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Risks and benefits of bariatric surgery: Current evidence

■ ABSTRACT

Patients typically lose more than 50% of their excess weight after bariatric surgery. Obesity-related diseases markedly improve, reducing cardiovascular risk and improving life expectancy. Obese patients lose more weight with bariatric surgery than with medical weight-loss treatment.

■ KEY POINTS

Patients undergoing bariatric surgery must commit to a program of lifestyle changes, diet, vitamin supplementation, and follow-up.

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 complications and a lower death rate. Early complications of gastric bypass surgery are bleeding, anastomotic leak, wound infection, thromboembolism, and anastomotic strictures. Longer-term complications can include marginal ulcers, bowel obstruction, gallstones, and nutritional deficiencies.

Complications of adjustable gastric banding include prolapse and erosions.

*Dr. Brethauer has disclosed receiving research support from the Ethicon Endo-Surgery, Bard Davol, and Tyco US Surgical corporations.

†Dr. Chand has disclosed serving as a consultant for the Ethicon Endo-Surgery, Sanofi-Aventis, and Gore corporations.

‡Dr. Schauer has disclosed receiving research support from, serving as a consultant for, or receiving speaking honoraria from the Ethicon Endo-Surgery, Bard Davol, Gore, Baxter, Stryker, Invacare, Wyeth, and Dowden corporations.

OUTCOMES 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 death rate seems to be lower for morbidly obese patients who undergo this surgery than for those who do not.

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Managing obesity-related comorbid 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.¹

This review examines the current evidence regarding the risks and benefits of bariatric surgery. We will emphasize the two most common procedures, laparoscopic Roux-en-Y gastric bypass and laparoscopic adjustable gastric banding, including the complications that internists caring for these patients should be aware of.

■ WHO IS ELIGIBLE FOR BARIATRIC SURGERY?

Candidates for bariatric surgery must have a body mass index (BMI) of at least 40 kg/m² or a BMI of at least 35 with significant obesity-



PATIENT INFORMATION

Bariatric surgery: Is it right for you? page 1008

TABLE 1

Candidates for bariatric surgery

Body mass index (BMI) ≥ 40 kg/m², or BMI ≥ 35 kg/m² with significant obesity-related disease
 Acceptable operative risk
 Documented failure of nonsurgical weight-loss programs
 Psychologically stable with realistic expectations
 Well-informed and motivated patient
 Supportive family and social environment
 Absence of uncontrolled psychotic or depressive disorder
 No active alcohol or substance abuse

Candidates for bariatric surgery: BMI ≥ 40 or BMI ≥ 35 with significant obesity-related disease

related disease, according to the 1991 consensus guidelines from the National Institutes of Health (TABLE 1).² TABLE 2 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 nonsurgical means must have failed, and the patient must complete a thorough, multidisciplinary preoperative evaluation designed to identify comorbid 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 comorbid conditions, and prolong life.^{3,4}

■ 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.⁵⁻⁹

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 (see below).

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,¹⁰ 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-mL to 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.

At **Cleveland Clinic**, we currently perform the Roux-en-Y gastric bypass in approximately 75% of our bariatric patients, and laparoscopic adjustable gastric banding in the rest. The risks and benefits of each procedure are evaluated in the context of the patient's preference, expectations, BMI, comorbidities, and ability to comply with the different follow-up requirements for each procedure. Surgeon experience and hospital volume directly affect outcomes in bariatric surgery and should play an important role in determining which procedure to perform.^{11,12} Overall, the benefits are greater than the risks for most patients undergoing laparoscopic Roux-en-Y gastric bypass or laparoscopic adjustable gastric banding; thus, these have become our procedures of choice.

■ RISKS OF BARIATRIC SURGERY

Open vs laparoscopic Roux-en-Y gastric bypass

Laparoscopic bariatric surgery was introduced in 1994 when Wittgrove et al¹³ 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 cases¹⁴⁻¹⁹ and three randomized controlled trials²⁰⁻²² 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

TABLE 2

Obesity-related diseases

Cardiovascular

- Congestive heart failure
- Coronary artery disease
- Hyperlipidemia
- Hypertension
- Left ventricular hypertrophy
- Venous stasis ulcers, thrombophlebitis

