Morbid obesity is a serious health problem that carries substantial morbidity and mortality. Obesity is defined as a body weight exceeding ideal body weight (IBW) by 20%, or a body mass index (BMI) of 30 kg to 35 kg/m². Morbidly obese individuals exceed IBW by 100 pounds or more, or are 100% over IBW. In 1991, the National Institutes of Health defined morbid obesity as a BMI of greater than 35 kg/m² with severe obesity-related comorbidity, or a BMI of greater than 40 kg/m² without comorbidity [1]. Superobesity is defined as a body weight exceeding IBW by 225% or more, or a BMI of greater than 50 kg/m².

Clinical presentation

There are a vast number of obesity-related comorbidities, which encompass virtually every organ system (Box 1).

The morbidly obese often present with chronic weight-related problems such as migraine headaches, back and lower extremity joint pain from degenerative joint disease, venous stasis ulcers, dyspnea on exertion, biliary colic, stress urinary incontinence, dysmenorrhea, infertility, gastroesophageal reflux, and inguinal, umbilical, and incisional hernias [2].

Preoperative screening for obesity surgery

The goal of preoperative screening is to identify patients with morbid obesity who are potential candidates for bariatric surgery and who are willing to commit to the postoperative lifestyle changes and follow-up. It may be helpful in detecting serious medical disorders heretofore unrecognized.

Patients with a BMI of greater than 35 kg/m² and weight-related comorbidity or those with a BMI of greater than 40 kg/m² without comorbidity are eligible for bariatric surgery. They must have attempted weight loss in the past by nonsurgical methods. Furthermore, they must be motivated to comply with postoperative dietary programs, vitamin supplementation, exercise regimens, and frequent follow-up. Traditionally, surgeons offered obesity surgery to adults aged 18 to 60 years. However, bariatric surgery is now offered to older adults at some institutions with no increase in morbidity or mortality. Adolescent patients with morbid obesity may be considered for bariatric surgery under select circumstances.

All patients should have a thorough history and physical examination. Important studies include a complete blood count, routine chemistries, electrolytes, blood urea nitrogen and serum creatinine, coagulation studies, lipid profile, blood type and screen, urinalysis, chest X-ray, and electrocardiogram. A urine pregnancy test and gynecologic examination with Pap smear should be obtained for females. Patients who will undergo gastric bypass or biliopancreatic bypass should have serum iron, total iron-binding capacity, vitamin B₁₂, and folate levels assessed preoperatively.
A number of previously unrecognized medical disorders may be discovered during preoperative screening for obesity surgery. Preoperative testing should be performed and additional studies should be considered depending on the patient’s comorbidities. Thyroid function tests and hemoglobin A1C levels are obtained to exclude hypothyroidism and diabetes mellitus. A right upper quadrant ultrasound is obtained to rule out gallstones.

The morbidly obese have an increased risk of hypertension, coronary artery disease, left ventricular hypertrophy, and congestive heart failure. A preoperative electrocardiogram should be obtained for all patients. Patients with cardiovascular disease should have preoperative cardiology evaluation. Echocardiography, stress testing, and cardiac catheterization may be indicated for some patients.

The presence of loud snoring or daytime hypersomnolence should prompt a work-up for respiratory insufficiency of obesity. The diagnosis is established by polysomnography. Patients with significant sleep apnea are treated with nasal continuous positive airway pressure. These patients should be monitored closely for acute upper airway obstruction in the postoperative period. Obesity hypoventilation syndrome is characterized by hypoxemia and hypercarbia with severe pulmonary hypertension and polycythemia. Patients diagnosed with obstructive sleep apnea, obesity hypoventilation syndrome, or severe asthma should have a preoperative pulmonary evaluation.

Patients with gastroesophageal reflux should undergo upper endoscopy with possible biopsy to rule out esophagitis or Barrett’s esophagus and to exclude distal gastric disease. Colorectal cancer screening is important because of an increased risk for this disease in morbid obesity.

Varicose veins and venous stasis disease may represent an underlying tendency for deep venous thrombosis or a hypercoagulable disorder. Ultraso-
nography of the abdomen may reveal cholelithiasis or fatty liver disease.

Nutritional evaluation and education are invaluable in the preoperative period. The dietitian may help determine whether the patient understands the necessary changes in postoperative eating habits and food choices.

