

# Surgical Management of Morbid Obesity

BENJAMIN E. SCHNEIDER, MD  
EDWARD C. MUN, MD

**O**besity imposes devastating health and financial tolls on society and those who suffer from it. Despite the growing awareness of the problem, the obesity epidemic, along with its associated complications, continues to expand at an alarming rate (1). The current nomenclature used to measure an individual's degree of obesity is BMI, which is calculated by dividing weight (in kilograms) by the square of height (in meters) (Table 1). Based on these criteria, the CDC (Centers for Disease Control and Prevention) reports a doubling of the obese population (BMI  $\geq 30$  kg/m<sup>2</sup>) in the period between 1976–1980 and 2001–2002 to reach an estimated number of 63 million obese people. Currently in the U.S., nearly two-thirds of adults are overweight (BMI  $>25$  kg/m<sup>2</sup>), nearly one-third are considered obese (BMI  $\geq 30$  kg/m<sup>2</sup>), and 4.7% are extremely obese (BMI  $\geq 40$  kg/m<sup>2</sup>) (2). The financial cost of obesity in the U.S. is estimated to be in excess of \$100 billion/year (3). In addition to increased risk of diabetes and other comorbid diseases, obese individuals may expect significant decreases in life expectancy (4) (Table 2). This obesity-related diminution in longevity directly contributes to 280,000 deaths annually in the U.S. (5).

Medical (nonsurgical) weight loss therapies include combinations of diet, exercise, behavioral therapies, and medications. In 1998, an NIH (National Institutes of Health) expert panel, upon critical review of the literature, concluded that these modalities, either alone or in combination, can induce modest weight loss that confers health benefits to the patients (6). However, the weight loss induced by these therapies is often short lived. Furthermore, medical management

must continue indefinitely to be effective, or weight regain is common. Such medical therapies have not been shown to be effective in maintaining long-term weight loss in a morbidly obese patient population. Thus, most physicians realize that surgery remains the best option for many morbidly obese patients.

Because severe obesity is associated with increased risk for premature death, the 1991 NIH consensus panel set out guidelines for surgical therapies in patients with extreme obesity (BMI  $>40$  kg/m<sup>2</sup> or 35–40 kg/m<sup>2</sup> with comorbidities) (7) (Table 3). A follow-up NIH consensus meeting was held recently in June 2004, and new recommendations will be available in the near future. A more recent procedure, adjustable gastric banding, is expected to be included in the updated surgical procedures.

## SURGICAL THERAPIES AND OUTCOMES

— In response to the relatively poor durable weight loss experienced by patients undergoing medical treatment for morbid obesity, the demand for weight loss surgery has greatly increased in recent years. The number of bariatric operations performed nationwide increased from 16,000 to  $>100,000$ /year in 2003 (8). More than 140,000 procedures are anticipated for 2004. Numerous surgical techniques were developed over the last 40 years to treat morbid obesity. Some of these procedures evolved with time, whereas others have become obsolete. Bariatric surgical techniques share two fundamental designs: intestinal malabsorption and gastric restriction. Malabsorptive operations shorten the functional length of the intestinal surface for nutrient absorption, while restrictive procedures decrease

food intake by creating a small neogastric pouch and the outlet. The goals of surgery are to achieve and maintain significant weight loss and to reverse or prevent many of the obesity-induced comorbidities. The ideal bariatric procedure must be safe, durable, and effective and performed with relative ease.

## Malabsorptive procedures

Malabsorptive procedures induce decreased small intestinal absorption of nutrients and calories by bypassing or excluding intestinal loops. Such decrease in functional absorptive surface area of the small intestine represents surgically induced short-gut syndrome and results in a negative energy balance and weight loss. Weight loss caused by malabsorption is often accompanied by excessive protein calorie malnutrition and macro- and micronutrient deficiencies. This has been the Achilles' heel of these procedures, and their wide use has been limited by such metabolic side effects.