Endocrine

- Insulin resistance
- Polycystic ovary syndrome
- Type 2 diabetes

Gastrointestinal and hepatobiliary

- Abdominal hernia
- Gallstones
- Gastroesophageal reflux disease
- Nonalcoholic fatty liver disease

Genitourinary

- Stress urinary incontinence
- Urinary tract infections

Hematopoietic

- Deep venous thrombosis
- Pulmonary embolism

Musculoskeletal

- Carpal tunnel syndrome
- Degenerative joint disease
- Gout
- Plantar fasciitis

Neurologic and psychiatric

- Anxiety
- Depression
- Pseudotumor cerebri
- Stroke

Obstetric and gynecologic

- Fetal abnormalities and infant mortality
- Gestational diabetes
- Infertility
- Miscarriage

Pulmonary

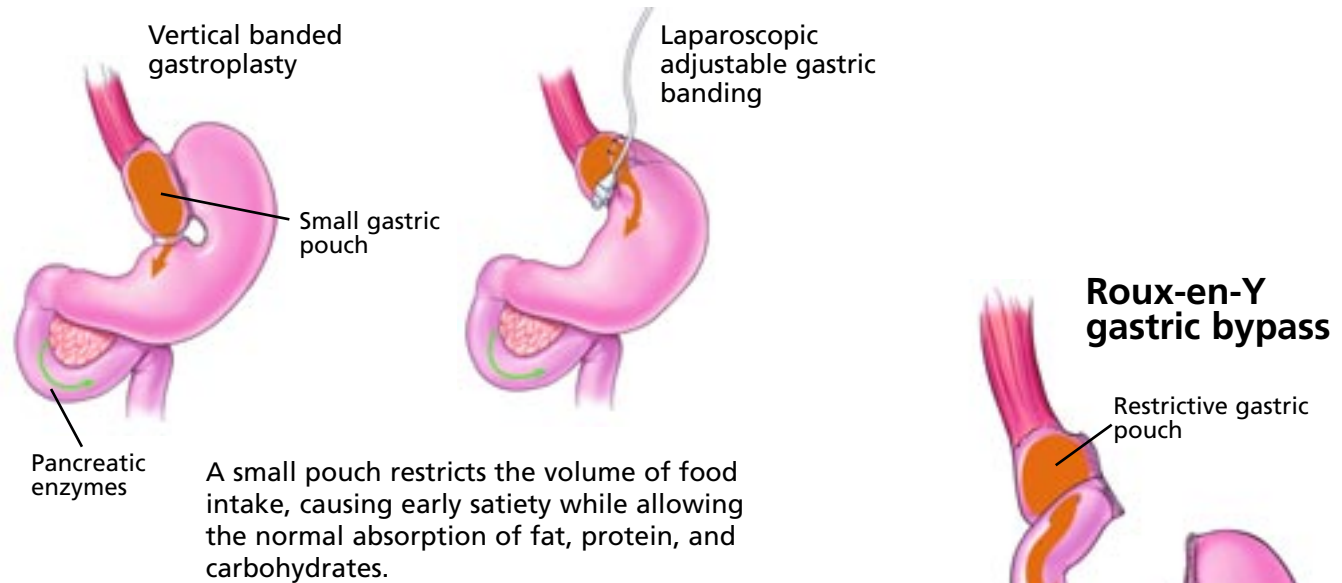
- Asthma
- Obesity hypoventilation syndrome
- Obstructive sleep apnea
- Pulmonary hypertension

