Bariatric surgery

Positive and negative effects

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Bariatric surgery is now recognised as a legitimate treatment for obesity. Knowledge of its key long-term outcomes, such as durability of weight loss, remission of obesity-related comorbidities and surgical complications, has grown exponentially in recent years. Further insights into the physiological mechanisms underlying outcomes will drive more effective and less invasive techniques that can be individualised to a patient's needs.

Key points

- **Weight loss surgery now has long-term data supporting its efficacy and safety in the treatment of obesity.**
- **Bariatric surgery produces sustained weight loss, leading to remission of type 2 diabetes, reduction in mortality and improvement in many cardiac risk factors.**
- **Physicians should be familiar with the acute and chronic complications of the widely performed bariatric procedures.**
- **Postoperative nutritional status and psychological wellbeing need to be monitored carefully in patients who undergo bariatric surgery.**

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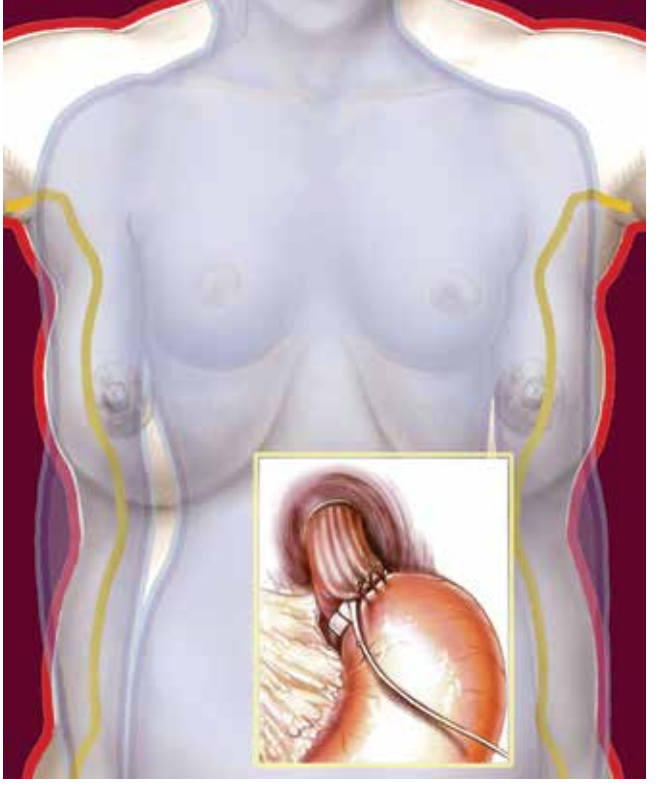

In countries where it is more common to be overweight than not, such as Australia and the USA, obesity is now considered to be a major health issue. Despite clinical advances in our understanding of energy balance regulation, effective therapeutic outcomes elude many obese and overweight patients. The customary approach of recommending improvement to diet and exercise patterns does not produce sustained weight loss for most individuals. Newer pharmacological therapies have relatively limited efficacy and are costly, and they may be poorly tolerated because of side effects.

A paradigm shift has seen bariatric surgery legitimised as an effective treatment of obesity, and the evidence for its efficacy and safety has grown exponentially. Results from randomised controlled trials have demonstrated clear superiority for bariatric surgery over nonsurgical strategies, at least for short-term outcomes such as remission of type 2 diabetes. Evidence of long-term outcomes is derived largely from observational studies. Ongoing challenges include the identification of eligible patients for bariatric surgery and selection of the most appropriate procedure for each individual.