## Jejunioileal bypass

The jejunioileal bypass was the first widely performed operation designed for weight reduction (9). The procedure involved dividing the proximal jejunum, which was then attached to the ileum just proximal to the ileocecal valve, and therefore effectively bypassing most of the absorptive small intestine (Fig. 1A). Although relatively successful at inducing satisfactory weight loss, it was also associated with an unacceptable incidence of complications, which lead to the general abandonment of the procedure. Most of the severe complications arose from bacterial overgrowth in the bypassed or blind segment of the small intestine. Many patients developed severe complications, including oxalate kidney stones, polyarthralgia, cirrhosis, hepatic failure, and bypass enteritis and metabolic derangements such as metabolic bone disease and vitamin B<sub>12</sub> and vitamin D deficiency, that required surgical revision or reversal (10–15). Although no longer performed, there are still survivors of jejunioileal bypass alive today. Such patients are in need of lifelong surveillance of metabolic, hepatic, and renal function. Patients who demonstrate organ

From the Care Group, Harvard Medical School, Beth Israel Deaconess Medical Center, Boston, Massachusetts.

Address correspondence and reprint requests to Edward C. Mun, MD, Harvard Medical School, Care Group, Beth Israel Deaconess Medical Center, Boston, MA 02215. E-mail: emun@caregroup.harvard.edu.

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Table 1—BMI

	Obesity Class	BMI (kg/m <sup>2</sup> )
Underweight		<18.5
Normal		18.5–24.9
Overweight		25.0–29.9
Obesity	I	30.0–34.9
Severe obesity	II	35.0–39.9
Morbid obesity	III	40.0–49.9
Super-morbid obesity	III	>50.0

dysfunction may require an operative revision (16).

### Biliopancreatic diversion and duodenal switch

Biliopancreatic diversion and duodenal switch are other malabsorptive procedures and were developed to avoid the complications of the blind loop. The bil-

Table 2—Comorbidity

Coronary artery disease
Hypertension
Dyslipidemia
Hypercholesterolemia, hypertriglyceridemia, hyperlipidemia
Type 2 diabetes
Asthma
Obesity hypoventilation syndrome
Obstructive sleep apnea
Gastroesophageal reflux
Heartburn, reflux esophagitis
Hepatobiliary dysfunction
Fatty liver, cholelithiasis, nonalcoholic steatohepatitis
Stress urinary incontinence
Venous stasis disease
Ulcer(s), deep vein thrombosis, pulmonary embolus, superficial thrombophlebitis
Hernias
Inguinal, ventral, umbilical, incisional
Sexual hormone dysfunction
Irregular menstruation, hirsutism, gynecomastia, infertility
Cancer
Colon, prostate, uterine, breast
Infection
Cellulitis, panniculitis, postoperative wound infections
Degenerative joint disease, osteoarthritis
Migraine headache
Pseudotumor cerebri (idiopathic intracranial hypertension)
Clinical depression

Table 3—Surgical criteria

Criteria for bariatric surgery
BMI $\geq 40$ kg/m <sup>2</sup> or BMI $\geq 35$ kg/m <sup>2</sup> with significant obesity-related comorbidities
Age between 16 and 65 years
Acceptable operative risks
Documented failure at nonsurgical approaches to long-term weight loss
A psychologically stable patient with realistic expectations
A well-informed and motivated patient
Commitment to prolonged lifestyle changes
Supportive family/social environment
Commitment to long-term follow-up
Resolution of alcohol or substance abuse
Absence of active schizophrenia and untreated severe depression

ioipancreatic diversion operation involves performing a distal (80%) gastrectomy and a Roux-en-Y reconstruction consisting of a 200-cm alimentary (food) limb, a long biliopancreatic (bile and pancreatic juice) limb, and a 50-cm common limb (17) (Fig. 1B). Significant weight loss occurs in these patients due to inadequate digestion of food in the common limb because of the short segment of common limb where mixing of food and digestive enzymes occur. The duodenal switch is similar to the biliopancreatic diversion but also includes a sleeve gastrectomy and duodenoileostomy to avoid the complication of marginal ulcer often seen in biliopancreatic diversion (18,19) (Fig. 1C). Isolated sleeve gastrectomy has been successfully used as a first-stage procedure in high-risk super-obese patients before more definitive surgical treatment at a later date (20). Despite excellent long-term weight loss and improvement in comorbid conditions following these procedures, concerns regarding long-term complications (protein calorie malnutrition, metabolic bone disease, hepatic dysfunction, and vitamin deficiencies) still exist (21). This combined with the fact that relatively few centers perform these procedures renders them investigational (22).

