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REVIEW ARTICLE

Overview of Emerging Concepts in Metabolic Surgery

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Introduction

There is now a worldwide epidemic of obesity. According to the Centers for Disease Control and Prevention,[1] the prevalence of obesity among all age groups has increased significantly since 1990; about two-thirds of US adults are overweight or obese.[2]

Obesity is classified according to body mass index (BMI)[3]; overweight is a BMI of 25 to 29.9 kg/m^2, class I obesity is a BMI of 30 to 34.9 kg/m^2, class II obesity is a BMI of 35 to 39.9 kg/m^2, and class III obesity is a BMI of ≥40 kg/m^2.

The 1998 National Heart, Lung, and Blood Institute guidelines recommended a combination of low-calorie diet, exercise, and behavioral therapy as first-line treatment for obesity. Such a comprehensive approach results in weight loss of 8% to 10%[4]; nonetheless, weight regain is common after two years.[5]

Metabolic or bariatric surgery induces durable and sustainable weight loss. The 1991 National Institutes of Health Consensus Conference Statement defined the criteria for bariatric surgery as a BMI of ≥40 kg/m^2 or of ≥35 kg/m^2 with comorbidities (Tables 1 and 2).[6,7] The most recent guidelines of the American Diabetes Association[8] state that "bariatric surgery should be considered for adults with BMI >35 kg/m^2 and type 2 diabetes, especially if the diabetes is difficult to control with lifestyle modification and pharmacologic therapy." Surgical candidates must have tried other weight-loss modalities (diet, exercise, etc) before consideration of bariatric surgery. It is estimated that about 3% of the US population, or approximately five million people, meet the weight criteria for bariatric surgery.[9]

The prevalence of serious comorbidities such as metabolic syndrome is 39% among patients undergoing bariatric surgery.[10] More importantly, among individuals with type 2 diabetes, 85% are overweight and 55% are obese.[11] The Nurses' Health Study demonstrated that individuals with a BMI of 35 kg/m^2 had a 40-fold increase in their likelihood of developing diabetes.[12] The link between diabetes and obesity is due to induction of insulin resistance by excess adipose tissue and generalized low chronic inflammation.

The role of metabolic surgery in the treatment of obesity is well established.[13] The Swedish Obese Subjects (SOS) study demonstrated that metabolic surgery induces remission of diabetes in 69% of obese-diabetic patients.[14] Furthermore, in a meta-analysis of 136 studies, the proportion of patients who had diabetes before surgery (median, 11%; range, 3%–100%) and who showed fewer effects from or resolution of diabetes after surgery ranged from 64% to 100% (median, 100%).[15] Improvements in insulin sensitivity within the first few days after Roux-en-Y gastric bypass (RYGB), before any measurable weight loss, is commonly observed, and has been maintained at

Table 1. Comorbidities associated with obesity

Category	Comorbidity
Neurologic	Pseudotumor cerebri
Pulmonary	Obstructive sleep apnea
	Obesity hypoventilation syndrome
Circulatory	Hypertension
	Cardiomyopathy
	Pulmonary hypertension
	Deep venous thrombosis
Gastrointestinal	Gastroesophageal reflux disease
	Cholelithiasis
	Nonalcoholic steatohepatitis
Genitourinary or gynecologic	Stress urinary incontinence
	Polycystic ovary syndrome
Musculoskeletal	Mechanical arthropathy
Metabolic	Diabetes mellitus
	Hyperlipidemia
	Hypercholesterolemia
	Metabolic syndrome
Psychiatric	Depression
	Binge-eating disorder
	Somatization disorder
	Body dysmorphic disorder

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Table 2. Effects of bariatric surgery on obesity-related comorbidities

Comorbidity	Preoperative incidence (%)	Remission >2 years after surgery (%)
Type 2 diabetes mellitus, IFG, or IGT	34	85
Hypertension	26	66
Hypertriglyceridemia and low HDL cholesterol level	40	85
Sleep apnea	22 (in men)	40
	1 (in women)	
Obesity-hypoventilation syndrome	12	76