Types of bariatric surgery

The most commonly performed types of bariatric surgery are laparoscopic adjustable gastric banding (LAGB), laparoscopic sleeve gastrectomy (LSG) and Roux-en-Y gastric bypass (RYGB). These procedures and their effects are described in Figures 1a to c and Table 1. Recently, LSG has dominated weight-loss surgeries in both Australia and the USA, possibly because it is less invasive and more straightforward than gastric bypass.[1,2] LAGB operations are still being performed more frequently than RYGB in Australia, but the rate at which RYGB procedures are being performed is slowly increasing while that of LAGB has been slowly decreasing.[1]

A newer procedure, the mini gastric bypass (MGB), has shown promising results for weight loss and metabolic outcomes. MGB has certain advantages over RYGB, such as a single anastomosis, a shorter learning curve for surgeons, fewer defects leading to herniation and

Figures 1a to c. Types of bariatric surgery. a (left). Laparoscopic adjustable gastric banding (LAGB). b (centre). Laparoscopic sleeve gastrectomy (LSG). c (right). Roux-en-Y gastric bypass (RYGB).

easier reversal.[3] Although newer surgical procedures such as this are being performed in Australia, the numbers are still very small compared with the standard procedures.

Positive effects of bariatric surgery

Weight loss

Compared with conventional treatments, bariatric surgery can produce long-term weight loss that is greater and more sustainable. In 1991, a National Institutes of Health consensus panel on bariatric surgery reached a decision that RYGB and vertical banded gastroplasty (VBG, which is now rarely performed) were safe and effective procedures for patients with BMI ≥40 kg/m^2 and for patients with BMI ≥35 kg/m^2 if medical complications of obesity were present.[4] These criteria were developed at a time when open procedures were usual and surgical morbidity and mortality rates were higher than presently.

Data from the large observational Swedish Obese Subjects (SOS) study, published in 2012, showed that bariatric surgery (predominantly VBG) was associated with greater weight loss than standard care at two years (23% vs 0%) and 20 years (18% vs 1%).[5] The prospective Utah Obesity Study demonstrated more effective weight loss for a group of patients undergoing RYGB (27.7%) compared with a nonsurgical control group (0.2% weight gain) after six years of follow up.[6] There have been few head-to-head comparisons of RYGB, LSG and LAGB, but an analysis of UK data has documented four-year weight loss to be 38 kg for RYGB, 31 kg for LSG and 20 kg for LAGB.[7] In an Australian study, patients who underwent RYGB or LAGB were able to maintain more than 50% excess weight loss (defined as the proportion of weight above BMI 25 kg/m^2 that is lost) after more than 10 years of follow up.[8] Overall, the literature suggests that RYGB has a greater effect on both weight loss and metabolic complications than other options. However, the Bariatric Surgery Registry has documented that LAGB and LSG are the most frequently performed bariatric operations in Australia.[1]

Type 2 diabetes

Although the metabolic benefits of weight loss induced by bariatric surgery are well documented, only a minority of patients with type 2 diabetes are offered this therapy. It could be argued that the risk of mortality from diabetes itself far outweighs the risk of mortality at expert centres performing bariatric surgery – a surgical mortality rate of 0.44% for RYGB was reported in a 2015 review.[9] The rapidity of the effect on glucose homeostasis after RYGB or LSG implies that it is mediated independently of the weight loss. In contrast, improvements in glucose regulation after LAGB are entirely dependent on weight loss. Hyperinsulinaemic–euglycaemic clamp studies have demonstrated an increase in insulin sensitivity with LSG and RYGB compared with LAGB; whether this is due to the greater weight loss achieved with these procedures or to hormonal changes is unclear. LSG and RYGB have each been shown to induce changes in gut hormones, such as glucagon-like peptide-1 (GLP-1) and gastric inhibitory polypeptide (GIP), as well as insulin, which can reduce postprandial glucose levels.[10,11] GLP-1 also assists with appetite control by inhibiting gastric emptying and acting centrally to reduce food intake. These procedures have also been shown to increase another anorectic hormone, peptide YY (PYY), and to decrease the orexigenic hormone ghrelin, at least in the short term.[11]

Several high-quality randomised controlled trials have shown significant rates of diabetes remission at one or two years, with

Table 1. Relative effects of commonly performed bariatric surgeries on key parameters

Parameter	Laparoscopic adjustable gastric banding (LAGB)	Laparoscopic sleeve gastrectomy (LSG)	Roux-en-Y gastric bypass (RYGB)
Malabsorption	–	+	++
Type 2 diabetes remission	+	++	+++
Hormonal changes	–	++	+++
Weight loss	+	++	+++

