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Surgical Procedures to Achieve Weight Loss

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1. Introduction

Obesity is one of the leading medical problems facing our society today. At least two thirds of the U.S. adult population is considered overweight and approximately one-third of American adults are obese, creating an epidemic of obesity. Clearly, there has been an increase in the number of individuals struggling to lose weight. Additionally, obesity has become increasingly prevalent in the pediatric population and 30% of U.S. children have a BMI greater than the 85th percentile for their age.[1] The relationship of childhood and adolescent obesity to adult obesity is a strong one with 20% of children who are obese at 4 years of age and 80% of adolescents who are obese will be obese as adults.[2] The annual cost of managing obesity in the United States alone amounts to approximately $100 billion, of which $52 billion are direct healthcare costs. Hypertension, sleep apnea, diabetes, stroke, myocardial infarction and malignancy is a short but representative list of problems associated with obesity. Approximately 300,000 U.S. deaths per year are related to obesity.

While medical options such as weight loss programs, diets and drug therapies are ever-present and increasing, only 3-7% of patients with a diagnosis of obesity are able to achieve effective and consistent weight loss. [3] This statistic demonstrates the continued failure of the medical management of obesity. On the other hand, patients undergoing bariatric surgery demonstrate 23% weight loss at 2 years after operative intervention and 16% by 10 years.[4] These patients had dramatic improvement in quality of life scores and validated measures of psychiatric dysfunction compared with only minor and inconsistent improvement in patients undergoing medical treatment for their obesity. After 10 years of follow up the improvement in the surgical group diminished somewhat due to weight regain. Regardless, outcomes of groups of patients undergoing surgical treatment were superior to those treated medically.[5,6] Surgical options for weight loss have been consistently more successful at helping individuals to lose weight and maintain that achievement permanently.[7-9]

Weight loss surgery has been evolving since its inception and the final chapter is yet to be written. Since the 1950's astute minds and dedicated surgeons have tried to find the one operation that would yield the definitive answer to the problem of obesity. As time has progressed, no silver bullet has been identified. It is clear that there is no procedure that is superior to another for every patient.

Each operation that will be discussed here has its own story to tell in terms of patient selection, operative technique, outcomes and complications. Each has an important role to play in the world of weight loss surgery and it behooves those involved in the trenches of

bariatric surgery and the subsequent care of these patients to be familiar with the individual nuances of the operations. In this chapter, we will discuss the various common, and not so common, surgical options currently being employed to assist the morbidly obese patient.

1.1 Patient selection

The patient selection criteria consist of a group of objective and variable components. The objective component was set by the National Institutes of Health (NIH) in 1991. In order to be eligible for bariatric surgery the patient must have a body mass index (BMI) of 40kg/m^2 or a BMI of 35 kg/m^2 with associated co-morbidities. These co-morbidities can include medical conditions such as:

1. Hypertension
2. Diabetes
3. Obstructive sleep apnea
4. Hyperlipidemia
5. GERD
6. Degenerative joint disease[4]

Other subjective criteria include:

1. Sustained attempts at weight loss over a period of at least five years
2. Recognition of the effect of morbid obesity on the patient's health
3. Demonstration of a reasonable understanding of the surgical tools available for weight loss with the associated risks and benefits
4. Ability to understand and conform to the postoperative diet and lifestyle changes necessary for success
5. Realistic expectations of the desired surgical procedure.[10,11]

1.2 Weight loss

Weight loss patterns in bariatric surgery are one of the major differences between the various surgical tools available. While most patients are concerned about the absolute weight loss in terms of pounds or kilograms, in order for there to be an objective method of comparing the differences in weight loss between the different procedures other means of measurement have evolved with time. Weight loss is generally measured according to the patient's BMI or a change in the percentage of excess weight lost (%EWL).[12,13]

1.3 Complications

Intimate knowledge of the exact operation is necessary for any clinician to be able to assess and manage post bariatric surgical patients. Some postoperative complications such as infection, pneumonia, urinary tract infections, deep venous thrombosis and pulmonary embolism may be standard concerns after intra-abdominal surgery but other issues such as erosions or slippage of a gastric band, internal hernias, bleeding and anastomotic leakage require a physician to be knowledgeable about the intricacies and variations of weight loss operations, as many complications may be overlooked or missed by the unsuspecting observer. Complications specific to each operation will be discussed with the review of each operation.

