Anaesthesia in obese patients

With an increasing number of obese patients requiring surgery, this article outlines important factors in preoperative assessment, the impact obesity has upon intraoperative anaesthetic technique and which surgeries are currently recommended for weight loss.

The Health Survey for England (NHS Information Centre, 2010) indicated that as of 2009 22.1% of men and 23.9% of women are obese. Morbid obesity affects 1.3% of men and 3.5% of women. Alarmingly, year on year the prevalence of morbid obesity in England is increasing.

Bariatric surgery is an effective, cost-efficient way of tackling the obesity epidemic and the Department of Health is encouraging primary care trusts to refer patients who are eligible according to National Institute for Health and Clinical Excellence (2006) guidelines.

Anaesthetists are increasingly being asked to preoperatively assess bariatric patients' suitability for general anaesthesia. The Department of Health (2002) day surgery operational guide suggests that patients up to a body mass index of 40 kg/m^2 would normally be suitable for day surgery. Patients with a body mass index of 40 kg/m^2 or more should have their notes reviewed by an experienced anaesthetist before acceptance. The challenge is increasingly to provide safe anaesthesia in an optimal setting.

Patient population for bariatric surgery

National Institute for Health and Clinical Excellence guidelines allow for weight loss surgery to be considered in all morbidly obese patients who have reached physiological maturity and who have failed non-surgical means of weight loss for at least 6 months. The candidates should have either a body mass index >40 kg/m^2 or a body mass index >35 kg/m^2 with comorbidities such as hypertension, type 2 diabetes, osteoarthritis, hypercholesterolaemia or obstructive sleep apnoea, all of which may improve with weight loss (National Institute for Health and Clinical Excellence, 2006).

Before being listed for surgery an endocrinologist rules out medical causes of obesity such as thyroid or hypothalamic dysfunction. A psychologist assess patients for substance use, health-related risk-taking behaviour, their cognitive functioning, knowledge of obesity and surgical interventions, their coping skills, eating stressors, their use of social support and any causative or associated psychopathology such as depression. The surgeon, in conjunction with a dietician, will determine what surgery is appropriate for the patient's age and eating habits. The patients are often well educated as many attend the British Obesity Surgery Patient Association (www.bospa.org) support groups.

Bariatric surgery

Bariatric surgery comprises a group of procedures that promote weight loss and are very effective at treating the comorbidities associated with morbid obesity. A meta-analysis of 621 studies found that 78.1% of diabetic patients had complete resolution of their condition following bariatric surgery (Buchwald et al, 2009). A separate meta-analysis found that obstructive sleep apnoea was improved or resolved in 83.6% of patients and complete resolution of hypertension occurred in 61.7% postoperatively (Buchwald et al, 2004).

Bariatric surgery has health benefits for morbidly obese patients. It also has economic benefits via resolution of chronic health conditions and an increase in patients returning to paid work following weight loss (Hawkins et al, 2007).

Laparoscopic adjustable gastric band

The gastric band acts as a restrictive device, creating a gastric pouch of 10–15 ml thus inducing satiety. The silicone band that sits around the gastric cardia can be inflated or deflated via a silicone reservoir placed over the fascia of the abdominal wall. The advantages of a gastric band operation are that it is reversible, can be performed as a day case procedure, does not need diet supplements postoperatively and has low mortality (0.05–0.07%) (Christou et al, 2004). However, there is a 1–2% 10-year re-operation rate, most commonly as a result of either band slippage or erosion. Patients can expect to lose approximately 62% of their excess body weight at 1 year (Fielding et al, 1999); this is less than following gastric bypass. Weight loss is very dependant upon postoperative band adjustments by specialist nurses and the evidence suggests that patients are likely to reaccumulate more weight over a 10-year period than following gastric bypass (Sjöström et al, 2007).