HDL = high-density lipoprotein; IFG = impaired fasting glucose; IGT = impaired glucose tolerance.
Table adapted and reprinted from Endocrinology and Metabolism Clinics of North America 1996 Dec 1, 25(4), Greenway FL, Surgery for obesity:1005-27, Copyright 1996, with permission from Elsevier.[6]

12 months after surgery.[16] Similarly, in a randomized study, laparoscopic adjustable gastric banding (LAGB) was far superior to standard nonsurgical therapy in inducing remission of diabetes.[17]

The remission of obesity-related comorbidities such as metabolic syndrome after bariatric surgery is accompanied by increased longevity. In the SOS study, metabolic surgery reduced overall mortality by 29%.[18] In a larger cohort of patients who underwent RYGB, deaths from coronary artery disease were reduced by 56%, cancer-related deaths decreased by 60%, and more importantly, disease-specific mortality from diabetes decreased by 92%.[19]

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Surgically induced weight loss reduces other markers of metabolic syndrome such as serum triglyceride and cholesterol levels,[20] as well as hypertension in at least 62% of patients.[21,22] In addition, metabolic surgery significantly improves obstructive sleep apnea,[23] gastroesophageal reflux disease,[24] mechanical arthropathy,[25] fatty liver,[26] fertility problems, and urinary incontinence.[27]

Moreover, metabolic surgery reduces obesity-related costs and use of health care resources. It is estimated that the cost of surgical interventions for class II to class III obesity is offset by the subsequent reduction in pharmaceutical and hospitalization cost within the first two years after bariatric surgery.[28,29]

Additionally, surgical treatment of obesity improves quality-of-life measures. The SOS study found a positive correlation between improvement in quality of life and the degree of weight loss.[30] This was echoed by another study, in which 95% of those who had undergone bariatric surgery had improvements in their quality of life.[31]

Physicians who care for patients after bariatric surgery need to be familiar with common postoperative syndromes that result from specific nutrient deficiencies: protein, vitamin, and trace-element (iron, zinc) deficiencies.[32] Nutritional consequences of bariatric surgery could lead to anemia, neurologic disorders, visual disorders, skin disorders, and edema.[32] Therefore, patients who have undergone bariatric surgery require indefinite, regular follow-up care by their primary care physicians. The surgical mortality rates are 0.1% for LAGB and 0.5% for RYGB.[21]

Types of Metabolic Procedures

Bariatric procedures fall into two categories: restrictive procedures, such as LAGB and sleeve gastrectomy (SG), which limit the amount of oral intake, and diversionary procedures that divert nutrients from the stomach and duodenum and use the Roux anatomy in combination with either mild restriction, such as in RYGB, or malabsorption, as in biliopancreatic diversion/duodenal switch. The vertical banded gastroplasty and jejunoileal bypass are no longer undertaken, owing to insufficient weight loss[33] and devastating malabsorptive sequelae,[34] respectively.

LAGB was first introduced in Europe during the 1990s and was approved for use in the US by the Food and Drug Administration in 2001. It involves placing a band around the cardia of the stomach (Figure 1). The inner diameter of the band can be adjusted during an outpatient office visit by injecting normal saline into a subcutaneous reservoir. Several studies suggest that LAGB is associated with fewer complications and a lower mortality rate (0%–0.7%) than are other restrictive