2. Laparoscopic vs. Open Approach

All bariatric operations have been performed using the open approach. With increases in knowledge, technology, skill and ingenuity, all of these procedures are now possible via a laparoscopic approach. Over time, laparoscopic surgery has gained wide acceptance and is now more common in primary procedures in bariatric surgery than the open approach.[14-16] Regardless of the method used to perform any particular weight loss procedure the surgical endpoints are the same. All primary bariatric procedures can generally be performed laparoscopically with clinical results comparable to those of an open counterpart. The major reported benefits of the laparoscopic approach include: superior exposure, reduced soft tissue trauma, better postoperative pulmonary function, less postoperative pain, decreased rates of wound infection, decreased rates of abdominal wall hernias, earlier return to physical activities, decreased length of stay, earlier return to work and better cosmetic results. The laparoscopic approach can also serve as a useful diagnostic tool in bariatric patients when imaging studies may be impossible to perform, or when signs and symptoms of an ongoing surgical problem may be vague due to the patient's body habitus. Disadvantages of the laparoscopic approach primarily include higher operative costs, longer operative times, need for specialized training and steep learning curves.

3. Types of Surgery

In general, the bariatric surgical procedures are classified by their mechanism of action. They are subdivided in three types:

1. Restrictive operations are based on decreasing the size of the stomach, limiting portion size, and increasing early satiety. [17,18]
   - Vertical Banded Gastroplasty (VBG)
   - Sleeve Gastrectomy (SG)
   - Adjustable Gastric Banding (AGB)
2. Malabsorptive operations rely on the surgical rearrangement of the gastrointestinal system to decrease the absorption by limiting the exposure of the small bowel to the ingested meal. [17,18]
   - Jejuno-ileal bypass (JIB)
3. Mixed operations are a combination of the restrictive and malabsorptive procedures.[17,18]
   - Roux-en-Y Gastric Bypass (RYGB)
   - Biliopancreatic Bypass with Duodenal Switch (BPD-DS)
   - Laparoscopic Sleeve Gastrectomy with Duodenojejunal Bypass (LSG-DB)
   - Ileal Interposition with Sleeve Gastrectomy (IL-SG)

4. Vertical Banded Gastroplasty

The Vertical Banded Gastroplasty (VGB) is like many other bariatric operations which experienced changes from its initial inception until the accepted version that was performed. The procedure, which was first performed in 1971 by Mason, underwent an evolution. The initial operation included a transverse gastroplasty which served to partition the stomach. The final variation involved the creation of a vertical gastroplasty along the lesser curvature. Operatively, a window is made through the anterior and posterior gastric wall using a

circular stapler positioned close to the lesser curvature. A linear non-cutting stapler is then applied through the gastric window, created by the circular stapler, in a vertical fashion directed towards the angle of His. A ring of polypropylene mesh is then placed through the gastric window around the lesser curvature (see Figure 1). This procedure has since been adapted to the laparoscopic approach in which the stomach is generally transected vertically.[17,18,19,20] This anatomic change results in early satiety with reduced meal portions.

Fig. 1. Vertical Banded Gastroplasty

4.1 Weight loss

This procedure generally was able to effect a 50-60% EWL within two years. The VBG appears to be more dependent on the patient's ability to maintain lifelong alterations of his or her eating habits. These changes include avoiding high-calorie liquids and such calorie-rich foods as cake, cookies, and other junk foods that undergo substantial liquefaction in the mouth and thus arrive in the VBG pouch as a liquid slurry that is not restricted by the outlet. This dependence on patient behavior led to a higher failure rate due to weight regain which in turn has led many to abandon the VBG in preference to other simpler restrictive procedures.[20-22]

4.2 Complications

The majority of problems with the VBG generally surrounded stomal issues. The stoma could be too loose which would lead to little restriction and ultimately poor weight loss. Conversely, the stoma could develop a stricture which could then lead to difficulty with oral intake.

Staple-line dehiscence was also a well known problem. Small dehiscences do not substantially impede the restrictive effects of the operation. A dehiscence larger than 1 cm would generally lead to both weight regain and gastroesophageal reflux disease. This would render the operation ineffective as the restriction would be lost, yield inadequate long-term weight loss and require revision of the initial operation. Sporadic staple–line dehiscence was also seen in postpartum patients—the reason for this association is unknown.[23,24] It is

possible to restaple a dehisced staple line; however, reapplying staples to a thickened, scarred stomach wall may be associated with not only another dehiscence, but tearing of the tissue. The success rate in resuming and maintaining weight loss with reapplication of staples is also generally less satisfactory when compared to the degree of weight loss after the initial operation.