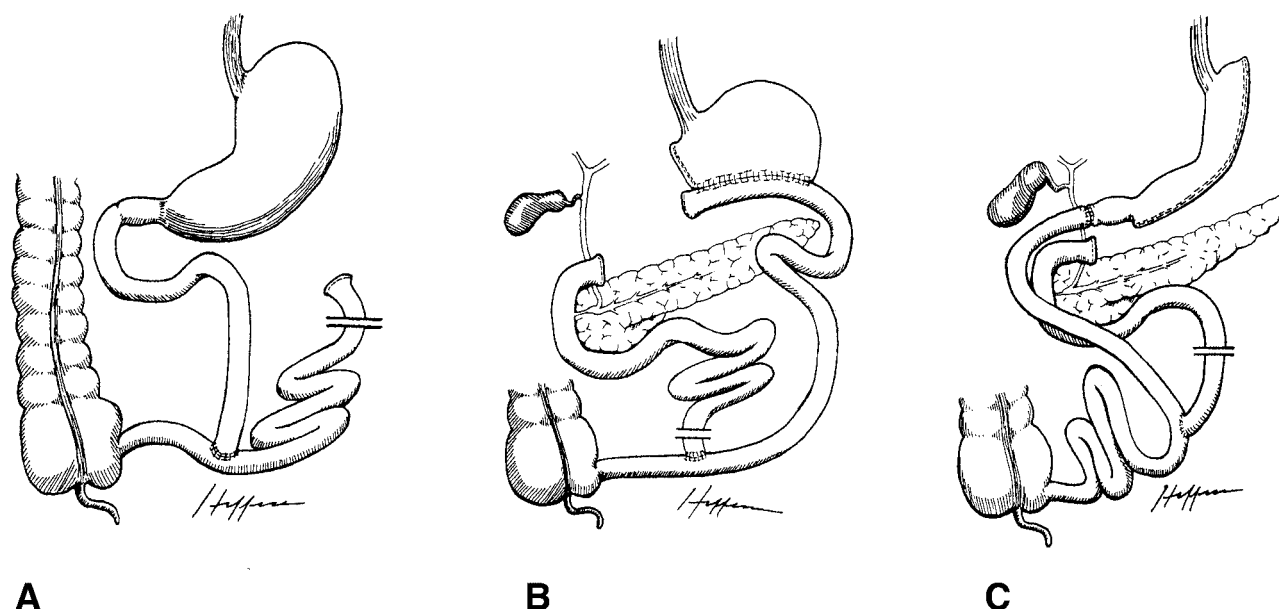
### Restrictive procedures

All restrictive procedures share one common feature that decreases the storage capacity of the stomach. A small stomach pouch is associated with prompt filling by a small amount of food, early satiety, de-

creased meal size, and calorie intake, ultimately resulting in weight loss. Purely restrictive procedures do not involve alterations in the small bowel anatomy and are therefore rarely associated with metabolic complications. Roux-en-Y gastric bypass is primarily a restrictive operation in which a small upper stomach pouch is fashioned, but the additional modification of the small intestine makes it a unique procedure with multiple mechanisms for weight loss. These restrictive procedures are in general simpler to perform with less procedural risks when compared with malabsorptive operations and achieve good weight loss. This reduction in mortality and major complications has led to their current popularity.

