Why the Need for Bariatric Surgery?

Obesity is associated with increased morbidity and an increased incidence of comorbid illness. Failure of sustained weight loss following dietary therapy and the proven long-term success of weight loss surgery have driven the increasing popularity of bariatric operations in the United States. Emerging data regarding the improvements in metabolic disorders following bariatric surgery, such as type 2 diabetes mellitus (T2DM), are not explained simply by weight loss alone. The complex hormonal and molecular signaling changes encountered following many weight loss procedures today have resulted in increased popularity of the term “metabolic surgery” to describe the field more completely.

Definition of Obesity, Current Indications for Surgery, and the Metabolic Syndrome

Obesity is divided into three classes, with class I, II, and III obesity defined as a body mass index (BMI) of 30 to 34.9 kg/m², 35 to 39.9 kg/m², and 40 kg/m² or greater, respectively.1 Morbid obesity encompasses those within class III or patients who are more than 100 pounds above ideal body weight. The National Institutes of Health Consensus Statement drafted in 1991 still dictates the criteria for who should undergo bariatric surgery.2 Patients can undergo bariatric surgery if they have a BMI greater than or equal to 40 kg/m² or a BMI between 35 and 39 kg/m² if an additional major comorbidity is present. Major comorbidities include T2DM, hypertension, and obstructive sleep apnea (OSA). Since the release of this statement, the profound effects of bariatric surgery on metabolic diseases such as T2DM have been thoroughly documented3-5; also, several studies are currently under way to investigate the effects of various bariatric operations on T2DM in patients with a BMI less than 35 kg/m².

Metabolic syndrome involves the presence of multiple metabolic risk factors for the development of cardiovascular disease and T2DM. Specifically, hypertension, dyslipidemia, glucose intolerance, and central obesity cluster together to form metabolic syndrome.6 To be officially diagnosed with metabolic syndrome, one must meet three of the five criteria presented in Table 1.7 The diagnosis of metabolic syndrome carries increased mortality,8,9 and weight loss is an effective method to manage this disease to reduce both cardiovascular risk and mortality. The impacts of bariatric surgery on all aspects of the metabolic syndrome are discussed separately in this chapter.

Medical Management of Obesity

Either alone or in combination, the global epidemic of obesity has not been well managed using behavior modification, dietary management, exercise, or pharmaceutical interventions. Medical management of obesity is clearly the mainstay and initial focus of treatment of both obesity and obesity-related comorbid illnesses. The impact of modest weight loss has been clearly shown. Lifestyle modification has also been shown to produce a robust 8.6% weight loss in the Look-AHEAD study at 1 year; however, by 4 years, there was significant weight regain.10 However, this is a remarkably intense program that may be difficult to implement in clinical reality. Caloric restriction in addition to lifestyle modification produces even more significant weight loss, as much as 15.5% of total body weight11; however, a number of these studies demonstrate rapid regain of weight. Long-term follow-up in these studies has been a significant challenge.

Surgical Procedures: An Overview

Bariatric surgery has changed dramatically in the last several years. Over the last two decades, jejunoileal bypass and vertical banded gastroplasty have become obsolete. The Roux-en-Y gastric bypass (RYGB) has become the “gold standard.” The quick rise of the adjustable gastric band (AGB) has been overcome by the introduction of vertical sleeve gastrectomy (VSG). The biliopancreatic diversion with duodenal switch (DS) has maintained a small but constant presence.

Procedures can be grouped into either restrictive, malabsorptive, or a combination of both. An example of a purely restrictive procedure would be the AGB. The VSG is also theoretically a purely restrictive procedure; however, there may be a hunger suppression effect following the VSG that far exceeds its restrictive value, possibly modulated through the hormone ghrelin.12 The RYGB and DS work via restrictive mechanisms but also add a component of malabsorption. With the RYGB, the total intestinal bypass is typically no more than 250 cm but will involve most of the stomach and the entire duodenum, which will have a significant impact on iron, vitamin B₁₂, and calcium absorption. Given that folic acid is absorbed throughout the entire gastrointestinal tract, its absorption will be affected differentially. With the DS, the stomach and a small portion of ileum are in continuity, making vitamin B₁₂ absorption less of a concern. Iron absorption following DS may be marginally improved compared with the RYGB given the small amount...
Adapted from Alberti KGMM, Eckel RH, Grundy SM.\(^7\) HDL-C = high-density lipoprotein cholesterol.

of duodenum in continuity with the stomach. The presence of duodenum distal to the stomach may confer some protection against marginal ulceration.

**OPEN PROCEDURES**

In 2004, the number of laparoscopic gastric bypass operations exceeded that of open procedures according to a national audit of bariatric surgery performed at academic centers.\(^13\) Open procedures are associated with larger incisions, greater postoperative pain, a greater number of wound-related complications, and a higher incidence of both readmission (2.6% versus 4.7%) and mortality (0.1% versus 0.3%) at 30 days.\(^14\) In addition, laparoscopic procedures achieve comparable weight loss. However, open procedures have a role in select patients with previous intrabdominal operations, particularly in patients undergoing revision bariatric surgery.

**Preoperative Preparation**

**WEIGHT LOSS**

The role of preoperative weight loss in perioperative outcomes has been a significant area of consideration in bariatric surgery over the past few years. Indeed, a major impetus for preoperative weight loss has come from insurance companies, presumably to ensure that patients have made adequate attempts at weight loss. This, however, has fallen out of favor. Rather, the focus has been more on demonstrating compliance preoperatively. Preoperative weight loss may be a means to ensure patient compliance with dietary regimens.

An emerging rationale is to improve perioperative safety by reducing the size of the liver. Liver size has been demonstrated in a number of studies to be impacted greatly by weight loss preoperatively, which can facilitate the laparoscopic approach.\(^17\) Preoperative weight loss has other advantages, such as improving OSA, hyperglycemia, and other weight-related comorbid illnesses that can adversely affect the patient in the perioperative period. Whether long-term weight loss outcomes are impacted by preoperative weight loss is unclear.\(^19\)

**NUTRITION**

The role of the nutritionist/dietitian in the bariatric surgery process has evolved significantly over recent years. Historically, it primarily included involvement in the immediate postoperative period alone. However, with the dramatic rise in the number of surgical procedures being performed and an increased awareness of possible nutritional complications, the role of the nutritionist or dietitian has become a vital component of both the pre- and the postoperative process. Nutritional assessment and the ongoing management of nutritional needs in surgical weight loss have both been shown to be an important correlate with long-term success.\(^20\)

A comprehensive nutritional assessment should be completed preoperatively on all patients who are considering weight loss surgery. This assessment process is often initiated several months prior to surgery and may involve multiple visits with a dietitian or other qualified health professional. It is essential to determine any preexisting nutritional deficiencies and necessary diet interventions to assist with weight management or loss prior to surgery and to develop a plan for behavior modification in dietary intake postoperatively. The preoperative nutritional assessment should include weight history, medical history, laboratory values, psychological history, current dietary intake, eating behavior, current level of physical activity, and psychosocial components that may affect compliance postoperatively. A list of all recommended laboratory tests for patients undergoing bariatric surgery is provided in Table 2.

The dietitian must also prepare patients for surgery via education. Extensive counseling to ensure understanding of the planned procedure, guidelines for progression of diet consistency, postoperative dietary restrictions, and potential nutritional complications is critical. Patients must understand that weight loss surgery is only a tool and that modification of lifestyle is paramount to both successful weight loss and maintenance.