Routine preoperative psychiatric assessment is required for patients with a history of psychiatric disease or for those taking psychotropic medications. However, whether psychiatric screening is necessary for all bariatric surgical candidates is a matter of debate. A preoperative psychiatric evaluation may help determine whether patients understand and are prepared to handle the potential psychological changes and altered interpersonal relationships that may accompany rapid surgically induced weight loss. Furthermore, it may help to diagnose patients with depression or psychotic disorders that were previously unrecognized and may require intervention.

**Mechanism of action of bariatric surgery**

Restrictive operations restrict the amount of food intake by reducing the quantity of food that can be consumed at a time. This restriction results in a reduction in caloric intake. Malabsorptive procedures limit the absorption of nutrients and calories from ingested food by bypassing the duodenum and predetermined lengths of small intestine.

Gastric restrictive procedures include vertical banded gastroplasty and gastric banding. Malabsorptive procedures include long-limb gastric bypass, biliopancreatic diversion, and biliopancreatic diversion with duodenal switch. The gastric bypass has features of both restriction and malabsorption. The advent of laparoscopic techniques in the 1990s allowed surgeons to offer minimally invasive approaches to these bariatric procedures.

**Efficacy**

Overall, surgery provides the most effective method of achieving durable, medically significant weight loss in the morbidly obese. In 1991, the National Institutes of Health Consensus Development Conference stated that surgical therapy should be offered to morbidly obese patients who have failed nonsurgical programs for weight loss [1]. The operations advocated at that time were gastric bypass and vertical banded gastroplasty. In an update in 1996, the panel reaffirmed that “surgery remains the only effective treatment for patients with morbid obesity” [3].

**Vertical banded gastroplasty**

**Mechanism of action**

The vertical banded gastroplasty (VBG) (Fig. 1) is a restrictive procedure that limits the amount of solid food that can be consumed at once. A proximal gastric pouch empties through a calibrated stoma, which is reinforced by a strip of mesh or silastic ring.

**Method**

Mason [4] first described the VBG in 1982. An Ewald tube is passed into the stomach. An anvil for a circular stapler is held in the lesser sac against the posterior stomach. A trocar is pushed through both walls of the stomach and into the anvil. A 2.5-cm window is created through the proximal stomach with a circular stapler. Four rows of linear staples from the circular opening to the angle of His are fired to create a pouch of 50 mL or smaller. A strip of polypropylene mesh is placed around the lesser curvature channel and is sutured to itself.

Silastic ring gastroplasty was introduced in 1981. It does not require creation of a circular window in the stomach. A silastic ring is sutured to the distal end of the vertical staple line to restrict pouch outflow [5].

For the laparoscopic VBG, a five-trocar technique is used. A circular stapler is used to create a window through the stomach near the lesser curvature of the stomach. A linear stapler is inserted into this opening and is fired along an esophageal bougie to create a divided staple line leading to the angle of His. A band of polypropylene mesh is sutured around the gastric pouch [6]. Another technique involves use of a linear...
cutting stapler to excise a wedge of fundus, thereby creating a 20-mL pouch. A polypropylene mesh band is sutured around the end of the gastroplasty [7,8].

Results

VBG achieves acceptable weight loss results. In Mason’s [9] study of long-term results following VBG, 250 patients followed for 5 years had a mean excess weight loss (EWL) of 60% for the morbidly obese and 52% for the superobese. In Naslund’s [10] series of 60 laparoscopic VBG patients, mean preoperative BMI was 44.4 kg/m² and mean follow-up was 23 months. Fifteen patients were converted to an open procedure. Mean postoperative BMI was 37 kg/m² for both the laparoscopic and open patients.

A significant number of VBG patients have required reoperation [11]. In a study from Spain, 25% of 100 patients followed for a minimum of 5 years required reoperation for complications [12]. A prospective study of 71 patients who underwent VBG with 99% 10-year follow-up reported that only 26% had maintained a loss of at least 50% of their excess weight, and 17% had a bariatric reoperation [13]. These studies are pessimistic about the long-term success rate of VBG.