### Vertical banded gastroplasty

The vertical banded gastroplasty represents a purely restrictive procedure in that the stomach is partitioned using a surgical stapling device to create a very small proximal pouch. A mesh band is placed as reinforcement around the stoma between the pouch and the gastric remnant, thus effectively limiting food passage into the body of the stomach (23) (Fig. 2A). Filling of the upper stomach pouch results in satiety, and decreased solid food consumption leads to weight loss. Follow-up after vertical banded gastroplasty and comparison with other bariatric procedures exist. Several studies have demonstrated complications such as staple-line dehiscence and stomal stenosis, as well as inferior long-term weight loss after gastroplasty, when compared with Roux-en-Y gastric bypass (24–27). Weight loss outcomes are conventionally reported in terms of excess weight loss, where excess weight is defined as the difference between a person's actual and ideal body weight. Results following gastroplasty demonstrate an average 5-year excess weight loss of between 30 and 50%. As a result of unfavorable comparisons between vertical banded gastroplasty and gastric bypass in terms of both inferior weight loss and resolution of comorbidities, the vertical banded gastroplasty has fallen into disfavor among most surgeons (28–30). A newer and safer restrictive procedure, the laparoscopic adjustable gastric band, has helped to further push the vertical banded gastroplasty out of fashion.



**Figure 1**—Malabsorptive procedures. A: Jejunioleal bypass (purely malabsorptive); B: Biliopancreatic diversion (primarily malabsorptive); and C: Biliopancreatic diversion with duodenal switch (primarily malabsorptive).

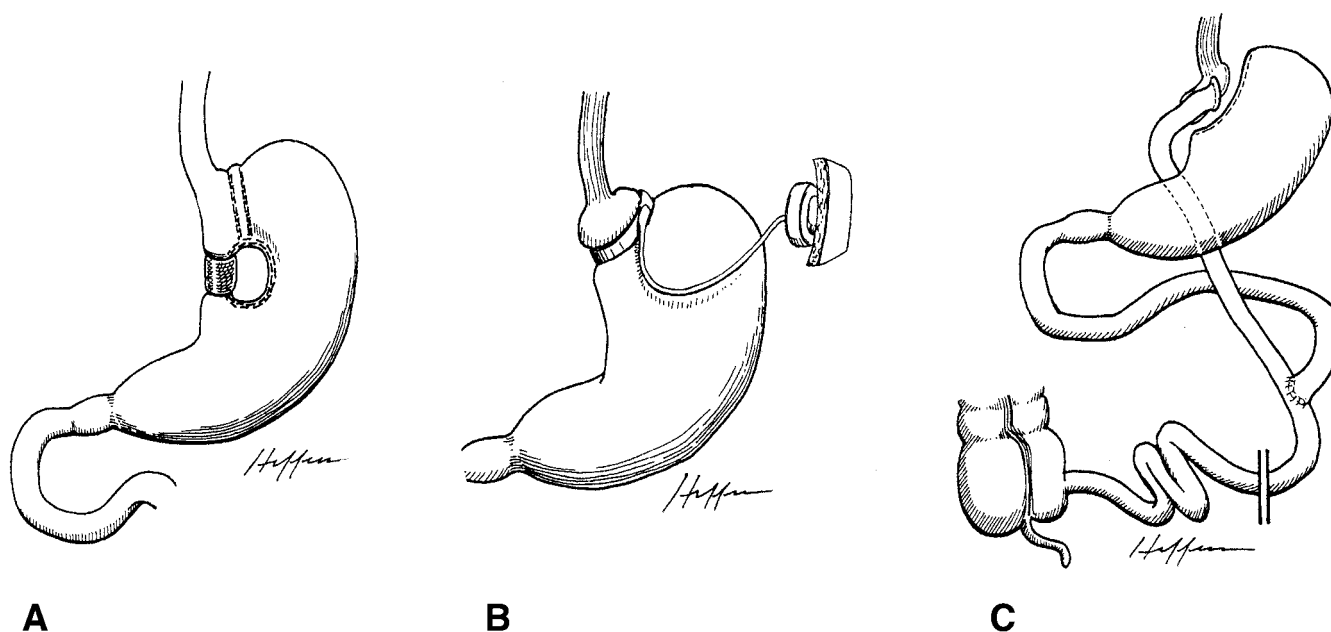
### Gastric band

Gastric banding represents the least invasive among frequently performed bariatric procedures. Although available and widely used abroad for a decade, the FDA (Food and Drug Administration) approved a single device for implantation in the U.S. in 2001 (LAP-BAND; Inamed Health, Santa Barbara, CA). The device consists of a sili-

