Bariatric Surgery for Patients With Diabetes

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Obesity is fast becoming one of the most prevalent chronic medical conditions in America. The U.S. Centers for Disease Control and Prevention estimates that there are ~ 60 million obese adults in the United States, or about 30% of the adult population.[1] Perhaps even more ominous is that ~ 16% of children and teens between the ages of 6 and 19 years are overweight, suggesting that the prevalence of adult obesity will continue to increase in the foreseeable future.[1] This major segment of the population is at higher risk of developing many diseases, including diabetes. It is estimated that as many as 280,000 deaths annually may be attributable to adult obesity.[2]

The rise in the prevalence of diabetes has paralleled the rise in obesity. In fact, risk of diabetes is directly proportional to degree of obesity.[3–5] Furthermore, studies have conclusively shown that reductions in weight are associated with lower risks of diabetes[6] and other risk factors for coronary artery disease, such as hypertension.[1,7] With such a clear relationship between obesity and chronic health problems such as diabetes, why aren't more people losing weight?

Unfortunately, few patients are able to successfully lose weight with diet and lifestyle interventions. Reduced-calorie diets are usually successful in achieving a loss of ~ 8% total body weight over a period of 6–12 months. Regaining of lost weight is common, and long-term studies suggest that prolonged weight loss of only ~ 4% of total body weight is a realistic expectation.[1] Other studies have demonstrated a sustained weight loss of 10–12 kg over 72 months with an approach combining behavioral therapy and a reduced-calorie diet. Interestingly, subjects pursuing a balanced low-calorie diet (1,200 kcal/day) experienced a similar degree of long-term weight loss compared to those on an initial very-low-calorie diet (420 kcal/day) followed by a maintenance diet.[8] Even with these intensive approaches, however, most obese patients probably could not achieve sufficient weight loss to correct their obesity.

Medical treatment for obesity is suboptimal. Pharmacotherapies are associated with considerable side effects, and weight frequently reaccumulates following cessation of therapy.[9] Other studies have not demonstrated improvements in glucose control despite weight loss using pharmacotherapy.[10] Although newer agents, such as endocannabinoid receptor blockers and incretins, may produce more sustainable weight reduction, long-term studies are lacking.[11]

Because noninvasive weight loss results are frequently suboptimal, surgical treatment of obesity is becoming increasingly common. There are several accepted methods of intervention, which use either restrictive or malabsorptive approaches or a combination of both mechanisms. With the growing national epidemic of obesity and the lack of other effective options, it is likely that surgical treatment will become increasingly common for obesity and that more diabetic patients will be initiating discussions with their primary care physicians regarding the benefits and risks of such procedures. It is important, therefore, that primary care physicians be familiar with the specific forms of bariatric surgery, as well as the expected outcomes and care of each type of surgery, especially with respect to diabetes.

IN BRIEF

Bariatric surgery is becoming increasingly common as a means to control weight in the United States. This article reviews the most common forms of bariatric surgery and their effects on diabetes and other components of the metabolic syndrome.

Selection of Subjects Appropriate for Surgery

One of the most difficult topics in regards to bariatric surgery is which patients should be considered for such procedures. This topic has been debated since the advent of bariatric surgery, and the National Institutes of Health (NIH) has offered recommendations. The NIH consensus statement on the evaluation, management, and treatment of obesity in adults[12] attempts to define the condition of obesity and overweight, as well as to offer recommendations for management of the disorder, including when surgical intervention should be considered. As described in Table 1, body habitus is classified by BMI measurement (weight in pounds × 703)/inches of height squared, or kg/m^2). Individuals with a BMI of 25–29.9 kg/m^2 are considered overweight, those with a BMI of 30–34.9 kg/m^2 are considered to have class I obe-