Patients must understand that bariatric surgery is not a quick fix

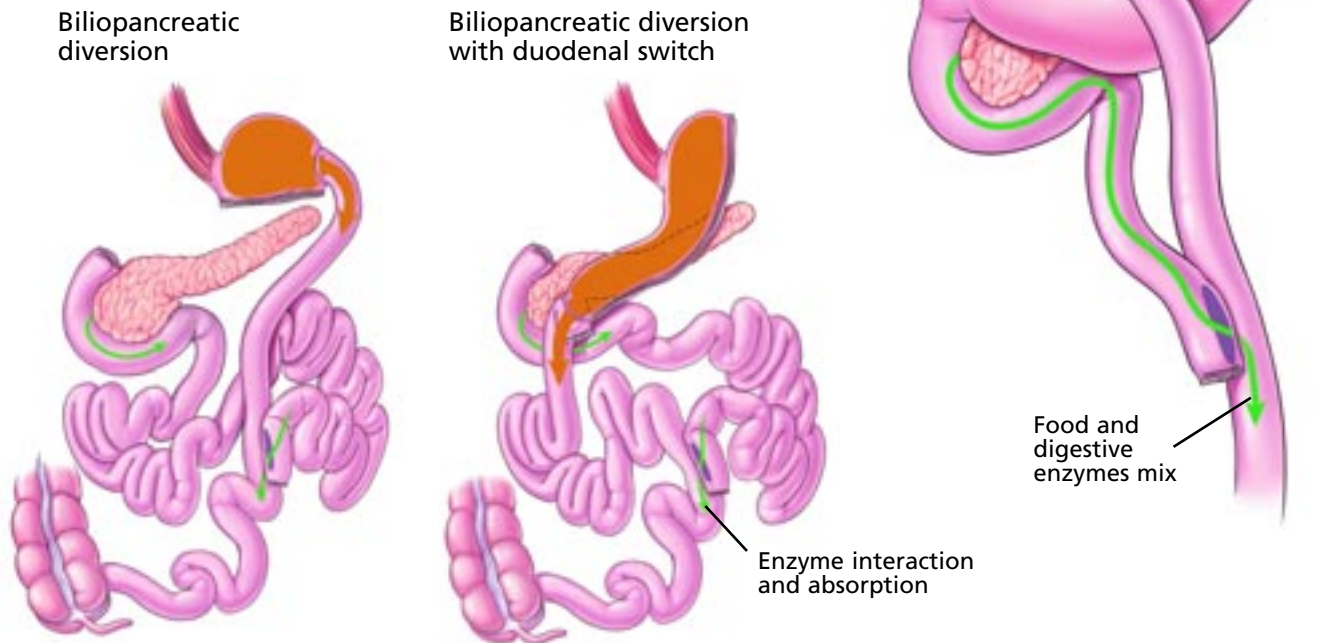
wall complications (up to 20% of patients have incisional hernias). One review of more than 3,000 gastric bypass cases showed that the laparoscopic approach results in less post-

Roux-en-Y combines the mechanisms of restrictive and malabsorptive procedures

Restrictive procedures



Malabsorptive procedures



Through surgical alteration of the intestinal tract, food bypasses the portions of the small intestine where normal digestion and absorption occur.

CCF
Medical Illustrator: Joseph Pangrace ©2006

FIGURE 1



operative 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.²³ 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.²³

Laparoscopic surgery takes time to learn, and complication rates with laparoscopic Roux-en-Y gastric bypass tend to decline as surgeons gain experience.²⁴ With experience, operative time and rates of technical complications such as gastrojejunal anastomotic leak decline to those seen with the open approach.

■ COMPLICATIONS 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 al²³ 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: Tachycardia is a presenting sign

Anastomotic leak is a dreaded complication of Roux-en-Y gastric bypass and carries a death 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 al²³ 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

We perform laparoscopic Roux-en-Y gastric bypass in about 75% of our patients

eliminates the risk of wound dehiscence or evisceration.

Thromboembolism

Obesity is a risk factor for venous thromboembolism in general surgery patients.²⁵ The higher the BMI, the higher the risk of venous thromboembolism in patients undergoing abdominal operations, even with low-dose heparin prophylaxis,²⁶ and obesity is an independent predictor of recurrent venous thromboembolism.²⁷ Morbid obesity is associated with elevated levels of fibrinogen, factor VII, factor VIII, von Willebrand factor, and plasminogen activator inhibitor,²⁸ and some evidence suggests a link between inflammatory mediators, central obesity, and a procoagulant state.²⁸

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.²⁹ 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%, $P = .09$).²³

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.³⁰

These patients should be treated as high-risk general surgery patients, and they should receive thromboprophylaxis according to the ACCP guidelines with low-dose unfractionat-

ed 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). Several studies found adjusted-dose unfractionated heparin and low-molecular-weight heparin effective in bariatric surgery patients.^{31,32} Dosing regimens for low-molecular-weight heparin, however, were developed for normal-weight patients undergoing general surgery procedures, and optimal dosing in morbidly obese patients has not been determined.

