Bariatric surgery for obesity and metabolic conditions in adults

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Introduction

Although the global pandemic of obesity has continued unabated over the past two decades, little progress has been made in its behavioral and drug treatment, especially in patients with severe obesity. By contrast, the evidence base for bariatric surgical procedures has expanded rapidly over this time, and it has yielded important short term and long term data on the efficacy and safety of surgical treatment for obesity and related metabolic disorders. Because trade-offs between the potential risks and benefits of bariatric surgical procedures exist, this review of the evidence for bariatric surgery aims to guide adult patients and their clinicians through a well informed, shared decision making process.

Prevalence

Nationally representative estimates from 2009 to 2010 indicate that 35.5% of the adult population in the United States is obese (defined as a body mass index (BMI) ≥30). About 15.5% of the US adult population has a BMI of 35 or more and 6.3% are severely obese (BMI ≥40). Data on the prevalence of severe obesity in other countries is scant, but the health survey of England showed that 1.7% of men and 3.1% of women had a BMI of 40 or more in 2012. In Sweden in 2005, 1.3% of men had a BMI of 35 or more, and in Australia in 2006, 8.1% of adults had a BMI of 35 or more.

The total number of bariatric procedures worldwide was estimated at 340 768 in 2011. The most commonly performed procedures were Roux-en-Y gastric bypass (46.6%), vertical sleeve gastrectomy (27.8%), adjustable gastric banding (17.8%), and biliopancreatic diversion with duodenal switch (2.2%). The largest number of operations were performed in the US and Canada together (101 645), followed by Brazil (65 000), France (27 648), Mexico (19 000), Australia and New Zealand (12 000), and the United Kingdom (10 000). No other nation performed 10 000 or more operations in 2011.

Obesity related complications

Severe obesity (most often defined as a BMI ≥35 with comorbid health conditions or a BMI ≥40 without such conditions) is a highly prevalent chronic disease, which leads to substantial morbidity, premature mortality, impaired quality of life, and excess healthcare expenditures. Severely obese adults are disproportionately affected by chronic health conditions, such as type 2 diabetes (28% of severely obese adults), major depression (7%), coronary heart disease (14-19%), and osteoarthritis (10-17%).

Treatment options

Treatments for severe obesity include lifestyle interventions, pharmacotherapy, and bariatric surgical procedures. Evidence from decades of weight loss research indicates that lifestyle interventions and pharmacotherapy often fail to help severely obese people lose enough weight to improve their health and quality of life in the long term. However, a growing body of evidence indicates that bariatric surgery can induce sustained reductions in weight, improve comorbidities, and prolong survival. Bariatric procedures were first developed more than 50 years ago. However, in the past 20 years, a dramatic increase in the prevalence of severe obesity combined with improvements in the efficacy and safety of bariatric surgical techniques has led to a 20-fold increase in the number of procedures performed annually in the US. Recent improvements in bariatric safety outcomes have been linked to an increase in the volume of cases performed, a shift to the laparoscopic technique, and an increase in the use of the lower risk adjustable gastric banding procedure. Current US guidelines recommend consideration of bariatric surgery for people who have not responded to non-surgical treatments if they have a BMI of at least 40 or at least 35 if they also have serious diseases related to obesity.

Types of bariatric surgery procedures and mechanisms of weight loss

Bariatric surgical procedures have evolved dramatically over the past 50 years. Modern procedures are most often described in anatomic terms according to their presumed mechanical effect, using phrases like “gastric restrictive” or “intestinal bypass” for ease of understanding, but recent basic science investigations may soon change this characterization to one based on physiology. In addition, since the 1990s the standard surgical technique has shifted from an open incisional approach to a minimally invasive or laparoscopic approach, almost exclusively.

The first bariatric procedure in wide use was known as the jejunoileal bypass, and it involved an intestinal bypass in which the proximal jejunum was bypassed into the distal ileum. This resulted in extreme weight loss by way of profound malabsorption and was eventually abandoned some years later after many patients developed severe protein-energy malnutrition.
The next major bariatric procedures to be introduced were the horizontal gastroplasty and the vertical banded gastroplasty, which were thought to be purely restrictive procedures made possible through the development of surgical stapling devices. In a horizontal gastroplasty, a pouch was created in the upper stomach by introducing a horizontal suture line with several staples removed (the stoma) to allow for the passage of food (fig 1A). With vertical banded gastroplasty, a vertical staple line was created parallel to the lesser curvature of the stomach and the outlet or stoma was reinforced with a mesh collar to prevent enlargement (fig 1B). Both procedures have now been abandoned owing to the introduction of newer more effective laparoscopic procedures, and because the stomach staple line often separated or the stoma tended to enlarge, leading to weight regain or severe gastroesophageal reflux, or both.