Pouch enlargement was another well recognized complication of this procedure leading to gastric stasis and reflux. It primarily occurs due to repetitive vomiting, inclusion of an excessive amount of fundus during the initial procedure or continued overeating. One should be aware of the fact that one of the innate functions of the fundus is to dilate to accommodate ingestion of the food bolus. Thus, inclusion of a significant amount of fundus may promote pouch dilation. To help to avoid this, the initial vertical staple line should be placed precisely at the angle of His. The VBG was quite popular in the 1970's but is much less commonly performed today. [25,26]

5. Sleeve Gastrectomy

The Sleeve Gastrectomy (SG) was initially used as the first part of a two-stage procedure for the super-obese patients who were considered poor surgical candidates and who would not tolerate a prolonged or more involved procedure. The operation was designed to allow the patients an opportunity to achieve some weight loss before being converted to the more complex gastric bypass or biliopancreatic diversion with duodenal switch (BPD-DS).[27] Keen observation noted that the weight loss with the gastric sleeve alone was significant and, in fact, many patients refused further operative intervention to promote continued weight loss. Currently, this procedure is used as a definitive weight loss procedure. Despite the perceived simplicity and efficacy of gastric sleeve, enthusiasm for this procedure is often tempered by the lack of data on long-term outcomes beyond 5 years. It was discovered that SG also produces a decrease in ghrelin levels for up to a year, which may reduce the desire for food.[28,29]

Fig. 2. Sleeve Gastrectomy

The operation involves a vertical gastrectomy performed parallel to the lesser curvature. The more receptive greater curvature is resected and the patient is left with a long tube-like

stomach (see Figure 2). The operation consists of releasing the vascular supply of the greater curvature as well as the posterior gastric attachments. A bougie is advanced into the distal stomach or duodenum and the greater curvature of the stomach is resected. The transection of the stomach is begun approximately 4-5cm proximal to the pylorus. With the bougie in place to size the stomach along the lesser curvature, a vertical gastrectomy is created using a linear cutting stapler.[27] Different sized bougies have been used to date, somewhat limiting the comparison of available results. Standardization is still awaited for this procedure that is certainly a valuable addition to the surgical armamentarium.

5.1 Weight loss

While no long term weight loss statistics are available, medium-term results are indeed encouraging with an expected 62% EWL at 12 months and 68% EWL at 24 months.[27,30] Review of current literature also demonstrates that at 6 years, the %EWL is approximately 57.3-72.3%.[24,31]

5.2 Complications

Along with the standard postoperative concerns, the most common complications with the SG have surrounded staple line disruption, leakage from the long staple line and bleeding. The majority of leaks occur in the area of gastroesophageal junction.[32,33] It most likely occurs because this area has diminished blood supply compared to the rest of the stomach. Also the stomach wall in this area is thinner and hence less resistant to ischemia and thermal injuries by energy devices. [32,33] Another common site for a leak is along the antral staple line. Disruption of the staple line in this location is believed to occur due to the relative obstruction caused by the nearby pylorus.

Stenosis and dilatation of this narrow tubular stomach has also been reported.

The gastroesophageal junction and the angularis incisura are the two most common areas where stenosis occurs, and this can be diagnosed by an upper gastrointestinal series. The most common reasons for the development of narrowing or stenosis are over-sewing the staple line, using a bougie that is too small, creating non-parallel staple lines or using non-absorbable suture material.

Even though we mentioned that variable bougie sizes are being used by different surgeons, a 32 to 40 French bougie is most often utilized when SG is performed as a definitive operation. Larger bougie sizes, up to 60 French, can be used when SG is being performed as a part of a staged procedure such as BPD-DS.[32] Management of stenosis primarily consists of endoscopic dilation vs. stent placement. If the area of stenosis is too long, surgical intervention may be necessary with conversion to a gastric stricturoplasty, RYGB or resection with gastrogastrostomy. Management of gastric sleeve stretching is currently controversial. There are multiple reports of successful repeat sleeve gastrectomy as well as conversion of SG to RYGB or BPD-DS.

