

## OBESITY & ANAESTHESIA

Dr KD Rooney, SHO in Critical Care, Royal Devon & Exeter Hospital, Exeter, UK.  
 Dr GC Werrett, Anaesthesia Fellow, Christchurch Hospital, NZ.  
 E-mail: kierooney@hotmail.com

### Self Assessment

1. You are asked to assess a 42-year-old woman who requires an emergency extensor tendon repair to her left hand. There is no neurovascular deficit. She is 158cm tall and weighs 102kg. She last ate 2 hours ago. What factors will you especially need to consider in her pre-assessment?
2. A 55-year-old man with a Body Mass Index (BMI) of 37 is having an anterior resection for colon cancer. Twenty minutes into the case you notice his oxygen saturations are falling and are now 88% despite FiO<sub>2</sub> 0.5. What actions can you take to improve his oxygenation?
3. A 65-year-old woman with a BMI of 41 is 24 hours post an elective total knee replacement. She has been given intramuscular morphine 2 hourly overnight. She is hypoxic with a SpO<sub>2</sub> of 87% on room air. Her respiratory rate is 8 breaths per minute. What is your diagnosis and action plan?

#### Key Points

- Calculate a BMI for all patients.
- BMI >30 is obese, BMI >35 is morbidly obese.
- Obesity is a multi organ disease.
- Significant cardiorespiratory disease is particularly common.
- Perioperative mortality and morbidity increases with BMI.

### Introduction

Approximately 7% of the worldwide adult population is obese. Obesity is a global health problem and the prevalence varies with socio-economic status. In affluent cultures, the poor have the highest prevalence (27% of the US population and 17% of the UK population are obese). In the developing world it is the affluent that are at the highest risk. There is also a recent trend to an increasing prevalence of obesity in adolescents and children. Importantly 60-85% of obese schoolchildren will remain obese as adults.

The difference between normality and obesity is arbitrary but the Body Mass Index (BMI) is normally used to define obesity. It can be calculated by dividing the patient's weight in kilograms by their height in metres squared (kg/m<sup>2</sup>).

Interestingly, the regional distribution of excess fat is thought to be more predictive than BMI for

BMI (kg/m <sup>2</sup> )	
<25	Normal
25-29	Overweight
30-35	Obese
>35	Morbidly Obese

morbidity and mortality. Excessive abdominal fat, "central obesity" is particularly predictive for NIDDM, dyslipidaemia and cardiovascular disease. Waist circumferences need to be sex and race specific. The table below is specific for Caucasian waist circumferences.

	Risk of obesity-associated metabolic problems	
	Increased	Substantially increased
Men	≥94cm (37inches)	≥102cm (40 inches)
Women	≥80cm (31.5 inches)	≥88cm (34.5 inches)

**Since obesity is a multisystem disease affecting all organs, there are a number of implications relevant to the conduct of anaesthesia.**

### Respiratory system

#### Obstructive Sleep Apnoea (OSA)

At least 5% of morbidly obese patients will have OSA particularly if they have associated risk factors such as large collar size (over 16.5 inches), evening alcohol consumption and pharyngeal abnormalities. The disease is caused by passive collapse of the pharyngeal airway during deeper planes of sleep, resulting in snoring and intermittent airway obstruction. Resultant hypoxaemia and hypercapnia results in arousal and disruption of quality sleep thus causing the characteristic daytime somnolence. Pulmonary and systemic vasoconstriction, polycythaemia, right ventricular failure and cor pulmonale can all occur. Indeed the relative hypoventilation can cause a progressive desensitisation of the respiratory centres to hypercapnia with resultant Type 2 respiratory failure. Formal diagnosis is by sleep studies and treatment includes removal of precipitants, weight loss and nocturnal CPAP.

**Specific Implications for Anaesthesia:** Take a very careful preoperative history looking particularly for evidence of the characteristic increasing snoring and subsequent apnoea (ask a relative) and daytime somnolence. Avoid sedative premedication. Maintenance of the airway might be difficult. Airway obstruction is very likely to occur in the postoperative period – nurse in an HDU/ ICU setting, sit up if at all possible, give oxygen and apply CPAP if required. Regional techniques and short acting anaesthetic agents are ideal to reduce postoperative drowsiness. OSA occurs most frequently during rapid eye movement (REM) sleep, which predominantly occurs on the second night post surgery. Consider nocturnal oxygen for up to 5 days following major surgery if available.

#### *Airway*

Obese patients tend to have short, fat necks making both mask ventilation and direct laryngoscopy technically more challenging. A BMI of 46 is associated with a 13% risk of difficult intubation. The increased bulk of soft tissues in the upper airway make them prone to partial obstruction with the loss of consciousness.