The gastric bypass was originally introduced in 1969 by Mason and Ito, and it was later modified into a Roux-en-Y gastric bypass configuration for drainage of the proximal gastric pouch to avoid bile reflux (fig 1C). Over time, the Roux-en-Y gastric bypass has been refined into its current laparoscopic form. This includes a small proximal gastric pouch of 15-20 mL, a measured and smaller gastric-to-intestinal stoma size (with or without cuff restriction), and a complete staple line transection to avoid staple line separation or failure (fig 1D).

The next major procedure to be introduced was the adjustable form of gastric banding, which has been modified for laparoscopic placement and creates a small superior gastric pouch with an adjustable outlet (fig 1E). The adjustable gastric band is a silicone belt with an inflatable balloon in the lining that is buckled into a closed ring around the upper stomach. A reservoir port is placed under the skin for adjustments to the stoma size.

Two procedures that use a more extreme intestinal bypass along with some modest gastric reduction are the biliopancreatic diversion and the biliopancreatic diversion with duodenal switch operations, which are most often used for “super” obese patients (usually BMI ≥50). Biliopancreatic diversion combines a subtotal (2/3rds) distal gastrectomy and a very long Roux-en-Y anastomosis with a short common intestinal channel for nutrient absorption (fig 1F). Biliopancreatic diversion with duodenal switch combines a 70% greater curve gastrectomy with a long intestinal bypass, where the duodenal stump is defunctionalized or “switched” to a gastroileal anastomosis (fig 1G).

Finally, the most recent major bariatric procedure to be introduced is the vertical sleeve gastrectomy, and it is rapidly increasing in popularity. This technique consists of a 70% vertical gastric resection, which creates a long and narrow tubular gastric reservoir with no intestinal bypass component (fig 1H).
Despite the basic “restrictive” and “intestinal bypass” anatomic conceptualizations of bariatric surgical procedures, there is much research ongoing in animal and human models towards understanding their underlying mechanisms of action. These actions may be more physiological (altered gastrointestinal signals) than nutrient restrictive and are likely to be both endocrine and neuronal in nature.41 Some of the potential candidates for the mechanisms of action of bariatric procedures include alterations in ghrelin, leptin, glucagon-like peptide-1, cholecystokinin, peptide YY, gut microbiota, and bile acids.42-45 It may be necessary in the future to group bariatric procedures not on the basis of anatomic surgical similarities but on how they affect key physiological variables, which would provide greater mechanistic insight into how the procedures work.41

**Effectiveness of bariatric surgery compared with non-surgical management**

Table 1 summarizes key findings from randomized trials and major long term observational studies that compare bariatric procedures with non-surgical management of obesity. It provides an overview of the results of these studies in terms of weight change, remission from and incidence of type 2 diabetes, as well as long term survival.

**Complications of bariatric surgery**

Bariatric surgery is not without risks. Perioperative mortality for the average patient is low (<0.3%) and declining,46 but it varies greatly across subgroups, with perioperative mortality rates of 2.0% or higher in some patient populations.90-93 The incidence of complications in the first 30-180 days after surgery varies widely from 4% to 25% and depends on the definition of complication used, the type of bariatric procedure performed, the duration of follow-up, and individual patient characteristics.15 26 91 94 95

**Findings from major studies**

Among the 11 RCTs (796 patients) that have compared bariatric surgery with non-surgical care, rates of adverse events were higher in patients having surgery, but follow-up was limited to two years.94 No cardiovascular events or deaths were seen in either group, but the most common adverse events after surgery were iron deficiency anemia (15% with intestinal bypass operations) and reoperations (8%).21 These RCTs were not large enough to compare safety across procedure types, and most of the comparative data on complications come from larger observational studies.

The first phase of the Longitudinal Assessment of Bariatric Surgery (LABS-1) study prospectively assessed 30 day complications in 4776 severely obese patients who underwent a first bariatric surgical procedure (25% adjustable gastric banding, 62% laparoscopic Roux-en-Y gastric bypass, 9% open Roux-en-Y gastric bypass, and 3% another procedure) between 2005 and 2007.91 The 30 day mortality rate was 0.3% for all procedures, with a major adverse outcome rate (predefined composite endpoint that included death, venous thromboembolism, reintervention (percutaneous, endoscopic, or operative), or failure to be discharged from the hospital in 30 days) of 4.1%. Major predictors of an increased risk of complications were a history of venous thromboembolism, a diagnosis of obstructive sleep apnea, impaired functional status (inability to walk 61 m; 1 m=3.28 ft), extreme BMI (>60), and undergoing Roux-en-Y gastric bypass by the open technique.91

Other large observational studies, such as SOS, have shown higher rates of complications, with 14.5% having at least one non-fatal complication over the first 90 days, including (in order of frequency) pulmonary complications, vomiting, wound infection, hemorrhage, and anastomotic leak.44 However, the SOS included mostly open and vertical banded gastroplasty procedures, which are rarely performed today. Nonetheless, the 90 day mortality rate in SOS was low at 0.25%.
**FUTURE RESEARCH QUESTIONS**

What are the specific mechanisms of action responsible for weight loss and the type 2 diabetes response to bariatric surgical procedures?