Overall complication rate with VBG is under 10% [14], and mortality rate is 0% to 0.38% [15,16]. Early complications include splenectomy (0.3%) and peritonitis from leak (0.6%). Late complications include stomal stenosis [17] and staple line dehiscence, which occurs in up to 48% of patients [18]. Reflux esophagitis may occur in 16% to 38% of patients; patients may require revision to gastric bypass for severe symptoms [19]. Intractable vomiting has been seen in up to 50% [20]. Thirteen to 35% of patients require reoperation following VBG [16,20].

Early complications following laparoscopic VBG include staple line leak in 0.5% to 2% of patients, stomal stenosis (0%–2%), venous thromboembolism (0%–2%), subphrenic abscess (0%–2%), bleeding (0%–1%), and pulmonary complications (0%–3%). Late complications include gastroesophageal reflux (0.5%–12%), band erosion, stomal stenosis (0%–2%), pouch enlargement (0%–2%), and staple line disruption (4%–15%) [10,21].

A randomized, prospective trial comparing laparoscopic with open VBG was reported by Azagra et al [22]. Despite significantly longer operative times for the laparoscopic VBG than for the open VBG, the laparoscopic group had significantly fewer wound infections and incisional hernias. Weight loss was similar in the two groups.

Laparoscopic adjustable gastric banding

Mechanism of action

Laparoscopic adjustable gastric banding (LAGB) (Fig. 2) involves the placement of a silicone band around the proximal stomach to restrict the ingestion of solid food. The amount of restriction can be increased or decreased depending on the patient’s weight loss.

Method

Six trocars are placed. A retrogastric tunnel is created from the lesser curvature to the angle of His. The silicone band is passed around the cardia of the stomach. The tail of the band is passed through the buckle and is locked into place. A calibration tube is reinserted to determine the stoma diameter. Interrupted sutures are placed to secure the stomach to the band. The end of the silicone tube is brought out and is connected to the access port. The port, which will be used postoperatively for injection or withdrawal of saline for band volume adjustment, is secured to the anterior rectus sheath [23,24].

Band adjustment may be performed with fluoroscopic guidance initially at 10 to 12 weeks. Patients are assessed monthly for weight loss and tolerance of oral intake. Band adjustments are made accordingly every 4 to 6 weeks during the first year.

Results

O’Brien et al [25] reported on a series of 700 patients who underwent LAGB. The initial weight was 277 lbs ± 57 lbs and the initial BMI was 45 kg/m² ± 7 kg/m². The mean EWL at 12 and
24 months was 46% and 51% respectively. This result was maintained through 6 years postoperatively. Furthermore, there was resolution or improvement of diabetes, hypertension, asthma, dyslipidemia, reflux esophagitis, and sleep apnea in the majority of patients.

The dramatic weight loss results of LAGB in Australia and Europe have not been duplicated in the United States [26]. Intermediate-term results show a maximum weight loss of 34% to 42% in the United States [27]. EWL from one of the initial United States centers performing LAGB was 18% (range 5%–38%) [28].

Intraoperative complications include splenic injury, esophageal or gastric injury (0%–1%), conversion to open (1%–2%), and bleeding (0%–1%). Early postoperative complications include bleeding (0.5%), wound infection (0%–1%), and food intolerance (0%–11%). Late complications include band slippage (7.3%–21%), band erosion (1.9%–7.5%), tubing problems (4.2%), leakage of the reservoir, persistent vomiting (13%), pouch dilatation (5.2%), and gastroesophageal reflux [29,30]. Fixation of the band to the stomach has reduced the incidence of postoperative gastric prolapse.

In O’Brien’s [25] series of 700 patients, seven patients were converted to an open procedure. There were no mortalities. There were 10 significant adverse events (1.4%): seven port-site infections (1%), one deep venous thrombosis, one occurrence of hepatotoxicity, and one prolonged hospital stay because of failure of gastric emptying. Late complications requiring reoperation included gastric prolapse (15.1%), band erosions into the stomach (3.2%), and complications related to the tubing (4.7%). Among the patients requiring reoperation, 12 (1.7%) had the device removed.

In the Food and Drug Administration trial of the Lap-Band, which was initiated in the United States in 1995, the rate of reoperation for band slippage and removal of the band was significantly higher than that reported by investigators in Europe and Australia. DeMaria et al [28] removed 41% of bands from 37 patients, most commonly because of inadequate weight loss. Seventy-two percent had dysphagia, vomiting, or reflux.