**Specific Implications for Anaesthesia:** Always assess the airway with the simple, quick bedside tests such as Mallampati, thyromental distance, incisor gap and the ability to sublux the mandible. Combinations of tests improve the positive predictor value. Difficult mask ventilation can sometimes be transformed by placement of an oral airway. Obese women are more likely to have large breasts, which can interfere with easy placement of the laryngoscope, therefore aim for a degree of head-up tilt, avoid folding the arms across the chest and, if necessary, apply traction on the breasts to allow placement of the laryngoscope. Given the increased risk of aspiration (see later) and difficult intubation, a rapid sequence induction will often be the safest form of induction. Have all available intubation aids such as bougies and a variety of laryngoscope blades close to hand. Ensure there are adequate numbers of staff should the patient require turning. If a fibrescope is available, consider awake intubation but be wary of using any additional sedation.

#### *Ventilation*

The increased body mass and metabolically active adipose tissue leads to increased oxygen consumption and carbon dioxide production. Minute ventilation is thus increased to achieve normocapnia. There is reduced chest wall compliance (of up to 30%) due to the heavy chest wall, increased pulmonary blood volume and splinted diaphragm. This reduction in compliance, together with increased respiratory demand results in an increased work of breathing.

In addition, the functional residual capacity (FRC) declines exponentially with increasing BMI. The closing capacity in these patients can encroach on

the FRC even when conscious; therefore the onset of anaesthesia, a supine position and the abnormally high elevation of the diaphragm (due to increased visceral and abdominal wall fat) all combine to cause ventilation-perfusion mismatch, right-to-left shunting and arterial hypoxaemia.

**Specific Implications for Anaesthesia:** These patients are prone to hypoxia even when conscious and will desaturate particularly rapidly once apnoeic as their oxygen reserve is reduced (reduced FRC), and oxygen utilisation increased, thus necessitating meticulous pre-oxygenation. Ideally this should be done with the patient semi erect to increase the time to desaturation.

Due to the reduced chest compliance and sheer mass of the chest wall, higher inflation pressures are required to ventilate such patients. Such high pressures preclude the use of the laryngeal mask airway (LMA) for ventilation. Hypoventilation will often occur when breathing spontaneously via an LMA/ facemask and thus these techniques are not recommended. Application of PEEP via an endotracheal tube is particularly useful in improving oxygenation by reducing small airways collapse.

Extubation is usually best performed with the patient in the sitting position as awake as possible to allow maximal diaphragmatic excursion. Otherwise the left lateral position is very safe initially but abdominal splinting might subsequently lead to hypoxia. Sit up once awake.

The postoperative mortality of the obese patient is double that of the non obese. As previously stated, these patients are prone to hypoxia due to small airways collapse and shunt. This may be exacerbated if analgesia is inadequate. However, over-sedated or narcotised obese patients are even more likely to develop partial airway obstruction. For this reason obese patients should be maintained on oxygen, humidified if possible, on the ward postoperatively with continuous pulse oximetry.

Postoperative physiotherapy/incentive spirometry and use of regional techniques such as epidural analgesia should reduce atelectasis and postoperative respiratory failure. Early postoperative mobilisation is vital.

#### **Cardiovascular system**

Obesity is associated with a number of cardiac risk factors. These include hypertension, ischaemic heart disease (IHD), cardiomyopathies, cardiac failure, arrhythmias, sudden cardiac death and dyslipidaemias. Venous insufficiency, cerebrovascular and peripheral vascular disease exacerbated by atherosclerotic processes may also be present. Increased visceral fat is a cardiovascular risk factor even when the BMI is normal.

Hypertension is particularly common in obesity. These patients also have an increased absolute

blood volume and increased cardiac output. Thus left ventricular stroke work is increased and left ventricular hypertrophy can result. Left and right cardiac failure can both occur. Given the high prevalence of associated coronary artery disease, the tendency to hypoxia, tachycardia (increases in line with increasing cardiac output) and biventricular strain, the aetiology for ischaemic coronary events is strikingly apparent.

Venous return is also reduced. An obese abdomen will directly compress venous return from the legs (also increasing the risk of deep vein thrombosis (DVT) and pulmonary embolism). Once ventilated, higher inflation pressures and application of PEEP further reduces venous return, which may result in a fall in cardiac output.

The risk of pulmonary embolus and DVT is doubled in the obese. Other causative factors for this increase include hypoxia-induced polycythaemia, cardiac failure, decreased fibrinolysis and immobilisation.

