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Peri-operative management of the obese surgical patient 2015

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Guidelines

Peri-operative management of the obese surgical patient 2015

Association of Anaesthetists of Great Britain and Ireland

Society for Obesity and Bariatric Anaesthesia

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Summary

Guidelines are presented for the organisational and clinical peri-operative management of anaesthesia and surgery for patients who are obese, along with a summary of the problems that obesity may cause peri-

operatively. The advice presented is based on previously published advice, clinical studies and expert opinion.

This is a consensus document produced by expert members of a Working Party established by the Association of Anaesthetists of Great Britain and Ireland and the Society for Obesity and Bariatric Anaesthesia. It has been seen and approved by the elected Board/Council of both organisations. All AAGBI guidelines are reviewed to ensure relevance/accuracy and are updated or archived when necessary. Date of review: 2020.
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- *What other guidelines and statements are available on this topic?*
  The first Association of Anaesthetists of Great Britain and Ireland (AAGBI) guidelines on the peri-operative management of the obese patient were published in 2007 [1]. In 2012, a consensus statement on anaesthesia for patients with morbid obesity was published by the Society for Obesity and Bariatric Anaesthesia (SOBA) [2]. The Centre for Maternal and Child Enquiries (CMACE) and the Royal College of Obstetricians and Gynaecologists (RCOG) have published joint guidance on management of women with obesity in pregnancy [3].
- *Why were these guidelines developed?*
  There is an increased recognition that obese patients present a different set of challenges and require specific peri-operative care compared with non-obese patients. These guidelines are intended to inform anaesthetists about best practice management of obese surgical patients throughout the peri-operative period, as members of a multidisciplinary team.
- *How does this statement differ from existing guidelines?*
  These guidelines include new material on several topics including pharmacology, positioning and sleep-disordered breathing. The advent of bariatric (weight treatment) surgery has produced a subgroup of anaesthetists with more specific experience in the management of obese patients. The Society for Obesity and Bariatric Anaesthesia was set up in 2009 to share the knowledge gained from bariatric anaesthesia to improve the anaesthetic care of obese patients in general. This experience forms the basis of these guidelines.

Recommendations

1 Every hospital should nominate an anaesthetic lead for obesity.
2 Operating lists should include the patients' weight and body mass index (BMI).
3 Experienced anaesthetic and surgical staff should manage obese patients.
4 Additional specialised equipment is necessary.
5 Central obesity and metabolic syndrome should be identified as risk factors.
6 Sleep-disordered breathing and its consequences should always be considered in the obese.
7 Anaesthetising the patient in the operating theatre should be considered.
8 Regional anaesthesia is recommended as desirable but is often technically difficult and may be impossible to achieve.
9 A robust airway strategy must be planned and discussed, as desaturation occurs quickly in the obese patient and airway management can be difficult.
10 Use of the ramped or sitting position is recommended as an aid to induction and recovery.
11 Drug dosing should generally be based upon lean body weight and titrated to effect, rather than dosed to total body weight.
12 Caution is required with the use of long-acting opioids and sedatives.
13 Neuromuscular monitoring should always be used whenever neuromuscular blocking drugs are used.
14 Depth of anaesthesia monitoring should be considered, especially when total intravenous anaesthesia is used in conjunction with neuromuscular blocking drugs.
15 Appropriate prophylaxis against venous thromboembolism (VTE) and early mobilisation are recommended since the incidence of venous thromboembolism is increased in the obese.
16 Postoperative intensive care support should be considered, but is determined more by co-morbidities and surgery than by obesity per se.

Introduction

The World Health Organization (WHO) uses a class system to define obesity (Table 1). Statistics for 2013 from the UK, Health and Social Care

Table 1 World Health Organization classification of obesity [4].

Body mass index; kg.m^2	Classification
< 18.5	Underweight
18.5–24.9	Normal
25.0–29.9	Overweight
30.0–34.9	Obese 1
35.0–39.9	Obese 2
> 40.0	Obese 3 (previously 'morbid obesity')

Information Centre show that in adults, 24% of men and 25% of women are classified as obese and over 3% have class-3 obesity [5]. For an average UK district general hospital serving an adult population of 200 000, this equates to 52 000 obese and over 6000 class-3 obese patients [6].

Obese patients are more likely to present to hospital because they are more prone to concomitant disease. Between 2001–2002 and 2011–2012, there was an eleven-fold increase in the number of patients (from 1019 to 11 736) of all ages admitted to NHS hospitals with a primary diagnosis of obesity (Fig. 1) [6]. In 2007, the UK Government's Foresight Report predicted that 50% of the UK population would be clinically obese by 2050, costing the NHS an extra £45.5 billion (€61.5 billion; $70.1 billion) per year, but even this may be an underestimate [7].

This consensus guidance is a synthesis of expert opinion, current practice and literature review, designed to replace the 2007 edition [1] and act as a guide to the delivery of safe anaesthesia to this clinically demanding group.

Pathophysiology of obesity

Fat distribution (patient shape)

Not all fat within the body is identical. Unlike peripherally deposited fat, intra-abdominal fat is highly metabolically active and is known to be a contributor to several disease states [8]. Patients with centrally distributed or 'visceral' fat are at greater peri-operative risk than those with peripherally distributed fat, and are far more likely to exhibit the metabolic syndrome, which consists of central obesity, hypertension, insulin resistance and hypercholesterolemia [9, 10].

Central obesity can be defined as a waist circumference greater than 88 cm in a woman and 102 cm in a man; or a waist-to-height ratio greater than 0.55 [10, 11].

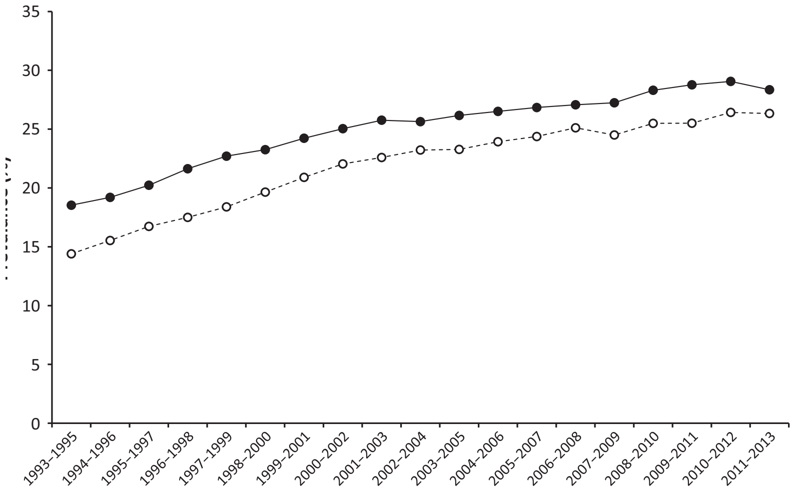

Figure 1 Adult trends in obesity (BMI ≥ 30 kg.m^2) in the UK male (○) and female (●) population, showing three-yearly averages. Redrawn from Health Survey England 2013 data (see http://www.hscic.gov.uk/catalogue/PUB16077) accessed 10/03/2015).

People who exhibit central, or visceral, obesity are often male and can be described as 'apple shaped', while those with a predominantly peripheral fat distribution are more likely to be female and are described as 'pear shaped'.

Respiratory system

Obesity results in reduced functional residual capacity (FRC), significant atelectasis and shunting in dependent lung regions [12], but resting metabolic rate, work of breathing and minute oxygen demand are increased. This combination means that, following the cessation of breathing, arterial oxygen levels decrease rapidly.