In a retrospective, multicenter study evaluating different enoxaparin (Lovenox) dosing regimens in 668 bariatric surgery patients,³³ pulmonary embolism occurred in 0.9%, and there was one case of deep vein thrombosis. These were clinically significant events and not detected by a specific surveillance protocol. Depending on the center, patients received enoxaparin 30 mg preoperatively, 40 mg postoperatively every 12 or 24 hours, or 30 mg every 24 hours for 10 days upon discharge. Fewer events occurred when prophylaxis was started in the hospital, and all events occurred after thromboprophylaxis was stopped. This study emphasizes the need to consider extended prophylaxis in selected bariatric patients.

We give enoxaparin 40 mg subcutaneously every 12 hours, starting the night of surgery. If the patient is at high risk (with a BMI > 55 or multiple risk factors), we continue the enoxaparin after discharge, stopping it on a case-by-case basis depending on the patient's activity level and risk.

Preoperative placement of inferior vena cava filters in high-risk bariatric surgery 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.^{34,35}

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 gastrojejunosto-

Tachycardia is often the only presenting sign of an anastomotic leak



my 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.^{15-19,36,37}

Strictures typically present within the first 3 months after surgery with nausea and vomiting. Most strictures either result 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.³⁶ Seventeen percent require a second dilation, and in a study by Nguyen et al,³⁸ 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 nonabsorbable sutures), nonsteroidal anti-inflammatory drug (NSAID) use, excessive acid exposure in the gastric pouch due to gastrogastic 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 series of patients undergoing laparoscopic Roux-en-Y gastric bypass,²³ 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 surgeon 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 the incidence of gallstones: 38% to 52% of patients develop stones within 1 year of surgery.^{39,40} 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.^{41,42}

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, cholesterosis, undetected cholelithiasis) in this patient population.⁴¹ 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 al⁴³ 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 as patients who underwent laparoscopic Roux-en-Y gastric bypass only.

We currently perform cholecystectomy at the time of laparoscopic Roux-en-Y gastric bypass for patients with symptomatic cholelithi-

Pulmonary embolism and anastomotic leak are major causes of death after Roux-en-Y gastric bypass

Mortality after bariatric and other surgery after age 65

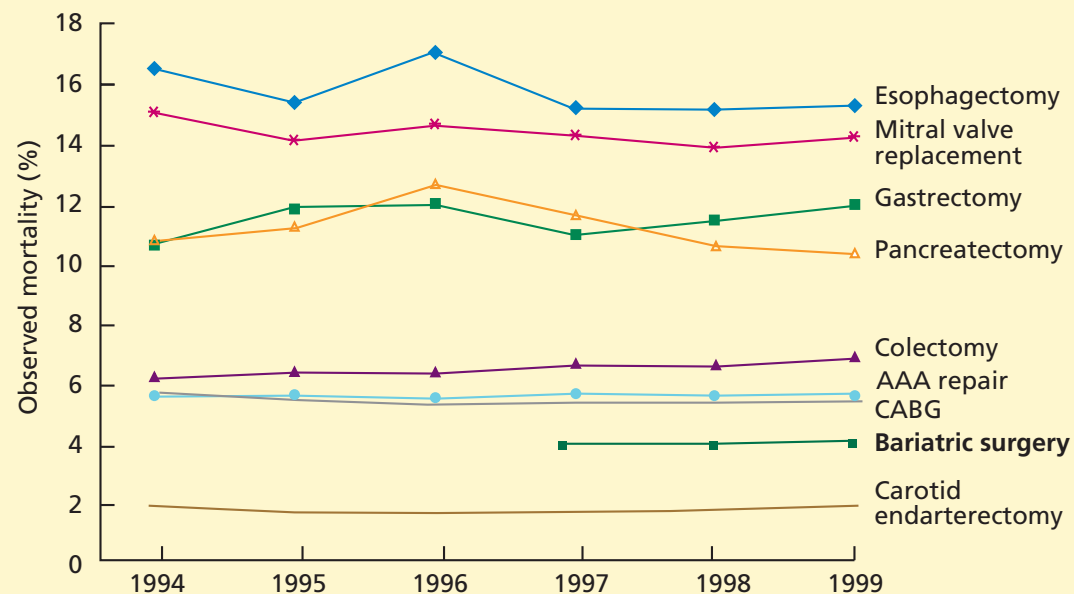


FIGURE 2. Unadjusted mortality rates for commonly performed cardiovascular procedures, gastrointestinal procedures, and bariatric surgery in Medicare patients over age 65. AAA = abdominal aortic aneurysm; CABG = coronary artery bypass grafting.