Laparoscopic roux-en-Y gastric bypass

The gastric bypass induces weight loss via a number of mechanisms. The small gastric pouch restricts intake, food bypasses the duodenum and thus malabsorption

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occurs and perhaps most significantly there is an alteration in gastric hormone profile. This hormonal alteration has been implicated in both the rapid resolution of type 2 diabetes and the decrease in appetite that patients experience.

The advantages of gastric bypass are that a patient can expect to lose between 65–70% (Buchwald, 2005) of his/her excess body weight at 1 year and is likely to reaccumulate less weight over a 10-year period than following gastric band placement (Sjöström et al, 2007). However, the overall mortality is 1% and can be as high as 7.4% if the patient is high risk according to the DeMaria risk score (see below). Patients need to take lifelong vitamin supplementation.

Laparoscopic biliopancreatic diversion and duodenal switch

This operation is very technical and is reserved for super-obese (body mass index >50 kg/m^2) patients where weight loss following band or bypass is considered to be less successful. A sleeve gastrectomy causes restriction and early satiety and the combination of the duodeno-ileostomy and diversion of the biliopancreatic juices to the distal alimentary limb cause profound malabsorption. Patients can expect to lose approximately 73% (Marceau et al, 1991) of their excess body weight. Mortality is quoted as between 0.4–0.57% (Christou et al, 2004) and patients need lifelong vitamin supplementation.

Table 1. Epworth sleepiness score

	<5 AHI	5–14 AHI	15–29 AHI	>30 AHI
Epworth sleepiness score (standard deviation)	7.2 (4.3)	7.8 (4.40)	8.3 (4.6)	9.3 (4.9)

Correlation of the Epworth sleepiness score to the number of observed apnoea-hypopnoea incidents (AHI). The standard deviation (indicated in brackets) highlights the broad overlap between a negative sleep study (AHI<5) and a diagnosis of severe obstructive sleep apnoea (AHI>30).

Table 2. STOP BANG score

STOP BANG consists of asking the following eight questions of a patient and then scoring each affirmative answer with one point:
Snore?
Tired?
Observed apnoeas?
Pressure? (hypertension)
Body mass index >35 kg/m^2
Age >50 years
Neck circumference >40 cm
Gender – male

A score of ≥3 indicates a high likelihood of obstructive sleep apnoea. When correlated to the apnoea-hypopnoea index >5, >15 and >30 the sensitivities are 83.6, 92.9 and 100% respectively (Chung et al, 2008). Patients scoring highly should be referred to a sleep clinic before surgery

Preoperative assessment

Preoperative assessment via a multidisciplinary team typically occurs 6–12 weeks before weight reduction surgery to allow for appropriate selection and optimization of the patients. The multidisciplinary team typically consists of an anaesthetist, a bariatric surgeon, an endocrinologist, specialist bariatric nurses and dieticians. The principles of preoperative assessment apply equally to obese patients presenting for other types of surgery.

Airway

Airway assessment should be carried out to assess ease of ventilation and intubation. The two most useful indicators of a potentially difficult intubation in the obese are the Mallampati score and the neck circumference. In 192 patients undergoing weight loss surgery 4.9% had a Cormack Lehane score ≥3 (Fox et al, 2008) – this is no greater than in the non-obese population. Not all predictors of difficult intubation are useful in the obese. Mallampati ≥3 was associated with 'problematic intubation' (>3 attempts) in a study by Brodsky et al (2002). They found that a neck circumference >40 cm gave a 5% probability of problematic intubation whereas >60 cm gave a 35% probability. Despite being 'problematic' successful intubation was achieved in all but 1 of the 100 morbidly obese patients. Therefore the exact neck circumference that should trigger additional airway planning is still unknown. Evidence that elevated body mass index is associated with difficult intubation is contradictory.

Respiratory

Smoking

Smoking is a major additional risk for postoperative morbidity. Stopping smoking 8 weeks before weight loss surgery improves cardiovascular parameters and reduces postoperative pulmonary complications (Ramaswamy et al, 2004).