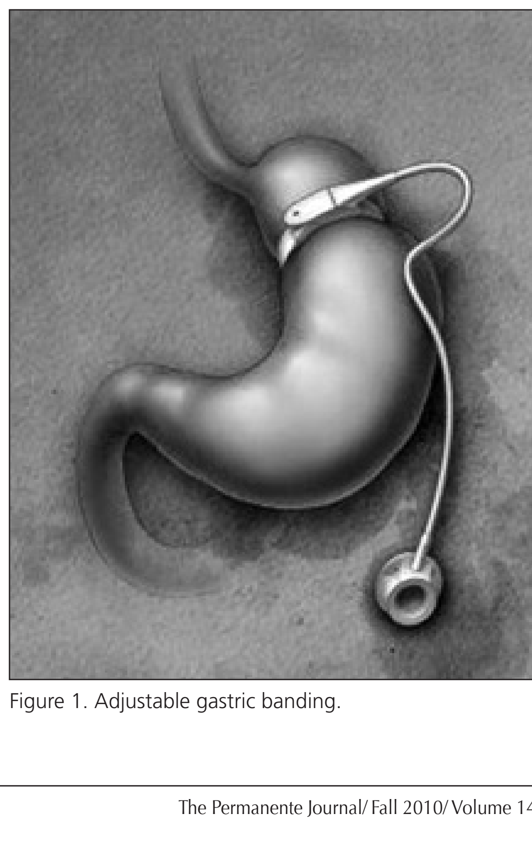

Figure 1. Adjustable gastric banding.

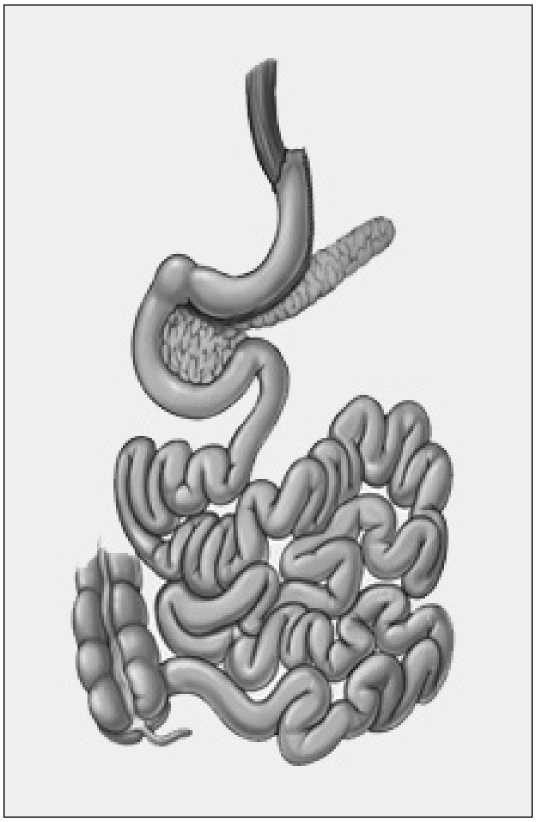

Figure 2. Sleeve gastrectomy.

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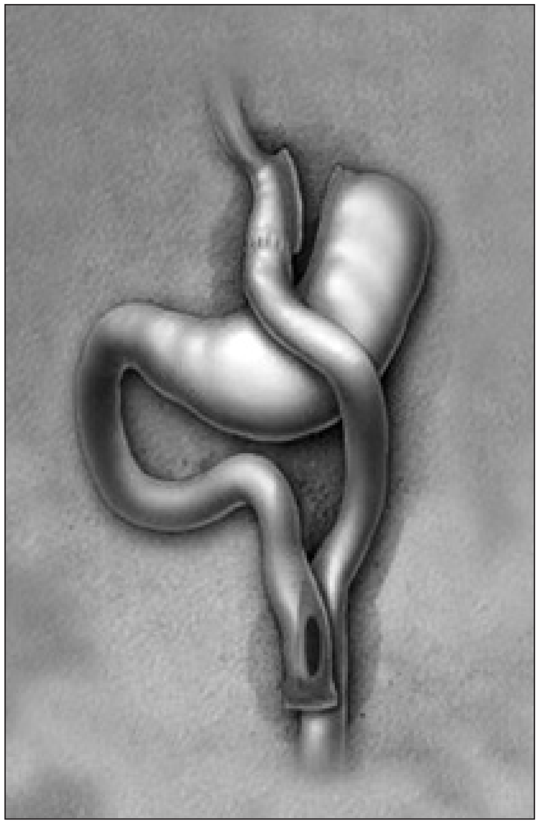

Figure 3. Roux-en-Y gastric bypass.

