BARIATRIC SURGERY; RISK AND BENEFIT

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Abstract
Obese patients lose more weight with bariatric surgery than with medical weight loss treatment. The laparoscopic Roux-en-Y gastric bypass procedure results in more short term weight loss than laparoscopic adjustable gastric banding, but the latter has fewer postoperative complication and lower mortality rate; long term comparative data are currently lacking. The decision regarding which procedure to perform should be based on individual patient and surgeon factors. Early complications of gastric bypass surgery are bleeding, anastomotic leak, wound infection, thromboembolism, and anastomotic stricture. Longer term complication scan include marginal ulcers, bowel obstruction, gaulstones, and nutritional deficiencies. Complication of adjustable gastric banding includes prolapsed and erosion. Patient typically loses more than 50% of their excess weight after bariatric surgery. Obesity related diseases markedly improve after bariatric surgery, reducing cardiovascular risk and improving life expectancy. Patient undergoing bariatric surgery must commit to a program of lifestyle changes, diet, vitamin supplementation, and follow-up.

Introduction
Outcome of bariatric surgery are getting better all the time, as surgeons gain experience in performing these technically demanding procedures laparoscopically. The risks are not trivial, but they are acceptably low. The benefits: not only do patients lose weight and keep it off, now there are convincing data that many patients are cured of obesity related diseases, notably type 2 diabetes. In fact, the procedure may pay for itself within a few years by reducing medical costs due to obesity related illness. Best of all, the long term mortality rate seems to be lower for morbidly obese patients who undergo this surgery than for those who do not. Managing obesity related co-morbid conditions is challenging, expensive, and often unsuccessful unless the patient can lose a significant amount of weight. Obesity is now epidemic in the United States, affecting more than 60 million people, and the problem will worsen in coming years as the incidence of childhood and adolescent obesity rises.

Who is eligible for bariatric surgery?
Candidates for bariatric surgery must have a body mass index (BMI) greater than 40 kg/m² or a BMI greater than 35 with significant obesity-related disease, according to the 1991 consensus guidelines from the National Institutes of Health (table I). Table II lists some of the major obesity-related diseases. Typical patients are between the ages of 18 and 60. However, carefully selected older patients and adolescents can also benefit from bariatric surgery, and the current indications will likely broaden as long-term data on various subgroups of patients mature.

Other criteria for surgery: prior attempts to lose weight by non surgical means must have failed, and the patient
must complete a thorough, multidisciplinary preoperative evaluation designed to identify co-morbid conditions so that they can be optimally managed prior to surgery and to identify any contraindications to surgery. Patients must be able to comprehend the significant lifestyle changes required after surgery and comply with the postoperative program of diet, vitamin supplementation, and follow-up.

Patients who cannot tolerate general anesthesia because of cardiac, pulmonary, or hepatic insufficiency cannot undergo bariatric surgery. Patients who have ongoing substance abuse or unstable psychiatric illness are poor candidates.

Most importantly, patients must understand that bariatric surgery is not a quick fix. Rather, it is a very powerful tool that, in conjunction with appropriate food choices and physical activity, can produce significant weight loss, resolve co-morbid conditions, and prolong life.

What procedures are being performed today?
The weight-loss procedures in use today range from placement of an intragastric balloon (the least invasive option) to open biliopancreatic diversion (the most invasive). Bariatric procedures are classified according to their mechanism of action: restrictive, malabsorptive, or a combination of restrictive and malabsorptive (Figure 1).

Restrictive procedures: are so called because the surgeon creates a small gastric pouch with a narrow outlet that restricts the amount of food that the patient can eat at one time. The two restrictive procedures most often performed are vertical banded gastroplasty and laparoscopic adjustable gastric banding.

Vertical banded gastroplasty was developed in 1980 but only 5% of bariatric surgeons still perform it; many patients had long-term complications that necessitated another operation, and long-term weight loss was small. Laparoscopic adjustable gastric banding has the advantage of using an adjustable inner collar that allows one to fine-tune the size of the outlet to minimize side effects and maximize weight loss. It was approved for use in the United States in 2001 and now is the second most commonly performed bariatric procedure, after the Roux-en-Y gastric bypass.