Wheeze in the obese may be due to airway closure rather than asthma: 50% of patients diagnosed with asthma 'recover' with weight loss [13]. Formal assessment of the effectiveness of bronchodilator therapy may be useful in differentiating the two conditions [14].

Sleep-disordered breathing

Sleep-disordered breathing describes the spectrum of conditions ranging from obstructive sleep apnoea (OSA) through obesity hypoventilation syndrome (OHS). Each of these conditions has a spectrum of severity, described according to the number and severity of oxygen desaturations occurring every hour and their impact upon the patient [15].

Severe OSA occurs in 10–20% of patients with BMI > 35 kg.m^{-2} and is often undiagnosed. Overall, a diagnosis of OSA is associated with a greater than doubling of the incidence of postoperative desaturation, respiratory failure, postoperative cardiac events and ICU admission [16]. The presence of multiple and prolonged oxygen desaturations increases the sensitivity to opioid-induced respiratory depression [17]. However, if identified pre-operatively and treated appropriately with continuous positive airway pressure (CPAP), the risk of complications is much reduced [18].

Increasing severity of OSA is associated with older age, cardiovascular disease secondary to heart strain, and the development of left ventricular dysfunction. It is also associated with a difficult airway and laryngoscopy. If untreated, OSA may progress to obesity hypoventilation syndrome, a triad of obesity (BMI > 35 kg.m^{-2}), sleep-disordered breathing (usually OSA) and daytime hypercapnia ($pCO_2 > 6$ kPa) [19]. The combination of chronic hypoxaemia and hypercapnia make this subgroup particularly susceptible to the effects of anaesthetic agents and opioids, which may precipitate acute and chronic hypoventilation and respiratory arrest in the early postoperative period [20].

Formal diagnosis of sleep-disordered breathing is with polysomnography, but in the majority of cases, diagnosis can be made by overnight oximetry testing at home [21]. Nocturnal CPAP is the usual treatment in patients with significant degrees of OSA, but around 50% of patients are poorly compliant with CPAP therapy and thus will not obtain benefit, usually because of problems with the fitting of the mask. Seeking information on compliance during pre-operative assessment is advised.

Cardiovascular system

Obesity leads to increased blood pressure, cardiac output and cardiac workload. People with untreated OSA may have associated pulmonary hypertension and heart failure [15].

There is an increased incidence of arrhythmias, predominantly secondary to sino-atrial node dysfunction and fatty infiltration of the conducting system. This results in a relative risk of 1.5 for atrial fibrillation [22], and a markedly increased risk of sudden cardiac death [23]. There is an increased incidence of prolonged QT interval with increasing BMI [24], and therefore a potential increased risk with drugs such as ondansetron [25].

Ischaemic heart disease and heart failure are more prevalent in the obese population, with heart failure the predominant risk factor for postoperative complications [26].

Thrombosis

Obesity is a prothrombotic state and is associated with increased morbidity and mortality from thrombotic disorders such as myocardial infarction, stroke and VTE [27]. The postoperative incidence of VTE may be 10 times higher in obese women compared with their healthy-weight counterparts [28]. Previous VTE is an independent risk factor for patients having gastric bypass surgery [29]. A hypercoagulable state may extend beyond two weeks, warranting extended postoperative VTE prophylaxis depending on the type of surgery and the patient's BMI [30].

Diabetes

Obesity is strongly associated with increased insulin resistance [31]. Poor glycaemic control in the peri-operative period is associated with increased morbidity, and good glycaemic control is recommended [32].

Gastric bypass surgery causes a unique neurohumeral response, resulting in a rapid, dramatic reduction in insulin requirement, starting immediately after surgery. In this cohort of patients, cautious postoperative reintroduction of diabetic medication and frequent blood sugar monitoring are essential [33].

Pharmacology

Body composition

There are a number of terms used to describe the weight of a patient; the four most useful are shown in Table 2.

Drug dosing

There is limited information on the effect of obesity on the pharmacology of commonly used anaesthetic drugs. Much of the excess weight is fat, which has a relatively low blood flow. While lipophilic drugs will have a larger volume of distribution than hydrophilic ones, the current evidence indicates that changes in volume of distribution in the obese are drug-specific, so generalisations are difficult [37]. For most anaes-

Table 2 The four most useful terms for describing patients' weight.

Total body weight (TBW)	The actual weight of the patient
Ideal body weight (IBW)	What the patient should weigh with a normal ratio of lean to fat mass. Varies with age, and is usually approximated to a function of height and sex: $$\text{IBW (kg)} = \text{height (cm)} - x \text{ (where } x = 105 \text{ in females and } 100 \text{ in males)}$$
Lean body weight (LBW)	The patient's weight excluding fat. Many of the formulae for calculating lean body weight are complex but one of the most widely used is that of Janmahasatian et al. [34]: $$\text{LBW (kg)} = \frac{9270 \times \text{TBW (kg)}}{6680 + (216 \times \text{BMI (kg.m}^{-2}))} \text{(men)}$$ $$\text{LBW (kg)} = \frac{9270 \times \text{TBW (kg)}}{8780 + (244 \times \text{BMI (kg.m}^{-2}))} \text{(women)}$$ Regardless of total body weight, lean body weight rarely exceeds 100 kg in men and 70 kg in women (Fig. 2) [35]
Adjusted body weight (ABW)	Takes into account the fact that obese individuals have increased lean body mass and an increased volume of distribution for drugs. It is calculated by adding 40% of the excess weight to the IBW [36]: $\text{ABW (kg)} = \text{IBW (kg)} + 0.4 \text{ (TBW (kg)} - \text{IBW (kg))}$

thetic agents, dosing to total body weight is rarely appropriate and increases the risk of relative overdose. Fortunately, most anaesthetic agents are dosed to affect, e.g. loss of eyelash reflex, nerve stimulator response or relief of pain. Given the paucity of information, the recommendation, based on current practice amongst experts in bariatric

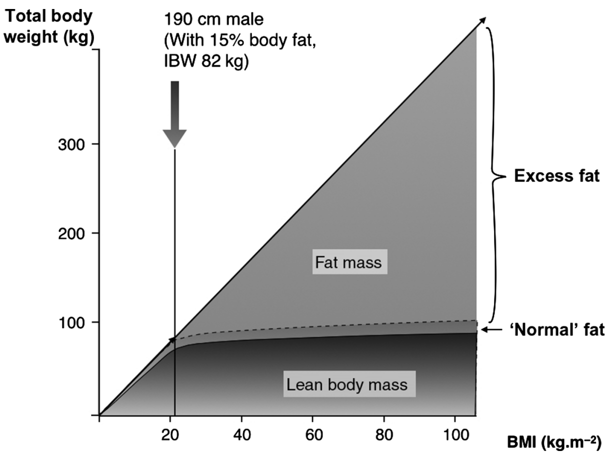

Figure 2 Relationship between total body weight and body mass index (BMI), showing how lean body mass effectively plateaus despite increasing BMI. A male of height 190 cm and ideal body weight (IBW) is indicated, demonstrating how IBW includes a normal 15% fat mass.

anaesthesia, is that lean or adjusted body weight are used as the scalars for calculating initial anaesthetic drug doses rather than total body weight (Table 3).