Obstructive sleep apnoea

In a study by O'Keeffe and Patterson (2003), obstructive sleep apnoea was diagnosed in 77% of 170 patients presenting for bariatric surgery. Obstructive sleep apnoea can lead to chronic hypertension, coronary artery disease, arrhythmias and heart failure. Treating obstructive sleep apnoea with nocturnal continuous positive airway pressure can lower blood pressure and halt progression of atherosclerosis. Untreated obstructive sleep apnoea can lead to pulmonary hypertension, cor pulmonale and right heart failure, so making the diagnosis and commencing treatment is imperative.

Obstructive sleep apnoea is defined as more than five apnoea-hypopnoea incidents an hour. To make a provisional diagnosis of obstructive sleep apnoea clinicians commonly use either the Epworth sleepiness score (*Table 1*) or the STOP BANG score (*Table 2*). The Epworth sleepiness score relies on accurate self-reporting. A score ≥10 is suggestive of obstructive sleep apnoea. Although

the mean Epworth sleepiness score increases with severity of obstructive sleep apnoea the spread of scores means a low score does not entirely exclude obstructive sleep apnoea (Gottlieb et al, 1999).

There is little evidence that optimization of obstructive sleep apnoea with nocturnal continuous positive airway pressure changes outcomes following bariatric surgery. One approach is to recommend 12 weeks of continuous positive airway pressure before surgery. If the patient is unable to comply with the treatment it raises the dilemma of whether to proceed with the surgery regardless as bariatric surgery is a very effective treatment for obstructive sleep apnoea. Patients with obstructive sleep apnoea will require postoperative high dependency unit care.

Obesity hypoventilation

Obesity hypoventilation differs from obstructive sleep apnoea in that it results in an elevated arterial partial pressure of CO_2 ($PaCO_2$) during the day (>45 mmHg). The patient will also have either obstructive sleep apnoea or sleep hypoventilation ($PaCO_2$ >10 mmHg over daytime level). Pathological consequences and treatments are similar to those for obstructive sleep apnoea.

Cardiovascular

These patients have an increased cardiac output, oxygen demand, carbon dioxide production and absolute circulating blood volume (as a result of increased activity in the renin–angiotensin system and secondary polycythaemia). Obese patients are at an increased risk of developing hypertension, diabetes and hypercholesterolaemia, and obesity is an independent risk factor for coronary artery disease. Hypertension can lead to left ventricular dilatation, elevated wall stress, hypertrophy and ultimately a reduction in ventricular compliance. Left ventricular failure and pulmonary vasoconstriction (secondary to increased blood volumes and obstructive sleep apnoea hypoxia) can result in pulmonary hypertension and right-sided heart failure. The cumulative incidence (ages 40 to >70 years) of heart failure over a 10-year period is 6.8% in obese women and 10% in obese men. This is approximately 100% greater than in patients with a body mass index ≤25 kg/m^2 (Kenchaiah et al, 2002).

History taking and examination can be challenging as heart sounds are muffled, the jugular venous pressure can be difficult to see and peripheral oedema is often present as a result of lifestyle and body habitus. The patients are often breathless on minimal exertion, making establishing metabolic equivalents (METs) difficult. However, if the patient is able to perform activities equivalent to 4 METs he/she is considered at low risk of cardiovascular complications.

The revised cardiac risk index is a valid tool used in both obese and non-obese patients having non-cardiac surgery (Lee et al, 1999).

Goals for pre-operative control of hypertension are the same as in the non-obese population.

Electrocardiograms

Electrocardiograms can be difficult to interpret in the obese patient because of attenuation of the signal and elevation of the diaphragm causing horizontal displacement of the heart. Flattened T waves in the inferior leads (II, III, aVF) and lateral leads (V4–V6) can be normal and will resolve with weight loss. T-wave inversion is always pathological (Fraley et al, 2005).

When diagnosing left ventricular hypertrophy in the obese, as with non-obese subjects, specificity is high (95%) but sensitivity is low (Okin et al, 1996). The Cornell product and Cornell voltage electrocardiogram criteria (*Table 3*) are used to diagnose left ventricular hypertrophy as they are the most sensitive criteria in obese patients.