Key: – no effect; + minimal effect; ++ moderate effect; +++ maximal effect.

positive results even at three to five years' follow up. The type 2 diabetes remission rates observed in these clinical trials are summarised in Table 2.[9,12-17] In one of these trials, a single-centre open-label study of patients with diabetes (over more than five years) in Italy, the diabetes remission rate was 75% in patients treated with RYGB and 0% in patients treated with conventional medical therapy at two years.[12] At five years, 37% of the RYGB group maintained remission compared with none of the medically treated patients.[13] (This study also included a group undergoing biliopancreatic diversion, a procedure that is now rarely performed in Australia.) In the more recent STAMPEDE trial of bariatric surgery and intensive medical therapy for diabetes, 38% of patients undergoing RYGB and 24% of patients undergoing LSG achieved the primary endpoint (HbA_{1c} less than 42 mmol/mol [6%]) three years after randomisation compared with 5% of patients receiving medical therapy alone.[14] The average duration of diabetes in the STAMPEDE study population was 8.3 years; at baseline, the mean HbA_{1c} was 9.3% and 43% of patients were taking insulin.[14] In an Australian study conducted in patients with diabetes of shorter duration (less than two years), a remission rate of 73% was observed two years after LAGB compared with 13% after conventional therapy.[16] In another study, 38% of a RYGB group achieved an HbA_{1c} less than 42 mmol/mol (6%) compared with only 7% in the nonsurgical group.[17]

Table 2. Type 2 diabetes remission rates: bariatric surgery vs nonsurgical treatment*

Randomised controlled trial	Diabetes remission rate (%)	
	Short-term follow up	Longer-term follow up
Mingrone et al, 2012 and 2015[12,13]		
Nonsurgical treatment	0 (at 2 years)	0 (at 5 years)
Roux-en-Y gastric bypass	75 (at 2 years)	37 (at 5 years)
Biliopancreatic diversion†	95 (at 2 years)	63 (at 5 years)
Schauer et al, 2012 and 2014 (STAMPEDE trial)[14,15]		
Nonsurgical treatment	12 (at 1 year)	5 (at 3 years)
Roux-en-Y gastric bypass	42 (at 1 year)	38 (at 3 years)
Laparoscopic sleeve gastrectomy	37 (at 1 year)	24 (at 3 years)
Dixon et al, 2008[16]		
Nonsurgical treatment	13 (at 2 years)	
Laparoscopic adjustable gastric banding	73 (at 2 years)	
Ikramuddin et al, 2015[17]		
Nonsurgical treatment	7 (at 2 years)	Not yet available
Roux-en-Y gastric bypass	38 (at 2 years)	Not yet available

* Adapted from O'Brien 2015 (reference 9).
† Biliopancreatic diversion is now rarely performed in Australia.

Overall, the predictors of diabetes remission with bariatric surgery appear to be lower fasting glycaemia at baseline, shorter duration of diabetes, and procedures that divert gastric contents into the small intestine, such as RYGB.[18] These findings imply that bariatric surgery could be more broadly available to people with type 2 diabetes and included in diabetes management algorithms and guidelines.

Bariatric surgery also has an important role in the prevention of diabetes. Follow-up data from the SOS study at 15 years have shown that the group who received bariatric surgery had an incidence of type 2 diabetes that was 78% lower than the group receiving conventional therapies.[19]

Mortality and cardiovascular risk factors

Many reports of long-term outcomes for bariatric surgery stem from the SOS study, which is characterised by strong long-term follow-up data for many endpoints. This study documented a 29% reduction in mortality for patients who underwent bariatric surgery after almost 11 years of follow up.[20] A lower incidence of myocardial infarction and stroke was also reported, although it must be noted that only a minority of patients underwent RYGB or LAGB (most patients underwent VBG, a procedure that produces a proximal gastric pouch, which has been largely superseded by the simpler and safer LSG). The Utah Obesity Study has reported a reduction in all-cause mortality of 40% and cardiovascular mortality of 49% after RYGB, over a mean follow-up of 7.1 years.[6]