**Specific Implications for Anaesthesia:** Perform a thorough preoperative assessment looking for evidence of IHD and cardiac failure on history, examination and ECG. Chest X-ray and echocardiography may be technically difficult but potentially useful tests. Measure non-invasive blood pressure with the correct sized cuff. The sphygmomanometer cuff should be 20% greater than the diameter of the upper arm (remember, if the cuff is too small, the BP will be over-estimated). In the morbidly obese, invasive BP monitoring is advisable. Continue cardiac drugs throughout the perioperative period. Heparin prophylaxis, TED stockings and early mobilisation are some measures to reduce the incidence of DVT. Postoperative oxygen may particularly reduce nocturnal ischaemic events.

#### **Gastrointestinal, endocrine and other systems**

There is an increased incidence of hiatus hernia in the obese. The volume and acidity of gastric contents is often increased and as stated earlier, intubation might be difficult. Thus the risk of aspiration is particularly increased. Non-insulin dependent diabetes mellitus (and its associated microvascular and macrovascular changes) is much more common in the obese, caused by insulin resistance and inadequate insulin production. Hypercholesterolaemia, hypothyroidism, gout, osteoarthritis, back pain, hepatic impairment, gallstones, abdominal herniae, breast and endometrial malignancies are all more common in the obese.

**Specific Implications for Anaesthesia:** Prescribe oral H<sub>2</sub> receptor antagonists (e.g. ranitidine 150mg) or proton pump inhibitors (e.g. omeprazole 20-40mg) routinely 1-2 hours preoperatively, and if in doubt, perform rapid sequence induction with cricoid pressure at induction and extubate when fully awake. Perform a random blood sugar test on all obese patients. Ensure good perioperative sugar control to reduce infection and risk of myocardial events.

Continue statins over the perioperative period as they might improve coronary plaque stability.

#### **Drug handling in obesity**

In the obese patient, volumes of distribution, binding and elimination of drugs are unpredictable. This uncertainty necessitates that the anaesthetist pay more attention to the clinical end points of drug action such as loss of verbal contact, tachycardia etc. rather than focusing specifically on whether to dose on ideal, lean or actual body weight.

Some pharmacological certainties are a reduction in total body water, higher fat mass, relatively higher lean mass, higher GFR, increased renal clearance and normal hepatic clearance. The apparent volume of distribution for a fat-soluble drug such as thiopentone is increased because of its lipophilic nature and therefore the dose should be increased but a raised volume of distribution also results in reduced elimination resulting in prolonged effects. Recent work suggests that suxamethonium should be given at a dose of 1mg/kg actual body weight.

Slow emergence after use of fat-soluble volatile agents may be due to central sensitivity as much as due to delayed release from adipose stores. If available, use relatively insoluble agents as much for speed of reversal as to reduce postoperative drowsiness. The risk of halothane hepatitis may be higher in obese patients, although overall it is still very low.

#### **Regional anaesthesia**

Good regional anaesthesia may reduce opioid and inhalational requirements intraoperatively in thoracic and abdominal surgery and may also be used as the sole technique in peripheral surgery. However it is technically harder because of the loss of landmarks, increased movement of the skin and the need for long

<b>DRUG</b>	<b>DOSING GUIDELINE</b>
Propofol	Dose between lean and actual body weight
Thiopentone	Dose between lean and actual body weight
Suxamethonium	Up to 1mg/kg actual body weight
Atracurium	Dose according to actual body weight
Vecuronium	Dose according to lean body weight
Fentanyl	Dose according to actual body weight
Morphine	Dose according to lean body weight. Titrate to effect

needles. Initial failure rate is higher in the obese. The sitting position is usually easier for spinal and epidural placement. In the absence of clear bony landmarks the 7th cervical prominence and gluteal cleft will indicate the midline and patients also can assist by verbally redirecting the needle when it strikes the lamina. It is relatively uncommon for the epidural space to be more than 8cm deep. Leave extra catheter in the space as it may be subject to drag as the flexed patient relaxes.

Due to the engorged extradural veins and extra fat constricting the potential space, less local anaesthetic is needed for epidurals. 75-80% of the normal dose may well be sufficient.

Venous access, as a routine part of any anaesthetic technique is also technically more difficult in the obese, especially central venous access, where ultrasound is particularly useful if available.

### **Surgical and mechanical issues**

Surgery is technically more difficult due to reduced surgical access, difficult visualisation of underlying structures and excess bleeding. This leads to longer operating times, with subsequent exacerbation of many of the factors already mentioned. There is a higher risk of infection. The poor blood supply to the fatty tissues increases the chance of both wound infection and wound dehiscence. There may also be impaired immune system function due to neurohumeral factors.