Table 1. NIH Obesity Classification[1]	
Classification	**BMI (kg/m²)**
Underweight	< 18.5
Normal	18.5–24.9
Overweight	25–29.9
Obese class I	30–34.9
Obese class II	35–39.9
Extreme obesity	≥ 40

sity, those with a BMI of 35–39.9 kg/m² are considered to have class II obesity, and those with a BMI ≥ 40 kg/m² are considered severely obese.[1,12]

Because surgery is invasive, treatment of obesity should begin with dietary modification, exercise, and behavioral therapy. Common recommendations include reduction of caloric intake to produce a deficit of 500–1,000 kcal/day. The NIH recommends a more aggressive approach in which men pursue a balanced-nutrient diet containing ~ 1,200–1,600 kcal/day to produce this deficit, and women pursue a balanced-nutrient diet of 1,000–1,200 kcal/day. This should produce a weight loss of ~ 1–2 lb per week. It is important for physicians to partner with patients in this approach and to provide positive feedback whenever possible. Physicians should also encourage moderate exercise, both to increase weight loss and for its other positive health effects.

Surgical intervention is generally reserved for patients with severe obesity for whom the above efforts have failed. NIH guidelines recommend consideration of surgery when the above approach is unsuccessful for patients with a BMI ≥ 40 kg/m² or a BMI ≥ 35 kg/m² if obesity-related comorbidities such as diabetes are present. Although the NIH does not give a specific recommendation regarding the amount of time patients should attempt weight loss before pursuing surgery, it does recommend a reassessment of treatment strategy for patients who have not lost 10% of their body weight in 6–12 months of therapy.[1,12]

Patients need a multidisciplinary team for appropriate preoperative evaluation and postoperative care. An ideal preoperative evaluation consists of psychosocial, medical, and surgical components, as well as an assessment of nutritional status. For the psychosocial evaluation, a mental health professional assesses for untreated eating disorders, depression, and readiness to change. A thorough medical exam, including screening for obesity-related comorbidities, is indicated before approval for surgery. Medications, treatment for obstructive sleep apnea, and preoperative weight loss reduce the risk of perioperative complications. All patients with diabetes who are > 50 years of age or have anginal symptoms need screening and treatment for coronary artery disease before surgery.[13]

Selected Surgical Procedures

Roux-en-Y gastric bypass

Also known as gastric bypass, the roux-en-Y gastric bypass (RYGB) has become the most common bariatric procedure preformed. For that reason, it will be discussed here in more detail than the other procedures (Table 2). The RYGB leads to weight loss resulting from restriction and malabsorption. Data from the past 30 years shows that ~ 90% of patients lose at least 50% of their excess body weight and have significant improvement, if not resolution, of their obesity-related comorbidities. Excess weight loss is defined as the actual weight loss ÷ excess weight. Excess weight is the total preoperative weight minus ideal body weight.[14]

An RYGB creates a small, 20–30 cc, gastric pouch that limits the intake of food (Figure 1). In addition, a portion of the small intestine is bypassed, which leads to malabsorption. The amount of small intestine bypassed is based on the patient's initial BMI. There is greater weight loss if more small intestine is bypassed; however, the risk of vitamin and nutrient deficiencies is greater. The procedure can be performed openly or laparoscopically. Laparoscopic patients

Table 2. Major Forms of Bariatric Surgery With Some Advantages and Disadvantages of Each Procedure		
Surgery	**Strengths**	**Weaknesses**
Roux-en-Y gastric bypass	Most common form of bariatric surgery in the United States Less malabsorptive than duodenal switch Improvement in hypertension, hyperlipidemia, and diabetes	More invasive than gastric banding Malabsorption may lead to vitamin deficiencies Higher risk of complications than gastric banding
Duodenal switch	Highest rate of weight loss Improvement in hypertension, hyperlipidemia, and diabetes	Greatest risk of vitamin deficiencies Greatest risk of complications
Gastric banding	Smallest risk of complications Least invasive procedure	Least improvement in hyperlipidemia, hypertension, and diabetes