Pseudoachalasia following laparoscopic adjustable gastric band placement has been reported in 9 out of 120 patients from Switzerland, despite normal band position and stomal size [31]. Esophageal motility may be adversely affected by the band, manifesting as impairment of lower esophageal sphincter relaxation and abnormal esophageal peristalsis [32].

**Biliopancreatic diversion**

**Mechanism of action**

The biliopancreatic diversion (BPD) (Fig. 3) combines gastric restriction with an intestinal malabsorptive procedure.

**Method**

For the BPD, a 50-cm common absorptive channel is created proximal to the ileocecal valve; digestion and absorption are limited to this segment of bowel. A distal gastrectomy is performed and a 200-cm alimentary limb is connected to the stomach, which has a residual volume of between 200 cm and 500 cm [33].

Marceau [34] reported a modification of the BPD by lengthening the common channel to 100 cm and using a sleeve gastrectomy with duodenal switch instead of a distal gastrectomy (Fig. 4). Maintenance of the continuity of the antrum, pylorus, and first portion of the duodenum allows for a lower marginal ulcer rate (0%–1%) and a lower incidence of dumping syndrome.

Ren et al [35] first described the laparoscopic BPD with duodenal switch. A 150-mL to 250-mL sleeve gastrectomy is performed. A Roux-en-Y anastomosis is created 100 cm proximal to the ileocecal valve, and an alimentary limb of 150 cm of small intestine is anastomosed to the gastric pouch with a 2-cm to 3-cm stoma. A concomitant cholecystectomy is performed because of the high incidence of postoperative cholelithiasis with this degree of malabsorption.

Six to eight laparoscopic ports are inserted. A sleeve gastrectomy is performed to create a gastric reservoir of 150 mL to 200 mL. To perform the BPD with duodenal switch, the continuity of the antrum,
pylorus, and first portion of the duodenum is maintained. The ileum is divided 250 cm proximal to the ileocecal valve and is anastomosed to the stomach. A Roux-en-Y anastomosis is created, leaving a common channel 100 cm long.

Results

Weight loss results with BPD are excellent and durable. At 8 years, patients weighing up to 120% of ideal body weight and those weighing more than 120% of ideal body weight maintained 72% and 77% mean EWL, respectively. A group of 40 patients had a mean EWL of 70% for a 15-year period [33].

The results of laparoscopic BPD with duodenal switch in 40 patients with a mean follow-up of 12 months were reported [34]. There was one conversion to open procedure (2.5%). The mean EWL at 6 and 9 months was 46% ± 2% and 58% ± 3% respectively, with a median follow-up of 6 months.

The incidence of postoperative complications is quite high following BPD. The most common morbidities include anemia (30%), protein-calorie malnutrition (20%), dumping syndrome, and marginal ulceration (10%). The duodenal switch modification is associated with a lower ulceration rate (1%) and a lower incidence of dumping syndrome. Other complications include vitamin B12 deficiency, hypocalcemia, fat-soluble vitamin deficiencies, osteoporosis, night blindness, and prolongation of prothrombin time. The postoperative mortality rate ranges from 0.4% to 0.8%.

From Scopinaro’s series [33], early surgical complications included wound infection and dehiscence (1.2%). Late complications included incisional hernia (8.7%), intestinal obstruction (1.2%), protein malnutrition (7%), iron deficiency anemia (< 5%), stomal ulcer (2.8%), and acute biliopancreatic limb obstruction. Bone demineralization was seen in 25% of patients preoperatively; at 1 to 2 years, it was observed in 29%. At 3 to 5 years it was present in 53%, and at 6 to 10 years in 14%.

In the series from Ren et al [35], there was one death (2.5%). Major morbidity rate was 15%, including anastomotic leak (2.5%), venous thrombosis (2.5%), staple-line hemorrhage (10%), and subphrenic abscess (2.5%).

Roux-en-Y gastric bypass

Mechanism of action

Roux-en-Y gastric bypass (RYGBP) (Fig. 5) is both a gastric restrictive procedure and a mildly malabsorptive procedure [36]. A small gastric pouch restricts food intake while the Roux-en-Y configuration provides malabsorption of calories and nutrients.