6. Adjustable Gastric Banding

In 1983, while looking for a safe surgical method to fight obesity, Dr. Lubomyr Kuzmak introduced a Dacron-reinforced silicon band. This original system had no ability to adjust the gastric restriction and was considered a permanent implant. The Adjustable Gastric

Banding System was introduced in 1985 by Dr. Dag Hallberg of Sweden. Laparoscopic adjustable gastric banding (LAGB) was advocated in 1992 by Favretti and Cadiere and made a revolutionary change in the history of bariatric surgery. Over time and with technological improvements, the first laparoscopic adjustable gastric band device was approved by the FDA for use in the United States in 2001.

Fig. 3. Adjustable Gastric Banding

Adjustable Gastric Banding (AGB) procedures have now virtually replaced the VBG throughout the world. A number of bands are available on the market, but only two devices are currently FDA approved and available in the United States.

Gastric banding procedures rely on the restriction of enteral intake to achieve weight loss and its maintenance. There is no alteration of the native anatomy and as such the neurohormonal mechanisms involved in weight control are largely left intact.[34,35]

Over a period of time many modifications to the gastric band were created by different manufacturers.

The AGB is commonly placed laparoscopically, generally with a short operative time and limited morbidity. Hospital stay is often one day and, recently, is more commonly being performed as an outpatient procedure. Operatively, the goal is to place the band in a position at the gastric cardia near the gastroesophageal junction that will yield a small gastric pouch with a 20-30 mL capacity. The small pouch provides the restriction needed to assist in weight loss. The optimal technique has changed with time and is now agreed upon to be the pars flaccida technique. The band encircles the upper stomach, and its ultimate position is determined by using a calibration tube as a guide intraoperatively. It is then sutured in place with the use of anterior gastro-gastric sutures for stability, while posteriorly the band is held in place by natural attachments between the posterior stomach and the right diaphragmatic crus.[34,35]

The band system consists of three components (see Figure 3):

1. The band which is placed at the gastric cardia near the gastroesophageal junction and effectively divides the stomach into two segments; an upper smaller pouch and the larger intact stomach.

2. The port which is the access point for adjustments. The port is placed on the abdominal wall, directly attached to the rectus abdominis fascia. An adjustment consists of using a Huber needle to access the subcutaneous port at which point normal saline can be injected or aspirated from the band. The injection or aspiration of fluid changes the tightness of the band around the stomach and can therefore assist with the management of food consumption, appropriate early satiety and subsequent weight loss.
3. The silastic tubing which connects the band to the port.

The major advantages of the gastric band include the minimally invasive nature of the operation, its reversibility, the adjustability of the band and the maintenance of gastrointestinal anatomy.

6.1 Weight loss

The weight loss patterns for the two available AGBs are comparable. The expectations for weight loss are for the patient to obtain a 30-35% EWL in the first year, 50% EWL at the second year and 60% EWL in the third year. Ultimately the goal is to achieve a gradual, effective and durable means to lose weight. These results have been quite variable in the literature and ultimately are still being debated.[34-37]

6.2 Complications

Perioperative complications occur in 1-2% of cases and this safety profile associated with the AGBs make them an attractive choice for many patients and surgeons when compared to the other surgical options available for weight loss. One band-related complication includes stoma obstruction. This occurs most commonly due to inclusion of excess perigastric fat, use of a band of insufficient diameter for the thickness of the tissue, significant tissue edema, band infection, delayed gastric emptying or gastric perforation. The majority of these require surgical management, including band removal or repositioning.

Late band related complications include erosions, slippage or gastric prolapse, port or tubing malfunction, port migration, leakage at the port site, tubing or band, pouch or esophageal dilatation and esophagitis.[35] Slippage is diagnosed when a portion of the stomach below the band has traversed the band and now lies above it. This movement initially creates a large upper gastric pouch which diminishes the restrictive function of the adjustable band. As more of the inferior stomach passes cephalad, it ultimately leads to obstruction of the stoma which will present with persistent nausea and vomiting and inability to tolerate even saliva. This is a scenario which must be diagnosed early as it can lead to gastric necrosis if not identified and treated in a timely fashion. Erosion is an infrequent but serious complication of gastric banding. It often presents with evidence of a port site infection, but there have been reports of gastric outlet obstruction from an intraluminal band. A high index of suspicion is crucial to avoid a delay in diagnosis. The diagnosis of an erosion mandates the removal of the gastric band. This can be done operatively or endoscopically in select cases.