con elastomer with an adjustable inner balloon that effectively allows for control of stomal aperture (Fig. 2B). The band encircles the proximal stomach to create a very small (15- to 20-ml) pouch that effectively restricts the amount of food ingested without re-routing the remainder of the gastrointestinal tract. Adjustments are later performed at the bedside by needle ac-

cessing of the subcutaneous port, which is sutured to the abdominal wall fascia.

The gastric band procedure is performed under a general anesthetic. The laparoscopic approach is standard, with a very low reported conversion rate to an open procedure (0–3.1%) (31–33). Among all bariatric procedures, mortality is the lowest following gastric band (0–0.7%) (34,35). Although early complica-



**Figure 2**—Restrictive procedures. A: Vertical banded gastroplasty (purely restrictive); B: Laparoscopic adjustable gastric band (purely restrictive); and C: Roux-en-Y gastric bypass (primarily restrictive).

tions are uncommon, late complications may be seen. One to 13% of patients will require revision of their band (33,36,37). Band prolapse or slipping of the band from its intended site may occur in 2–14.2% of patients (31,38). Erosion of the band into the gastric wall may occur in as many as 2.8% of patients (34).

Despite international data demonstrating acceptable weight loss and improvement of comorbid conditions, the device has only been slowly adopted in the U.S. Early U.S. data were discouraging both in terms of weight loss and complications. These initial outcomes may have been somewhat tainted because U.S. surgeons were working to determine the optimal operative technique and follow-up regimen. A growing body of evidence suggests that U.S. patients may expect outcomes similar to those attained worldwide (39). More recent trials show improved weight loss with decreased complication rates. Average excess weight loss has been reportedly 34.5–58% at 12 months, 36–87% at 24 months, 36.2–64% at 36 months, and 44–58.8% at 48 months (32,38,40,41). An emerging series (42) demonstrates that weight loss appears to have long-term durability. In addition to weight loss, improvement in comorbidities (asthma, triglyceridemia, and hypertension) has been established following gastric banding (43). Type 2 diabetes resolves in 54–65% of patients, with demonstrable improvement in both insulin sensitivity and  $\beta$ -cell function (44–46). As a result of both international and U.S. efforts, the adjustable gastric band is emerging as a safe and effective alternative to other operations in the treatment of morbidly obese patients.

### Gastric bypass

Since its conception in 1967, the gastric bypass has undergone a number of technical refinements (47). More recently, surgeons have applied laparoscopic techniques to accomplish the same procedure in an effort to reduce pain, incisional hernia, and wound infection and improve quality of life (48,49). In its current form, the operation entails creation of a very small pouch that is divided from the remainder of the stomach (Fig. 2C). This effectively restricts the size of a meal that a patient is able to ingest. Additionally, the configuration of the intestinal reconstruction bypasses a portion of the intestine, creating some degree malabsorption, and

may result in dumping symptoms. The later phenomenon may occur following ingestion of a meal high in carbohydrates and may result in diaphoresis, nausea, palpitations, diarrhea, abdominal pain, or lightheadedness (50). For patients struggling to avoid sweets, this negative reinforcement may be advantageous. In addition, more recent studies show that changes in metabolically important gut hormones such as ghrelin occur after gastric bypass. Bypassing of the fundus of the stomach, which is the major production site of the orexigenic hormone ghrelin, results in a significant decrease in its serum level and, in turn, the patient's appetite (51,52). Such a decrease in ghrelin levels has not been observed in other bariatric procedures (53). Thus, in addition to physically restricting the amount of food ingested, gastric bypass may provide other mechanisms of weight loss.