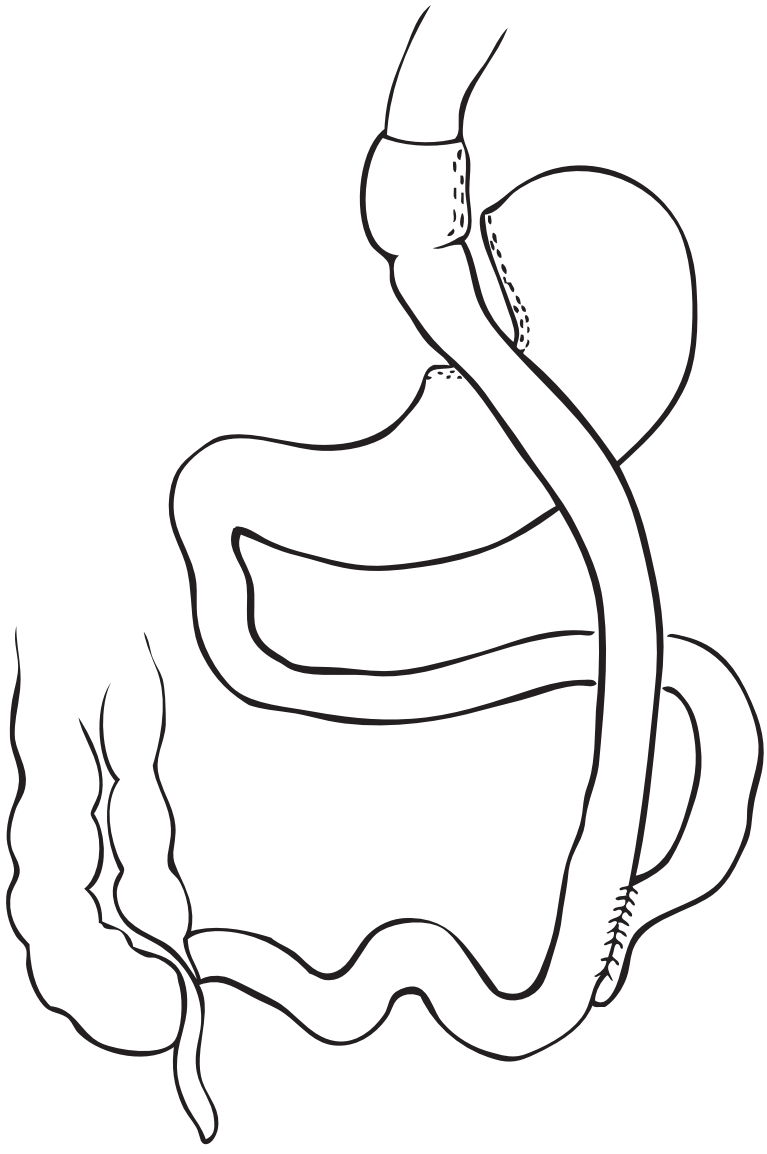

Figure 1. RYGB

have shorter lengths of stay in the hospital and appear to have equivalent weight loss.[15]

For many surgical centers, RYGB is the procedure of choice for moderate to severe obesity. However, it is not appropriate for everyone. Like all bariatric surgeries, RYGB is only recommended for patients with a BMI > 40 kg/m^2 or > 35 kg/m^2 with at least two obesity-related comorbidities.[16] At this time, there are few data to support RYGB in adolescents. A reversible procedure, such as gastric banding (discussed below), is likely more appropriate for adolescents.[17,18]

Surgeons are also selective about who is able to have laparoscopic procedures. Before-surgery BMI > 55 kg/m^2 or weight > 400 lb, older age, and male sex are all associated with an increased chance of conversion from laparoscopic to open surgery.[18] Some surgeons are also hesitant to perform laparoscopic bariatric surgery on patients > 500 lb or who have a history of previous gastric stapling or Nissen fundoplication.

After surgery, patients are started on a liquid diet. Clear liquids are started immediately after surgery. After 2–7 days, patients progress to protein shakes, yogurt, and soups until ~ 3 weeks after surgery. Soft solids are introduced next, and patients progress based on how well they tolerate the increasing complexity of foods.