Special equipment may need to be ordered for the very obese patient. Most theatre tables have a weight limit of approximately 130kg and can often be too narrow for these potentially very wide patients. "Overflow" from the side of the table increases the risk of pressure sores or nerve damage, as the patient is "wedged" in place to ensure they do not fall off. This may also interfere with the tipping/tilting function of some tables. The sheer mass of the patient means they are harder to position, and present an increased risk to theatre staff during handling/lifting. Given such problems it is preferable to induce anaesthesia in theatre to avoid such transferring.

Day case surgery is not contraindicated in the obese. Rather than having a rigid cut off based on BMI, it is preferable to have a policy based upon the type of surgery to be performed. It has been shown that with careful selection patients with a BMI over 35 have similar outcomes to "normal" patients.

Bariatric surgery is defined as surgery specifically for severely obese patients. It is increasingly considered for the treatment of morbidly obese patients who have serious comorbidity or in whom medical or behavioural weight reduction therapies are ineffective. Operations include gastric banding, gastric bypass, biliopancreatic diversion, liposuction and jaw wiring. However, the choice of the optimal therapeutic strategy in these patients depends on a risk/benefit ratio, which needs to be assessed individually. It can achieve long-term

weight reduction and is increasingly being used in management of the severely obese. Economic and practical issues and significant morbidity limit it to the most extreme cases. The surgery itself is usually laparoscopic, and leads to less opioid consumption and more rapid recovery and mobilisation.

## **ANSWERS TO SELF-ASSESSMENT**

### **No. 1**

*You are asked to assess a 42-year-old woman who requires an emergency extensor tendon repair to her left hand. There is no neurovascular deficit. She is 158cm tall and weighs 102kg. She last ate 2 hours ago. What factors will you especially need to consider in her pre-assessment?*

Her calculated BMI is 40.85; therefore she is defined as morbidly obese. She is not adequately starved, and is not an emergency, therefore she should be delayed for at least another 4 hours, if possible overnight. A careful history should be taken, specifically considering symptoms of sleep apnoea, gastro-oesophageal reflux, diabetes, ischaemic chest pain and her normal exercise tolerance should be established. Pre-operative investigations would include a blood sugar, an ECG, pulse oximetry and non-invasive blood pressure with an appropriately sized cuff. Discussion should take place with the patient and surgeon as to the option of a regional technique. If she requires a GA then she will need intubation so a careful assessment of her airway is required additionally considering factors such as breast size to facilitate laryngoscope placement. Pre-medications would ideally include a proton pump inhibitor or H<sub>2</sub> antagonist. Sedation of any sort would ideally be avoided.

### **No. 2**

*A 55-year-old man with a BMI of 37 is having an anterior resection for colon cancer. Twenty minutes into the case you notice his oxygen saturations are falling and are now 88% despite FiO<sub>2</sub> 0.5. What actions can you take to improve his oxygenation?*

Increase the FiO<sub>2</sub> to 100% immediately with an appropriate increase in volatile agent if previously using nitrous oxide. Check the position of the endotracheal tube and confirm bilateral air entry with auscultation and the presence of a CO<sub>2</sub> trace on the capnograph. Ensure adequate muscle relaxation. Try a recruitment manoeuvre such as increasing the tidal volume with hand ventilation or a sustained increase in airway pressure of 30-40cmH<sub>2</sub>O for up to 40 seconds. Beware of cardiovascular compromise. If not already applied, add PEEP to keep any recruited alveoli patent. If the surgery allows, then the reverse Trendelenburg position might help.

### **No. 3**

*A 65-year-old woman with a BMI of 41 is 24 hours post an elective total knee replacement. She has been given intramuscular morphine 2 hourly overnight. She is hypoxic with a SpO<sub>2</sub> of 87% on room air. Her respiratory rate is 8 breaths per minute. What is your diagnosis and action plan?*

She has respiratory depression from excess opioid. There is a high chance that this lady suffers sleep apnoea and is particularly sensitive to the effects of opioids.

She is in imminent danger of respiratory arrest. Give 100% oxygen and assist ventilation with a bag-valve-mask. Give IV naloxone 100-200mcg initially and up to 400mcg if required. Given naloxone has

a shorter half-life than morphine; close monitoring of respiratory rate, sedation score and oxygen saturation is vital for the subsequent 2 hours. It is highly likely the lady will require a further bolus or possibly an infusion of naloxone.

### **References and further reading**

Shankman Z, Shir Y, Brodsky J. Perioperative management of the obese patient. Br J Anaesth 1993, 70: 349-59

Adams JP, Murphy PG. Obesity in anaesthesia and intensive care. Br J Anaesth 2000, 85: 91-108

Cheah MH, Kam PCA. Obesity: basic science and medical aspects relevant to anaesthetists. Anaesthesia 2005, 60: 1009-25.

Saravanakumar K, Rao SG, Cooper GM. Obesity and obstetric anaesthesia. Anaesthesia 2006, 61: 36-48