Brain natriuretic peptide and N-terminal probrain natriuretic peptide

Measurement of brain natriuretic peptide and N-terminal pro-brain natriuretic peptide is recommended by National Institute for Health and Clinical Excellence for ruling out heart failure when there is clinical suspicion. These proteins are released from the ventricular muscle upon stretch. Sensitivity is reported as between 82% and 98% depending on cut-off levels with a specificity of around 50%. A consensus by Cowie et al (2010) recommended a level of <50 pcg/ml of brain natriuretic peptide to rule out heart failure for patients in non-acute settings. For N-terminal pro-brain natriuretic peptide the levels recommended are <50 pcg/ml for patients aged <60 years and <100 pcg/ml for patients aged 60–75 years.

A positive blood test should trigger referral to cardiology for further investigation. This may be an echocardiogram (often yields poor quality images because of the patient's body habitus), a cardiac positron emission tomography scan (limited by the patient's weight or girth), cardiopulmonary exercise testing (limited by availability and the patient's ability to exercise as a result of body habitus and co-morbidities such as osteoarthritis) or a cardiac magnetic resonance imaging (limited availability but it is the gold standard).

Vascular access

Vascular access can be difficult and it is worth examining the patient to see if extra time may need to be allocated on the list. Ultrasound can sometimes aid cannulation.

Table 3. Cornell criteria

Best left ventricular hypertrophy criteria in the obese	Sensitivity in the obese
Cornell product (Cornell voltage x QRS duration)	39–52%
Cornell voltage best usable (RaVL + SV3 = >28 mm in men, >20 mm in women)	36–45%

Diabetes

Diabetes needs to be managed as it would in any other patient. Type 2 diabetes improves and often resolves before weight loss as a result of the altered gastric hormone profile following gastric bypass. Requirements for glycaemic control will decrease almost immediately. Therefore postoperative follow up by a specialist diabetic nurse or the patient's GP is essential.

Risk scores

The obesity surgery mortality risk score (DeMaria et al, 2007) is the only validated score of 90-day mortality in gastric bypass surgery. There are five parameters, each of which scores one point:

1. Male
2. Age ≥45 years
3. Body mass index ≥50 kg/m^2
4. Hypertension
5. Risk of pulmonary embolus – a history of any of the following: previous deep vein thrombosis or pulmonary embolus, previous inferior vena cava filter, right heart failure, pulmonary hypertension, hypoventilation or venous stasis (venous ulcers or brawny oedema).

These scores are then used to calculate the risk of 90-day mortality (*Table 4*). The risk balance should be discussed with the patient. If the score is ≥2 the anaesthetist should consider whether a high dependency unit bed is needed postoperatively.

Risk scoring for non-bariatric surgery uses generic scores such as Lee's revised cardiac risk index which does not have a point specifically for obesity. However, most overweight patients will have a high risk score as they have ischaemic heart disease, heart failure and/or diabetes.

Intraoperative management

Plan to minimize manual handling by ensuring a hover mattress is in theatre on the operating table. If possible ask the patient to get him-/herself onto the operating table and anaesthetize in theatre. Ensure the patient's postoperative bed is electric to enable sitting him/her upright for extubation. Most operating tables can support up to 200 kg, but some patients weigh more than this.

Patient positioning is important to minimize postoperative rhabdomyolysis and nerve compression.

Table 4. Obesity surgery mortality risk score to predict 90-day mortality in gastric bypass surgery

Score	90-day mortality
0–1	0.3%
2–3	1.9%
4–5	7.56%

From DeMaria et al (2007)

Rhabdomyolysis occurred in 22.7% of 66 consecutive patients undergoing laparoscopic bariatric surgery in a study by Mognol et al (2004). As none of these patients developed acute renal failure the clinical significance of the rhabdomyolysis is uncertain.