Patients are counseled to prioritize protein consumption. All patients are given chewable multivitamins containing calcium with vitamin D. Some patients also require additional vitamin B_{12} and iron.

Six successful habits of patients who lose weight after RYGB have been described by Cook and Edwards.[19] Most patients in this study ate three balanced meals and two snacks per day, drank 40–64 oz per day, avoided carbonation, took vitamins daily, slept 7 hours per night, and exercised for 40 minutes at least four times per week. Two-thirds of the successful patients weighed themselves weekly. Successful patients viewed weight loss as their personal responsibility.

A meta-analysis found the average excess weight loss with gastric bypass is ~ 62%. The same study found 84% of patients with diabetes had improvement in or resolution of their diabetes after RYGB. Interestingly, most of the improvement in diabetes is seen before any weight loss, often before the patient even leaves the hospital. Seventy-one percent of patients with hyperlipidemia had improvement after RYGB. Similar improvements have been seen in hypertension (87% improvement or resolution) and obstructive sleep apnea (95% improvement or resolution).[20]

Many factors influence the complication rate associated with RYGB. The surgeon and surgery center's experience is directly correlated with complication rates.[21] A patient's level of compliance also influences the complication rate.[22] Complications are classified as occurring early (< 4 weeks), mid-term (1–6 months), or late (> 6 months) after surgery.