**OBSTRUCTIVE SLEEP APNEA**

OSA is a potentially fatal complication of morbid obesity. A diagnosis of OSA should be suspected when there is a history of loud snoring, frequent nocturnal awakening with

<table>
<thead>
<tr>
<th>Measure</th>
<th>Categorical Cut Points</th>
</tr>
</thead>
<tbody>
<tr>
<td>Elevated waist circumference</td>
<td>Population- and country-specific definitions</td>
</tr>
<tr>
<td>Elevated triglycerides (drug treatment for elevated triglycerides is an alternate indicator)</td>
<td>( \geq 150 \text{ mg/dL (1.7 mmol/L) } )</td>
</tr>
<tr>
<td>Reduced HDL-C (drug treatment for reduced HDL-C is an alternate indicator)</td>
<td>(&lt; 40 \text{ mg/dL (1.0 mmol/L) in males; } &lt; 50 \text{ mg/dL (1.3 mmol/L) in females } )</td>
</tr>
<tr>
<td>Elevated blood pressure (antihypertensive drug treatment in a patient with a history of hypertension is an alternate indicator)</td>
<td>Systolic ( \geq 130 ) and/or diastolic ( \geq 85 \text{ mm Hg } )</td>
</tr>
<tr>
<td>Elevated fasting glucose (drug treatment of elevated fasting glucose is an alternate indicator)</td>
<td>( \geq 100 \text{ mg/dL } )</td>
</tr>
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</table>
Morbidly obese patients often have systemic hypertension, which can aggravate left ventricular dysfunction; however, mild left ventricular dysfunction can be documented in many morbidly obese patients in the absence of systemic hypertension. Circulating blood volume, plasma volume, and cardiac output increase in proportion to body weight. Significant weight loss corrects pulmonary hypertension and the left ventricular dysfunction associated with respiratory insufficiency.

**Psychological Assessment**

Clearly, obesity is associated with significant psychological burden, as are the comorbidities associated with obesity, particularly T2DM. The spectrum of preoperative psychological evaluation is an unclear one in terms of its true benefit to improving outcomes in patients. The mainstay of focus for preoperative evaluations is to demonstrate if (1) the patient has psychological stability, (2) there is an adequate support group, (3) the patient understands that lifestyle modifications are necessary to be successful, and (4) the patient understands the procedure and its risks and potential benefits. Therefore, the psychological evaluation should evaluate for all of these parameters. Another important adjunct to the psychological evaluation is a detailed substance abuse history, which is typically not revealed during a routine history and physical examination by the bariatric surgeon. Another area that is stressed during the psychological assessment is any recent history of psychological instability such as psychiatric admissions or suicide attempts. Whether a Minnesota Multiphasic Personality Inventory (MMPI) is necessary for this is not completely clear, and a number of inventories and questionnaires have not demonstrated a significant impact in outcomes following bariatric surgery, although this area remains controversial at best.

**Gastrointestinal Evaluation**

By and large, the RYGB is a remarkably effective operation for the treatment of gastroesophageal reflux disease (GERD), whether it is alkaline or acid based. Hiatal hernias can be fixed concomitantly, and even dysphagia, due to the significant impact on GERD, can be improved following the RYGB. With the AGB, the data are far less clear, but it may improve GERD, with overall improvements in Demeester scores postoperatively. The presence of a hiatal hernia may complicate placement of the hand, although this has not been demonstratively confirmed. Operations such as VSG and the DS may, at least temporarily, negatively impact the symptoms of GERD in patients due to their strong restrictive nature.

A number of things need to be confirmed prior to the bariatric operation. Any patients with dysphagia, stricture, premalignant disease, or Barrett esophagus changes need to be carefully screened and evaluated before surgery. Patients with ulcer diathesis need to be screened for Helicobacter pylori, and this can be evaluated either through direct biopsy, stool analysis, or a breath test. Whether this should be a standard of care in all patients is unclear, but, certainly, patients with a known history of epigastric abdominal pain, a history of ulcer disease, or a history of gastritis should be screened and have this excluded; otherwise, it is not mandatory.

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**Table 2: Preoperative Laboratory Assessment for All Bariatric Patients**

<table>
<thead>
<tr>
<th>Test</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lipid panel</td>
<td>Cholesterol, triglycerides, high-density lipoprotein with reflex to low-density lipoprotein when triglycerides are greater than 400 mg/dL.</td>
</tr>
<tr>
<td>Comprehensive metabolic panel</td>
<td>Sodium, potassium, chloride, carbon dioxide, creatinine, blood urea nitrogen, glucose, calcium, albumin, alkaline phosphatase, alanine aminotransferase, aspartate aminotransferase, total bilirubin, total protein.</td>
</tr>
<tr>
<td>Complete blood count</td>
<td>Mandatory.</td>
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<tr>
<td>Ferritin</td>
<td></td>
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<tr>
<td>Folic acid</td>
<td></td>
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<tr>
<td>Magnesium</td>
<td></td>
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<tr>
<td>Phosphorus</td>
<td></td>
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<tr>
<td>Parathyroid hormone</td>
<td></td>
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<tr>
<td>Vitamin A</td>
<td></td>
</tr>
<tr>
<td>Vitamin B₁</td>
<td></td>
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<tr>
<td>Vitamin B₂</td>
<td></td>
</tr>
<tr>
<td>25-Hydroxyvitamin D (D₁ and D₃)</td>
<td></td>
</tr>
<tr>
<td>Zinc</td>
<td></td>
</tr>
<tr>
<td>Glycosylated hemoglobin</td>
<td>Only if there is a preoperative history of diabetes or borderline diabetes.</td>
</tr>
<tr>
<td>Random urine microalbumin</td>
<td></td>
</tr>
</tbody>
</table>

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*Cholesterol, triglycerides, high-density lipoprotein with reflex to low-density lipoprotein when triglycerides are greater than 400 mg/dL.

*Sodium, potassium, chloride, carbon dioxide, creatinine, blood urea nitrogen, glucose, calcium, albumin, alkaline phosphatase, alanine aminotransferase, aspartate aminotransferase, total bilirubin, total protein.

†Only if there is a preoperative history of diabetes or borderline diabetes.
For patients undergoing laparoscopic AGB, it is important to perform a careful history and physical examination to evaluate for evidence of dysphagia. For those patients who do have evidence of dysphagia, an upper gastrointestinal study to evaluate for hiatal hernia possibly followed by manometry and pH probe analysis as sequentially indicated can be very important adjuncts in the management of these patients.

Patients with inflammatory bowel disease should be evaluated very carefully when contemplating bariatric surgery. Crohn disease and ulcerative colitis, if active, are absolute contraindications. In quiescent disease, only the VSG is considered a potential option for Crohn disease. For ulcerative colitis, all procedures except for the DS are reasonable choices. Use of the AGB in these circumstances is considered off-label.

OSTEOARTHRITIS
Degenerative osteoarthritis of the knees, hips, and back is a common sequela of morbid obesity. Weight reduction alone may greatly reduce the pain and immobility that affect these patients. In some cases, the damage may be so extensive that a total joint replacement is desirable, and weight reduction by means of a bariatric operation can be followed by joint replacement after weight loss if pain and dysfunction persist. Studies have shown that patients undergoing weight loss surgery prior to joint replacement have fewer complications, such as fewer infections, readmissions, and dislocations, following joint replacement surgery compared with obese patients who do not undergo bariatric surgery first. Another issue that should be discussed with patients who have osteoarthritis is the fact that all nonsteroidal antiinflammatory medications must be stopped following RYGB.

PSEUDOTUMOR CEREBRI
Pseudotumor cerebri is an unusual complication of morbid obesity that is associated with benign intracranial hypertension, papilledema, blurred vision, headache, and elevated cerebrospinal fluid pressures. Patients with pseudotumor cerebri are not at any additional perioperative risk, and cerebrospinal fluid does not need to be removed before surgery. There is some theoretical concern that gastrointestinal contamination during gastric bypass surgery may cause shunt infection in patients who have been previously treated with indwelling shunts to relieve elevated intracranial pressures. Successful weight reduction cures pseudotumor cerebri.

GALLSTONES
Approximately one third of morbidly obese patients either have had a cholecystectomy or may have had gallstones noted at the time of another intra-abdominal operative procedure (e.g., a gastric operation for morbid obesity). Preoperative evaluation of the gallbladder may be technically quite difficult in morbidly obese patients because ultrasonography may fail to visualize gallstones. Intraoperative ultrasonography is probably more accurate. Should symptomatic gallstones be present in a patient undergoing a gastric procedure for obesity, the gallbladder should be removed if the surgeon judges it to be safe to perform this additional procedure. If placement of an AGB is contemplated, the cholecystectomy should be undertaken first and the indwelling device placed at a different time.