The fifth National Audit (NAP5) into accidental awareness under anaesthesia (AAGA) included a disproportionate number of obese patients who suffered AAGA. Half of the incidents of awareness occurred during the induction of anaesthesia and neuromuscular blocking drugs were used in 93% of these cases [38]. In the obese patient, after a bolus of anaesthetic induction agent, anaesthesia will occur before redistribution from the central compartment, and the induction dose required to produce unconsciousness correlates well with lean body weight [39]. However, more rapid redistribution of induction agents into the larger fat mass means that patients wake up more quickly than non-obese patients after a single bolus dose. With induction agents, a dose based on total body weight will last longer than one calculated using lean or adjusted body weight but is likely to result in significant hypotension. It is likely that in the cases of AAGA found in NAP5, small doses of induction agent based on lean or adjusted body weight were not quickly followed by the introduction of maintenance anaesthesia, thus raising the risk of AAGA. Thio-

Table 3 Suggested initial dosing scalars for commonly used anaesthetic drugs for healthy obese adults (notwithstanding the fact that titration to a suitable endpoint may be necessary).

Lean body weight*	Adjusted body weight*
Propofol (induction)	Propofol (infusion; see text)
Thiopental	Antibiotics
Fentanyl	Low molecular weight heparin
Rocuronium	Alfentanil
Atracurium	Neostigmine (maximum 5 mg)
Vecuronium	Sugammadex†
Morphine	
Paracetamol	
Bupivacaine	
Lidocaine	

*See Table 1 for definitions/calculations.
†See product literature.

pental is associated with a greater risk of awareness than propofol. It is strongly recommended that additional induction agent be given if there is a delay in commencing effective maintenance anaesthesia after induction.

Hydrophilic drugs such as neuromuscular blocking drugs are distributed primarily in the central compartment and lean body weight is a suitable dosing scalar. A dose of rocuronium based on total body weight does not significantly shorten the onset time, but will markedly increase the duration of action [40]. However, due to increased plasma cholinesterase activity, total body weight is appropriate for suxamethonium. Doses of neostigmine and sugammadex are related to the timing and total dose of neuromuscular blocking drugs to be reversed and can usually be titrated to effect.

For opioids, the clinical effect is poorly related to the plasma concentration [41]. Dosing using lean body weight is therefore a sensible starting point until the patient is awake and titration to effect is possible.

For target controlled infusions (TCI) of propofol, the Marsh and Schnider formulae become unreliable for patients weighing over 140–150 kg [40]. Because of this, none of the commercially available pumps allow input of weights above 150 kg using the Marsh model, or BMI > 35 $kg.m^{-2}$ (female) and 42 $kg.m^{-2}$ (male) using the Schnider model. There is a lack of evidence as to the best weight scalar to use with TCI techniques, and when used with neuromuscular blocking drugs, awareness is a significant potential risk. In these situations, some form of depth of anaesthesia monitoring is strongly recommended [42].

Pre-operative preparation

General considerations

The vast majority of obese patients presenting for surgery are relatively healthy and their peri-operative risk is similar to that of patients of normal weight. The patients at high risk of peri-operative complications are those with central obesity and metabolic syndrome, rather than those with isolated extreme obesity [10].

Particular attention should be focused on screening patients for sleep-disordered breathing and those at particularly high risk of VTE. A clear pathway for referral for specialist sleep studies should be identified.

The Obesity Surgery Mortality Risk Stratification score (OS-MRS) (Table 4) has been validated for patients undergoing gastric bypass surgery to identify the risk factors associated with mortality [43]. It includes features of metabolic syndrome and sleep-disordered breathing. Although only validated for bariatric surgical patients, it may be applicable to obese patients undergoing non-bariatric operations. Patients who

Table 4 The Obesity Surgery Mortality Risk Stratification score: (a) risk factors; (b) risk of mortality [43].

Risk factor	Score
(a)	
BMI > 50 kg.m^{-2}	1
Male	1
Age > 45 years	1
Hypertension	1
Risk factors for pulmonary embolism:	1
Previous venous thromboembolism	
Vena caval filter	
Hypoventilation (sleep-disordered breathing)	
Pulmonary hypertension	
	Risk of mortality
(b)	
Class A: 0-1 points	0.2–0.3%
Class B: 2–3 points	1.1–1.5%
Class C: 4–5 points	2.4–3.0%

score 4–5 on the OS-MRS are more likely to require closer postoperative monitoring.

All patients should have their height and weight recorded and BMI calculated, and these should both be recorded on the operating list to inform the teams that additional time, equipment and preparation may be needed. There may be an advantage in estimating lean and adjusted body weight and recording these in the patient's records to aid the calculation of drug doses.

Diagnostic testing should be based on the need to evaluate co-morbidity and the complexity of surgery, rather than merely as a result of the presence of obesity.

In bariatric surgery, it is routine to initiate a pre-operative 'liver shrinking' diet to reduce the size of the liver and make access to the stomach technically easier. There is evidence that 2–6 weeks of intense pre-operative dieting can improve respiratory function and facilitate laparoscopic surgery, and may be worth considering in the higher risk patients [44].

Pre-operative discussion can promote smoking cessation, clarify the importance of thromboprophylaxis and early mobilisation, plan the management of medication before admission and remind relevant patients to bring their own CPAP machine into hospital.

Respiratory assessment

Clinical evaluation of the respiratory system and exercise tolerance should identify functional limitations and guide further assessment. It is helpful to assess patients' arterial saturation in the pre-assessment clinic. Spirometry is also often useful.

The following features may indicate the presence of significant underlying respiratory disease and should prompt consideration of pre-operative arterial blood gas analysis [45]:

- Arterial saturation < 95% on air
- Forced vital capacity < 3 l or forced expiratory volume in 1 s < 1.5 l
- Respiratory wheeze at rest
- Serum bicarbonate concentration > 27 mmol.l^{-1}

An arterial PCO_2 > 6 kPa indicates a degree of respiratory failure and consequently the likelihood of increased anaesthetic risk.

It is essential to screen for sleep-disordered breathing. Of the several screening tools available, the STOP-BANG questionnaire (Table 5) is the best validated in obese patients. It is easy to calculate and has

Table 5 The STOP-BANG screening questionnaire for obstructive sleep apnoea (adapted with permission [46, 47]. One point is scored for each positive feature; a score ≥ 5 is a significant risk.

Snoring	Do you snore loudly (louder than talking or heard through a closed door?)
Tired	Do you often feel tired, fatigued or sleepy during the daytime? Do you fall asleep in the daytime?
Observed	Has anyone observed you stop breathing or choking or gasping during your sleep?
Blood Pressure	Do you have, or are you being treated for, high blood pressure?
BMI	BMI > 35 kg.m^2
Age	Age > 50 years
Neck	Circumference (measured around Adam's apple) > 43 cm (17 in) for males, > 41 cm (16 in) for females
Gender	Male

shown good correlation with the severity of postoperative apnoeas. A STOP-BANG score of 5 or greater indicates the possibility of significant sleep-disordered breathing and should prompt referral to a sleep physician if time allows [46, 47]. Even in the presence of a low STOP-BANG score, a history of marked exertional dyspnoea, morning headaches and ECG evidence of right atrial hypertrophy may indicate the presence of sleep-disordered breathing and should also prompt referral for assessment.

Patients with undiagnosed OSA, or those unable to tolerate CPAP, are at the highest risk of peri-operative respiratory and cardiovascular morbidity [48], while patients fully compliant with CPAP (usually indicated by symptomatic benefit) are at lower risk of peri-operative events. In general, patients with adequately treated sleep-disordered breathing do not have problems requiring high dependency care and may even be suitable for day surgery [49] (see below).

Airway assessment

Obesity is associated with a 30% greater chance of difficult/failed intubation, although predictors for difficult laryngoscopy are the same as for the non-obese [50]. A large neck circumference is a useful additional indicator and when greater than 60 cm, is associated with a 35% probability of difficult laryngoscopy [51].