Malabsorptive procedures: bypass a segment of the small intestine so that less food is absorbed. Biliopancreatic diversion was developed in 1979 by Scopinaro et al, and is performed at specialized centers using the open and laparoscopic techniques. The duodenal switch, a modification of the biliopancreatic diversion, was developed to decrease the incidence of dumping symptoms and anastomotic ulceration seen with biliopancreatic diversion. It too can be performed laparoscopically. These procedures are technically demanding to perform, and many patients develop nutritional deficiencies afterward. Therefore, they account for only about 5% of bariatric procedures performed in the United States.

Combination procedures, eg, the Roux en-Y gastric bypass, use both mechanisms to achieve weight loss. In this procedure, which can be performed either laparoscopically or as open surgery, food intake is restricted by creating a small (15–30 mL) gastric pouch, and absorption is limited by bypassing the proximal intestine with a Roux limb (Figure 1). The standard Roux limb is 75 to 150 cm long and bypasses the distal stomach,
duodenum, and a short segment of the jejunum. More than 95% of the small bowel is left intact, so malabsorptive side effects such as diarrhea and protein malabsorption are very uncommon. The Roux-en-Y gastric bypass now accounts for approximately 80% of all bariatric procedures performed in the United States.

**Risk of bariatric surgery**

**Open vs laparoscopic Roux-en-Y gastric bypass**

Laparoscopic bariatric surgery was introduced in 1994 when Wittgrove et al \(^\text{10}\) published the results of their first five Roux-en-Y gastric bypass cases. Since then, several large series of laparoscopic Roux-en-Y gastric bypass cases \(^\text{11-16}\) and three randomized controlled trials \(^\text{17-19}\) comparing laparoscopic and open Roux-en-Y gastric bypass have been published. Each approach poses unique risks. Open surgery results in more postoperative pain, slower return to normal activity, and higher rates of iatrogenic splenectomy and abdominal wall complications (up to 20% of patients have incisional hernias). One review of more than 3,000 gastric bypass cases showed that the laparoscopic approach results in less postoperative pain, better postoperative pulmonary function, and significantly fewer wound complications, but it has higher rates of anastomotic stricture (4.7% vs 0.7%, \(P<.001\)), gastrointestinal bleeding (1.9% vs 0.6%, \(P = .008\)), and late postoperative bowel obstruction (3.1% vs 2.1%, \(P = .02\)) than open surgery \(^\text{20}\). The incidence of anastomotic leak was higher with laparoscopic surgery in some series, but not in the randomized trials or in a comprehensive review of the topic \(^\text{20}\). Laparoscopic surgery takes time to learn, and complication rates with laparoscopic Roux-en-Y gastric bypass tend to decline as surgeons gain experience \(^\text{21}\). With experience, operative time and rates of technical complications such as gastrojejunal anastomotic leak decline to those seen with the open approach.

**Complication of laparoscopic gastric bypass**

**Conversion to open surgery**

In up to 8% of cases, surgery that is started laparoscopically must be completed as an open procedure. However, in experienced hands, this “conversion” rate is less than 5%. In a review of 3,464 laparoscopic gastric bypass procedures (10 series), Podnos et al \(^\text{20}\) found the conversion rate to be 2.2%. The most common reasons for conversion to an open procedure were hepatomegaly, equipment problems, inadequate instrument length, inadequate exposure, injury to the colon or a major blood vessel, and bleeding.

**Bleeding**

Bleeding complications occur in fewer than 4% of patients. Postoperative bleeding can be from mesenteric or omental vessels within the peritoneal cavity or from an anastomosis or staple line. In the laparoscopic Roux-en-Y gastric bypass, the staple or suture lines of the gastrojejunostomy and the jejunojejunostomy can bleed. Postoperative bleeding from the gastrojejunostomy can be diagnosed and managed endoscopically. Bleeding from the excluded gastric remnant can be more difficult to diagnose and treat, since there is no direct endoscopic access to this lumen after gastric bypass. Techniques to decrease the incidence of staple line bleeding include oversewing or buttressing the staple lines.