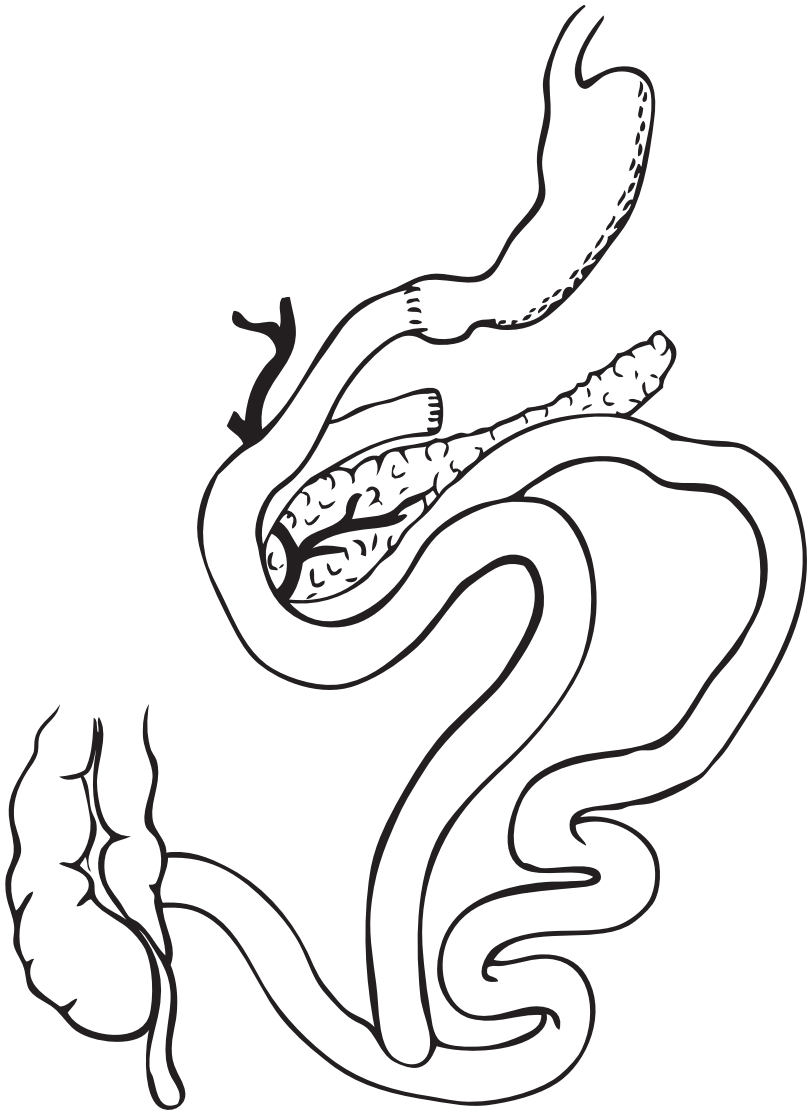

Figure 2. Duodenal switch

After bariatric surgery, patients must be monitored closely for surgical complications. Patients are usually discharged 2–3 days postoperatively. Patients are monitored closely for the first 6 weeks to assure adequate hydration. Early complications include wound infections, deep venous thrombosis, nausea, vomiting, diarrhea, and constipation. The most life-threatening early complications are anastomotic leakage and pulmonary embolus.[23]

Midterm complications include gallstones, stomal stenosis, marginal ulcers, dumping syndrome (rapid gastric emptying), and nausea. Gallstones can be prevented either by prophylactic cholecystectomy at the time of RYGB or with prophylactic ursodiol.[24] Stomal stenosis can be evaluated and dilated endoscopically. Marginal ulcers are treated with acid reducers such as H_2-blockers or proton pump inhibitors. Dumping syndrome is often associated with sugar consumption. Patients may need further education from a dietitian to avoid sugar products that may lead to dumping.[25]

Late complications include mineral and vitamin deficiencies. Iron, folate, vitamin B_{12}, and vitamin D levels should be followed and repleted if indicated. Complete blood count should be used to assess for anemia. Hernias and staple-line dehiscence leading to fistulas are uncommon late complications of both laparoscopic and open procedures. The risk of malnutrition and protein malnutrition increases with the degree of malabsorption and in some patients requires supplementation with parenteral nutrition. Patients are at increased risk for bowel obstructions.[25]

Pregnancy should be avoided for the first 18 months postoperatively. After 18 months, patients can often successfully conceive and have a healthy pregnancy. However, patients will need additional supplementation for iron, folate, vitamin B_{12}, and vitamin D.[26]

Although the rate of weight regain is lower with RYGB than with any other bariatric surgery, patients will regain some amount of weight. The weight regain typically starts 18–24 months after the surgery.[27] Patients need continual care of the multidisciplinary team to minimize the amount of weight regained.

Duodenal switch

The second major form of bariatric surgery is the partial gastrectomy with biliopancreatic diversion, or "duodenal switch." This procedure involves a partial gastrectomy that attempts to preserve the integrity of the vagus nerve and anastomosis of the remainder of the stomach to the distal ileum (Figure 2).

This procedure is associated with a greater degree of weight loss and improvement or remission of diabetes than other forms of bariatric surgery, according to a recent meta-analysis.[20] The meta-analysis demonstrated a mean weight loss of 46 kg, mean BMI decrease of 17.99 kg/m^2, and loss of 70% of excess weight. Furthermore, of 282 diabetic patients in studies of biliopancreatic diversion, 98.9% reported "resolution" of their diabetes, defined

as the ability to maintain essentially normal glucose levels without the use of medications. The percentage of patients reporting this level of improvement in their glucose levels was lower in the other forms of bariatric surgery. Like gastric bypass, what is not clear is whether this weight loss and improvement in diabetes results from simple malabsorption of nutrients and gastric restriction or whether it may also result from alterations of incretins or other gut hormones that may affect satiety, insulin sensitivity, insulin secretion, or other factors. Candidate hormones include glucagon-like peptide 1 neuropeptide YY, gastric inhibitory polypeptide, and other peptides. Improvement in hyperlipidemia appears to be better in duodenal switch with biliopancreatic diversion than in gastric banding, with > 70% of patients reporting improvement. Hypertension improvement or resolution was similar to other procedures, with 81.3% reporting improvement or resolution of hypertension.[20]