MODIFIED FROM GOODNEY PP, SIEWERS AE, STUKEL TA, LUCAS FL, WENNBERG DE, BIRKMEYER JD. IS SURGERY GETTING SAFER? NATIONAL TRENDS IN OPERATIVE MORTALITY. *J AM COLL SURG* 2002; 195:219–227.
BARIATRIC SURGERY DATA FROM FLUM DR, SALEM L, ELROD JA, DELLINGER LP, CHEADLE A, CHAN L. EARLY MORTALITY AMONG MEDICARE BENEFICIARIES UNDERGOING BARIATRIC SURGICAL PROCEDURES. *JAMA* 2005; 294:1903–1908.

Up to half of patients develop gallstones after bariatric surgery

asis. Patients with asymptomatic stones are observed, and those without cholelithiasis are prescribed ursodiol (Actigall) 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, $P < .01$).³⁹

Nutritional deficiencies

Because the stomach and duodenum are bypassed, iron, vitamin B₁₂, and other micronutrient deficiencies can occur after standard gastric bypass.⁴⁴

Taking a single multivitamin tablet alone is insufficient to prevent iron and vitamin B₁₂ 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 multivi-

tamin after surgery still develop vitamin B₁₂ 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 segment.⁴⁴ 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.⁴⁵

Series that reported nutritional deficiencies after gastric bypass varied greatly in terms of vitamin supplementation regimens. In a survey of 109 bariatric surgeons,⁴⁶ 96% said they prescribed multivitamins after Roux-en-Y gastric bypass, 63% prescribed



iron, and 49% prescribed vitamin B₁₂. Surveillance for deficiencies and patient compliance vary as well, although most bariatric surgeons recommend annual blood testing.

We obtain a complete blood count and iron and B₁₂ levels before surgery, 6 months and 1 year after surgery, and yearly thereafter. We recommend routine daily supplementation with a multivitamin, iron, vitamin B₁₂, and calcium.

Perioperative death

Buchwald et al³ 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 death rate for gastric bypass was 0.5%. The three randomized trials comparing open and laparoscopic Roux-en-Y gastric bypass showed no difference in death rates. Podnos et al²³ in their review found a lower death rate in laparoscopic patients. In laparoscopic Roux-en-Y gastric bypass series with more than 100 patients, the death rate ranged from 0% to 0.9%.^{15,17-19,47}

The risk of death after gastric bypass surgery increases with age. Livingston et al⁴⁸ found that patients older than 55 years had a death rate three times higher than that in younger patients, despite similar complication rates.⁴⁸ 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-en-Y gastric bypass), Flum et al⁴⁹ 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 (FIGURE 2).⁵⁰

A review of 60,077 Californians who underwent Roux-en-Y gastric bypass between 1995 and 2004 demonstrated mortality rates (0.33% at 30 days and 0.91% at 1 year) more consistent with published case series.⁵¹

■ COMPLICATIONS 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,³ all restrictive procedures had an operative mortality rate (\leq 30 days) of 0.1%. In a review of the international literature, Chapman et al⁵² 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.⁵³⁻⁵⁸ Bleeding after laparoscopic adjustable gastric banding is rare, occurring in only 0.1% of cases.^{53,54} Given that no anastomoses are formed during this procedure, no anastomotic leaks can occur. Iatrogenic bowel perforation during the procedure occurs in 0.5% of cases.⁵³ 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.^{53,57} 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.^{15,17-22,47,52-67}

In a systematic review of the international literature that included 64 studies and 8,504 patients, Chapman et al⁵² 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

One multivitamin per day is not enough after Roux-en-Y gastric bypass

TABLE 3

Risks of laparoscopic bariatric procedures

COMPLICATION	LAPAROSCOPIC GASTRIC BYPASS*	LAPAROSCOPIC ADJUSTABLE GASTRIC BANDING†
Conversion to open procedure	0%–8%	0%–3%
Bleeding	0.4%–4%	0.1%
Bowel leak	0%–4.4%	0.5%–0.8%
Wound infection	0%–8.7%	0.1%–8.8%
Deep vein thrombosis‡	0%–1.3 %	0.01%–0.15%
Pulmonary embolism‡	0%–1.1%	0.1%
Death	0%–2%	0%–0.7%