**Anastomotic leak**

Anastomotic leak is a dreaded complication of Roux-en-Y gastric bypass and carries a mortality rate of up to 30% when it occurs. The incidence after laparoscopic Roux-en-
Y gastric bypass ranges from 0% to 4.4%. Leakage from the gastrojejunal anastomosis can be contained or can result in diffuse peritonitis. Technical failures of the anastomosis manifest in the early postoperative period with rapid clinical deterioration, but most leaks occur around 5 days after surgery and result from perforation of an ischemic area at the anastomosis. Major complications often present with subtle signs in these patients, and physical findings that confirm peritoneal irritation are the exception rather than the rule when an abdominal catastrophe is developing. Often, tachycardia is the only presenting sign of an anastomotic leak. A heart rate greater than 120 should prompt an investigation, even if the patient looks and feels well. Tachypnea or decreasing oxygen saturation can also signal early sepsis from a leak, and this presentation may be clinically indistinguishable from a pulmonary embolism. Surgeons or internists caring for bariatric patients should aggressively evaluate any postoperative fever, tachycardia, or tachypnea, and the patient should return to the operating room early if diagnostic tests are inconclusive but clinical suspicion for a leak is high. If a patient is diagnosed with a contained leak on computed tomography or an upper gastrointestinal study and is clinically stable, nonoperative management with adequate drainage, bowel rest, and antibiotics may be appropriate.

**Wound infection**

Wound infection after laparoscopic Roux-en-Y gastric bypass occurred in fewer than 5% of cases in most series. In a pooled analysis, Podnos et al found that wound infections occurred in 97 (2.9%) of 3,258 laparoscopic cases, compared with 34 (6.6%) of 513 open cases ($P < .001$). Laparoscopic port site infections are easy to manage with a short course of antibiotics and wound care and are less serious than open wound infections. The laparoscopic approach eliminates the risk of wound dehiscence or evisceration.

**Thromboembolism**

Obesity is a risk factor for venous thromboembolism in general surgery patients. The higher the BMI, the higher the risk of venous thromboembolism in patients undergoing abdominal operations, even with low-dose heparin prophylaxis and obesity is an independent predictor of recurrent venous thromboembolism. Morbid obesity is associated with elevated levels of fibrinogen, factor VII, factor VIII, von Willebrand factor, and plasminogen activator inhibitor and some evidence suggests a link between inflammatory mediators, central obesity, and a pro coagulant state.

The rate of deep vein thrombosis after laparoscopic Roux-en-Y gastric bypass with thromboprophylaxis ranges from 0% to 1.3%, and the rate of pulmonary embolism ranges from 0% to 1.1%. Pulmonary embolism and anastomotic leak are two major causes of death after Roux-en-Y gastric bypass, and pulmonary embolism accounts for 50% of postoperative deaths. During laparoscopic surgery the peritoneum is inflated, which increases the abdominal pressure and impedes venous return, increasing the risk of deep vein thrombosis. On the other hand, laparoscopic surgical patients can get up and walk sooner after surgery than patients who undergo open surgery, which should decrease the risk. In pooled data comparing 2,771 open and 3,464 laparoscopic surgical cases, there were no differences in clinically significant thromboembolic events (0.78% vs 0.41%, $P = .09$). Currently, the American College of Chest Physicians (ACCP) recommends routine perioperative thromboprophylaxis for patients at increased risk but provides no specific recommendations for bariatric surgery patients. A survey found that more than 95% of bariatric surgeons used routine deep vein thrombosis prophylaxis and 38% used a combination of two or
more methods of prophylaxis. These patients should be treated as high risk general surgery patients, and should receive thromboprophylaxis according to the ACCP guidelines with low-dose unfractionated heparin 5,000 U twice a day or low-molecular-weight heparin up to 3,400 U once daily (grade 1A evidence) with the addition of leg compression devices if multiple risk factors are present (grade 1C evidence). Preoperative placement of inferior vena cava filters in high-risk bariatric patients is controversial, but it should be considered in patients with known risk factors for fatal pulmonary embolism including venous stasis disease, obesity hypoventilation syndrome, BMI 60 or greater, prior thromboembolism, or a known hypercoagulable state.

Anastomotic strictures
Anastomotic strictures develop at the gastrojejunostomy after laparoscopic Roux-en-Y gastric bypass in 2% to 16% of cases. The rate of this complication largely depends on the surgeon's experience and the technique used to create the anastomosis. The gastrojejunostomy can be hand-sewn (resulting in the lowest stricture rate) or created with a linear stapler or a circular stapler (resulting in the highest stricture rate). Larger studies (with >100 patients) reported stricture rates of less than 6%; these series included all three techniques.

Strictures typically present within the first 3 months after surgery with nausea and vomiting. Most strictures result either from ischemia at the anastomosis due to tension on the Roux limb or are associated with a marginal ulcer. About 85% of anastomotic strictures are managed with a single endoscopic dilation. Seventeen percent require a second dilation, and in a study by Nguyen et al., only 1 of 29 patients with a stricture required a third endoscopic dilation.