Complications reported by bariatric surgical centers demonstrate a mortality rate of 1% and an early complication rate of 10% following gastric bypass (16). Frequent complications may include gastrointestinal leak, thromboembolic events, bleeding, anastomotic stricture, incisional or internal hernia, marginal ulceration, vitamin and protein malnutrition, gallstone formation, and wound infection (Table 4). Many such complications following laparoscopic gastric bypass may be reduced once the surgeon has ascended the significant "learning curve" necessary to master the technical demands of the procedure (54). Furthermore, the potential for long-term vitamin and mineral abnormalities necessitates life-long follow-up of patients in order to avoid deficiencies in calcium, iron, thiamine, folate, and vitamin B<sub>12</sub>.

Maintenance of long-term weight loss has been well documented following gastric bypass. Although only short-term data are currently available following laparoscopic gastric bypass (68–80% excess weight loss at 12–60 months), durable long-term excess weight loss has been described following open gastric bypass (49–62% excess weight loss at 10–14 years) (55–60). Resolution of comorbid conditions following gastric bypass has been well established (Table 5). The majority of patients with type 2 diabetes (82.9%) or glucose intolerance (98.7%) will experience normalization of glucose, HbA<sub>1c</sub>, and insulin levels (56). Other comorbid conditions, such as hyperten-

**Table 4—Complications following weight loss surgery**

Laparoscopic gastric bypass	
Anastomotic leak	0–4.4%
Deep vein thrombosis/ pulmonary embolism	0–1.3%
Symptomatic cholelithiasis	0–3.8%
Bleeding	0.6–4%
Anastomotic stricture	2.0–11.4%
Bowel obstruction	2.9–10.5%
Incisional hernia	0–1.8%
Wound infection	0–8.7%
Internal hernia	
Conversion to open procedure	0–8%
Mortality	0–3.3%
Laparoscopic adjustable gastric band	
Gastric prolapse	2.2–24%
Gastric outlet obstruction	0–14%
Esophageal dilation	0–71%
Gastric band erosion	0–2.8%
Device leak	0.4–7%
Infection	0.3–8.8%
Need for revision	1–13.5%
Conversion to open procedure	0–3.1%
Mortality	0–0.7%

Data from selected series data (31–35,37,41,57–61,63–72).

sion (52–91.5%), sleep apnea (74–97.8%), and hypercholesterolemia (63–97%), also have been noted to resolve (57,58,61).

All weight loss surgical procedures achieve profound weight loss in morbidly obese patients, regardless of their mechanism of action. The extent weight loss is far greater than most medical therapies

**Table 5—Outcomes following laparoscopic gastric bypass**

Excess weight loss (>12 months)	68–80.4%
Resolution of type 2 diabetes	50–98%
Resolution of hypertension	36–70%
Resolution of gastroesophageal reflux disease	52–98%
Resolution of stress urinary incontinence	44–88%
Resolution of obstructive sleep apnea	74–100%
Resolution of hypercholes- terolemia	63%
Improvement in osteoarthritis pain	41–76%

Data from selected series data (31–35,37,41,57–61,63–72).



can provide and is usually more than adequate to reverse many of the comorbid conditions found in these patients. Roux-en-Y gastric bypass has been shown by numerous studies to improve or resolve glucose intolerance and type 2 diabetes in the majority of patients. Such improvement often occurs almost immediately following surgery and well before weight loss is observed (56,62). Bypassing of the foregut area (body of stomach, duodenum, and proximal jejunum) appears to be the key anatomical change associated with such rapid improvement in insulin sensitivity. Gastric banding also results in significant improvement and resolution of glucose intolerance and diabetes; however, such improvement is usually gradual and is associated with weight loss (46). From these observations, it is clear that interruption of intestinal signaling may help explain the rapid resolution in diabetes following gastric bypass in contrast to purely restrictive procedures such as the vertical banded gastroplasty or gastric band.

Until medical and pharmacologic therapies are developed to better address the growing obesity epidemic, surgical solutions are the best option for many morbidly obese patients. Future research emphasis is necessary to optimize postoperative outcomes and to further improve patient safety.

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