7. Jejunoileal Bypass (JIB)

The jejunoileal bypass (JIB) was first introduced in the 1950s at the University of Minnesota. It was the first most commonly used procedure for the treatment of severe obesity. The

operation consisted of creating a jejunoileostomy and shortening the effective length of the small intestine. Observing patients suffering from short gut syndrome spawned the idea of using jejunoileal bypass in order to lose weight. A short length of proximal jejunum (8 to 14 inches from the ligament of Treitz) was connected to the distal ileum (4 to 12 inches proximal to the ileocecal valve) as an end-to-end or end-to-side anastomosis (see Figure 4). Patients with the end-to-end anastomosis, which could achieve a higher degree of weight loss, also required decompression of the bypassed small intestine into the colon via an ileocecostomy. The diminished length of the functional small bowel exposed to food boluses as well as the diminished surface area for absorption was the key to the JIB. It was indeed successful in its objective of weight loss but it later became apparent that the dramatic weight loss was not the only outcome.

Fig. 4. Jejunoileal Bypass

Approximately 25,000 patients underwent JIB in the United States when it was realized that complications of this procedure were, ultimately, common and would present with significant morbidity and mortality. Complications such as severe diarrhea, electrolyte imbalance, kidney stones, kidney failure, gastro-intestinal tract bacterial overgrowth and liver failure were unexpected problems which ultimately led to the abandonment of this procedure and the reversal of JIB in many patients. Variations of this small bowel bypass were used in the 1960's, but over time these were abandoned as well given inadequate weight loss or unacceptable complication rates. As a result, the JIB is only discussed today for its historical significance. Armed with the knowledge that surgical manipulation of the gastrointestinal (GI) tract could lead to significant and reproducible weight loss, many surgeons embarked on this journey in pursuit of the perfect operation which could produced the desired weight loss with an acceptable complication profile.[17,18,38]

8. Gastric Bypass

The Gastric Bypass (GB) has emerged as the most common operation performed for weight loss in the United States. In fact, it is often referred to as the "gold standard" of bariatric

surgery. Its long history of good weight loss with low complication rates have led to this status. The original GB was performed by Mason and Ito in 1967, after they recognized that patients undergoing partial gastrectomy for indications other than weight loss, like peptic ulcer disease, had difficulty gaining weight in the postoperative period.[39] The original version of gastric bypass consisted of a 150-mL gastric pouch and a loop gastrojejunostomy. It has subsequently undergone a number of modifications until it was recognized that a smaller gastric pouch of 20 – 30 mL in conjunction with a Roux-en-Y reconstruction is the most effective combination to achieve maximum weight loss with the lowest rates of amount of complications. The laparoscopic Roux-en-Y gastric bypass (LRYGB) was introduced in 1994 by Wittgrove and Clark.

Fig. 5. Gastric Bypass

The operation uses two methods to achieve weight loss. First, the restrictive component of the procedure is created by dividing the stomach to create a smaller gastric pouch. The larger remnant is left in situ. Second, the malabsorptive component is created when the remnant stomach, duodenum, and a short segment of the proximal jejunum is bypassed. Initially the jejunum is divided 30-50 cm distal to the ligament of Treitz. The length of the Roux limb, which consists of the distal transected jejunum, is selected based on the patient's BMI. A 75-100 cm long Roux limb is chosen for a BMI < 50 kg/m^2 and a 150 cm long Roux limb is used for a BMI ≥ 50 kg/m^2. A jejunojejunostomy between the Roux limb and biliopancreatic limb is created in a side-to-side fashion. The Roux limb is brought up to the transected stomach and a gastrojejunostomy is created (see Figure 5).

Several techniques for the creation of the gastrojejunostomy exist. It can be hand sewn or stapled with either a linear stapler or circular stapler. The gastrojejunostomy can be created in a retrogastric or antegastric fashion, while the Roux limb can be passed in an antecolic or retrocolic fashion. The decision for which approach is used ultimately depends on a few factors, but is largely surgeon preference.[17,40,41] There are advantages and disadvantages to each approach and the surgeon should be familiar with these so as to be able to address post-operative complications.