Marginal ulcers
Marginal ulcers are postsurgical ulcers that occur at the gastrojejunal anastomosis, usually on the jejunal side. Marginal ulcers may be related to tension or ischemia on the anastomosis and have also been associated with foreign material (staples or non-absorbable sutures), nonsteroidal anti-inflammatory drug (NSAID) use, excessive acid exposure in the gastric pouch due to gastrogastrosopic fistula, and smoking. Patients present with abdominal pain, vomiting, and bleeding or anemia. The incidence of marginal ulcer after laparoscopic Roux-en-Y gastric bypass surgery ranges from 0.7% to 5.1%. This complication is treated with acid suppression therapy and by stopping the offending agent (NSAID, tobacco). Rarely, anastomotic revision is required for a refractory ulcer.

Bowel obstruction
Bowel obstruction after Roux-en-Y gastric bypass can result from adhesions or internal hernias. Fewer intra-abdominal adhesions form after laparoscopic surgery, presumably because there is less tissue trauma and bowel manipulation; this may allow for more internal hernias to develop in a laparoscopic approach (due to fewer adhesions, more mobile loops of bowel that can herniate through a mesenteric defect or band) but may decrease the incidence of adhesive obstructions compared with an open procedure.

In 10 large laparoscopic Roux-en-Y gastric bypass series, bowel obstruction occurred in 3% of patients. To reduce the incidence of internal hernias, the mesenteric defects are carefully closed during the procedure. Patients with intermittent, crampy abdominal pain that occurs months to years after gastric bypass should be referred back to their bariatric surgeons for evaluation. We typically perform exploratory laparoscopic surgery in these patients to look for mesenteric defects or internal hernias.

Cholelithiasis is common
Weight loss after gastric bypass surgery is accompanied by a rise in
incidence of gallstones: 38% to 52% of patients develop stones within 1 year of surgery.\textsuperscript{33,34} Between 15% and 28% of all patients, irrespective of gallstone status at the time of gastric bypass, require urgent cholecystectomy within 3 years.

Symptomatic cholelithiasis at the time of laparoscopic Roux-en-Y gastric bypass is an indication for cholecystectomy during the bypass procedure. In patients with asymptomatic cholelithiasis or no gallstones, however, this practice remains controversial.\textsuperscript{35,36}

Some surgeons advocate prophylactic cholecystectomy at the time of laparoscopic Roux-en-Y gastric bypass for all patients, due to the high incidence of undiagnosed gallbladder disease (sludge, cholesterolosis, undetected cholelithiasis) in this patient population.\textsuperscript{35} The disadvantages of this approach include the potential of performing an unnecessary procedure and the risks (bleeding, bile duct injury, prolonged operative time) of performing a concomitant procedure in a morbidly obese patient. Hamad et al.\textsuperscript{37} confirmed the safety of performing combined laparoscopic cholecystectomy and gastric bypass in patients with asymptomatic cholelithiasis, but patients undergoing the combined procedure had an operative time that was 50 minutes longer and a hospital stay nearly twice as long compared with patients who underwent laparoscopic Roux-en-Y gastric bypass only.

Patients with asymptomatic stones are observed, and those without cholelithiasis are prescribed ursodiol 600 mg daily by mouth for the first 6 months after the procedure, which significantly reduces the incidence of gallstone formation (2% vs 32% with placebo, P < .01).\textsuperscript{33}

**Nutritional deficiencies**

Because the stomach and duodenum are bypassed, iron, vitamin B\textsubscript{12}, and other micronutrient deficiencies can occur after standard gastric bypass.\textsuperscript{38} Taking a single multivitamin tablet alone is insufficient to prevent iron and vitamin B\textsubscript{12} deficiencies after laparoscopic Roux-en-Y gastric bypass. Iron deficiency occurs in 13% to 52% of patients within 2 to 5 years after surgery, and supplementation with iron can reduce iron deficiency significantly. Up to 37% of patients who are prescribed a multivitamin after surgery still develop vitamin B\textsubscript{12} deficiency. Once a specific deficiency is identified during follow-up, additional supplementation is indicated. Calcium absorption in the duodenum and jejunum and vitamin D absorption in the jejunum and ileum are impaired after Roux-en-Y gastric bypass as well. Calcium deficiencies can occur in up to 10% of patients, and vitamin D deficiency in up to 51%, depending on the length of the bypass.\textsuperscript{38} These deficiencies can lead to secondary hyperparathyroidism and can result in increased bone turnover and decreased bone mass as early as 3 to 9 months after surgery.\textsuperscript{39}