Bag-mask ventilation is also known to be more difficult in the obese [52, 53]. Beards in particular can cause problems with bag-mask ventilation and are quite common in the obese male population. If time allows, it is recommended that all facial hair should be removed pre-operatively, or at the very least clipped short.

Cardiovascular assessment

Obese patients should be assessed in the same way as any other patient group. Features of the metabolic syndrome should be actively identified as there is a strong association with cardiac morbidity [54]. Assessment of exercise tolerance can be a valuable tool. The requirement for specific cardiac investigations should be based on: the degree of exercise tolerance; the presence of additional co-morbidity; and the site and extent of the anticipated surgery.

Cardiopulmonary exercise testing (CPET) may predict those at high risk of postoperative complications and increased length of stay [55, 56]. Standard CPET equipment may not be suitable and recumbent bikes are available for heavier patients.

Planning postoperative care

The planned postoperative management of most obese patients should resemble the enhanced recovery programmes of many surgical specialities.

Obesity alone is not a clinical indication for high-dependency postoperative care. Factors that warrant consideration for a level-2 or -3 setting include the following:

- Pre-existing co-morbidities
- Indicated high risk (e.g. OS-MRS 4-5 or limited functional capacity)
- Surgical procedure
- Untreated OSA plus a requirement for postoperative parenteral opioids
- Local factors including the skill mix of ward staff

An important consideration for all patients is the degree and site of surgery. If longer acting opioids (e.g. morphine) are necessary, then these patients will require closer monitoring, specifically watching for developing hypercapnia, and level-2 care may be indicated [57].

Intra-operative care

Preparation of patients

Patients' dignity is important, so suitably sized theatre gowns and disposable underwear should be available. Antacid and analgesic premedication should be considered. As previously mentioned, it may be appropriate to ask male patients with beards to shave/trim them before surgery.

Preparation of staff

The specific peri-operative requirements of the obese patient should be included in the pre-operative team brief of the WHO surgical checklist to ensure the presence of appropriate equipment, including suitable operating tables, beds and trolleys (see below).

Extra time should be allowed for positioning the obese patient and performing anaesthesia. Anaesthetists should recognise when additional personnel (another trained anaesthetist or additional operating department practitioners) are needed.

The seniority of both the anaesthetist and the surgeon should be considered. Patients with an OS-MRS score > 3 should be discussed with a consultant, and those with a score of 4–5 should be anaesthetised by an anaesthetist experienced in the management of such patients. An experienced surgeon will reduce operative time and this will help to limit peri-operative morbidity.

Regional anaesthesia

Where possible, regional anaesthesia is preferred to general anaesthesia, although a plan for airway management is still mandatory [58]. There is a higher risk of failure of regional techniques in the obese, and appropriate patient counselling/consent is advised. [59] If sedation is required during regional anaesthesia, this should be kept to the minimum. Specific equipment such as extra-long spinal or epidural needles should be available and ultrasound might be a useful adjunct [60].

There are advantages to the patient (comfort) and practitioner (success rates) in using the sitting position for neuraxial techniques, and it may be helpful to tilt the bed towards the operator so the patient naturally leans forward [61]. To reduce epidural catheter migration, it is recommended that at least 5 cm catheter should be left in the epidural space [62].

It is safer to calculate local anaesthetic drug dose using lean body weight. Despite the potential reduction in neuraxial volume due to adipose tissue, standard doses of local anaesthetic are recommended for central neuraxial blockade [63].

The anaesthetist should be aware that hypotension following neuraxial anaesthesia may be more problematic in the obese as they are less tolerant of lying flat or in the Trendelenberg position.

Induction of general anaesthesia

Easily reversible drugs, with fast onset and offset, are the agents of choice for obese patients.

Anaesthetising the patient in the operating theatre has the advantages of avoiding the problems associated with transporting an obese anaesthetised patient, and will also reduce the risk of arterial desaturation and AAGA associated with disconnection of the breathing system during transfer [38, 64]. In addition, the patient can position him/herself on the operating table and can help identify pressure points for protection.

There were a number of learning points from the fourth National Audit Project (NAP4) which looked at airway complications that are pertinent to the airway management of the obese patient [65]:

- There was often a lack of recognition and planning for potential airway problems
- As a result of the reduced safe apnoea time, when airway complications occurred, they did so rapidly and potentially catastrophically
- There was evidence that rescue techniques such as supraglottic airway devices and emergency cricothyroidotomy had an increased failure rate
- Adverse events occurred more frequently in obese patients when anaesthetised by inexperienced staff

Since the work of spontaneous breathing is increased in the obese patient, tracheal intubation with controlled ventilation is the airway management technique of choice. Use of supraglottic airway devices as the primary airway device should be reserved for highly selected patients undergoing short procedures and, where the patient can be kept head-up during surgery. The upper airway should be accessible at all times and there must be a plan for tracheal intubation if required.

During induction of anaesthesia, the patient should be positioned in a ramped position with the tragus of the ear level with the sternum, and the arms away from the chest (Fig. 3). This will improve lung mechanics, thereby assisting oxygenation and ventilation and as a result, maxi-

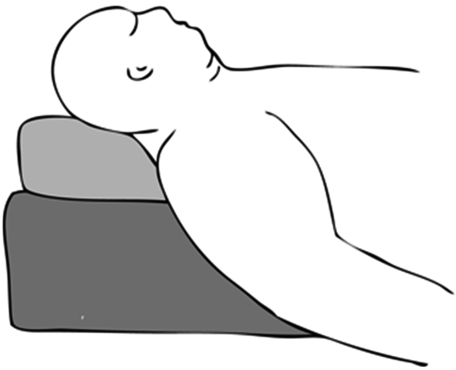

Figure 3 Ramping position for obese patients. Note the tragus of the ear level with the sternum.

mising the safe apnoea time. The addition of positive end-expiratory pressure (PEEP) may further facilitate pre-oxygenation [66]. Minimising the time from induction to intubation will reduce the risk of oxygen desaturation should bag-mask ventilation prove difficult. It has been demonstrated that ramping improves the view at laryngoscopy in the obese patient and this is therefore the recommended default position during induction in all obese patients [67]. Any difficulty with/failure of direct laryngoscopy should be promptly managed in accordance with the Difficult Airway Society guidelines [68].

Suxamethonium-associated fasciculations increase oxygen consumption and have been shown to shorten the safe apnoea time [69]; consequently, it is unlikely to wear off before profound hypoxia occurs, and so may not be the drug of choice for obese patients [70]. With the advent of sugammadex, aminosteroids could instead be considered the neuromuscular blocking drugs of choice. The use of rocuronium can minimise the apnoea time from cessation of spontaneous ventilation to control of ventilation via a secure airway if bag-mask ventilation is difficult. The dose of sugammadex for emergency reversal should be pre-calculated and be immediately available for preparation if required [71].

Ideal body weight should be used to size tracheal tubes and to calculate tidal volume during controlled ventilation. Tracheal diameter reduces slightly with increasing BMI [72]. During controlled ventilation, no particular mode of controlled ventilation has been proven to be superior; however, greater tidal volumes for a given peak pressure can often be achieved using pressure-controlled, rather than volume-controlled, ventilation. The addition of sufficient PEEP and recruitment manoeuvres will reduce intra- and postoperative atelectasis [73]. For laparoscopic surgery, flexion of the patient's trunk, i.e. a slight sitting position, allows increased abdominal excursion and slightly lower airway pressures [74].

As intravenous access is often difficult in the obese, it is prudent to site two intravenous cannulae while in theatre. Ultrasound may prove useful to help locate peripheral veins but consideration should be given to unusual sites for intravenous access such as the upper arm and anterior chest wall. Central venous access should only be used if peripheral access is impossible, or if specifically indicated.