In past studies, rapid weight loss led to the development of gallstones in 25 to 40% of patients who underwent RYGB. The risk of cholelithiasis in this setting can be reduced to 2% by administering ursodeoxycholic acid, 300 mg orally twice daily. Laparoscopic cholecystectomy at the time of laparoscopic gastric bypass can be technically challenging; consequently, many surgeons prefer to take an expectant approach to the gallbladder rather than complicate the bariatric procedure with a simultaneous cholecystectomy. If a patient has the indications, then he or she should undergo concomitant cholecystectomy if the operating surgeon feels it can be performed safely. Recent studies suggest that approximately 7.0% of patients following RYGB will develop symptomatic biliary disease requiring post-RYGB cholecystectomy and that this rate does not warrant prophylactic cholecystectomy at the time of bariatric surgery. The additional short-term complications that a concomitant cholecystectomy adds has not been completely elucidated.

DEEP VEIN THROMBOSIS AND PULMONARY EMBOLISM
Morbidly obese individuals have difficulty walking, tend to be sedentary, have a large amount of abdominal weight resting on their inferior vena cava, and have increased intrapleural pressure (which impedes venous return). All of these conditions increase the tendency toward venous thrombosis. Patients are most at risk when immobilized in the supine position for long periods in the operating room.

The risk of deep vein thrombosis (DVT) increases with prolonged operation or a postoperative period of immobilization and increases even further in the morbidly obese patient. Standard or low-molecular-weight heparin should be administered subcutaneously 30 minutes before operation and at appropriate intervals thereafter (depending on the type of heparin used) for at least 2 days or until the patient is ambulatory. Because respiratory function in the morbidly obese patient is greatly enhanced with the reverse Trendelenburg position, intermittent sequential compression devices should be used in the operating room to counteract the increased venous stasis and the propensity for clotting. It is important that the intermittent venous compression boots be used before induction of anesthesia and throughout the operative procedure. Such boots are usually part of a standard preoperative protocol in gastric procedures for weight control; their use should not be unintentionally neglected in preparation for other elective or emergency procedures on morbidly obese patients.

For patients at high risk for DVT or pulmonary embolism or who have pulmonary arterial hypertension, prophylactic insertion of an inferior vena cava filter should be considered, and a hematology consultation may be warranted. All patients should make every attempt to ambulate the evening after operation.

Operative Techniques
All patients should receive DVT chemoprophylaxis and sequential compression devices in the preoperative area.
Antibiotics with gram-negative coverage should be administered within 30 minutes of the incision and every 4 hours thereafter. Operating room tables should be rated to hold at least 1,000 pounds and provide 45° of the reverse Trendelenburg position. A footboard should be placed to prevent patient movement during manipulation of the operating room table, and the table should have the option to be fitted with length and width extensions if needed. For laparoscopic procedures, extra-long instruments are necessary.

**Laparoscopic Adjustable Gastric Banding**

The current approach to placing the laparoscopic AGB [see Figure 1] (LapBand, Allergan, Irvine, CA or REALIZE Band, Ethicon Endo-Surgery, Cincinnati, OH) is the pars flaccida technique. In short, the pars flaccida or bursa omentalis represents the peritoneal reflection above the superior aspect of the pancreas, leaving a relatively dense layer of tissue to prevent posterior slippage or slippage of stomach underneath the band. It is clearly a preferable technique as demonstrated by studies looking at postoperative complications following banding.

Patients are placed supine on the table, and the steep reverse Trendelenburg position is achieved. We use a five-trocar technique with a 15 mm port placed in the left midabdomen, which will facilitate placement of the band itself. First, we inspect for a hiatal hernia, and if found, we fix all of these definitively with a posterior approach with closure of the crus. The band is placed in the pars flaccida approach as mentioned and brought together and snapped parallel to the gastroesophageal junction. Three gastrogastric sutures are used, and we exteriorize the tubing before securing the gastroesophageal junction. Three gastrogastric sutures as mentioned and brought together and snapped parallel to the lesser curve with a 6 cm linear endostapler. Following this, the endostapler should transect the remainder of the neurovascular pedicle transversely approximately 2 to 3 cm inferior to the gastroesophageal junction, just distal to the left gastric artery.

The goal is to create a 20 to 30 mL vertically oriented gastric pouch, with care taken to avoid incorporation of any gastric fundus into the pouch. This is accomplished with 3.5 mm staples or “blue” loads. First, the stapler is applied transversely followed by subsequent applications being directed toward the angle of His and parallel to the lesser curve. A hemostatic agent, such as Surgicel (Ethicon Inc, Somerville, NJ), can be applied to the staple line to minimize oozing.

Next, the gastrojejunostomy is created. We recommend an antecolic, antegastric anastomosis. To locate the ligament of Treitz, the table should be returned to the neutral position and the ligament identified by lifting the transverse mesocolon rostrally. One hundred centimeters of jejunum is measured out from the ligament of Treitz, at which point, a small defect is created in the mesentery so that a Penrose drain can be looped through. In an antecolic, antegastric fashion, the loop of jejunum is brought up to the level of the gastric pouch following a one-half clockwise turn of the proximal bowel. This places the bowel down so that the Roux limb is oriented to the patient’s right and the biliopancreatic limb is oriented toward the patient’s left.
Return the operating room table to the reverse Trendelenberg position and place the back row of sutures along the gastrojejunostomy using an Endostitch suturing device (Covidien, Norwalk, CT) with 3-0 braided nylon [see Figure 5]. The posterior row should be a running seromuscular suture that begins at the angle of His on the gastric pouch and along the start of the mesentery on the Roux limb. The gastrotomy is made at the right, inferior portion of the gastric pouch using a Harmonic scalpel; an enterotomy is created at the corresponding point on the Roux limb. The goal is to create a gastrojejunostomy no larger than 2 cm in diameter; this is accomplished by placing a linear staple with a 3.5 mm staple cartridge into the pouch and the Roux limb no more than 2.0 cm [see Figure 6].

The assistant then moves to the head of the bed to place a 30 French endoscope into the pouch and into the Roux limb.

Figure 2  Final anatomy following a Roux-en-Y gastric bypass.
Figure 3 Final port placement for a Roux-en-Y gastric bypass. A 5 mm trocar is placed at the left upper quadrant (the site of Veress needle insufflations); an 11 mm trocar is placed 15 cm below the xiphoid just to the left of the midline; one 5 mm trocar is placed subcostally on the right at the midclavicular line; a 12 mm port is placed medial to the midclavicular line and just superior to the camera port; and a 5 mm trocar is placed in the patient’s right flank to assist with liver retraction.

The defect is closed in two layers over the endoscope using an Endostitch. The jejunum is divided to the left of the anastomosis using a “white” staple load, and the Penrose drain is removed from the abdomen. The anastomosis should be tested for leak by placing a bowel clamp approximately 5 cm distal to the newly formed anastomosis and insufflating air through the endoscope while submerging the anastomosis in normal saline irrigation fluid. Defects should be oversewn if identified and the submersion process repeated.

We make a 150 cm Roux limb that is measured out from the gastrojejunostomy. The use of 150 cm is principally to avoid alkaline reflux. Weight loss differences beyond 2 years are not significantly different with shorter Roux limbs.⁴⁰

Figure 4 A laparoscopic view demonstrating the liver retractor in place elevating the left lobe of the liver anteriorly.

Figure 5 The first stitch creating the back wall of the gastrojejuno- stomy anastomosis. The Penrose drain is seen looped through the jejunum on the right. A running suture is started near the angle of His on the gastric pouch.

The biliopancreatic limb is sutured to the Roux limb at the 150 cm point along their antimesenteric borders to form the back wall of the anastomosis. It is very important that extra caution be taken to be certain that the mesenteries are appropriately aligned to prevent twisting of the bowel. A functional side-to-side anastomosis is formed by making enterotomies in both the Roux limb and the biliopancreatic limb with a Harmonic scalpel. A 6 cm linear endostapler loaded with a white cartridge is inserted to its full length into each limb and fired. The heal of the anastomosis is secured with a single suture. The common enterotomy is closed with one additional white staple load using a 6 cm linear endostapler.