Series that reported nutritional deficiencies after gastric bypass varied greatly in terms of vitamin supplementation regimens. In a survey of 109 bariatric surgeons,\textsuperscript{40} 96% said they prescribed multivitamins after Roux-en-Y gastric bypass, 63% prescribed iron, and 49% prescribed vitamin B\textsubscript{12}. Surveillance for deficiencies and patient compliance vary as well, although most bariatric surgeons recommend annual blood testing. They obtain a complete blood count and iron and B\textsubscript{12} levels before surgery, 6 months and 1 year after surgery, and yearly thereafter. They recommend routine daily supplementation with a multivitamin, iron, vitamin B\textsubscript{12}, and calcium.

**Perioperative mortality**

Buchwald et al.\textsuperscript{3} performed a meta-analysis of 136 studies that included 22,094 patients who underwent restrictive, malabsorptive, or gastric bypass procedures (open and laparoscopic). The 30-day mortality rate for gastric bypass was 0.5%. The three randomized trials comparing open
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and laparoscopic Roux-en-Y gastric bypass showed no difference in mortality rates. Podnos et al. in their review found a lower mortality rate in laparoscopic patients. In laparoscopic Roux-en-Y gastric bypass series with more than 100 patients, the mortality rate ranged from 0% to 0.9%. The risk of death after gastric bypass surgery increases with age. Livingston et al. found that patient's older than 55 years had a threefold higher mortality rate compared with younger patients, despite similar complication rates. Sepsis was the leading cause of death in the older patients.

In a review of 16, 155 Medicare patients who underwent bariatric surgery (81% Roux-Y gastric bypass), Flum et al. found that older age, male sex, and lower surgeon volume were associated with a higher risk of early death. Overall, the 30-day all-cause mortality rate was 2.0%, and the 90-day rate was 2.8%. For patients older than 65 years, these rates increased to 4.8% and 6.9%, respectively, and were significantly higher than in younger patients (1.7% and 2.3%). This increase in risk after age 65 is consistent with that after other major gastrointestinal and cardiovascular operations. A review of 60,077 Californians who underwent Roux-en-Y gastric bypass between 1995 and 2004 demonstrated mortality rates more consistent with published case series (0.33% at 30 days and 0.91% at 1 year).

Complication of laparoscopic adjustable gastric banding

The risk of death with laparoscopic adjustable gastric banding is the lowest for any bariatric surgery performed today, making it an attractive option for many surgeons and patients. In the meta-analysis of Buchwald et al., all restrictive procedures had an operative mortality rate (≤30 days) of 0.1%. In a review of the international literature, Chapman et al. compared the safety and efficacy of laparoscopic adjustable gastric banding, vertical banded gastroplasty, and Roux-en-Y gastric bypass. The operative mortality rate was 0.05% for laparoscopic adjustable gastric banding, compared with 0.5% for Roux-en-Y gastric bypass.

Early postoperative complications occur in 0.8% to 12% of patients. Bleeding after laparoscopic adjustable gastric banding is rare, occurring in only 0.1% of cases. Given that no anastomoses are formed during this procedure, no anastomotic leaks can form. Iatrogenic bowel perforation during the procedure occurs in 0.5% of cases. Wound infection rates are similar to those with laparoscopic Roux-en-Y gastric bypass and, like other laparoscopic wound infections, are easily managed with minimal morbidity. The risks of deep vein thrombosis (0.01%-0.15%) or pulmonary embolism (0.1%) after laparoscopic gastric banding are lower than for other bariatric procedures. This may be related to patient selection or shorter operative times.

However, band-related complications can occur in the early postoperative period or years after the procedure. The placement of a silicone prosthesis in the abdomen carries with it a unique set of mechanical complications not seen with other bariatric procedures. The range of complication rates reported in selected large case series of laparoscopic adjustable gastric banding is shown in Table 3.

In a systematic review of the international literature that included 64 studies and 8,504 patients, Chapman et al. reported tube or port malfunction requiring reoperation in 1.7% of cases, band erosion into the gastric lumen in 0.6%, and pouch dilation or band slippage in 5.6%. Overall, complications requiring reoperation can occur in up to 18% of patients, but complications decrease as experience with this procedure increases.