The 'SDB-safe' anaesthetic

A simple and safe principle is to assume that all obese patients have some degree of sleep-disordered breathing (whether formally tested or not) and to modify the anaesthetic technique accordingly. Useful peri-operative strategies therefore include the following:

- Avoidance of general anaesthesia and sedatives where possible
- Use of short acting agents
- Use of depth of anaesthesia monitoring techniques to limit anaesthetic load, particularly when neuromuscular blocking drugs and/or a total intravenous anaesthetic technique are utilised
- Use of neuromuscular monitoring to maintain a level of block compatible with surgery and to ensure complete reversal of block before waking the patient
- Maximal use of local anaesthetic and multimodal opioid-sparing analgesia
- Maintaining the head–up position throughout recovery
- Monitoring of oxygen saturations until mobile postoperatively

If long-acting opioids are required and the patient is not stabilised on CPAP pre-operatively, then the use of level-2 care is recommended.

Maintenance of anaesthesia

There is limited evidence at present to favour either TCI of propofol or volatile agents for maintenance of anaesthesia in the obese. However, due to the increased risk of AAGA in the obese, it is important that maintenance is commenced promptly after induction of anaesthesia [38]. Fat-insoluble volatile agents such as desflurane or sevoflurane have a faster onset and offset than isoflurane. There is evidence of faster return of airway reflexes with desflurane compared with sevoflurane in the obese [75].

Multimodal analgesia techniques, including local anaesthesia, enable opioid sparing and are strongly recommended.

Emergence from anaesthesia

Both NAP4 and NAP5 showed a high incidence of problems during extubation in the obese. An extubation plan must therefore be in place in accordance with the Difficult Airway Society extubation guidelines [76].

Reversal of neuromuscular blockade should be guided by a nerve stimulator. The aim is to restore motor capacity before waking the patient [38]. Patients should have return of their airway reflexes and be breathing with good tidal volumes before tracheal extubation, which should be performed with the patient awake and in the sitting position.

In those patients with confirmed OSA, the insertion of a nasopharyngeal airway before waking helps mitigate the partial airway obstruction that is commonly seen during emergence from anaesthesia.

Postoperative care

Immediate post-anaesthesia care

Full monitoring should be maintained in the post-anaesthesia care unit (PACU). The patient should be managed in the sitting position or with a 45° head-up tilt.

Oxygen therapy should be applied to maintain pre-operative levels of arterial oxygen saturation and should be continued until the patient is mobile postoperatively. If the patient was using CPAP therapy at home, it should be reinstated on return to the ward or even in the PACU if oxygen saturation levels cannot be maintained by the use of inhaled oxygen alone [57]. If supplemental oxygen is necessary, this can either be given via the patient's CPAP machine or via nasal specula under the CPAP mask.

Before discharge from the PACU, all obese patients should be observed whilst unstimulated for signs of hypoventilation, specifically episodes of apnoea or hypopnoea with associated oxygen desaturation, which will warrant an extended period of monitoring in the PACU. Ongoing hypoventilation will require anaesthetic assessment to establish the need for further respiratory support and level-2 care.

The patient is safe to return to the ward only when:

- Routine discharge criteria are met
- The respiratory rate is normal and there are no periods of hypopnea or apnoea for at least one hour
- The arterial oxygen saturation returns to the pre-operative values with or without oxygen supplementation

Analgesia and ward care

An enhanced recovery protocol is essential [77]. Early mobilisation is vital and most patients should be out of bed on the day of surgery. If possible, restricting the patient with a urinary catheter, intravenous infusions or other devices should be avoided. Calf compression devices can be disconnected for mobilisation.

The intramuscular route of drug administration is to be avoided owing to unpredictable pharmacokinetics.

The use of patient-controlled analgesia (PCA) systems needs careful consideration because of the increased risk of respiratory depression in those with undiagnosed sleep-disordered breathing. In those patients with suspected or poorly treated sleep-disordered breathing, increased postoperative monitoring in a level-2 unit is recommended if PCA is required.

Subarachnoid block with an opioid adjunct is a useful technique resulting in reduced postoperative opioid requirements. Epidural infusions are associated with reduced postoperative mobility and may be counterproductive.

In the ward, oxygen therapy should be continued until baseline arterial oxygen saturations are achieved, and pulse oximetry should continue until oxygen saturations remain at baseline without supplemental oxygen and parenteral opioids are no longer required.

Postoperative tachycardia may be the only sign of a postoperative complication and should not be ignored (see below).

Thromboprophylaxis

Obesity per se is a risk factor for VTE and it is recommended that all obese patients, undergoing all but minor surgery, should receive VTE prophylaxis. Guidelines for postsurgical VTE prophylaxis were published by the National Institute for Health and Care Excellence in 2010 [78]. Strategies to reduce the risk of VTE include: early postoperative mobilisation; mechanical compression devices; thromboembolic device (TED) stockings; anticoagulant drugs; and vena caval filters. There is

Table 6 Dosing schedule for thromboprophylaxis [80].

	< 50 kg	50–100 kg	100–150 kg	> 150 kg
Enoxaparin	20 mg once daily	40 mg once daily	40 mg twice daily	60 mg twice daily
Dalteparin	2500 units once daily	5000 units once daily	5000 units twice daily	7500 units twice daily
Tinzaparin	3500 units once daily	4500 units once daily	4500 units twice daily	6750 units twice daily

currently limited evidence to support the use of TEDs in obesity, but if used, it is essential that they be fitted correctly to avoid vascular occlusion. Current evidence does not support the routine use of venal caval filters in the obese population [79].

The mainstay of VTE prophylaxis in obesity is pharmacological, with the criteria for pharmacological prophylaxis including: prolonged immobilisation; total theatre time > 90 min; age > 60 years; BMI > 30 $kg.m^{-2}$; cancer; dehydration; and a family history of VTE.

Oral agents such as rivaroxiban and dabigatran are licensed for VTE prophylaxis following orthopaedic surgery, but there is limited evidence for their use in obesity. At present, dose adjustment for oral agents is not recommended for the obese.

There is evidence regarding dose adjustments for low molecular weight heparins in obesity. The Haemostasis, Anticoagulation and Thrombosis (HAT) Committee published the dosing schedule reproduced in Table 6 in April 2010 [80].

Rhabdomyolysis

A rare but serious complication in the obese patient is rhabdomyolysis. Apart from obesity, pre-disposing risk factors include hypotension, immobility, prolonged operative procedures and dehydration.

Rhabdomyolysis should be considered if the patient has postoperative deep tissue pain, classically in the buttocks. Serum creatinine kinase concentration should be measured promptly, and if rising, aggressive fluid resuscitation, diuretics and urinary alkalinisation may be required to prevent further acute kidney injury [81].

Special circumstances

Sedation

Pre-operative evaluation for patients undergoing sedation should be similar to those having general anaesthesia. Patients with sleep-disordered breathing are likely to have airway obstruction with even minimal sedation. Obese patients are not suitable for solo operator-sedator procedures [82].

Emergency surgery

It is particularly important that obese patients requiring emergency surgery are managed by an anaesthetist experienced in the care of the obese, along with an experienced surgeon in order to minimise the operative time and the risk of complications [83]. Postoperative level-2 nursing care is far more likely to be required owing to the much higher risk from emergency surgery complications.

Obese patients can look deceptively well and abdominal examination can be notoriously difficult. Tachycardia, the new onset of abdominal pain or unexplained fever may be the only signs of intra-abdominal sepsis and should be an indication for measuring arterial blood gases and serum lactate.