Arm boards allow additional patient width and so minimize potential nerve compression. The legs are strapped to the table to prevent slipping or flexing of the knees on positioning the table in reverse Trendelenburg. National Institute for Health and Clinical Excellence (2011) guidelines should be followed for warming the patient. Providing there are no contraindications, the patient should wear thromboembolism prevention stockings perioperatively and intermittent calf compression boots intraoperatively. Blood pressure cuffs of adequate width should be available. If the patient's arm is too short placing a suitable cuff on the forearm works well. Invasive blood pressure monitoring is not usually required. An ultrasound can prove useful for locating venous access. Antibiotics should be given before knife to skin as postoperative wound infection is the commonest surgical complication following gastric bypass.

Induction

Despite an increased incidence of gastro-oesophageal reflux there is no evidence of an increased risk of pulmonary aspiration in starved obese patients (Bergland et al, 2008). Rapid sequence induction is not routinely indicated for first time bariatric procedures unless clearly warranted by the preoperative assessment. Preoxygenation should be carried out in a 25° head up position to maximize functional residual capacity as desaturation (in the absence of ventilation) can occur quickly as a result of increased demands and reduced functional residual capacity. If end tidal O_2 is failing to rise positive end expiratory pressure up to 10 cmH_2O may prove useful. Ventilation via a Guedel airway will reduce insufflation of the stomach and subsequent need for a nasogastric tube, although some weight loss surgeries require a nasogastric tube for administration of methylene blue to test intra-abdominal suture lines. A 'ramped' position also helps with intubation (Collins et al, 2004).

Drugs

Obesity leads to altered pharmacokinetics and thus altered drug dosing depending on volume of distribution (*Table 5*). Drugs are either dosed according to total body weight, ideal body weight (weight for a body mass index of 25 kg/m^2 at the patient's height) or lean body mass (ideal body weight +40% of the excess body weight).

Propofol does not accumulate and it is therefore logical that induction and maintenance doses should be based upon total body weight. However, in view of the haemodynamic consequences of such large doses lean body mass is recommended. Target controlled infusion pump algorithms for propofol are not designed to cover the larger body mass indexes (>35 kg/m^2). In the absence of an

algorithm for the morbidly obese no consensus has been reached on what weight to programme into the pump, but it is the authors' practice to programme in lean body mass, run propofol and remifentanil in conjunction and monitor depth of anaesthesia.

Rapid emergence from anaesthesia in order that the patient may regain control of his/her airway is desirable. Remifentanil with desflurane or propofol target controlled infusion provides excellent anaesthesia and emergence. Propofol offers the advantage of avoiding emetogenic volatiles and gaining a smooth emergence. Using lean body mass for the morbidly obese in the current pump algorithms is not well validated and consequently there is a risk of awareness. Nitrous oxide is avoided because of the possibility of gastric expansion. Postoperative nausea and vomiting is mitigated by minimizing preoperative starvation of fluids, giving 1–2 litres of crystalloid and anti-emetics. Analgesia is provided by loading with paracetamol, local anaesthetic to the port sites and 0.1–0.2 mg/kg ideal body weight of morphine, plus or minus non-steroidal anti-inflammatory drugs.

Ventilation

Body mass index, centripetal body habitus (known colloquially as an 'apple' body shape or android), supine positioning and general anaesthesia combine to dramatically reduce the functional residual capacity. Closing volume can encroach on functional residual capacity during normal tidal ventilation, leading to ventilation/perfusion mismatching. There is a linear increase in alveolar–arterial oxygen tension gradient with increasing body mass index. Positive end expiratory pressure of between 5 and 10 cmH_2O should usually be used. Inspiratory resistance is 68% higher and static compliance is 30% lower in supine, anaesthetized, morbidly obese patients compared with normal weight patients. Placing the patient head up or down had little impact on the already compromised respiratory mechanics (Sprung et al, 2002).