In a series of 1,120 patients, O'Brien and Dixon reported a low incidence of early major complications (1.5%) but higher rates of late complications. Prolapse occurred in 25% and erosion occurred in 3% of their first 500 patients. In their last 600 patients,
prolapse occurred in 4.7% of patients and there were no erosions. Table 3 compares complication rates in large case series of laparoscopic Roux-en-Y gastric bypass and laparoscopic adjustable gastric banding.

Benefits of bariatric surgery

Weight loss

Weight loss after bariatric surgery is typically expressed as the percentage of excess weight lost—excess weight defined as the number of pounds above the patient’s ideal body weight. In the meta-analysis of Buchwald et al., excess weight loss for all bariatric procedures combined was 61%. Analyzed by procedure, excess weight loss was highest after biliopancreatic diversion (70%), followed by gastropasty (68%), gastric bypass (62%), and gastric banding (48%). Excess weight loss at 1 to 5 years after laparoscopic Roux-en-Y gastric bypass is similar to that with the open procedure and ranges from 68% to 80%. Durable weight loss after open Roux-en-Y gastric bypass has been demonstrated up to 14 years. Superobese patients (BMI > 50) have less excess weight loss than patients with lower BMIs after standard Roux-en-Y gastric bypass. Excess weight loss after Roux-en-Y gastric bypass and laparoscopic adjustable gastric banding is shown in Table 4.

Patients typically lose less weight after laparoscopic adjustable gastric banding than after laparoscopic Roux-en-Y gastric bypass and lose it more gradually (the peak excess weight loss is at 2 to 3 years vs 12 to 18 months with laparoscopic Roux-en-Y gastric bypass). However, Chapman et al. reviewed the international literature and found that weight loss at 4 years was similar with both procedures. The success with laparoscopic adjustable gastric banding in Europe and Australia was not reproduced in most early US trials. Some recent US studies of laparoscopic adjustable gastric banding have approached the success rates seen in international studies, though, including a report of 1,014 laparoscopic adjustable gastric banding procedures with 64% excess weight loss at 4 years.

Morbidly obese patients lose less weight with medical therapy than with bariatric surgery. Medical weight-loss therapy consisting of diet modification, exercise, behavioral therapy, and pharmacotherapy can be effective in the short term, particularly when used in combination, but recidivism rates approaching 100% are typical among morbidly obese patients. In a meta-analysis of the US literature, low-calorie or very-low-calorie (≤ 800 calories/day) diets resulted in the loss of 2.1% and 6.6% of total body initial weight, respectively, after 5 years. At 1 to 2 years, behavioral therapy results in 8% to 10% total body weight loss, but patients return to their baseline weight without continued behavioral intervention.

Currently, two weight-loss agents are approved for long-term use. Sibutramine suppresses appetite by inhibiting reuptake of serotonin, norepinephrine, and dopamine. At 1 year, average weight loss with sibutramine in combination with a low-fat, low-calorie diet is 5.5% of total weight, and in a meta-analysis of randomized controlled trials, patients receiving sibutramine had a 4.6% greater weight reduction than those taking placebo. Orlistat acts by competitively inhibiting intestinal lipase and blocking the absorption of approximately 30% of dietary fat. Average total body weight loss at 1 year is 7.6%, and a 4-year trial reported an average weight loss of 5.2%. In a meta-analysis of 11 randomized controlled trials, patients receiving orlistat lost 2.9% more weight than patients receiving placebo. This drug typically provides an additional 2-kg weight loss over behavioral therapy alone.

Resolution of comorbidities

Obesity-related diseases dramatically resolve or improve after bariatric surgery. No other medical or surgical
intervention simultaneously treats as many disease processes as bariatric surgery does. Comorbidiry resolution after laparoscopic Roux-en-Y gastric bypass has been studied extensively (Figure 2)\(^4,12,15,16,69-74\). For diabetes, resolution is defined as biochemical evidence of resolution (normal fasting plasma glucose or normal hemoglobin A\(_1c\) off medication. For other comorbid conditions, the clinical absence of the condition as determined by history, physical examination, clinical testing, or normal values after stopping of medication determines resolution.

In a study of 70 patients who underwent liver biopsy before and after surgery, there was significant improvement in liver steatosis, inflammation, and fibrosis. In these same patients, 80% had resolution of the metabolic syndrome based on the Adult Treatment Panel III criteria (three or more risk factors including abdominal obesity, elevated fasting glucose, hypertension, hypertriglyceridemia, and elevated high-density lipoprotein cholesterol)\(^70\). Pro inflammatory and pro thrombotic states are included in the definition of metabolic syndrome, but markers for these risk factors are not routine diagnostic tests.