Elevated triglyceride and LDL cholesterol levels as well as reduced HDL cholesterol levels are typical of obesity-related dyslipidaemia. Improvements in total cholesterol and triglyceride levels as well as HDL levels have been demonstrated two years after RYGB.[12] The Diabetes Surgery Study showed no significant difference between RYGB and intensive medical management in achieving an LDL cholesterol level less than 2.6 mmol/L.[17] This finding was likely because 70% of subjects in both groups achieved this target and the majority of both groups were already on lipid-lowering therapy.[17] Improvements in the lipid profile have also been described with LAGB and LSG but the magnitude of change appears to be greater with RYGB, which is possibly due to an effect on intestinal fat absorption.[11]

The impact of bariatric surgery on hypertension is less well established. In a trial of 120 patients who received an intensive lifestyle and medical management protocol, no significant difference was observed in the proportion of patients with systolic blood pressure below 130 mmHg in the group that was randomly assigned to undergo

additional RYGB and the group that was not.[17] Other studies have described reduction or cessation of antihypertensive medications without formally analysing the data. The National Institutes of Health study of long-term outcomes of bariatric surgery published hypertension remission rates of 38.2% after RYGB and 17.4% after LAGB, but this observational study lacked a nonsurgical control population.[4] The SOS study showed a reduction in blood pressure in the surgical group compared with controls after two years of follow up but no difference after 10 years, despite weight loss being maintained over this period.[21]

Quality of life

Robust data from both observational studies and randomised trials indicate positive outcomes for health-related quality of life after bariatric surgery. Statistically significant improvements two years after LAGB have been reported using the Short Form Health Survey (SF-36).[14] For patients undergoing RYGB, significantly higher scores in all domains of quality of life have been demonstrated after five years of follow up compared with patients who are medically managed.[13] Improvement in female sexual function and pregnancy rates after bariatric surgery has been described.[22] RYGB has been associated with increased testosterone levels and improved sexual function in men two years after surgery.[23]

Negative effects of bariatric surgery

Overall, bariatric surgery is remarkably safe. Mortality rates for bariatric procedures in expert centres are comparable with those for other common operations such as laparoscopic cholecystectomy. Nonetheless, complications can be lethal and require prompt treatment by clinicians who are familiar with the procedure and its potential adverse outcomes.

Inclusion criteria for bariatric surgery emphasise the importance of a patient's comprehension of the risks and consequences of the operation as well as the necessary preparation for surgery. Patients are often required to follow a very low energy diet for at least two weeks preoperatively in order to minimise hepatomegaly, which can make surgery more technically difficult. Patients taking antihypertensive or glucose-lowering medication need close supervision during this period. Smoking and alcohol excess are also generally viewed as contraindications to bariatric surgery.[24] After the surgery and acute recovery stage, mandatory long-term multidisciplinary input requires motivation and compliance from the patient.

Acute complications

Acute complications can occur in 5 to 10% of patients, depending on the operation. Many complications are similar to those that arise after other abdominal surgeries, such as haemorrhage, obstruction, anastomotic leaks, infection, arrhythmia and pulmonary emboli.[24]

Complications following LAGB include enlargement of the proximal gastric pouch (regurgitation, heartburn); band slippage leading to obstruction (vomiting, dysphagia), and band erosion through the stomach wall (epigastric pain, bleeding, infection). Revision is required in 1 to 2% of cases each year; most complications can be managed through band adjustments and appropriate dietary advice.[25] LSG can result in leaks at the staple line, haemorrhage or gastro-oesophageal reflux (GORD). Severe GORD is therefore viewed as a contraindication to LSG. RYGB can be complicated by acute anastomotic leaks (1 to 3%) or ulcers, internal hernias or strictures leading to obstruction.[25] Strictures may manifest as frequent vomiting and usually mandate prompt investigation and surgical assessment.