What patient level factors can predict success (weight loss, health improvements, and cost savings) after bariatric surgical procedures?

Is bariatric surgery more effective than nonsurgical care for the long term treatment of type 2 diabetes in people with less severe obesity (body mass index <35)?

On implementation of standardized reporting of complications across bariatric studies, what are the long term complication rates after different bariatric procedures?

What is the effect of bariatric surgery on long term microvascular and macrovascular event rates?

A meta-analysis of 361 studies (97.7% non-randomized observational design) of 85,048 patients reported important differences in mortality up to 30 days across different laparoscopic bariatric procedures. It found 0.06% (0.01% to 0.11%) for adjustable gastric banding, 0.21% (0.00% to 0.48%) for vertical banded gastroplasty, 0.16% (0.09% to 0.23%) for Roux-en-Y gastric bypass, and 1.11% (0.00% to 2.70%) for biliopancreatic diversion with duodenal switch. The review also found significantly higher mortality with open procedures than with laparoscopic procedures. A clinically useful prognostic risk score has been developed and validated in 9382 patients to predict 90 day mortality after Roux-en-Y gastric bypass surgery using five clinical characteristics: BMI 50 or more, male sex, hypertension, known risk factor for pulmonary embolism, and age 45 years or more.

Patients with four to five of these characteristics are at higher risk of death (4.3%) by 90 days than those with none or one of these characteristics (0.26%).

A systematic review of 15 RCTs of vertical sleeve gastrectomy found no deaths in 795 patients but a 9.2% mean complication rate (range 0–18%). In the American College of Surgeons Bariatric Surgery Network database, mortality 30 days after vertical sleeve gastrectomy was 0.11%, between that for adjustable gastric banding (0.05%) and Roux-en-Y gastric bypass (0.14%). The 30 day complication (morbidity) rate was 5.6% for vertical sleeve gastrectomy, 1.4% for adjustable gastric banding, and 5.9% for Roux-en-Y gastric bypass.

**Reoperation**

A worrying trend is the relatively frequent rate of reoperation as a result of complications or insufficient weight loss (or both), especially for adjustable gastric banding. In a prospective cohort of 3227 patients who had undergone this procedure, 1116 (35%) patients underwent revisional procedures. These were performed because of proximal enlargement (26%), port and tubing problems (21%), and erosion (3.4%), with no acute band slippages specifically noted. The need for revision because of proximal enlargement of the gastric pouch decreased dramatically over 17 years as the surgical technique evolved, from 40% to 6.4%, and no acute slippages were specifically noted; however, the band was ultimately removed in 5.6% of all people.

**Psychosocial risks**

Emerging data from observational studies suggest that some bariatric procedures introduce a greater long term risk of substance misuse disorders, suicide, and nutritional deficiencies. Pharmacokinetic studies indicate that the gastrointestinal anatomy after Roux-en-Y gastric bypass and vertical sleeve gastrectomy leads to more rapid absorption of alcohol and marked increases in blood alcohol concentrations per dose. This may inadvertently increase the frequency of physiological binges and subsequent alcohol misuse disorder.

In the SOS study, Roux-en-Y gastric bypass was associated with increased alcohol consumption and an increase in alcohol misuse events (hazard ratio 4.9) over 20 years, but more than 90% of patients remained below the World Health Organization cut off for low risk alcohol consumption. Similarly, in the LABS-2 study, alcohol misuse disorders were more common in the second postoperative year (9.6%) in those undergoing Roux-en-Y gastric bypass than at baseline (7.6%).

The risk of suicide may be increased after bariatric surgery, although the cause is unclear. The Utah Mortality study showed a 58% increase in all non-disease causes of death in the Roux-en-Y gastric bypass group compared with the matched control population, including a small but significant increase in suicides, accidental deaths, and poisonings. Similar findings were observed in the second Utah Obesity Study, and another observational study found that suicide rates in post-bariatric surgery patients were significantly higher than age and sex matched rates in the US. Given the paucity of data on preoperative psychological risk assessment and long term follow-up after bariatric surgery, rigorous research is needed to inform future practice guidelines and care standards in this area.