Figure 6 Creation of the gastrojejunostomy is performed using a linear endostapler with a 3.5 mm cartridge. The gastrojejunostomy should be about 2 cm in size.
The “antiobstruction” stitch is placed from the Roux limb to the biliopancreatic limb to prevent kinking, and a running suture is used to approximate the mesenteric defect. Fibrin glue can be applied to the staple line to reduce hemorrhage. A purse-string suture is used to close the Petersen defect [see Figure 7]. Trocars are removed, and skin incisions are approximated with staples. Drains are not commonly left in place.

**Laparoscopic Vertical Sleeve Gastrectomy**

The VSG [see Figure 8] is an operation that has been in evolution over the last several years. We currently use a technique that preserves the antrum and is constructed over a 34 French bougie. All of the short gastric and epicardial vessels are taken down from approximately 5 to 6 cm proximal to the pylorus opposite the nerves of Latarjet all the way up to the angle of His. The left crus is identified, and this ensures that we have an adequate posterior dissection. With the bougie in place, we then divide the greater curvature of the stomach with 3.5 mm staples and oversew it completely with a running 3-0 braided nylon. We do not routinely test this staple line with submersion and insufflation unless there are complications or problems with the staple line.

The size of the bougie does appear to make a difference with regard to weight loss; however, techniques of both stapling along the bougie and oversewing of the staple line vary between centers, making this a challenging area to definitively address. Controversy also exists regarding removal or preservation of the gastric antrum with this procedure, but no convincing evidence exists to convincingly support either side of this argument.

**Laparoscopic Biliopancreatic Diversion with Duodenal Switch**

We perform a laparoscopic, robot-assisted DS operation [see Figure 9]. The procedure is performed through six abdominal trocars. Access to the abdomen is obtained through a left upper quadrant Veress needle as long as previous surgical history does not preclude this. A 12 mm port is placed at the site of the Veress needle. Next, a 15 mm port is placed just cephalad and left of the umbilicus. A 5 mm port is used in the lateral left flank, and two additional 12 mm working ports are placed on the right side. One additional 5 mm port is necessary for liver retraction where the left lateral segment of liver is elevated with a triangular retractor. The patient is placed in the revere Trendelenburg position.

Ultrasonic shears are used to take down the short gastric and epiploic vessels, beginning 5 cm proximal to the pylorus and progressing to the angle of His. A 4.8 mm stapler load is used to divide the greater curvature 5 cm from the pylorus while remaining 2 cm from the angularis incisura. Multiple 3.5 mm stapler loads are used for the gastric resection, progressing up to the angle of His, to complete the VSG. A 40 French bougie is then inserted transorally into the stomach so that the entire staple line is oversewn snugly over the bougie with 2-0 nonabsorbable suture.

At this point, we begin the duodenal dissection 2 cm distal to the pylorus. A tunnel posterior to the duodenum is created and the duodenum divided with a 3.5 mm stapler cartridge. The duodenal stump on the pyloric side is completely mobilized. When performing this procedure laparoscopically, we do not oversew the duodenal remnant staple line unless abnormalities in the staple line are noted.

With the patient now placed in the Trendelenburg position, the right side of the table is elevated. One hundred centimeters of ileum is traced proximally from the cecum, and the mesentery is marked with clips to denote the beginning of the common channel. The small bowel is run 150 cm further proximally along the mesenteric border. A Penrose drain is then looped around the bowel. This loop is then brought up to the posterior aspect of the proximal duodenal remnant just beyond the pylorus. A running 2-0 nonabsorbable suture is used to secure the ileal loop to the duodenum; this serves as the back wall of the duoden ileostomy. In our experience, the robot adds significant precision when placing sutures to create the duoden ileostomy.

We next perform the ileoileostomy. The small bowel is divided just to the left of the duoden ileostomy with a single 2.5 mm stapler cartridge to separate the alimentary limb from the biliopancreatic limb. Two 2.0 mm stapler loads are used to divide the mesentery. The distal biliopancreatic limb is moved toward the beginning of the common channel. Stay sutures are placed to approximate both limbs. Enterotomies are made, and a 2.5 mm stapler load is inserted and fired. A suture is placed at the heel of the anastomosis to relieve tension. The enterotomy defect is then closed with another 2.5 mm staple load.

An antiobstruction suture is placed and continued in a running fashion toward the root of the mesentery, thereby closing the ileal mesenteric defect. The Petersen defect is identified and closed in a similar fashion.

Initially, we performed a two-layer duoden ileostomy anastomosis with an inner layer of running 2-0 absorbable suture and an outer layer of running 2-0 nonabsorbable suture. Currently, we perform a two-layer anastomosis with the da Vinci Robot (Intuitive Surgical, Sunnyvale, CA), employing an inner and an outer running 3-0 absorbable suture layer to complete the anastomosis. We make our

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*Figure 7 A purse-string suture is placed to close the Petersen defect.*

Scientific American Surgery
enterotomies above the staple line in the duodenum and ileum. A 16 French red rubber nasogastric tube is inserted into the proximal portion of the anastomosis to stent it and to be used to instill methylene blue at the completion of the anastomosis to test for leakage.

The Postoperative Patient

LIFELONG CARE

Surgery is, in effect, a “tool.” The care of the bariatric surgery patient extends beyond that of the immediate postoperative period. Bariatric surgery is not comparable to most other surgical disciplines wherein the surgeon plays a minimal long-term role in the care of the patient. The bariatric surgeon maintains an integral role in the lifelong care of the patient by the bariatric team. This lifelong involvement includes continuous monitoring of weight, nutritional status, evolution of comorbidities, complication management, and potential surgical revisions.

WEIGHT LOSS OUTCOMES BY PROCEDURE

The Swedish Obesity Study provides the best long-term data available regarding weight loss [see Figure 10]. Obese patients not undergoing surgery maintained their weight over the entire observation period. All surgical groups experienced their greatest weight loss within the first 2 years (mean ± SD, 32 ± 8% for RYGB versus 20 ± 10% for the AGB). All groups also experienced weight regain that plateaued by 10 years. Percent weight loss at 15 years for RYGB and AGB was 27 ± 12% and 13 ± 14%, respectively.

NUTRITION

Long-term, postoperative, nutritional follow-up is essential. Regular visits that emphasize the continued importance of appropriate food choices, adequate fluid and protein intake, proper supplementation, monitoring of laboratory data, and a regular exercise routine are necessary to guarantee a good outcome. A variety of methods for follow-up are acceptable, ranging from clinic visits to telephone calls.

Figure 8  Final anatomy following vertical sleeve gastrectomy.
Figure 9  Final anatomy following a duodenal switch with biliopancreatic diversion.
section focuses on both macronutrient and micronutrient deficiencies.

There are nutritional issues unique to different types of bariatric operations. Significant malabsorption of macronutrients, such as that seen with the DS, may lead to significant fat malabsorption, loose stools, and hypoalbuminemia. Nutritional follow-up of patients who have undergone malabsorptive procedures is critical, and they must be followed more closely than patients who have undergone a purely restrictive operation.

Also of concern is the late development of post-RYGB postprandial hypoglycemia, which can be quite severe. Postprandial hypoglycemia may be derived from an elevated incretin effect that can result in stimulation of insulin by pancreatic beta cells. Nesidioblastosis (an increase in pancreatic beta-cell mass) has not been proven in humans. Therapy involves dietary advice on lowering glycemic load and may possibly use drugs such as acarbose and verapamil. Surgical revision may be required or conversion to another bariatric surgical procedure if diet and pharmaceutical interventions are unsuccessful. Partial pancreatectomy has been used to mitigate symptoms. We have observed improvement following conversion of an RYGB to a DS, which slows gastric emptying.

One of the most important aspects of patient care following bariatric surgery is the clinical and biochemical assessment of nutrition and micronutrient supplementation. Surprising to some, severe obesity is commonly associated with an element of malnutrition. Particularly, vitamin D deficiency is so prevalent that it should be considered a comorbidity of obesity. The Third National Health and Nutrition Examination Survey (NHANES III; 1988 to 1994) report showed that higher BMIs were also associated with deficiencies of vitamins A, E, C, and D; selenium; folate; and carotenoids.44 The extent of malnutrition seems proportional to the amount of intestinal diversion, although all bariatric surgical procedures are associated with long-term risk related to malnutrition.