Day surgery

It is acceptable for obese patients to undergo surgery as a day case if: the management would not be modified if they were admitted as an inpatient; and being treated as a day case will not alter the peri-operative risk.

The exclusion of obese patients from the advantages that day surgery may offer should not be made on the basis of weight alone. There is an increased risk of anaesthetic-related complications in obese patients in the day surgery environment, but these tend to occur on induction of anaesthesia, intra-operatively or in the early recovery phase [84]. Obesity has no influence on the rate of unanticipated admission, postoperative complications, readmission or other unplanned contact with health professionals after home discharge [85].

Current guidelines advocate automatic acceptance of patients with BMI < 40 $kg.m^{-2}$ [86, 87]. A casenote review should be carried out by an anaesthetist to determine whether individualised discussion and assessment may be required before the day of surgery for those with co-morbidities or BMI > 40 $kg.m^{-2}$.

A review and meta-analysis by the Society for Ambulatory Anesthesia provides useful advice on day surgery for patients with sleep-disordered breathing [49]. Patients with a known diagnosis of OSA can be considered for day surgery: if they have, and are able to use, a CPAP device after discharge; if any co-morbid conditions are optimised; and if postoperative pain relief can be provided predominantly by non-opioid analgesics.

Laparoscopic cholecystectomy and laparoscopic gastric banding are increasingly being performed as a day-case procedure [88–90].

Obstetrics

Maternal obesity is recognised as one of the most commonly occurring risk factors seen in obstetrics, with outcomes for both mother and baby poorer than in the general population [3].

The CMACE report and the Obstetric Anaesthetists' Association have made a number of recommendations regarding the care of obese pregnant women [91, 92]. Obese women have an increased risk of co-morbidity during pregnancy, in particular gestational diabetes and pre-eclampsia [93, 94]. Obesity and pregnancy are both significant risk factors for the development of VTE in pregnancy.

Compared with a non-obese parturient, an obese woman is more likely to have her labour induced and require instrumental delivery [95, 96]. There is an increased risk of operative and postoperative complications, including increased rates of postpartum haemorrhage, prolonged operative times, and infective complications such as endometritis and wound infection [97].

Fetal outcomes in obese pregnant women are poorer compared with the general population, with stillbirth rates in women with a BMI > 35 kg.m^{-2} twice as high as the national stillbirth rate. There is an increased risk of preterm delivery in pregnant obese women [98].

In addition, babies born to obese mothers are at increased risk of shoulder dystocia, brachial plexus lesions, fractured clavicle and congenital birth defects such as neural tube defects [99].

Specific anaesthetic considerations are similar to those in the non-obstetric obese patient:

- Obese patients are particularly vulnerable to aortocaval compression
- Vascular access may be more difficult and should be established early in labour in a woman with a BMI > 40 kg.m^{-2} [3]
- The provision of general anaesthesia and central neuraxial blockade is associated with increased difficulties [100–102]. This can lead to

an increased decision-to-delivery interval in women who require a category-1 or -2 caesarean section.

The obese obstetric patient is particularly at risk of VTE and conversely, postpartum haemorrhage. The recommended dosing of anticoagulants is generally higher for pregnant women; the Royal College of Obstetricians and Gynaecologists' Green-top Guideline provides current recommendations [103].

Critical care

Outcomes of obese patients in critical care remain controversial. In several recent studies, obesity was not associated with increased mortality; however, it was associated with a prolonged requirement for mechanical ventilation, tracheostomy and prolonged length of stay in a critical care unit [104, 105].

Airway interventions in the obese are associated with an increased risk of hypoxia and complications and should only be undertaken by appropriately skilled personnel. Many would advocate an early tracheostomy if long-term airway management is anticipated. Custom-made tracheostomy tubes with an adjustable flange may be required to ensure an adequate length to reach the trachea. Tracheostomies are usually performed in the intensive care unit using a percutaneous approach, but surgical placement may be considered, depending on the experience of the available medical staff.

For mechanical ventilation, ideal body weight is used to calculate the initial recommended tidal volume of 5–7 $ml.kg^{-1}$, ensuring the peak inspiratory pressure remains < 35 cmH_2O [106].

Enteral absorption of drugs is not altered in the morbidly obese. However, owing to the altered pharmacokinetics, monitoring of serum levels is considered more important in this group of patients to ensure that drug levels remain within the therapeutic range [37].

Prophylaxis against VTE is vitally important for the morbidly obese patient in critical care and should follow the guidelines given above.

All critically ill patients are prone to develop protein malnutrition as a result of metabolic stress and despite having excess fat stores, the morbidly obese are no different. However, there is some evidence suggesting that hypocaloric feeding regimens can achieve adequate nitrogen balance with more favourable outcomes [107].

Early aggressive rehabilitation and physiotherapy should be undertaken as soon as is possible to encourage early mobilisation. Increased numbers of staff are needed to roll these patients to prevent formation of pressure sores.

Cardiopulmonary resuscitation

Morbid obesity presents additional problems during resuscitation. There may be delays caused by difficulties in placement of defibrillator pads, establishment of vascular access or securing an effective airway. Physical and biological factors related to obesity may affect the quality of chest compressions delivered, the efficacy of administered vasoactive drugs or the efficacy of defibrillator shocks applied, because none of these measures are standardised to a patient's BMI. The American Heart Association has concluded that no alterations to resuscitation have been shown to affect outcome [108].

Inspiratory airway pressures will be higher than normal, and excessive leak with supraglottic airway devices may mean that chest compressions will have to be paused to enable ventilation (i.e. a standard 30:2 compression-ventilation ratio). The high airway pressures that can occur during resuscitation of very obese patients may impair coronary perfusion pressure and ultimately reduce the chance of survival [109].

Chest compressions will be difficult to perform in many patients, simply because of suboptimal positioning of rescuers. A step or platform may be required, or compressions can be performed from the patients' head end. Recommended defibrillation energies remain unaltered in the morbidly obese, though there is evidence that the thoracic impedance is higher [110]. If defibrillation remains unsuccessful, the defibrillator pads should be repositioned and the shock energy increased to the maximum setting.

If intravenous access is difficult, the intraosseous route for drug delivery is recommended. The upper humerus is a well-established point of access, and drug delivery during resuscitation is effective via this route. Standard doses of adrenaline and amiodarone should be used.

Patients with adjustable gastric bands in situ

Laparoscopic adjustable gastric banding is a recognised treatment for obesity. However, patients with a gastric band in situ are at increased risk of pulmonary aspiration during general anaesthesia owing to oesophageal dysmotility and dilatation above the band. The dilatation may persist following band deflation. There are case reports of regurgitation of food even after prolonged fasting and a tracheal tube is recommended in all patients who have a gastric band [111, 112]. Current advice is not to deflate the band before surgery; however, depending on the extent and type of surgery, a decision to deflate the band may be made on an individual basis. Discussion with the bariatric surgical team is advised.

An important side note is that patients with gastric bands in situ who present with sudden onset of dysphagia or upper abdominal pain should be considered as having a band slippage until proved otherwise. This is a surgical emergency and should be treated by immediate deflation of the gastric band and referral to a competent general surgeon. Delay in deflating the band can lead to gastric infarction and perforation.

For the management of other bariatric surgical emergencies, readers are referred to the American Society for Metabolic and Bariatric Surgery website (see below).

Resources

Equipment

A 2011 review of incidents related to obesity reported to the National Patient Safety Agency highlighted that many of these involved inadequate provision of suitable equipment. This is a clinical governance issue and hospitals need to invest in appropriate equipment to assist in the safe management of obese patients. A suggested but not exhaustive list of equipment to be considered is given in Table 7 [113].