Comorbidities resolve significantly after laparoscopic adjustable gastric banding as well. The resolution rates for hypercholesterolemia (74%), gastroesophageal reflux disease (76%-89%), and sleep apnea (94%) after laparoscopic adjustable gastric banding are comparable to rates seen with laparoscopic Roux-en-Y gastric bypass. Diabetes resolves in 54% to 64% of patients after laparoscopic adjustable gastric banding, and hypertension resolves in 55% of patients\(^30,51\). In their meta-analysis, Buchwald et al\(^3\) calculated that diabetes improved or resolved in 86% of patients, hyperlipidemia improved in 70%, hypertension improved or resolved in 78.5%, and obstructive sleep apnea improved or resolved in 83.6%. Diabetic outcomes varied with operative procedure. Diabetes resolved completely in 99% of biliopancreatic diversion/duodenal switch patients, 84% of gastric bypass patients, 72% of gastroplasty patients, and 48% of gastric banding patients. Biliopancreatic diversion and gastric bypass patients had the most improvements in hyperlipidemia postoperatively (99% and 97% resolution, respectively).

**life expectancy**

Morbid obesity is associated with decreased life span. The life expectancy of a man in his 20s is 13 years shorter if his BMI is over 45.\(^35\). In their observational cohort study, Christou et al\(^4\) found that the 5-year mortality rate in the bariatric surgical group was 0.68% compared with 16.2% in the medically managed patients- an 89% relative risk reduction. Flum and Dellinger\(^76\) evaluated survival after gastric bypass in a retrospective cohort study and found a 27% lower 15-year mortality rate in morbidly obese patients who underwent gastric bypass compared with those who did not. After the surgical patients reached the first postoperative year, the long-term survival advantage increased to 33%.

**Is bariatric surgery cost effective?**

The direct and indirect costs of morbid obesity are high. Most of the costs of obesity are related to the chronic comorbidities of diabetes, hypertension, and cardiovascular disease. In 2000, the Centers for Disease Control and Prevention estimated the total cost of obesity at $117 billion per year. Several studies evaluated the cost-effectiveness of bariatric surgery. Sampalis et al\(^77\) compared long-term direct health care costs in 1,035 patients who underwent bariatric surgery and 5,746 age-matched and gender-matched obese controls. Open Roux-en- Y gastric bypass accounted for 79% of procedures. The surgical group had lost 67% of their excess body weight at 5 years. At 3.5
years, the cost of surgery was compensated for by a reduction in total costs. At 5 years, there was a 29% reduction in costs for the surgical group. Medication cost, specifically for antihypertensive and diabetic medications, are reduced by as much as 77% after bariatric surgery. Snow et al. found that after laparoscopic Roux-en-Y gastric bypass, the savings in drug costs was equal to the cost of surgery at 32 months. The Swedish Obese Subjects trial compared drug use in 510 surgically treated patients, 455 medically treated patients, and 958 normal-weight controls. At 6 years, surgical patients had a significant reduction in costs for diabetic and cardiovascular medication, but this was offset by increased use of gastrointestinal medication and nutritional supplements. Assessments of quality-adjusted lifeyears have also been conducted and favor bariatric surgery over nonsurgical treatment of obesity.

The future
As new technologies emerge, bariatric surgery will undoubtedly change. Endoluminal approaches to bariatric surgery utilizing flexible endoscopy are being investigated. These techniques may further decrease the risk associated with bariatric surgery.
Fig. 1 & 2: Types and benefits of bariatric surgical procedures

**Restrictive procedures**
- Laparoscopic adjustable gastric banding
- Vertical banded gastroplasty

**Malabsorptive procedures**
- Biliopancreatic diversion

**Combination procedures**
- Roux-en-Y divided gastric bypass
- Biliopancreatic diversion with duodenal switch
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- Depression: 55% resolved
- Obstructive sleep apnea: 74-98% resolved
- Asthma: 82% improved or resolved
- Cardiovascular disease: 82% risk reduction
- Hypertension: 52-92% resolved
- GERD: 72-98% resolved
- Stress urinary incontinence: 44-88% resolved
- Degenerative joint disease: 41-76% resolved
- Mortality: 89% reduction in 5-year mortality