*References 15,17–22,47,54,59–62

†References 53,54,56–58,63–67

‡Diagnosis based on symptoms and standard clinical testing

TABLE 4

Percent of excess weight lost after bariatric surgery

	LAPAROSCOPIC GASTRIC BYPASS	LAPAROSCOPIC ADJUSTABLE GASTRIC BANDING
All patients	68%–80%*	44%–68%†
Preoperative body mass index > 50 kg/m ²	51%–69%‡	47%–49%§
Meta-analysis	61%	48%

*At 12–60 months, references 15,17–22,47,59

†At 12–72 months, references 52,56,57,69

‡At 12–36 months, references 37,52,55,70

§At 12–36 months, references 55,69,71

||Includes open gastric bypass and nonadjustable band series, reference 3

requiring reoperation can occur in up to 18% of patients, but complications decrease as the surgeon's 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.⁵⁶

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

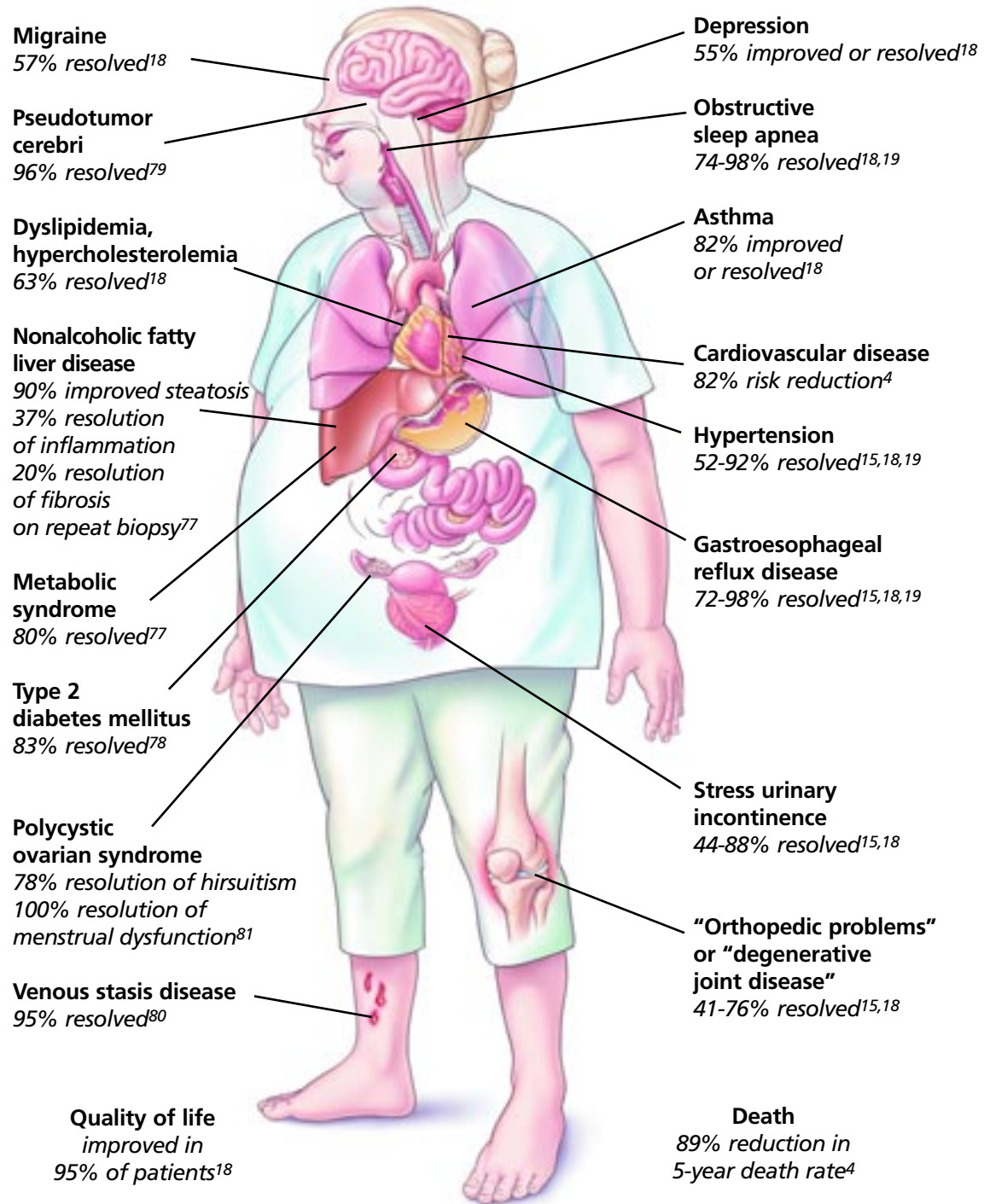
Weight loss after bariatric surgery is typically expressed as the percentage of excess weight lost (excess weight defined as the number of pounds above the patient's ideal body weight). In the meta-analysis of Buchwald et al,³ excess weight loss for all bariatric procedures combined was 61%. Analyzed by procedure, excess weight loss was highest after biliopancreatic diversion (70%), followed by gastroplasty (68%), gastric bypass (62%), and gastric banding (48%).³