Nutritional deficiencies and dumping syndrome

Adherence to nutritional advice and vitamin and mineral supplementation is crucial to mitigating potential adverse outcomes after bariatric surgery. The increase in insulin secretion, particularly after RYGB, can predispose patients to postprandial hypoglycaemia, which can be minimised by eating small frequent meals containing low glycaemic index carbohydrate. The anatomical changes induced by malabsorptive procedures such as RYGB increase the risk of various micronutrient and vitamin deficiencies commonly within the first year after surgery. Iron deficiency is frequent, especially in menstruating women, due to bypassing of the duodenum and proximal jejunum and intolerance of iron-rich foods such as red meat.

Vitamin B_{12} deficiency occurs in up to 30% of patients after RYGB, despite administration of standard multivitamin preparations, because of decreased digestion of protein-bound cobalamins and impaired formation of intrinsic factor. Patients undergoing restrictive procedures such as LAGB and LSG (unlike RYGB), may be maintained postoperatively on a lower-dose daily vitamin B_{12} supplementation.[26] Steatorrhoea induced by malabsorptive surgeries can cause fat-soluble vitamin deficiencies (e.g. vitamin A); patients should be assessed for these at least annually. Restrictive procedures such as LAGB and LSG can induce digestive symptoms, food intolerance or maladaptive eating behaviours that can also lead to protein malnutrition or micronutrient deficiencies.

Dumping syndrome can occur in 70 to 76% of patients after RYGB and leads to abdominal pain, cramping, nausea, diarrhoea, flushing, tachycardia and syncope.[26] Recent studies suggest that food bypassing the stomach and entering the small intestine triggers secretion of gut peptides that cause these symptoms.[26] Nutritional modifications, such as eating smaller food portions and avoiding simple carbohydrates, can alleviate symptoms. In severe cases, somatostatin analogues can also be used.[26]

Bone health

Bariatric surgery can lead to clinically significant loss of bone mass at weightbearing sites such as the hip. Proposed mechanisms include an adaptation to skeletal unloading that is related to the rate and extent of weight loss. Furthermore, longstanding vitamin D deficiency, which is common in obese patients, may be exacerbated by malabsorption after bypass surgery. Calcium and magnesium deficiencies can lead to secondary hyperparathyroidism, which has been shown to correlate with cortical bone loss.[27] A growing body of literature also implicates changes in circulating concentrations of fat-derived adipokines and gut-derived appetite-regulatory hormones such as

peptide YY, GLP-1 and ghrelin in skeletal homeostasis postsurgery.[28] Hence, it is crucial that the potential for bone loss is recognised and that vigilant long-term monitoring of bone health is undertaken.

Psychosocial consequences

Mental health problems are prevalent in patients who are severely obese (and vice versa). Poorly controlled depression, substance misuse and eating disorders can compromise surgical outcomes and are frequently regarded as contraindications to bariatric surgery. Consequently, a preoperative psychological evaluation is recommended in most institutions. One systematic review showed the risk of suicide to be fourfold higher among patients after bariatric surgery compared with the background population.[29] A recent cohort study of bariatric surgery, in which 98.5% of patients underwent RYGB, confirmed an increased rate of self-harm emergencies after surgery in patients older than 35 years, those with a low-income status, and those living in rural areas.[30] Notably, 93% of the events occurred in patients with an existing mental health disorder that was diagnosed in the five years preceding surgery.[30]

Conclusion

Knowledge of key long-term outcomes of bariatric surgery, such as durability of weight loss, remission of obesity-related comorbidities and surgical complications, has grown exponentially in recent years. Further insights into the physiological mechanisms underlying the outcomes will drive more effective and less invasive techniques that can be individualised to a patient's needs. Once the appropriate procedure for a patient has been selected, the specific surgical referral pathway should be guided by the familiarity and experience of the surgeon with that procedure. Ultimately, bariatric surgery should be offered to motivated and well informed patients, especially those with refractory complications of obesity. However, comprehensive medical and psychological evaluation should exclude patients who are at risk of noncompliance or self-harm in the postoperative period. **ET**

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A list of references is included in the website version of this article (www.endocrinologytoday.com.au).

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