The most common nutrients patients are deficient in following bariatric surgery, especially gastric bypass, are vitamin D, iron, vitamin B_12_, folic acid, and calcium. Importantly, thiamine (vitamin B_1_) deficiency must be prevented and treated without delay if encountered. Wernicke encephalopathy has been reported following bariatric surgery, and administration of parenteral thiamine is necessary if Wernicke encephalopathy is suspected to prevent permanent neurologic deficits.

Following RYGB, particularly in premenopausal women, iron deficiency is common; reasons for this include reduced red meat in the diet, hypochlohydria, and exclusion of the duodenum and upper jejunum from nutritional absorption. It is mandatory that iron be supplemented and serum levels be followed closely to ensure that dosing is appropriate.

Vitamin B_12_ absorption is compromised after both RYGB and VSG, and supplementation needs to be in dosages
beyond those found in standard multivitamins. Folate deficiency has varied after bariatric surgery but has been reported as common in some series; therefore, supplementation is recommended for all bariatric surgery patients. Elevated homocysteine levels have been reported following bariatric surgery and may suggest deficiency of B vitamins. Use of homocysteine for evaluation of cardiac risk assessment in this setting is not warranted.

Metabolic bone disease, due to decreased calcium and vitamin D absorption, is more likely following surgeries with a malabsorptive component such as RYGB and DS. Supplementation is necessary, along with close monitoring of vitamin D, parathyroid hormone, and alkaline phosphatase. Recommended laboratory surveillance factors created in part by the American Society for Metabolic and Bariatric Surgery are presented in Table 3.

### Outcomes on Comorbid Illness

#### IMPACT ON HYPERTENSION

A large meta-analysis published in 2004 demonstrated a resolution rate of 61.4% and a resolution or improvement rate of 78.5% following bariatric surgery [see Table 4]. In contrast, longer-term follow-up data from the Swedish Obesity Study noted no significant difference between surgical and nonsurgical patients with regard to hypertension. Bariatric surgery and the weight loss associated with it should certainly not be considered as a cure for hypertension, and patients previously diagnosed with hypertension warrant appropriate blood pressure monitoring lifelong by their bariatric surgeon and their primary care physician to ensure that it is being appropriately medically managed.

#### IMPACT ON HYPERLIPIDEMIA

The 2004 meta-analysis noted a 79.3% overall improvement in dyslipidemias. Improvement in dyslipidemia paralleled weight loss and therefore surgery type with 58.9%, 96.9%, and 99.1% improvement with regard to AGB, RYGB, and DS, respectively. Table 4 highlights the decrease in low-density lipoprotein by procedure type. Again, in comparison with subjects from the Swedish Obesity Study, surgical patients maintained significant improvement compared with nonsurgical patients with respect to hypertriglyceridemia and low levels of high-density lipoprotein. Bariatric surgery patients who are removed from medications that treat dyslipidemia should be monitored appropriately in case they need to be reinstated.

#### IMPACT ON OBSTRUCTIVE SLEEP APNEA

Our best data again come from the large meta-analysis published in 2004 demonstrating in several studies that signs of OSA are resolved in 94.6%, 86.6%, and 95.2% of patients following gastric banding, gastric bypass, and DS, respectively. An additional meta-analysis that specifically addressed the affect of bariatric surgery on sleep apnea in 342 patients found a significant reduction in the apnea-hypopnea index following weight loss. The baseline apnea-hypopnea index decreased from 54.7 events per hour (95% CI 49.0 to 60.3) to 15.8 events per hour (95% CI 12.6 to 19.0).

### Table 3 Recommended Nutrition Surveillance for Patients Who Have Undergone a Malabsorptive Procedure

<table>
<thead>
<tr>
<th>Surveillance Factor</th>
<th>Roux-en-Y Gastric Bypass</th>
<th>Biliopancreatic Diversion with Duodenal Switch</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time interval</td>
<td></td>
<td></td>
</tr>
<tr>
<td>First year</td>
<td>Every 3–6 months</td>
<td>Every 3 months</td>
</tr>
<tr>
<td>Thereafter</td>
<td>Annually</td>
<td>Every 3–6 months</td>
</tr>
<tr>
<td>Laboratory tests</td>
<td>Complete blood count</td>
<td>Complete blood count</td>
</tr>
<tr>
<td>Platelets</td>
<td>Platelets</td>
<td></td>
</tr>
<tr>
<td>Electrolytes</td>
<td>Electrolytes</td>
<td></td>
</tr>
<tr>
<td>Glucose</td>
<td>Glucose</td>
<td></td>
</tr>
<tr>
<td>Iron studies, ferritin</td>
<td>Iron studies, ferritin</td>
<td></td>
</tr>
<tr>
<td>Vitamin B&lt;sub&gt;12&lt;/sub&gt;</td>
<td>Vitamin B&lt;sub&gt;12&lt;/sub&gt;</td>
<td></td>
</tr>
<tr>
<td>Liver panel</td>
<td>Liver panel</td>
<td></td>
</tr>
<tr>
<td>Lipid profile</td>
<td>Lipid profile</td>
<td></td>
</tr>
<tr>
<td>25-Hydroxyvitamin D</td>
<td>Albumin and prealbumin</td>
<td></td>
</tr>
<tr>
<td>Thiamine</td>
<td>Red blood cell folate</td>
<td></td>
</tr>
<tr>
<td>Red blood cell folate</td>
<td>Fat-soluble vitamins*</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Vitamin A</td>
<td></td>
</tr>
<tr>
<td></td>
<td>25-Hydroxyvitamin D</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Vitamin E</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Vitamin K</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Metabolic bone evaluation†</td>
<td></td>
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<tr>
<td></td>
<td>Intact PTH</td>
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<tr>
<td></td>
<td>24-hour urine calcium</td>
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<tr>
<td></td>
<td>Urine N-telopeptide</td>
<td></td>
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<tr>
<td></td>
<td>Osteocalcin</td>
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<tr>
<td></td>
<td>Metabolic stone evaluation‡</td>
<td></td>
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<tr>
<td></td>
<td>24-hour urine calcium</td>
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<tr>
<td></td>
<td>Citrate</td>
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<td></td>
<td>Uric acid</td>
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<td></td>
<td>Oxalate</td>
<td></td>
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<tr>
<td></td>
<td>Trace elements§</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Zinc</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Selenium</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Miscellaneous&lt;sup&gt;1&lt;/sup&gt;</td>
<td>Carnitine</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Essential fatty acids</td>
</tr>
</tbody>
</table>


PTH = parathyroid hormone.

*Every 6 to 12 months.

†Annually or as needed.

‡As needed.
**Table 4** Improvement in Major Comorbidities by Procedure

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Adjustable Gastric Band</th>
<th>Roux-en-Y Gastric Bypass</th>
<th>Biliopancreatic Diversion or Duodenal Switch</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hemoglobin $\text{A}_{1c}$ (%), mean change (95% CI)</td>
<td>$-1.96$ ($-1.76$, $-1.16$)</td>
<td>$-3.03$ ($-4.97$, $-1.09$)</td>
<td>N/A</td>
</tr>
<tr>
<td>LDL (mmol/L), mean change (95% CI)</td>
<td>$-0.11$ ($-0.40$, $0.17$)</td>
<td>$-0.89$ ($-1.15$, $-0.63$)</td>
<td>$-1.36$ ($-1.93$, $-0.79$)</td>
</tr>
<tr>
<td>Hypertension, % resolved (95% CI)</td>
<td>$43.2$ ($30.4$, $55.9$)</td>
<td>$67.5$ ($58.4$, $76.5$)</td>
<td>$83.4$ ($73.2$, $93.6$)</td>
</tr>
</tbody>
</table>

Adapted from Buchwald H, Avidor Y, Braunwald E, et al.4 LDL = low-density lipoprotein; N/A = not applicable.