8.1 Weight loss

The overall expectation of the operation is a 60-70% EWL over the course of 12-18 months. During this period of time, close follow-up is essential in order to identify any potential problems which the patient may experience and prevent micronutrient and protein deficiencies.[40]

8.2 Complications

Complications associated with LRYGB are often divided into early and late complications. The most notable early complications after the gastric bypass operation are: bleeding, pulmonary embolism, and anastomotic dehiscence. Pulmonary embolism and anastomotic dehiscence are the two most common reasons for mortality associated with the gastric bypass. The mortality rate varies between reports but generally ranges between 0.5 to 1%.

Bleeding can occur from a number of sites including:

1. Incision/port sites
2. Anastomotic sites (gastrojejunostomy is more common)
3. Gastric pouch or remnant staple line
4. Divided mesentery

The bleeding can be either intra-luminal or extra-luminal. Intraluminal bleeding may present with signs and symptoms of upper or lower GI bleeding such as hematemesis, bright red blood per rectum or melena. Extra-luminal bleeding may only be suspected by clinical findings such as hypotension and tachycardia with a falling hematocrit and decreased urine output. Abdominal distention and abdominal pain are often not reliable physical findings in the morbidly obese patient.

Leakage, likewise, can occur at a number of sites:

1. Gastrojejunostomy
2. Gastric pouch staple line
3. Gastric remnant staple line
4. Jejunojejunostomy

Persistent tachycardia is the hallmark sign for a leak and requires immediate investigation, with a low threshold to return to the operating room. Late complications of the gastric bypass include anastomotic stricture (2-16%). The etiology is unclear, however tissue ischemia or increased tension on the gastrojejunostomy are the most likely reasons. The rate of stenosis is higher when a circular stapler is used for creation of the gastrojejunostomy or when the Roux limb is in an ante-colic position. Marginal ulceration (1-5%), another late complication of RYGB, can develop due to different reasons including re-exposure of the gastrojejunostomy to gastric acid via a gastro-gastric fistula, ischemic changes to the anastomosis most often due to nicotine use, the presence of foreign material (sutures and staples), chronic NSAID use and H. pylori infection.

Iron deficiency (6-52%), vitamin B12 deficiency (3-37%), calcium, thiamine and folate deficiency are the most common micronutrient deficiencies observed in post-bariatric surgery patients. If dietary changes are not maintained, protein malnutrition can result which presents as hair loss. This is reversible if adjustments are made to increase protein intake.

Along with vitamin deficiencies gastric bypass, due to the lack of a pylorus, can result in dumping syndrome. Dumping syndrome occurs in early and late forms. Early dumping syndrome (10 to 30 minutes after ingestion of a meal) is the more common form and occurs in about 25% of patients after gastric surgery. It is characterized by the rapid gastric emptying of hyperosmolar contents into the small bowel. Patients can suffer from abdominal cramps, nausea, explosive diarrhea, tachycardia, lightheadedness and syncope. This is often a self-limited phenomenon and can be treated by dietary modification or manipulation. Late dumping syndrome is usually associated with meals that have high carbohydrate contents. The symptom onset begins from 1 to 4 hours after ingestion of such meals and invariably includes reactive hypoglycemia in addition to some of the vasomotor symptoms seen with early dumping syndrome.

Endoscopic access to the gastric remnant and proximal small bowel becomes challenging and poses potential difficulties in the future, specifically when evaluating for remnant gastric lesions or attempting endoscopic retrograde cholangiopancreatography.[4]

Small bowel obstructions are a standard postoperative risk after any abdominal surgery. They can occur in 1-10% of patients and can be specifically related to trocar sites in laparoscopic surgery. Internal hernias are a special cause of bowel obstructions and have occurred most frequently in the setting of marked weight loss and the creation of inter-mesenteric defects or by failure to close mesenteric defects at the primary operation.

Three potential areas of internal herniation are:

- The mesenteric defect at the jejunojejunostomy
- The space between the transverse mesocolon and Roux-limb mesentery (Peterson's space)
- The defect in the transverse mesocolon if the Roux-limb is passed in a retrocolic fashion

Internal hernias can be intermittent and, therefore, difficult to detect radiographically. Several studies have shown that the "mesenteric swirl" sign on computed tomography (CT) scan is the best indicator of an internal hernia following gastric bypass.[42] Although often debated, closure of all potential sites for internal hernias is highly recommended at the original operation. Long-term follow-up is essential with these patients as complications, such as internal hernias and nutritional deficiencies, can occur at any time. Intimate knowledge of the new anatomy is essential in order to optimally diagnose and treat these potential complications.[43]

9. Biliopancreatic Diversion with Duodenal Switch

The Biliopancreatic Diversion (BPD) was described and championed by Dr. Nicola Scopinaro of Italy in 1979. To date it still remains the most effective surgical intervention for morbid obesity. It is particularly suited for patients who fall in the super-obese category with a BMI greater than 50kg/m^2. The main limitation has been that which is common to intense malabsorptive procedures: potential significant long-term nutritional deficiencies.