Table 5. Drug doses used in anaesthesia for the obese

Drug		Dose
Propofol	Induction	2–5 mg/kg lean body mass
	Maintenance	3–8 μg/ml lean body mass
Suxamethonium		1 mg/kg ideal body weight
Rocuronium		0.6 mg/kg ideal body weight
Atracurium		0.5 mg/kg ideal body weight
Remifentanil		3–9 ng/ml ideal body weight
Fentanyl (induction)		1–2 μg/kg ideal body weight
Alfentanil		5–10 μg/kg total body weight
Morphine		0.1–0.2 mg/kg ideal body weight
Desflurane		No change

There is the potential for raised airway pressures and volutrauma when using volume controlled ventilation or hypercarbia in pressure controlled ventilation. Pressure or volume control ventilation are equally suitable in obese patients when aiming for approximately 10 ml/kg ideal body weight. This may need to be pragmatic based on plateau airway pressure and the principle of best ventilation for least peak pressure across the airways. Volume controlled ventilation appears more efficient at eliminating carbon dioxide in morbidly obese patients (De Baerdemaeker et al, 2008). Volutrauma should not be caused in the pursuit of normocapnia particularly as many of these patients have chronic hypoventilation with a degree of pre-existing hypercarbia. Shunt can lead to hypoxaemia and potentially pulmonary hypertension and right heart strain. In the event of hypoxaemia normal measures should be introduced such as increasing fraction of inspired oxygen, using positive end expiratory pressure and reducing the pneumoperitoneum.

Cardiovascular

The pneumoperitoneum and reverse Trendelenburg can compromise venous return. Invasive monitoring is indicated for patients with pre-existing cardiovascular disease. Avoiding dehydration decreases postoperative nausea and vomiting. Giving >15 ml/kg total body weight of intravenous fluids intraoperatively does not alter the occurrence of rhabdomyolysis (Wool et al, 2010).

Postoperative management

The patient should be extubated once fully awake and reversed in a sitting upright position to maximize functional residual capacity. Hypoxia will invariably result if the patient is extubated supine. Thromboprophylaxis should be prescribed. There is some evidence that extended thromboprophylaxis may be of benefit in gastric bypass patients. If the patient uses nocturnal continuous positive airway pressure at home this should be re-instituted on the ward. Patients should be encouraged to mobilize as soon as possible to minimize the risk of deep vein thrombosis. Analgesia can usually be managed without a patient-controlled analgesia system.

Anaesthesia for bariatric patients outside of bariatric surgery

Preoperative assessment should be carried out as outlined above. Practicalities need to be considered to protect staff from manual handling injuries and the patients from harm. A hover mattress, a variety of blood pressure cuffs, an operating table of adequate width and an electric bed for postoperative emergence are invaluable.

When deciding what airway to use consideration needs to be given to the patient's body habitus. Women do not usually have a centripetal fat distribution, resulting in less compromise to ventilation upon lying supine. Ventilation without leak via proseal laryngeal mask airway with the gastric port open is achieved with airway pressures up to 29 cmH_2O.

Anaesthesia for patients post weight reduction surgery

If the patient has undergone previous weight loss surgery there is a risk of pulmonary aspiration and rapid sequence induction should be performed (Jean et al, 2008).

Conclusions

Bariatric surgery is an emerging specialty. With predicted trends for obesity and the acknowledgement from the Department of Health that bariatric surgery has both proven health benefits and saves money we can expect to see more surgeries carried out in the future. Anaesthesia can be delivered in a safe, appropriate manner providing adequate pre-assessment and planning are put into place. BJHM

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KEY POINTS

- Obese patients presenting for all forms of surgery is increasingly common.
- Difficult intubation is no more prevalent than in the non-obese population.
- Intubation should not be difficult if care is taken with positioning.
- The STOP BANG questionnaire is a useful screening tool to exclude obstructive sleep apnoea.
- The DeMaria risk score enables estimation of 90-day mortality for gastric bypass surgery.
- Measuring natiuretic peptides is a useful screening tool to rule out heart failure and guide cardiology referral.
- Use the appropriate body weight when considering drug doses.
- Be cautious with long-acting opiates.
- High dependency unit postoperative care is commonly required.