**IMPACT ON TYPE 2 DIABETES MELLITUS**

The prevalence of T2DM has increased with the rise of obesity. By 2030, the World Health Organization predicts that nearly 366 million people will have T2DM worldwide.6 The strongest association for the development of T2DM is an increase in weight.7 The bariatric literature is replete with reports demonstrating improvement in glycemia parameters in patients with T2DM who undergo bariatric surgery,8,9 with a large proportion of these studies highlighting the RYGB.

With regard to glycemic control in bariatric surgery, a meta-analysis by Buchwald and colleagues found that hemoglobin $\text{A}_{1c}$ ($\text{HbA}_{1c}$) decreased on average $1.3\%$ (95% CI $0.9$ to $1.6$) for laparoscopic adjustable banding (LAGB) patients and $4.0\%$ (95% CI $0.7$ to $5.0$) for RYGB patients.10 An additional meta-analysis by Buchwald and colleagues demonstrated that the best outcomes for bariatric surgery patients with T2DM occurred in those who lost the most weight, specifically the DS patients.11 This meta-analysis found that $56.7\%$, $80.3\%$, and $95.1\%$ of patients following AGB, RYGB, and DS, respectively, showed complete resolution of their T2DM.

A case-matched study comparing outcomes of the AGB and the DS to the RYGB by exclusively including patients diagnosed with morbid obesity and T2DM was recently performed.12 At 1 year, there were decreases in both HbA$_{1c}$ values and diabetes-related medication scores in RYGB patients, but AGB patients, despite having a significant decrease in BMI, experienced no significant change in HbA$_{1c}$ or medication score. The matched DS and RYGB cohorts in this study observed significant and commensurate weight loss in both groups postoperatively. Medication scores were significantly reduced in both groups. However, $85\%$ of DS patients did not require any diabetes medications at 1 year compared with $48\%$ of gastric bypass patients. More impressively, the mean HbA$_{1c}$ was reduced to $5.3\%$ by 1 year in the DS cohort compared with $6.4\%$ in the gastric bypass cohort. Diabetes resolution, defined by an HbA$_{1c}$ of less than $6.5\%$ while off all antihyperglycemia medications, occurred in $20\%$ of all AGB patients and in $60\%$ of matched gastric bypass patients at 1 year. Furthermore, diabetes resolution was significantly greater in DS patients ($81.5\%$) compared with matched gastric bypass patients ($48.1\%$) at 1 year despite no significant difference in weight loss between the two groups. This discrepancy is likely attributable to the increased malabsorption offered by the DS.13 As discussed later in the chapter, complication rates associated with the DS are significantly greater than the gastric bypass, a fact that prohibits the DS from being the preferred operation in obese patients with T2DM. Additionally, RYGB may be effective for patients with T2DM with a BMI less than $35\text{ kg/m}^2$.13

**Mechanisms of Improvement**

The numerous reports of improvement of T2DM and long-term reduction in diabetes-related death have led to considerable investigation as to the mechanism of improvement in T2DM following bariatric surgery. First, it is important to know that whereas weight loss dramatically improves T2DM, bariatric procedures have a differential impact on improvement in T2DM that may or may not be linked necessarily to the degree of weight loss. There are a number of important considerations, including the ability of the patient to produce insulin (i.e., the beta secretory capacity) and the degree of insulin resistance that determines additional insulin needs. Currently, there are two prevailing mechanisms that may be complementary for improvement in hyperglycemia following an RYGB. Generally, these can be divided into (1) hormonal response to meals and (2) improvement in glycemic control in the fasting state. A third and far less recognized mechanism involves malabsorption, particularly of fats and fatty acids, as potential drivers of improvement in insulin resistance separate from weight loss.14

A number of studies have demonstrated that in patients who undergo the gastric bypass, in comparison with the gastric band and overweight medical controls, insulin secretion following a mixed meal is augmented following the gastric bypass. The mechanism for insulin augmentation was described previously by Creutzfeldt and Ebert and was termed the incretin effect.15 The incretin effect is the observation that orally ingested, particularly intrajejunally delivered, sugars will produce a more robust secretion of insulin compared with intravenously administered sugars. Curiously, patients with T2DM appear to have a blunting of this rapid rise in insulin secretion following ingestion of a meal. There are a number of speculative explanations for this, including impaired gastric emptying or the effect of other hormonal mediators on insulin secretion. But after gastric bypass, the first phase of rapid production of insulin appears to be restored in patients who clearly have the capacity to produce insulin.

A physiologic correlation of this comes from changes in gut hormones, and the two principal drivers of the incretin

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effect are glucagonlike peptide–1 (GLP-1) and gastrointestinal inhibitory peptide (GIP). GLP-1 is secreted by the L cells, which are the neuroendocrine cells located in the ileum and colon. In response to a mixed meal, GLP-1 will augment the effect of insulin by impairing hepatic gluconeogenesis, increasing insulin secretion, attenuating the effect of pancreatic glucagon secretion, slowing gastric emptying, and directly impacting the hypothalamus to reduce hunger. GIP is another widely recognized factor of insulin secretion, but its clinical implications in this setting are not well understood.

Although postprandial hyperglycemia may be addressed with more robust insulin secretion, patients following a gastric bypass, compared with the VSG or an AGB, demonstrate a more marked reduction in glucose levels very early after surgery. The mechanisms for this are quite unclear and poorly explored. Glucose and insulin dynamics are improved dramatically in a way that is consistent between the gastric bypass and equivalent caloric reduction. Although these studies are not well controlled, they certainly raise the interest for further investigation into this area. Thus, the importance of caloric restriction in this setting cannot be underemphasized. Also, following gastric bypass, patients have a marked reduction in hunger that may also contribute.

Another putative factor is the hormone ghrelin, the “hunger hormone.” Ghrelin is a 28–amino acid peptide that is secreted by the stomach and pancreas. Its exact function is unclear, but in its active form, ghrelin will induce hunger in humans. Ghrelin has a cyclical behavior that rises before and is reduced by ingestion of a mixed meal. The reduction in ghrelin is profound following both the gastric bypass and the VSG. Long-term results are contradictory regarding ghrelin secretion patterns following gastric bypass procedures.

Clearly, the most robust long-term results for T2DM improvement come from the most malabsorptive procedures. Although these have been demonstrated to have the most weight loss in comparative trials, it appears that the DS may have an augmented effect on reduction of HbA1c, one of the key parameters for the control and management of T2DM. By its very nature, this operation involves malabsorption, and as such, it may be that malabsorption of certain types of fat known to increase insulin resistance, particularly ceramides, may impact insulin signaling at the level of muscle. It is important to understand that of the multiple tissue determinants of insulin resistance, which include fat, liver, and muscle, not to mention reduced glucose responsiveness at the level of the pancreas, muscle is the most important determinant of whole body insulin resistance. It is curious that regarding the most sophisticated studies, insulin resistance is not reduced early after bariatric surgery and that these changes are not seen until 6 months later. Tissue-specific measurements of insulin resistance after bariatric surgery comparing different operations or dietary interventions have not been thoroughly investigated.

OUTCOMES ON GERD

The effect of bariatric surgery on GERD is an important consideration in procedural selection. Of the four procedures considered primary, the gastric bypass, the VSG, the AGB, and the DS, relatively little is known about direct comparisons of the various operations to impact on GERD. Considering the band, patients tend to have initial improvement in GERD. Long-term GERD appears to be a potentially significant comorbid illness, potentially due to overtightening, particularly associated with nocturnal reflux. There have been no good studies evaluating concomitant repair of hiatal hernias as there tends to be a dichotomous approach to repair of these either to anterior plication of the cura or dissection posteriorly. The latter tends to be performed less commonly. It was accepted to be the definitive way to repair a hiatal hernia, principally because of concerns over slippage of the band, but this has never been substantiated. The VSG is an operation that clearly worsens GERD, at least initially, based on a number of studies.