An 'obesity pack' is useful; this can include specialised documentation, the SOBA single-sheet guidelines (see below) and smaller items of equipment plus a list of where the larger items are located.

Staff

All units managing obese surgical patients must have the ability to escalate care appropriately in the event of acute deterioration of patients.

It is recommended that a single person in the anaesthetic department be nominated as the obesity lead. It would be his/her responsibility to ensure that equipment and training are up to standard and could act as a point of contact for advice.

Theatre teams should have training in managing obese patients, which can be provided either internally or externally. In hospitals where there is a bariatric service, all staff should periodically observe practice in this area. Specific training on moving the morbidly obese patient should be provided.

Table 7 Equipment for managing obese surgical patients.

Ward equipment
Specialised electrically operated beds that can raise a patient to standing without the need for manual handling with pressure-relieving mattresses
Suitable bathrooms with floor-mounted toilets, suitable commodes
Large blood pressure measuring cuffs
Extra-large gowns
Suitably sized compression stockings and intermittent compression devices
Larger chairs, wheelchairs and trolleys, all marked with the maximal recommended weight
Scales capable of weighing up to 300 kg
On-site blood gas analysis
Continuous positive airway pressure or high-flow oxygen delivery device for the post-anaesthesia care unit
Patient hoist or other moving device (may be shared with other departments)
Theatre equipment
Bariatric operating table, able to incorporate armboards and table extensions, attachments for positioning such as leg supports for the lithotomy position, and shoulder and foot supports
Gel pads and padding for pressure points
Wide Velcro strapping to secure the patient to the operating table
Ramping device/pillows
Raised step for the anaesthetist
Large tourniquets
Readily available difficult airway equipment
Anaesthetic ventilator capable of positive end-expiratory pressure and pressure modalities
Portable ultrasound machine
Hover-mattress or slide sheet
Long spinal and epidural needles
Long arterial lines if femoral access is necessary
Neuromuscular blockade monitor
Depth of anaesthesia monitoring to minimise residual sedation

In ideal circumstances, all anaesthetic trainees should complete a module in bariatric anaesthesia to gain insight and hands-on experience in the management of the morbidly obese surgical patient.

The SOBA single-sheet guide

This is designed as an aide memoire to be laminated and left in the anaesthetic room for reference when required. It is available on the SOBA website and updated every six months as new evidence becomes available (see www.sobauk.com).

Useful websites

The Society for Obesity and Bariatric Anaesthesia UK: www.sobauk.com.

British Obesity Surgery Patient Association: www.bospauk.org.

British Obesity and Metabolic Surgery Society: www.bomss.org.uk.

American Society for Metabolic and Bariatric Surgery: www.asmbs.org.

References

1. Association of Anaesthetists of Great Britain and Ireland. *Peri-operative Management of the Morbidly Obese Patient*. London: Association of Anaesthetists of Great Britain and Ireland, 2007.
2. Bellamy MC, Margarson MP. Designing intelligent anesthesia for a changing patient demographic: a consensus statement to provide guidance for specialist and non-specialist anesthetists written by members of and endorsed by the Society for Obesity and Bariatric Anaesthesia (SOBA). *Perioperative Medicine* 2013; **2**: 12.
3. Modder J, Fitzsimons KJ. *CMACE/RCOG Joint Guideline: Management of Women with Obesity in Pregnancy*. London: Centre for Maternal and Child Enquiries and the Royal College of Obstetricians and Gynaecologists, 2010.
4. Public Health England. Measurement of Obesity. 2014. http://www.noo.org.uk/NOO_about_obesity/measurement (accessed 08/01/2015).
5. Health and Social Care Information Centre. *Statistics on Obesity, Physical Activity and Diet: England, 2013*. Leeds: Health and Social Care Information Centre, 2013.
6. National Obesity Forum. State of the nation's waistline – obesity in the UK: analysis and expectations. 2014. http://www.nationalobesityforum.org.uk/media/PDFs/StateOfTheNationsWaistlineObesityintheUKAnalysisandExpectations.pdf (accessed 08/01/2015).
7. Kopelman P, Jebb SA, Butland B. Executive summary: foresight ''Tackling Obesities: Future Choices'' project. *Obesity Reviews* 2007; **8** (Suppl. 1): vi–ix.
8. Kissebah AH. Intra-abdominal fat: is it a major factor in developing diabetes and coronary artery disease? *Diabetes Research and Clinical Practice* 1996; **30**(Suppl. 1): S25–S30.
9. Ball J, McAnulty G. Ignoring our evolution: the 'pandemic' of over-nutrition. Not simply a metabolic syndrome? *Anaesthesia* 2014; **69**: 203–7.
10. Glance LG, Wissler R, Mukamel DB, et al. Perioperative outcomes among patients with the modified metabolic syndrome who are undergoing noncardiac surgery. *Anesthesiology* 2010; **113**: 859–72.

11. Schneider HJ, Glaesmer H, Klotsche J, et al. Accuracy of anthropometric indicators of obesity to predict cardiovascular risk. *Journal of Clinical Endocrinology and Metabolism* 2007; **92**: 589–94.
12. Pelosi P, Croci M, Ravagnan I, et al. The effects of body mass on lung volumes, respiratory mechanics, and gas exchange during general anesthesia. *Anesthesia and Analgesia* 1998; **87**: 654–60.
13. Sikka N, Wegienka G, Havstad S, Genaw J. Respiratory medication prescriptions before and after bariatric surgery. *Annals of Allergy, Asthma and Immunology* 2010; **104**: 326–30.
14. Schachter LM. Obesity is a risk for asthma and wheeze but not airway hyperresponsiveness. *Thorax* 2001; **56**: 4–8.
15. Berry RB, Budhiraja R, Gottlieb DJ, et al. Rules for scoring respiratory events in sleep: update of the 2007 AASM manual for the scoring of sleep and associated events. *Journal of Clinical Sleep Medicine* 2012; **8**: 597–619.
16. Mutter TC, Chateau D, Moffatt M, et al. A matched cohort study of post-operative outcomes in obstructive sleep apnea. *Anesthesiology* 2014; **121**: 707–18.
17. Doufas AG, Tian L, Padrez KA, et al. Experimental pain and opioid analgesia in volunteers at high risk for obstructive sleep apnea. *PLoS ONE* 2013; **8**: e54807.
18. Weingarten T, Flores A. Obstructive sleep apnoea and perioperative complications in bariatric patients. *British Journal of Anaesthesia* 2010; **106**: 273–3.
19. Mokhlesi B. Obesity hypoventilation syndrome: a state of the art review. *Respiratory Care* 2010; **55**: 1347–62.
20. Leykin Y, Brodsky JB. *Controversies in the Anesthetic Management of the Obese Surgical Patient*. New York: Springer, 2012.
21. Chung F, Liao P, Elsaid H, Islam S, Shapiro CM, Sun Y. Oxygen desaturation index from nocturnal oximetry. *Anesthesia and Analgesia* 2012; **114**: 993–1000.
22. Wanahita N, Messerli FH, Bangalore S, Gami AS, Somers VK, Steinberg JS. Atrial fibrillation and obesity – results of a meta-analysis. *American Heart Journal* 2008; **155**: 310–5.
23. Peeters A, Barendregt JJ, Willekens F, Mackenbach JP, Mamun Al A, Bonneux L. Obesity in adulthood and its consequences for life expectancy: a life-table analysis. *Annals of Internal Medicine* 2003; **138**: 24–32.
24. Lavie CJ, Milani RV, Ventura HO. Obesity and cardiovascular disease: risk factor, paradox, and impact of weight loss. *Journal of the American College of Cardiology* 2009; **53**: 1925–32.
25. Medicines and Healthcare products Regulatory Agency. Ondansetron for intravenous use: dose-dependent QT interval prolongation – new posology. 2013. http://www.mhra.gov.uk/Safetyinformation/DrugSafetyUpdate/CON296402 (accessed 08/01/2015).
26. Hernandez AF, Whellan DJ, Stroud S, Sun JL, O'Connor CM, Jollis JG. Outcomes in heart failure patients after major noncardiac surgery. *Journal of the American College of Cardiology* 2004; **44**: 1446–53.
27. Blokhin IO, Lentz SR. Mechanisms of thrombosis in obesity. *Current Opinion in Hematology* 2013; **20**: 437–44.