Although some benefits may be greater in the duodenal switch with biliopancreatic diversion compared to other procedures, there are greater risks. The above-mentioned meta-analysis demonstrated a 1.1% operative mortality rate, but initial studies of this procedure reported a mortality rate of 1.9%. One possibility for lower mortality reported in the meta-analysis includes gradual improvement in surgical techniques and experience since the advent of the procedure. Potential morbidity associated with the procedure includes risks of gastric retention (6%), abdominal abscess (2.4%), pancreatitis (1.7%), anastomotic fistulae (1.7%), and wound infection (1%).[28] Because of the potentially higher risk of morbidity and mortality, decisions regarding referral for this operation should be based on the experience of the center performing the procedure.

Restrictive procedures

The third class of bariatric surgery is purely restrictive procedures. The most common types of surgeries in this category include laparoscopic adjustable gastric banding and vertical banded gastroplasty (VBG). VBG has been abdondoned and is no longer performed because it has been proven to be ineffective over the long term. In the United States, laparoscopic adjustable gastric banding is the predominant restrictive procedure. It involves the laparoscopic placement of an inflatable silicone ring in the superior aspect of the stomach. This ring drastically narrows the stomach's upper orifice and limits the ability of food to enter the stomach.[29] After surgery, the ring must be gradually inflated over time, usually in an outpatient setting via percutaneous injection into a subcutaneous reservoir. This injection typically takes place five to six times the first year and two to three times the second year after surgery.[30] The adjustment in the gastric ring may be titrated based on patient tolerance and weight loss (Figure 3).

Typical weight loss is ~ 1–2 lb per week,[31] and total weight loss tends to be less than that with other procedures. Recent meta-analysis suggests that gastric banding results in loss of ~ 47% of excess weight, which is less than gastric bypass or duodenal switch. The mean weight change was 28 kg, with a BMI decrease of 10.4 kg/m^2. The same meta-analysis found that although 80% of patients reported improvement in their diabetes, only ~ 47% reported resolution of diabetes (as defined above). There also appeared to be less improvement in hyperlipidemia, hypertension, and obstructive sleep apnea than with other procedures.[20]

Although there may be less profound weight loss associated with this procedure, a major advantage is the lower rate of complications. Operative mortality is estimated to be 0.05%.[31] Morbidity includes a low risk of gastric herniation through the band (1–2%), gastric prolapse (1.8–5%), band erosion (0–7%), and, rarely, technical difficulty with port access. Rarely, patients cannot tolerate the band and require removal because of

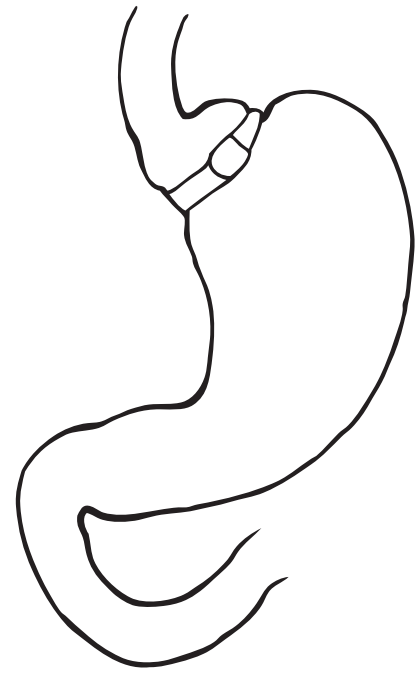

Figure 3. Laparascopic adjustable gastric banding

esophageal dilation.[30] One recent study found the overall major complication rate of laparoscopic gastric banding to be less than half of that in the RYGB (1.7 vs. 4.2%).[32] Another study showed that time to resumption of normal activity after gastric banding surgery was less than half of that for RYGB patients.[33] In summary, the lower amount of weight loss is accompanied by a lower risk of perioperative morbidity and mortality.