The RYGB demonstrates significant improvement in GERD, and although it is controversial, if a traditional anti-reflux surgery such as the Nissen fundoplication is compromised in its outcome on a morbidly obese patient, it is clear that the RYGB improves many other comorbid conditions beyond GERD. Although there are no clear head-to-head comparisons in assessing pH studies before and after the AGB and RYGB, there appears to be no significant change in the Demeester score following banding; however, a significant reduction in the Demeester score following the RYGB has been reported. In comparing the RYGB with the DS, we expect there to be a similar increase in GERD following DS, at least initially, putatively related to the difficulty of passage of food through the narrow sleeve. Typically in a DS, the sleeve is a little larger, and alkaline contents will be diverted; however, in a study by Prachand and colleagues, it appears that GERD is significantly more prevalent in patients with a BMI greater than 50 kg/m² who undergo DS versus the gastric bypass.

OUTCOMES ON SURVIVAL

Two long-term studies have examined long-term survival following bariatric surgery. The Swedish Obesity Study is a large prospective analysis comparing bariatric surgery with no surgery in morbidly obese patients. With nearly 11 years of average follow-up, the Swedish Obesity Study found a significant mortality benefit for patients who underwent bariatric surgery with a mortality rate of 5% compared with 6.3% for obese patients who did not undergo weight loss surgery. Interestingly, there was also a significant decrease in mortality related to cardiovascular events and cancer among the surgery group. A study performed by Adams and colleagues examined mortality as well. This study also found a significant survival advantage for obese patients who underwent weight loss surgery compared with those who did not. Other large-scale studies have not been able to show a significant survival advantage when the follow-up is less than 7 years. Also of significance, death related to accidents and suicide is reported to be significantly greater among patients who undergo bariatric procedures.

OUTCOMES ON CANCER

Specifically addressing cancer-related deaths, Adams and colleagues at 7 years found a 60% reduction in cancer-related deaths among patients who underwent RYGB compared with matched BMI patients who did not undergo...
surgery. With 11 years of average follow-up in the Swedish Obesity Study, the risk of death from cancer was significantly greater among patients who underwent surgery (1.4%) compared with those who did not (2.3%). An additional study by Adams and colleagues reported that patients who underwent gastric bypass had a significantly lower incidence of cancer compared with obese, nonsurgical controls (hazard ratio 0.76; 95% CI 0.65 to 0.89). This study also found that patients who underwent gastric bypass had a reduction in cancer-related mortality of 46% compared with nonoperative controls.

Complications

MORTALITY AND READMISSION RATE

One of the greatest achievements in bariatric surgery over the past 20 years is the dramatic improvement in perioperative mortality rates. Recent publications place the 30-day mortality rate at 0.15%. Readmission, however, continues to be a concern, especially in the era of payers imposing penalties on institutions for readmissions. At 1 year, readmission rates have been reported as high as 11.6% following gastric bypass, 6.7% following AGB, and 14.8% following DS. Overall complication rates for the procedures at 1 year were 15.1%, 10%, and 40.7% for the gastric bypass, gastric band, and DS, respectively. These high complication rates associated with the DS preclude it from being the preferred procedure for weight loss despite its superior effect on metabolic diseases such as dyslipidemia and T2DM.

GASTROINTESTINAL LEAK

One of the most feared complications is a gastrointestinal leak occurring either at an anastomosis or a staple line. We recommend a routine upper gastrointestinal swallow study on all laparoscopic RYGB patients on the morning of postoperative day 1 prior to instituting a clear liquid diet. Increasing abdominal pain, peritoneal signs, and tachycardia should all raise suspicion for a leak. Early exploration is paramount to reduce the serious sequelae that can result from such an insult.

STRUCTURE

Stricture formation can occur in up to 7% of patients following RYGB. It is heralded by a discrete inability to progress in terms of dietary intake. The definitive diagnosis is made by performing an upper endoscopy, which should be as soon as possible to the time of presenting symptoms. Classically, the time of presentation is about 3 weeks after surgery but can be found later. Our standard approach to management of this is dilatation with a 12 mm 36 French balloon up to six atmospheres for 5 minutes. In many cases, fluoroscopic guidance is not necessary except with very tight strictures, in which case, a guide wire may be necessary to pass through the stricture. Upper gastrointestinal swallow evaluations have very little role in the acute management of these patients.

GASTRIC REMNANT DISTENTION

A surgical emergency in patients following RYGB that can occur is acute gastric remnant distention. Distention of the remnant can lead to gastric perforation or perforation of jejunoojejunostomy. Presenting symptoms can include a bloated sensation, left shoulder pain, hiccups, and, if severe, shock. The diagnosis can be confirmed by a plain upright abdominal film, which may reveal a dilated stomach. If the stomach is fluid filled, CT may be necessary for diagnosis. Urgent percutaneous decompression performed by an interventional radiologist is appropriate, but if this option is not available, then the patient will require an emergent laparotomy with gastrostomy tube placement. At the time of exploration, the integrity of the jejunojejunal anastomosis should be evaluated.

MARGINAL ULCER

Marginal ulceration is a common problem following RYGB, perhaps more so than any of the other bariatric procedures. Common causes for marginal ulceration include excessive use of nonsteroidal antiinflammatory agents, smoking, and possibly stress. It is difficult to control; however, removal of these risk factors is absolutely necessary. Placement of the patient on proton pump inhibitors is essential to control, as well as coating agents such as sucralfate. It is imperative that these be controlled as they are in this period anteriorly and chronic pain posteriorly. In many cases, admission to the hospital for intravenous proton inhibitors may be necessary with frequent endoscopies for monitoring.

INTERNAL HERNIA

The RYGB places patients at risk for internal hernia that can lead to bowel strangulation. Internal hernias can occur...
at locations where mesenteric defects are created, including the jejunojejunostomy, the transverse mesocolon if a retrocolic Roux limb is brought up to the gastric pouch, and through the Petersen defect, which is located posterior to the Roux limb between the Roux mesentery and the transverse mesocolon. Patients can present with periumbilical pain that is usually colicky in nature. Caution should be exercised with imaging at upper gastrointestinal contrast studies, and abdominal CT scans can be normal. Exploration is safest in these patients with recurring cramping and periumbilical pain. These defects should be closed at the time of primary operation to prevent the occurrence of internal hernia. The current internal hernia rate following laparoscopic gastric bypass is between 1 and 3%.60

DUMPING SYNDROME

Dumping syndrome is common after gastric bypass surgery and can be seen following sleeve gastrectomy. Sweating, flushing, weakness, tachycardia, palpitations, nausea, abdominal cramps, and loose stools are all signs and symptoms associated with dumping syndrome. Following RYGB, as many as 70% of patients will have some dumping symptoms, but less than 5% will have severe symptoms. Due to the loss of pylorus following RYGB, hyperosmotic food enters the jejunum more readily, resulting in fluid shifts and release of vasoactive substances such as serotonin. One to 3 hours after a meal, reactive hypoglycemia occurs and is generated by an exaggerated and prolonged insulin secretion. Most of these issues can be successfully treated with dietary advice, which includes small, frequent, dry meals with a low glycemic index and high protein. Medications are rarely needed to control symptoms, and most often symptoms improve over time.

GASTRIC BAND

There are three principal complications of the AGB that must be evaluated: slippage, erosion, and concentric dilatation. Slippage is the most common complication of the AGB and occurs in anywhere from 1 to 20% of cases.60–67 In many instances, this is heralded by signs and symptoms of difficulty swallowing and left upper quadrant pain. In these patients, it is important to obtain a flat plate of the abdomen and upper gastrointestinal study, which can demonstrate a change in angulation of the band. There are two types of slippage: anterior and posterior. Since the advent of the pars flaccida approach, the patient is less likely to have posterior slippage. Anterior slippage, however, is quite common, and there are no bona fide techniques that have been studied to reduce their occurrence. Chronic slippage can result in excessive weight loss, which often complicates the care of patients, such that they would like to keep their band longer; however, it must be removed to facilitate appropriate esophageal emptying. Acute obstruction without relief from removal of the fluid of the band necessitates emergent surgery with reduction of the stomach and removal of the band. This must not be delayed to prevent gastric strangulation and perforation.