or diversionary procedures[35,36]; however, it is associated with a higher likelihood for reoperation.[37,38] A meta-analysis of 136 studies showed that weight loss after LAGB ranged from 40% to 54%.[21]

SG, another restrictive procedure was introduced in 1993. It is a form of unbanded gastroplasty involving a subtotal vertical gastrectomy (Figure 2).[39] Complication rates range from 0% to 24%, and the mortality rate is 0.4%.[40] Resolution of comorbidities at 12 to 24 months after SG has been satisfactory, but long-term data are still lacking.[41]

RYGB is the most common bariatric procedure undertaken in North America. The stomach is divided to make a small pouch (15–30 mL) from the cardia. The midjejunum (Roux limb) is anastomosed to the gastric pouch. Gastrointestinal tract continuity is reestablished by anastomosing the biliopancreatic limb to the midjejunum forming the common channel where digestion and absorption occurs (Figure 3). RYGB is associated with an overall complication rate of 10% and a mortality rate of 0.4%.[42] Early complications include anastomotic leak (3%), deep vein thrombosis or pulmonary embolism (3%), bleeding (3%), and wound infection (4%). Late complications include anastomotic strictures (5%), ulcers (2%), and incisional hernia or small bowel obstruction (2%).

The foregut and hindgut hypotheses have been proposed to explain the resolution of diabetes after RYGB. Rubino et al[43] offered the foregut hypothesis: that when food bypasses the duodenum and proximal jejunum after bariatric surgery, a so-called anti-incretin or decretin factor that is yet unknown is inhibited and thus insulin resistance is decreased and glucose tolerance improves. Cummings et al[44] and Patriti et al[45] proposed the hindgut explanation, suggesting that the quick transit of nutrients to the distal bowel improves glucose metabolism by stimulating secretion of glucagon-like peptide-1 and peptide YY. Insulin secretion is increased and glucose tolerance improves, affecting body weight and food intake.

Most patients undergoing bariatric surgery have some degree of hepatic steatosis: Approximately 25% have nonalcoholic steatohepatitis, and 1% to 3% have cirrhosis that is incidentally found in the operating room.[46] All studies using standard RYGB have consistently demonstrated decreased steatosis on follow-up liver biopsy. The alteration in the gut hormone's response after RYGB—namely, the upregulation of glucagon-like peptide-1—has been shown to decrease the nonalcoholic fatty liver disease induced by obesity.[46]

Biliopancreatic diversion (BPD) and biliopancreatic diversion with duodenal switch (BPD/DS) involve a partial gastric resection and a short common channel (Figure 4).[46] Consequently, the likelihood of protein-calorie malabsorption approaches 7%; a smaller number of patients will require additional operations to lengthen the common channel.[47] In comparison to other bariatric procedures, patients who undergo BPD or BPD/DS have rapid and greater long-term weight loss that exceeds 70%.[48]

In our practice, we recommend RYGB for patients with diabetes or those with a BMI of >50 kg/m^2. Our experience suggests that patients with a BMI of >50 kg/m^2 who undergo LAGB may not lose enough weight to overcome their comorbidities and achieve the BMI of <40 kg/m^2 that is supported in the literature.[49] In addition, diabetes decreases immediately after RYGB, whereas the reduction of diabetes after LAGB depends on how much weight is lost.