One possible explanation for the lower amount of weight loss is that gastric banding causes weight loss simply by inducing reduction in caloric consumption, and there is less or no alteration in the hormones thought to play important roles in satiety and energy balance, such as leptin, ghrelin, integrins, adiponectin, and other agents.[34] Many investigators are studying the role of these factors in the setting of obesity and its surgical treatment.

Discussion

As with most medical therapies, perhaps the ultimate test of a weight loss intervention is whether it decreases mortality.

A few studies have attempted to address that question. The Swedish Obesity Study study was a prospective contemporaneously matched study comparing a group of patients who underwent either gastric banding or gastric bypass surgery and a conventionally treated group. After 10 years, the group undergoing surgery had statistically lower weight and less diabetes, hypertriglyceridemia, and hyperuricemia, but not less hypertension or hypercholesterolemia.[35] Another smaller retrospective study of diabetic patients undergoing gastric bypass surgery versus control patients found a lower mortality rate in patients undergoing bariatric surgery compared to patients who did not have surgery because of insurance company denial. The statistically significant difference was primarily because of a lower rate of cardiovascular mortality in the surgically treated group compared to the control group. Comparison was made at 9 years for the surgical group versus 6.2 years for the control group, which may further increase the significance of the differences.[36] Another observational cohort study that compared patients who underwent gastric bypass versus matched controls found a statistically significant decrease in mortality after 5 years. The same study also found a significant reduction in health care usage rates and health care costs in a nationalized health care system.[37]

Certain patient populations, however, may benefit less from weight reduction surgery. A recent study of Medicare beneficiaries found a higher rate of operative mortality in a Medicare population, particularly those > 75 years of age.[38] It is not known, however, if this higher mortality rate will still be offset by a lower cardiovascular mortality in long-term studies of Medicare patients.

In general, surgical risks appear to be reduced when the surgical procedure is performed by an experienced bariatric surgeon who works in a Center of Excellence (COE) as certified by the American College of Surgeons or the American Society of Bariatric Surgeons. To be certified as a COE, hospitals must have adequate infrastructure, personnel, and commitment to surgical treatment of morbidly obese patients.

As discussed in the case study by Dunn and Jagasia in this issue of *Clinical Diabetes* (p. 112), glucose must be monitored closely after bariatric surgery, and physicians must have a low threshold for decreasing insulin or other antidiabetic agents after surgery.

There are other important factors to consider beyond those associated with the metabolic syndrome. Depression has long been associated with diabetes.[39] Patients with severe obesity also have higher rates of depression, suggesting that depression is also a frequent comorbidity of obesity. One study evaluated markers of depression before weight loss surgery and at yearly follow-up for 4 years. Weight loss after surgery was associated with a significant improvement in markers of depression, especially in younger and female patients.[40] There is no current medical indication for bariatric surgery simply to treat depression in obese patients, but its potential impact on the disease remains a consideration.

The American Diabetes Association, in a 2006 position statement,[41] acknowledged that surgical interventions to treat obesity may be beneficial in some situations and are associated with improvements in diabetes control. However, it also recommended caution because long-term studies remain limited in size and scope. As described above, this position statement also pointed out that diabetes patients are at higher risk for perioperative cardiovascular mortality, and this factor should be considered when making decisions regarding surgery.[41]

In summary, as physicians, we help patients weigh the potential risks and potential benefits of medical and surgical therapies on a daily basis. Weight reduction surgery should be approached in a similar fashion. Surgical intervention to treat obesity is effective but not without risks. Currently, Medicare patients must have bariatric surgery performed in a COE.

Because of its rising popularity, it is also likely that more patients will be querying their physicians regarding the feasibility of weight reduction surgery as a manner of controlling both obesity and its complications. Because weight loss surgery is a heterogeneous group of procedures, it is important to be familiar with both the different forms of surgical intervention and the advantages and disadvantages of each. Primary care providers should also proactively inform patients of both short-term and long-term benefits and risks during such discussions. In this manner, patients and physicians can make medical decisions based on the most accurate medical information and with the most realistic expectations regarding surgical outcome.

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