Erosion of the band into the stomach occurs less frequently, perhaps in 1 in 100 cases [see Figure 12]. Risk factors for erosion are unclear and can sometimes occur early, which may be related to a subclinical perforation. Late perforation is due to the buckle eroding into the stomach; therefore, it is advised to angulate and turn the buckle away from the greater curvature during implantation.

More worrisome long-term complications include concentric dilatation and esophageal dilatation. Indeed, concentric dilatation may be a precursor to esophageal dilatation. In effect, concentric dilatations represent equal dilatation of the pouch of the stomach as opposed to slippage, which is an asymmetrical dilatation. This is often the case in a patient who has excess fluid in the band, but it is a very difficult clinical entity to deal with as there is no clear point of slippage. Thus, it is necessary to remove the fluid from the band, reinitiate careful eating habits, and observe if this process continues. If the size of the pouch exceeds the edges of the band fluoroscopically, then the band will need to be removed. If the patient is otherwise well, conversion to a RYGB may be considered. Similarly, with esophageal dilatation, the fluid in the band should be removed and reimaging performed to ensure a return to normal anatomy. If a return to normal anatomy does not occur, the band should be removed. Further, bariatric surgery should not be performed until the esophagus has returned to normal as visualized via endoscopy and fluoroscopic imaging.

VERTICAL SLEEVE GASTRECTOMY

Complications of VSG principally include nausea and vomiting, which will resolve with time; esophageal reflux disease, which, in rare cases, can be incapacitating; and leakage. Management of a leak from the VSG represents a unique clinical problem, principally in that the leak is potentiated by a relative distal obstruction, usually between the angularis incisura and the staple line. It is imperative that this relative obstruction be managed using either stents or indwelling tubes such as a T tube, which goes percutaneously through the leak and past the angularis incisura. Management of these leaks can be quite challenging, and adequate drainage of the abscess and adequate nutrition are essential for the healing process.

Failure of Bariatric Surgery and Revision

Failure of bariatric procedures is one of the most vexing problems that the bariatric surgeon has to manage. Failure can be defined in a number of ways, such as less than 30% excess weight loss or not achieving a BMI less than 35 kg/m².21 Multiple additional definitions exist that are relative to the preoperative BMI. Perhaps the single most understood preoperative factor that is related to failure long term is the preoperative BMI.62,74 Superobese patients, with a BMI greater than 50 kg/m², tend to do the worst and as a result are more likely suited for the most malabsorptive procedure (i.e., the DS) based on weight criteria alone. Revision surgery is clearly associated with more complications, and outcomes in terms of weight loss are mixed.25–29 It is important to note that preoperative consideration for such procedures needs to be discussed thoroughly as these procedures carry a higher postoperative morbidity risk.

The approach to revisions is determined by either the presence of complications, the failure of weight loss, or both. Approaches for the different operations are varied; with

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banding, for example, management is rather straightforward. Patients who have had slippages, outright failure, or technical problems with the band are best suited to having a conversion to either RYGB or DS. Although studies of outcomes are relatively small, evidence points to excellent outcomes with either of these operations\(^{80-82}\), the choice of revision procedure should be based on both comorbid illnesses and preoperative weight.

Failure of the RYGB, on the other hand, is a far more vexing problem. Different options include revision of the RYGB in its entirety, which carries a high risk without clear clinical benefit.\(^{83}\) In the case of a large gastric pouch (i.e., greater than three times normal) or gastrogastric fistula, revision might be considered, especially with the presence of concomitant complications such as ulceration. Another option is conversion to a long-limb RYGB. This operation has been performed extensively in the past, but the outcome in terms of protein malnutrition is significant.\(^{84}\) Notably, malnutrition can occur in the absence of significant weight loss, which can make the clinical picture confusing.\(^{85,86}\) A much more palatable option for those patients who have recurrent T2DM following gastric bypass is conversion to a DS if they still have the ability to secrete adequate levels of insulin. The prospect of this is certainly daunting and should be carried out only in specialized centers, but it may produce long-term demonstrable improvement in T2DM.\(^{87}\) In any event, this decision should be thoroughly discussed with the patient who has demonstrated the ability to follow up in clinic preoperatively before these considerations have been made. Although appealing, a simple reduction in the stomach pouch size, unless extremely large (greater than three times normal size), using endoscopic techniques or other methods has demonstrated no benefit long term and at this point should be considered experimental. The current climate of medical care is to perform one weight loss procedure per lifetime. As such, the goal is to avoid revision procedures in their entirety by choosing the right procedures for the right patient at the outset.

**Evaluation of Old Procedures**

Often a surgeon will see patients following either a jejunooileal bypass or vertical banded gastroplasty presenting for complications or for simple failure of weight loss. In the case of the jejunooileal bypass, these patients tend to be considerably older as this operation has not been performed routinely for many years in the United States; however, these patients can suffer significant problems, with arthralgias, skin rashes, hepatic and renal failure, and bacterial overgrowth issues. In these cases, it is routine to either reverse these operations or convert to another bariatric procedure. In patients who are suffering from significant metabolic compromises, reversal is the best option; however, it must be stressed that these patients may have significant differences in bowel caliber, which can make these very technically difficult. For vertical banded gastroplasty, many of these patients will present with complications, such as GERD, with loss of tooth enamel and maladaptive eating.
Some patients develop a gastrogastric fistula from breakdown of the staple line, which may be the cause of their failure. In patients who have significant comorbid illness, revision to an RYGB is an attractive option for those patients who demonstrate capacity to follow-up. Prior to revision of any procedure, all patients should undergo upper endoscopy to evaluate the anatomy and evaluate for the presence of fistulas, ulcers, erosions, or strictures.

Special Considerations

THE PREGNANT PATIENT

There are a number of issues to address in the pregnant patient who has had previous bariatric surgery. It is imperative that these patients have adequate nutritional supplementation and adequate caloric intake, as dictated by preoperative albumin levels. It is possible that these patients will lose a significant amount of weight early in their pregnancy, and it is important to consider the difference in weight loss with the potential for weight gain as defined by the Institute of Medicine.66 Over the past 20 years, the Institute of Medicine has dictated amounts for reasonable weight gain during pregnancy based on a patient’s BMI and has recommended that patients who are overweight gain the least amount of weight during their pregnancy. Naturally, this will be offset by the weight loss following bariatric surgery. It is imperative that RYGB and especially DS patients have careful assessment of nutritional laboratory values once learning that the patient is pregnant and certainly if the patient is contemplating pregnancy. The laboratory values that should be checked early in the pregnancy include the B vitamins, including vitamin B₁₂ (thiamine), vitamin B₆ (pyridoxal phosphate), vitamin B₉ (folic acid), and vitamin B₁₂. In addition, it is essential to check vitamins A and D in these patients.

In short, patients who become pregnant after bariatric surgery will have less pregnancy-induced hypertension, fewer hypertension disorders, and a lower incidence of gestational diabetes. Fetal effects include reduced macrosomia. However, the incidence of cesarean sections is not reduced.66

ACCESS TO THE BILIARY TREE

One of the key issues following the RYGB is access to the biliary tree. Patients who develop bile duct stones in this setting, particularly after open bariatric surgery, pose a real challenge for access to the common bile duct by traditional endoscopic retrograde cholangiopancreatography (ERCP) techniques. Many have described an approach to the gastric remnant by placing a 15 mm trocar and performing ERCP through this;66 this has been demonstrated to be very successful. It is reasonable at this point to leave a gastrostomy tube in place to facilitate access in the case of stent placement.

Conclusion

Bariatric and metabolic surgery is now established as a modern subspecialty within surgery. It is unique in that the true effect of surgery is dependent on so many other factors, such as psychological status and compliance, which make it quite different from other surgical interventions carried out today. Four principal procedures are performed, and they vary in their outcome and complication rate. Adequate preoperative and postoperative care is essential to optimize outcome regardless of the procedure. Prompt recognition of complications is essential to the practicing surgeon, whether a bariatric surgeon or not. It is essential that the surgeon is in a position to care for the post–bariatric surgery patient be well aware of the nutritional complications and technical issues surrounding these patients to best impact their outcome.

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Figures 1, 2, 8, and 9  Christine Kenney