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%.^{15,17–22,47,59} Durable weight loss after open Roux-en-Y gastric bypass has been demonstrated up to 14 years.⁶⁸ Superobese patients (BMI > 50) have less excess weight loss than patients with a lower BMI 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.^{15,17–22,37,47,55–56,58,59,69–71}

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 al⁵² 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



■ Benefits of bariatric surgery



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FIGURE 3. Resolution of obesity-related diseases after laparoscopic gastric bypass.^{4,15,18,19,77-81}

scopic adjustable gastric banding procedures with 64% excess weight loss at 4 years.⁷²

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 diets (< 800 calories/day) resulted in the loss of 2.1% and 6.6% of total body weight, respectively, after 5 years.⁷³ 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 (Meridia) 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.⁷⁴

Orlistat (Xenical) 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%.⁷⁵ 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.⁷⁶

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.

Resolution of comorbidities after laparoscopic Roux-en-Y gastric bypass has been studied extensively (FIGURE 3).^{4,15,18,19,77–81} 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).⁷⁷ Proinflammatory and prothrombotic 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.^{57,58}

In an observational cohort study, Christou et al⁴ evaluated long-term morbidity and death rates in 1,035 morbidly obese patients who underwent bariatric surgery (841 Roux-en-Y gastric bypass, 194 vertical banded gastropasty) and 5,746 age-matched and sex-matched morbidly obese controls whose weight was managed nonsurgically. The surgery group had a mean excess weight loss of 67% at 5 years, more than 60% excess weight loss at 16 years (72% follow-up), and significantly lower incidence rates of cardiovascular disease (4.7% vs 26.7%, 82% relative risk reduction), cancer (2% vs 8.5%, 76% relative risk reduction), infectious diseases (8.7% vs 37.3%, 77% risk reduction), and endocrinological (9.5% vs 27.3%, 65% risk reduction), musculoskeletal (4.8% vs 11.9%, 59% risk reduction), and respiratory disorders (2.7% vs 11.4%, 76% risk reduction) compared with the nonsurgical cohort.

In their meta-analysis, Buchwald et al³ cal-

**Life expectancy
of a man in his
20s is 13 years
shorter if his
BMI is > 45**



culated 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 patients who underwent biliopancreatic diversion and duodenal switch, 84% of gastric bypass patients, 72% of gastroplasty patients, and 48% of gastric banding patients. Biliopancreatic diversion and gastric bypass patients had the greatest 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 45.⁸²

In their observational cohort study, Christou et al⁴ found that the 5-year death 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 Dellinger⁸³ evaluated survival after gastric bypass in a retrospective cohort study and found a 27% lower 15-year death 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 US Centers for Disease Control and Prevention estimated the total cost of obesity at \$117 billion per year.

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Several studies evaluated the cost-effectiveness of bariatric surgery.

Sampalis et al⁸⁴ compared long-term direct health care costs in 1,035 patients who underwent bariatric surgery and 5,746 age-matched and sex-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 costs, specifically for antihypertensive and diabetic medications, are reduced by as much as 77% after bariatric surgery.⁸⁵

Snow et al⁸⁶ 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.⁸⁷

Assessments of quality-adjusted life-years have also been conducted and favor bariatric surgery over nonsurgical treatment of obesity.⁸⁵

■ 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. 

Improvement in comorbidities translates to future cost savings

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