Method

The abdomen is entered through a midline incision [37]. A 28 French red rubber tube is placed...
behind the stomach, and the open end of the tube is then brought through the opening in the mesentery. The red rubber tube is used to guide a 90-mm linear stapler across the stomach. Three superimposed staple lines are applied so as to create a proximal pouch of 15 mL to 30 mL. Some surgeons advocate dividing the stomach rather than leaving it in continuity.

The ligament of Treitz and a point 15 cm to 45 cm distally are identified. The jejunum is divided with a linear stapler. A side-to-side jejunoejunostomy is created with a linear stapler to create a 45-cm to 75-cm Roux limb for a standard gastric bypass or a 150-cm limb for a long-limb bypass in the superobese.

A 1-cm gastrojejunal anastomosis is created between the gastric pouch and the jejunum using a circular stapler or a handsewn, two-layer technique. The integrity of the anastomosis is tested by injecting methylene blue or air into a nasogastric tube. Some surgeons opt for banding of the pouch with a silicone band [38,39]. The mesenteric defects are sutured closed, namely the transverse mesocolon opening and the space behind the Roux limb that would cause a Petersen hernia [2].

Laparoscopic RYGBP was first described by Wittgrove et al [40] in 1993. After pneumoperitoneum is established, five or six access ports are inserted. A gastric pouch measuring 15 mL to 30 mL is created using sequential applications of a linear endoscopic stapler.

The ligament of Treitz is identified, and the jejunum is divided with a linear stapler. A 75-cm to 150-cm Roux limb is constructed and a side-to-side jejunoejunostomy is created with linear endoscopic staplers. Some groups use an elongated Roux limb of 150 cm to 250 cm for superobese.

The gastrojejunal anastomosis may be linear stapled, circular stapled, or handsewn [40–45]. The Roux limb may be passed either antecolic or retrocolic, and antegastric or antecolic [40–45].

Insufflation of the gastric pouch with air by endoscopy or via nasogastric tube is performed to test the integrity of the anastomosis, which is submerged in irrigation fluid. Alternately, methylene blue may be irrigated into a nasogastric tube. Port sites larger than 5 mm are closed at the fascial level.

**Results**

RYGBP results in weight loss that is superior to purely restrictive operations. Five-year weight loss results have ranged from 48% to 74% EWL [1]. Prospective, randomized trials have shown that GBP achieves better weight loss results than VBG. A randomized, prospective trial of VBG compared with GBP demonstrated a 37% mean EWL with VBG compared with 64% for GBP at 3 years [37]. “Sweets eaters” had a poorer result following VBG than GBP and also lost significantly less weight than “non-sweets eaters” following VBG. In 1996 the National Institutes of Health Consensus Conference stated that their previous endorsement of VBG may have been “premature” and that the long-term results of VBG were “disappointing” [3].

In the literature, the mean EWL for laparoscopic GBP ranges from 69% to 82% with follow-up of 24 months or less. Wittgrove’s [40] series had a mean EWL of 73% with follow-up of 60 months. In Schauer’s [41] study of 275 patients who underwent laparoscopic GBP, the mean EWL was 83% at 24 months and 77% at 30 months. Most comorbidities were improved or eradicated, including diabetes mellitus, hypertension, sleep apnea, and reflux. Quality of life was improved significantly.

Early complications following open GBP include anastomotic leak with peritonitis (1.2%), acute distal gastric dilatation, Roux limb obstruction, severe wound infection (4.4%), and minor wound infection or seroma (11.4%). Late complications include stomal stenosis (15%), marginal ulcer (13%), intestinal obstruction (2%), internal hernia (1%), staple line disruption (0%–1%), incisional hernia (16.9%), cholecystitis (10%), and mortality (0.4%). Metabolic complications include deficiencies of calcium, thiamine, Vitamin B12 (26%–70%), folate (9%–18%), and iron (20%–49%), and anemia (18%–35%).

Postoperative complications for laparoscopic GBP include pulmonary embolism (0%–1.5%), anastomotic leak (1.5%–5.8%), bleeding (0%–3.3%), and pulmonary complications (0%–5.8%). Stenosis of the gastrojejunalostomy is observed in 1.6% to 6.3%. Other complications include internal hernia (2.5%), gallstones (1.4%), marginal ulcer (1.4%), and staple-line failure (1%). Conversion to open procedure occurs in 3% to 9%. Mortality rate is 0% to 1.5% [40,41,44].