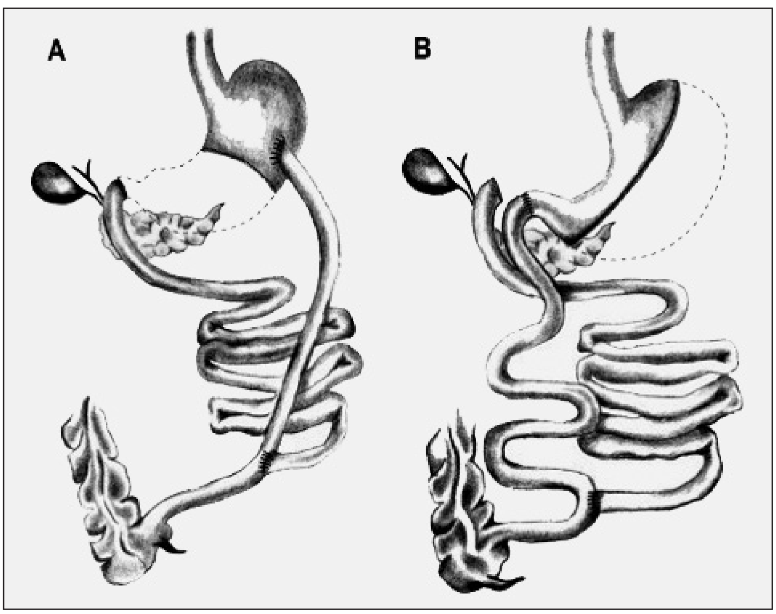

Figure 4. (A) Biliopancreatic diversion. (B) Biliopancreatic diversion with duodenal switch.

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Preoperative Evaluation

A multidisciplinary and comprehensive approach is preferred for the management of morbid obesity.[50] All patients who are considering bariatric surgery should be evaluated and screened by an interdisciplinary team that includes a bariatric surgeon, a bariatrician, a nutritionist, a psychologist, and an exercise physiologist. In addition to conducting a routine assessment, the interdisciplinary team should aim at reducing perioperative risks specifically in patients with a BMI of >50 kg/m^2, hypertension, or previous history of thromboembolism as well as in men and in patients older than 45 years.[51] Risk reduction may be achieved by preoperative weight loss, prophylactic inferior vena cava filter, and smoking cessation.[51] More importantly, the preoperative evaluation lays the foundation for healthy eating habits and lifelong behavior modification.

Postoperative Care

Patients with severe cardiac disease, diabetes, or severe obstructive sleep apnea are monitored in an intermediate or intensive care unit. Tachycardia is an important indicator of postoperative complications and should be addressed promptly and treated accordingly.[52] In our practice, β-blockers are given immediately after surgery to patients who were taking them before surgery and to selected high-risk patients. We initiate continuous positive airway pressure or bilevel positive airway pressure early in the recovery room by using the patient's own equipment. Oral food intake is initiated after an upper gastrointestinal tract study for fast tracking.

Follow-up Care

Restrictive procedures are not associated with alterations in intestinal continuity. As a result, nutritional deficiencies are uncommon. The anatomic changes because of diversionary surgical procedures, however, increase the likelihood of various nutrient deficiencies; therefore, we prescribe multivitamins with iron, vitamin B_{12} injections, calcium, and vitamin D supplements. Additionally, protein supplements should be given as soon as patients can tolerate oral intake.

The first postoperative office visit is scheduled two to three weeks after the procedure. By this time, most patients can tolerate semisolid food, and therefore it is important to differentiate between excessive oral intake, anastomotic strictures, and ulcers that also manifest as intolerance to food, nausea, and vomiting.

The frequency of follow-up visits depends on the type of procedure. Patients who undergo LAGB usually need their first band fill between four and eight weeks after surgery and every two months thereafter. Patients who have undergone RYGB are scheduled for follow-up visits every three to four months in the first year and twice yearly thereafter.

A complete blood cell count and liver function tests are conducted once or twice yearly, and levels of total serum protein, electrolytes, blood urea nitrogen, creatinine, and albumin are measured on this schedule too. Additionally, we recommend measuring levels of parathyroid hormone, vitamins D and B_{12}, folic acid, iron, and ferritin every one to two years after bariatric surgery or as needed.

The Future of Metabolic Surgery

The future of metabolic surgery lies with the innovative approaches of surgeons and the ever-expanding understanding of obesity by nonsurgeons. Several studies that are now examining the benefits of metabolic surgery in class II obesity are promising. Endoluminal applications and device interventions now in phase 1 and 2 studies are other exciting areas of research. In addition to preventing comorbidities, metabolic surgery may be used as a primary tool for the treatment of diabetes and obesity. ❖

Disclosure Statement

The author(s) have no conflicts of interest to disclose.

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