- Dyslipidemia: hypercholesterolemia 63% resolved
- Non-alcoholic fatty liver disease: 90% improved steatosis
- 37% resolution of inflammation 20% resolution of fibrosis?
- Metabolic syndrome: 80% resolved?
- Polycystic ovarian syndrome: 79% resolution of hirsuitism 100% resolution of menstrual dysfunction
- Venous stasis disease: 95% resolved

- Quality of life improved in 95% of patients

1.
### Table I: Candidates for bariatric surgery

1. Body mass index (BMI) > 40 kg/m² or BMI > 35 kg/m² with significant Obesity-related co-morbidities.
3. Documented failure of non-surgical weight-loss programs.
4. Psychologically stable with realistic expectations.
5. Well-informed and motivated patient.
6. Supportive family/social environment.
7. Absence of uncontrolled psychotic or depressive disorder.
8. No active alcohol or substance abuse.

### Table II: Obesity-related diseases

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<td>Nonalcoholic fatty liver disease</td>
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<table>
<thead>
<tr>
<th>Genitourinary</th>
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<tbody>
<tr>
<td>Stress urinary incontinence</td>
<td></td>
</tr>
<tr>
<td>Urinary tract infections</td>
<td></td>
</tr>
<tr>
<td>Asthma</td>
<td></td>
</tr>
<tr>
<td>Obesity hypoventilation syndrome</td>
<td></td>
</tr>
<tr>
<td>Obstructive sleep apnea</td>
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<table>
<thead>
<tr>
<th>Hematopoietic</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Deep venous thrombosis</td>
<td></td>
</tr>
<tr>
<td>Pulmonary embolism</td>
<td></td>
</tr>
</tbody>
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<table>
<thead>
<tr>
<th>Musculoskeletal</th>
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</tr>
</thead>
<tbody>
<tr>
<td>Carpal tunnel syndrome</td>
<td></td>
</tr>
<tr>
<td>Degenerative joint disease</td>
<td></td>
</tr>
<tr>
<td>Gout</td>
<td></td>
</tr>
<tr>
<td>Plantar fasciitis</td>
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<table>
<thead>
<tr>
<th>Neurologic and psychiatric</th>
<th></th>
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</thead>
<tbody>
<tr>
<td>Anxiety</td>
<td></td>
</tr>
<tr>
<td>Depression</td>
<td></td>
</tr>
<tr>
<td>Pseudo tumor cerebi</td>
<td></td>
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<tr>
<td>Stroke</td>
<td></td>
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<table>
<thead>
<tr>
<th>Obstetric and gynecologic</th>
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</tr>
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<tbody>
<tr>
<td>Fetal abnormalities and infant mortality</td>
<td></td>
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<tr>
<td>Gestational diabetes</td>
<td></td>
</tr>
<tr>
<td>Infertility</td>
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</tr>
<tr>
<td>Miscarriage</td>
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<table>
<thead>
<tr>
<th>Pulmonary</th>
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</thead>
<tbody>
<tr>
<td>Pulmonary hypertension</td>
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Table III: Risk of laparoscopic bariatric procedures

<table>
<thead>
<tr>
<th>Complication</th>
<th>Lap. bypass</th>
<th>Gastric banding</th>
<th>Adjustable gastric</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conversion to open procedure</td>
<td>0% - 8%</td>
<td>0% - 3%</td>
<td></td>
</tr>
<tr>
<td>Bleeding</td>
<td>0.4% - 4%</td>
<td>0.1%</td>
<td></td>
</tr>
<tr>
<td>Bowel leak</td>
<td>0% - 4.4%</td>
<td>0.5% - 0.8%</td>
<td></td>
</tr>
<tr>
<td>Wound infection</td>
<td>0% - 8.7%</td>
<td>0.1% - 8.8%</td>
<td></td>
</tr>
<tr>
<td>Deep vein thrombosis</td>
<td>0% - 1.3%</td>
<td>0.01% - 0.15%</td>
<td></td>
</tr>
<tr>
<td>Pulmonary embolism</td>
<td>0% - 1.1%</td>
<td>0.1%</td>
<td></td>
</tr>
<tr>
<td>Mortality</td>
<td>0% - 2%</td>
<td>0% - 0.7%</td>
<td></td>
</tr>
</tbody>
</table>

References

Obesity surgery: risk and benefit

Ismam Merdan


39. Coates PS, Fernstrom JD, Fernstrom MH, Schauer PR, Greenspan SL. Gastric bypass surgery for morbid obesity leads to an increase in bone turnover and a decrease in bone mass. J Clin Endocrinol Metab 2004; 89:1061-1065.