The BPD involves a horizontal gastrectomy that leaves a gastric pouch of about 250 mL that is anastomosed to a 200- to 250-cm Roux limb. The long biliopancreatic limb is anastomosed

to this Roux limb at 50 cm from the ileocecal valve to create the common channel (see Figure 6). This results in malabsorptive anatomy with modest restriction and without many of the side effects of the JIB. In 1993 Marceau described modifications to the BPD which have come to be known as the biliopancreatic diversion with duodenal switch (BPD-DS).[10,44-46] In this modification the horizontal gastrectomy was substituted by SG, which allowed for preservation of the pylorus and a decreased incidence of dumping syndrome.

Fig. 6. Biliopancreatic Diversion with Duodenal Switch

Even with the combined restrictive and malabsorptive properties of the gastric bypass, many super-obese patients fail to obtain the desired weight loss. The BPD-DS takes the surgical intensity to another level. It combines a moderate food restriction in the form of a vertical sleeve gastrectomy with the malabsorption of a long intestinal bypass. The sleeve gastrectomy capacity is approximately 100-150 mL. After completion of the sleeve gastrectomy, the pylorus is preserved and the duodenum is transected. The small bowel is then measured and marked 100 cm proximal from the ileocecal valve. This ultimately serves as the site for the anastomosis of a 100 cm common channel. An additional 150 cm of small bowel is measured from the future common channel towards the stomach. The small bowel is then transected at this site. The proximal site of transection is brought up and a duodenoilieal anastomosis is created. The distal small bowel transection site is brought to the 100 cm site and an ileoileal anastomosis performed. Ultimately the alimentary channel is 150 cm and the common channel is 100cm. The remaining small bowel is bypassed.[10,17] Modifications to these measurements are common in clinical practice. The first laparoscopic duodenal switch was performed by Gagner in 2000.

9.1 Weight loss

At 24 months postoperatively the patients can achieve up to 80% EWL with the BPD-DS, and an average of 76% at 10 years. Weight loss certainly exceeds that of the other bariatric procedures but it comes with a greater risk of nutritional complications.

9.2 Complications

Dedicated, long term follow up with nutritional counseling is essential. Patients are educated on the importance of a protein rich, low-carbohydrate diet and the necessity of life-time daily vitamin supplementation which includes iron, calcium, vitamin B12, folate, and a multivitamin. Separate fat soluble vitamin supplementation is also necessary.[44-46]

As with the gastric bypass, other significant complications include bleeding and leaks. Leaks can occur at a number of locations including the gastrectomy site, the anastomosis of the ileum to the duodenum or at the distal Roux-en-Y. These complications require the attention of the knowledgeable and astute physician for diagnosis and management. Internal hernias can also occur if mesenteric defects are not closed or if they reopen after significant weight loss.[47]

10. Laparoscopic Sleeve Gastrectomy with Duodenojejunal Bypass

Laparoscopic Sleeve Gastrectomy with Duodenojejunal Bypass (LSG-DJB) was introduced as a valuable bariatric procedure. The advantage of not having an excluded stomach after SG eliminates the need for technically complicated double-balloon enteroscopy used for surveillance of the excluded stomach after a RYGB. This advantage and the potential significant durable weight loss has made LSG-DJB a very popular surgical intervention in Asia, where the incidence of gastric cancer has been high and obesity is now on the rise.[48] The sleeve gastrectomy is performed, then the first portion of the duodenum is mobilized and subsequently divided with a linear cutting stapler. The biliopancreatic limb is measured to a distance of 150-200 cm and, at this location the small intestine is divided with a linear cutting stapler. A jejunojejunostomy is created, after which the mesenteric defect is closed. A gastrojejunostomy is created in an end-to-side fashion with the distal limb to restore intestinal continuity (see Figure 7). This procedure combines both restrictive and malabsorptive components to achieve weight loss.