**Nutritional deficiencies**

Finally, evidence indicates that vitamin and mineral deficiencies, including deficiencies of calcium, vitamin D, iron, zinc, and copper, are common after bariatric surgery. Guidelines suggest screening patients for iron, vitamin B₁₂, folic acid, and vitamin D deficiencies preoperatively.
Table 2 | Recommended postoperative nutritional monitoring* 112

<table>
<thead>
<tr>
<th>Recommendation</th>
<th>AGB</th>
<th>VSG</th>
<th>RYGB</th>
<th>BPD-DS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bone density (DXA) at 2 years</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>24 hour urinary calcium excretion at 6 months and annually</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Vitamin B	extsubscript{12} annually (methylmalonic acid and homocysteine optional) then every 3-6 months if supplemented</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Folic acid (red blood cell folic acid optional), iron studies, vitamin D, intact parathyroid hormone</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Vitamin A intially and every 6-12 months thereafter</td>
<td>No</td>
<td>No</td>
<td>Optional</td>
<td>Yes</td>
</tr>
<tr>
<td>Copper, zinc, and selenium evaluation with specific findings</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Thiamine evaluation with specific findings</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
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*AGB=adjustable gastric banding; BPD-DS=biliopancreatic diversion with duodenal switch; DXA=dual energy X ray absorptiometry; RYGB=Roux-en-Y gastric bypass; VSG=vertical sleeve gastrectomy.

Patients should also be given daily nutritional supplementation postoperatively, including two adult multivitamin plus mineral supplements (each containing iron, folic acid, and thiamine), 1200 to 1500 mg of elemental calcium, at least 3000 IU of vitamin D, and vitamin B	extsubscript{12} as needed. In addition, they should receive annual screening for specific deficiencies, including vitamin B	extsubscript{12} (table 2). 113 Insufficient evidence is available on optimal dietary and nutritional management after bariatric surgery, including how to manage some of the complications of surgery (such as chronic nausea and vomiting, hypoglycemia, anastomotic ulcers and strictures, and failed weight loss).

**Shared decision making in the management of obesity**

Given the considerable trade-offs between the risks, benefits, and uncertainties of the long term effects of bariatric procedures, the decision to undergo surgery should be based on a shared decision making process. 126 127 The essential components of this process are clear communication of the clinician’s expert judgment, elicitation of the patient’s own values and preferences, and use of a patient decision aid that provides objective information about all clinically appropriate treatment options and encourages the patient to be meaningfully involved in decision making. 128 One RCT showed that use of a video based patient decision aid for bariatric surgery led to greater improvements in patient knowledge, decisional conflict, and outcome expectancies than an educational booklet on bariatric surgery produced by the NIH. 129

The shared decision making approach was endorsed at the 1991 NIH consensus conference on bariatric surgery. 113 It recommended the following:

- All patients should have an opportunity to explore with the physician any previously unconsidered treatment options and the advantages and disadvantages of each
- The physician must fully discuss with the patient:
  - The probable outcomes of the surgery
  - The probable extent to which surgery will eliminate the patient’s problems
  - The compliance that will be needed in the postoperative regimen
  - The possible complications from the surgery, both short term and long term
- The need for lifelong medical surveillance after surgery should be clear
- With all of these considerations, the patient should be helped to arrive at a fully informed independent decision about his or her treatment. 113

**Conclusion**

High quality data from RCTs have clearly established that bariatric procedures are more effective than medical or lifestyle interventions for inducing weight loss and initial remission of type 2 diabetes, even in less obese patients with a BMI between 30.0 and 39.9. 17 18 Although evidence from randomized trials does not go beyond two years, a few rigorous observational studies have shown encouraging results. These include an improvement in long term survival, 17 18 a reduced risk of incident cardiovascular disease and diabetes, 68 74 and more durable improvements in obesity related comorbidities among patients who have undergone bariatric surgery than among matched non-surgical controls. 74 67

However, bariatric procedures are not without risks. The perioperative mortality for the average patient is low (<0.3%) and declining, 90 but varies across subgroups, with perioperative mortality rates of 2.0% or higher in some patient populations. 90–93 The incidence of complications after surgery varies from 4% to 25% and depends on the duration of follow-up, the definition of complication used, the type of bariatric procedure performed, and individual patient characteristics. 55 26 91 94 95

Emerging data from observational studies also show that some procedures are associated with a greater long term risk of substance misuse disorders, 102–105 suicide, 106 and nutritional deficiencies. 90 More research is needed to examine differences in long term outcomes across various procedures and heterogeneous patient populations, and to identify those who are most likely to benefit from surgical intervention. Given the persistent uncertainties about the long term trade-offs between the risks and benefits of bariatric surgery, the decision to undergo surgery should be based on a high quality shared decision making process.

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