Dumping syndrome occurs in a variable number of patients following GBP. It is due to rapid emptying of hyperosmolar boluses into the small bowel. Patients may experience bloating, nausea, diarrhea, chest pain, and abdominal pain after consuming sweets or milk products. Vasomotor symptoms such as palpitations, profuse sweating, and lightheadedness may also occur. Dumping syndrome may provide a beneficial effect in promoting weight loss by causing patients to avoid sweets.
Perioperative care

Prophylactic intravenous antibiotics (e.g., cefotetan) are administered in the holding area before surgery. Mechanical and antibiotic bowel preparation may further reduce the incidence of infectious complications.

Endotracheal intubation and intravenous access may be challenging in bariatric surgery patients. Fiber-optic intubation may be required for airway access.

Cardiac monitoring is recommended in patients with preoperative arrhythmias or cardiac disease. Intensive care unit monitoring is preferred in patients with obesity hypoventilation syndrome.

Postoperative ambulation is initiated early for prevention of atelectasis and pneumonia. Incentive spirometry, deep breathing, and coughing are also encouraged. Patients should be monitored with continuous pulse oximetry for the first 24 hours after surgery. Sleep apnea patients should have continuous positive airway pressure (CPAP) administered postoperatively.

For prevention of deep venous thrombosis and pulmonary embolism, bilateral sequential compression devices are applied to the lower extremities, and perioperative subcutaneous unfractionated heparin or low-molecular weight heparin is administered. Early mobilization is critical for prevention of thrombotic complications.

Oral liquid diet is initiated after a gastrograffin swallow confirms the absence of an anastomotic leak. After a variable period of time, the diet is advanced to a purée diet and gradually to soft and then solid food.

The bariatric patient’s medications may need to be adjusted early in the postoperative period. Diabetic patients should have frequent blood glucose checks. Their requirement for oral hypoglycemic agents or subcutaneous insulin commonly decreases early in the postoperative period. There is frequent improvement or complete resolution of hypertension, gastroesophageal reflux, dyslipidemia, and sleep apnea.

RYGBP has been demonstrated not only to prevent the progression of non-insulin dependent diabetes mellitus but also to reduce the mortality from diabetes mellitus, primarily through a reduction in the number of deaths from cardiovascular disease [46,47]. Durable control of diabetes mellitus is achieved following GBP, along with amelioration or resolution of other comorbidities such as hypertension, sleep apnea, and cardiopulmonary failure.

Other obesity-related medical illnesses that have shown improvement or resolution following diabetes mellitus include hyperlipidemia, hypertension, asthma, osteoarthritis, angina, venous stasis, and obesity-hypoventilation syndrome.

Patients must comply with lifelong follow-up, exercise, and vitamin supplementation after undergoing bariatric surgery. They must significantly alter their eating behavior for life because of their gastrointestinal neoanatomy. Follow-up includes assessment of weight-loss trends, evaluation of compliance with diet, exercise, and vitamin supplementation, and regular monitoring of metabolic and nutritional parameters. Support from family, friends, coworkers, and bariatric surgery support groups may improve outcomes in postoperative patients.

Laparoscopic versus open bariatric surgery

With the laparoscopic RYGBP, there is better cosmesis, less postoperative pain, and attenuation of the postoperative stress response. In a randomized study of laparoscopic versus open RYGBP, the laparoscopic RYGBP patients had a lower intraoperative blood loss, a shorter hospital stay, and a more rapid improvement in quality of life [48]. The laparoscopic approach to RYGBP eliminates the midline laparotomy incision and thus substantially reduces the morbidity from postoperative wound infections, dehiscence, and incisional hernias [41]. Furthermore, there is a significant improvement in postoperative pulmonary function with the laparoscopic RYGBP as compared with the open RYGBP [49].

Summary

Bariatric surgery is a safe and effective method for achieving durable weight loss for patients with morbid obesity. The laparoscopic approach to bariatric surgery has substantially improved postoperative recovery. Careful patient selection and preoperative work-up are extremely important. Patients may be diagnosed with a number of previously unrecognized medical conditions during the preoperative work-up. A high index of suspicion must be exercised in diagnosing postoperative complications. A number of medical comorbidities are improved after surgically induced weight loss.

References