Fig. 7. Laparoscopic Sleeve Gastrectomy with Duodenojejunal Bypass

10.1 Weight loss & complications

Short term EWL after LSG-DJB is comparable to EWL after LRYGB.49 However, long-term data is lacking as this procedure is relatively new. Complications specific for LSG-DJB include bleeding, leak, stenosis at any of the anastomotic sites, marginal ulceration, duodenal stump blowout and dumping syndrome.48

11. Ileal Interposition with Sleeve Gastrectomy

Ileal Interposition with Sleeve Gastrectomy (II-SG) is another operation that has been performed outside of the United States. It was one of many bariatric operations to treat morbid obesity, but also is used in non-obese patients with BMI 21-29 kg/m^2 to treat poorly controlled diabetes. In this case, II-SG is also called the neuroendocrine brake.[50] The sleeve gastrectomy is performed and then the jejunum is divided with a linear stapler 50 cm distal to the ligament of Treitz. The distal ileum is divided 30 cm proximal to the ileocecal valve. Subsequently, the ileum is divided a further 170-200 cm proximally. This segment of ileum is interposed with the proximal jejunum and anastomosed in an isoperistaltic fashion. Then three enteroanastomoses are performed to complete the operation: ileoileostomy, jejunoileostomy, ileojejunostomy (see Figure 8).

Fig. 8. Ileal Interposition with Sleeve Gastrectomy

11.1 Weight loss & complications

After 5-year follow up, the EWL associated with II-SG is 60%. It is still unclear what percentage of the total weight loss that each part of the operation is responsible for and this requires further investigation. The rate of diabetes remission is reported at 84%.[51] The potential complications of II-SG combine complications of small bowel bypass and SG. The incidence of complications after II-SG is approximately 0.8-2.0% and they include gastric and anastomotic leak, intestinal obstruction, internal hernia, gastric sleeve stricture, GI bleed and nutritional deficiencies.[52]

11.2 Conclusion

Weight loss surgery has been in evolution since the very beginning with the introduction of the JIB. The GB was introduced in the 1960's. Various gastroplasties were in common practice in the 1970s. We returned to the GB in the 1980's given the failure of the gastroplasties. The Scopinaro procedure (BPD) was introduced in the 1979. Modifications of the BPD were introduced in the 1980's. The 1990's brought us the AGBs. The SG became a distinct entity unto itself in the early 21st century and is the newest contender on the field. Finally, we have briefly described two other operations that are not widely used in the U.S. but may become much more common in the future. Not one operation has met all the needs of every patient and as such the search continues for the ultimate operation which will be performed using minimally invasive techniques and produce outstanding and sustainable weight loss with a limited complication profile.

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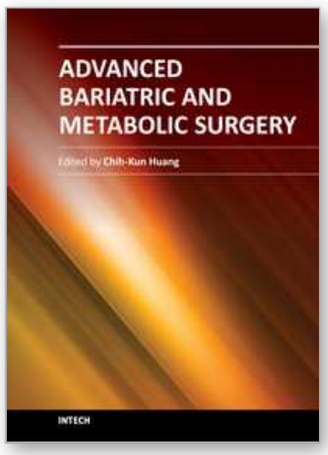

Advanced Bariatric and Metabolic Surgery

Edited by Dr. Chih-Kun Huang

ISBN 978-953-307-926-4
Hard cover, 326 pages
Publisher InTech
Published online 29, February, 2012
Published in print edition February, 2012

Bariatric surgery has gained importance in the last 20 years because of the high prevalence of global obesity, and the vast understating of the physiological and pathological aspects of obesity and associated metabolic syndromes. This book has been written by a number of highly outstanding authors and pioneering bariatric surgeons from all over the world. The intended audience for this book includes all medical professionals involved in caring for bariatric patients. The chapters cover the choice of operation, preoperative preparation including psychological aspect, postoperative care and management of complication. It also extends to concept and result of metabolic surgery and scarless bariatric surgery.

How to reference

In order to correctly reference this scholarly work, feel free to copy and paste the following:

Roman Grinberg, John N. Afthinos and Karen E. Gibbs (2012). Surgical Procedures to Achieve Weight Loss, Advanced Bariatric and Metabolic Surgery, Dr. Chih-Kun Huang (Ed.), ISBN: 978-953-307-926-4, InTech, Available from: http://www.intechopen.com/books/advanced-bariatric-and-metabolic-surgery/surgical-procedures-to-achieve-weight-loss

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