, Rutledge presented his first 1274 cases demonstrating excellent results, but he was immediately severely criticized by many surgeons, who confused the MGB with the Mason bypass and had become experts at the RYGB. Despite criticism from the USA, he insisted that MGB was a superior bariatric operation.

In 2001, he submitted his experience to Dr. Mervyn Deitel, a Founder and Past-President of the ASBS, a Founder of IFSO, who was a pioneer in bariatric surgery and Founding Editor-in-Chief of *Obesity Surgery*. Dr. Deitel then spent 2 weeks in Dr.Rutledge's operating-room and pre- and post-operative clinic. Although Deitel had already performed >2500 RYGBs, he was convinced to adopt this new procedure, and became a defender and driving force to promote MGB with scientific and logistical support [3].

Rutledge trained Drs. Kular, Peraglie and Hargroder in 2002–2004. Surgeons then published MGB series with thousands of patients [4–10]. Dr. Rutledge has been invited all over the world to perform and demonstrate the MGB in dozens of operating-rooms in Asia, India, Europe, South and Latin America, Australia, and the Middle East. He recorded many instructional videos, some available on YouTube, to demonstrate MGB. He has performed >6500 MGBs. The technique has remained essentially the same.

In 2002, Drs. Miguel A. Carbajo and Manuel Garcia Caballero in Spain, after having >10 years experience with the RYGB, read Rutledge's publication, and performed the first MGB in Europe. They modified the technique to prevent any possible GE bile reflux, by suturing laterally the biliopancreatic limb to the gastric pouch, that could also prevent any twist. They adapted the length of the biliopancreatic limb to the total length of the small bowel. They named this modified MGB *One-Anastomosis Gastric Bypass* (OAGB) or *BAGUA* (Bypass Gastrico de Una Anastomosis). In 2005, the excellent results of OAGB were reported [11]. Rutledge had been invited in 2004 to the Congress of the Spanish Society of Obesity, where the concept of MGB-OAGB was born with the two versions of a similar procedure. In 2008, Carbajo's group published their OAGB series of 1126 OAGB patients [12]. No patient of Dr. Carbajo has had to be revised for reflux [13]. This procedure became very popular in South America and México, led by Enrique Luque de Leon [14, 15] and many other eminent trainees.

Many other superb bariatric surgeons promoted the MGB-OAGB worldwide due to superior results. In 2005, Prof. Wei-Jei Lee of Taiwan published the first randomized controlled trial showing superior results of MGB vs. RYGB [16], with a 10-year follow-up [17]. Comparative studies of MGB-OAGB with other bariatric operations showed more durable weight loss, better quality of life, higher remission rate of diabetes, hypertension and lipid abnomalities, and fewer complications [17–23].

Fig. 33.1 At the Founding dinner

In 2008, the technique was introduced in France by Prof. Chevallier [6], who held two meetings in Paris on MGB-OAGB—2012–2013. In Europe, Drs. Musella, Rheinwalt, Noun, Ribeiro and others rapidly adopted the MGB-OAGB. In 2014, the MGB-OAGB consensus conference was held at IFSO Montreal under leadership of Drs. Chowbey, Chevallier, Kular and Deitel. In 2015, the MGB Conclave was held in Delhi, India under Drs. Arun Prasad and Kuldeepak Kular; it was decided to form a MGB-OAGB formal organization. During these meetings, the acronym MGB-OAGB was overwhelmingly voted for by the participants.

On Sept. 27, 2015 during the twentieth IFSO Congress in Vienna, after a Colloquium with 175 attendees, an enthusiastic group held a dinner meeting at the Steingenberger Hotel and founded the MGB-OAGB International Club (Fig. 33.1).

Surreptitious criticisms about fear of gastric cancer and bile reflux or malnutrition were published by surgeons who subsequently became strong advocates for the MGB-OAGB [24]. However, publication of carefully collected data was prevented by two related journals. The MGB-OAGB became the third most common bariatric operation [10] and proved to be safe and effective as metabolic and revisional surgery in the elderly [25] and adolescent [26].

In August 2016, the MGBCON Summit was held in London-Gatwick with >275 attendees (many had performed >1000 of these operations). In July 2017, the Fourth MGB-OAGB Annual Consensus Conference was held in Naples with Dr. Musella as Chairman, and confirmed worldwide interest in the procedures. MGB-OAGB

Fig. 33.2 Club logo

have become mainstream operations, with tens of thousands of the procedures having been performed throughout the world.

33.3 The MGB-OAGB International Club®

The designation *Club* indicates that this is a friendly, interactive networking scientific international organization to share data (Fig. 33.2). The Club website (www.mgb-oagb-club.org) provides membership application forms. The private Facebook page for Members is www.facebook.com/groups/mgboagbclub, and disseminates useful information with discussions, clinical advice, papers, videos, and meetings. Within 2 years, the Club has 407 members, and is growing daily. Past-President is K.S. Kular, Current President Mario Musella, Vice-President Miguel A. Carbajo, Second Vice-President Karl Rheinwalt, Treasurer Chetan Parmar. The MGB-OAGB International Club® is registered worldwide.

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Epilogue

Bariatric surgeons have poured out their knowledge, in order to provide detailed information in a clear manner. With an understanding of the proper techniques and dedicated patient care, the mini-gastric bypass and one-anastomosis gastric bypass result in essential weight loss in a safe manner, with resolution of co-morbidities. It is for these purposes that the authors have compiled their knowledge and experience.

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M. Deitel (ed.), *Essentials of Mini – One Anastomosis Gastric Bypass*,
https://doi.org/10.1007/978-3-319-76177-0

Index

M. Deitel (ed.), *Essentials of Mini – One Anastomosis Gastric Bypass*,
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