28. Parkin L, Sweetland S, Balkwill A, et al. Body mass index, surgery, and risk of venous thromboembolism in middle-aged women: a cohort study. *Circulation* 2012; **125**: 1897–904.
29. Demaria EJ, Portenier D, Wolfe L. Obesity surgery mortality risk score: proposal for a clinically useful score to predict mortality risk in patients undergoing gastric bypass. *Surgery for Obesity and Related Diseases* 2007; **3**: 134–40.
30. Magee CJ, Barry J, Javed S, Macadam R, Kerrigan D. Extended thromboprophylaxis reduces incidence of postoperative venous thromboembolism in laparoscopic bariatric surgery. *Surgery for Obesity and Related Diseases* 2010; **6**: 322–5.
31. Tasali E, Ip MSM. Obstructive sleep apnea and metabolic syndrome: alterations in glucose metabolism and inflammation. *Proceedings of the American Thoracic Society* 2008; **5**: 207–17.
32. Frisch A, Chandra P, Smiley D, et al. Prevalence and clinical outcome of hyperglycemia in the perioperative period in noncardiac surgery. *Diabetes Care* 2010; **33**: 1783–8.
33. Guidone C. Mechanisms of recovery from type 2 diabetes after malabsorptive bariatric surgery. *Diabetes* 2006; **55**: 2025–31.
34. Janmahasatian S, Duffull SB, Ash S, Ward LC, Byrne NM, Green B. Quantification of lean body weight. *Clinical Pharmacokinetics* 2005; **44**: 1051–65.
35. Ingrande J, Lemmens HJM. Dose adjustment of anaesthetics in the morbidly obese. *British Journal of Anaesthesia* 2010; **105**(Suppl. 1): i16–23.
36. Gepts E. Pharmacokinetic concepts for TCI anaesthesia. *Anaesthesia* 1998; **53** (Suppl. 1): 4–12.
37. Hanley MJ, Abernethy DR, Greenblatt DJ. Effect of obesity on the pharmacokinetics of drugs in humans. *Clinical Pharmacokinetics* 2010; **49**: 71–87.
38. Pandit JJ, Andrade J, Bogod DG, et al. The 5th National Audit Project (NAP5) on accidental awareness during general anaesthesia: protocol, methods and analysis of data. *Anaesthesia* 2014; **69**: 1078–88.
39. Ingrande J, Brodsky JB, Lemmens HJM. Lean body weight scalar for the anesthetic induction dose of propofol in morbidly obese subjects. *Anesthesia and Analgesia* 2011; **113**: 57–62.
40. Leykin Y, Pellis T, Lucca M, Lomangino G, Marzano B, Gullo A. The pharmacodynamic effects of rocuronium when dosed according to real body weight or ideal body weight in morbidly obese patients. *Anesthesia and Analgesia* 2004; **99**: 1086–9.
41. Hammoud HA, Aymard G, Lechat P, Boccheciampe N, Riou B, Aubrun F. Relationships between plasma concentrations of morphine, morphine-3-glucuronide, morphine-6-glucuronide, and intravenous morphine titration outcomes in the postoperative period. *Fundamental and Clinical Pharmacology* 2011; **25**: 518–27.
42. Absalom AR, Mani V, De Smet T, Struys MMRF. Pharmacokinetic models for propofol-defining and illuminating the devil in the detail. *British Journal of Anaesthesia* 2009; **103**: 26–37.
43. Demaria EJ, Murr M, Byrne TK, et al. Validation of the Obesity Surgery Mortality Risk score in a multicenter study proves it stratifies mortality risk in patients undergoing gastric bypass for morbid obesity. *Annals of Surgery* 2007; **246**: 578–84.

44. Edholm D, Kullberg J, Haenni A, et al. Preoperative 4-week low-calorie diet reduces liver volume and intrahepatic fat, and facilitates laparoscopic gastric bypass in morbidly obese. *Obesity Surgery* 2011; **21**: 345–50.
45. Mandal S, Hart N. Respiratory complications of obesity. *Clinical Medicine* 2012; **12**: 75–8.
46. Chung F, Subramanyam R, Liao P, Sasaki E, Shapiro C, Sun Y. High STOP-BANG score indicates a high probability of obstructive sleep apnoea. *British Journal of Anaesthesia* 2012; **108**: 768–75.
47. Chung F, Yang Y, Liao P. Predictive performance of the STOP-BANG score for identifying obstructive sleep apnea in obese patients. *Obesity Surgery* 2013; **23**: 2050–7.
48. Hallowell PT, Stellato TA, Petrozzi MC, et al. Eliminating respiratory intensive care unit stay after gastric bypass surgery. *Surgery* 2007; **142**: 608–12.
49. Joshi GP, Ankichetty SP, Gan TJ, Chung F. Society for Ambulatory Anesthesia consensus statement on preoperative selection of adult patients with obstructive sleep apnea scheduled for ambulatory surgery. *Anesthesia and Analgesia.* 2012; **115**: 1060–8.
50. Lundstrøm LH, Møller AM, Rosenstock C, Astrup G, Wetterslev J. High body mass index is a weak predictor for difficult and failed tracheal intubation: a cohort study of 91,332 consecutive patients scheduled for direct laryngoscopy registered in the Danish Anesthesia Database. *Anesthesiology* 2009; **110**: 266–74.
51. Brodsky JB, Lemmens HJM, Brock-Utne JG, Vierra M, Saidman LJ. Morbid obesity and tracheal intubation. *Anesthesia and Analgesia* 2002; **94**: 732–6.
52. Kheterpal S, Martin L, Shanks AM, Tremper KK. Predictions and outcomes of impossible mask ventilation: a review of 50,000 anesthetics. *Anesthesiology* 2009; **110**: 891–7.
53. Langeron O, Masso E, Huraux C, et al. Prediction of difficult mask ventilation. *Anesthesiology* 2000; **92**: 1229–36.
54. Apovian CM, Gokce N. Obesity and cardiovascular disease. *Circulation* 2012; **125**: 1178–82.
55. McCullough PA, Gallagher MJ, Dejong AT, et al. Cardiorespiratory fitness and short-term complications after bariatric surgery. *Chest* 2006; **130**: 517–25.
56. Hennis PJ, Meale PM, Hurst RA, et al. Cardiopulmonary exercise testing predicts postoperative outcome in patients undergoing gastric bypass surgery. *British Journal of Anaesthesia* 2012; **109**: 566–71.
57. Practice guidelines for the perioperative management of patients with obstructive sleep apnea: an updated report by the American Society of Anesthesiologists Task Force on Perioperative Management of patients with obstructive sleep apnea. *Anesthesiology* 2014; **120**: 268–86.
58. Nielsen KC, Guller U, Steele SM, Klein SM, Greengrass RA, Pietrobon R. Influence of obesity on surgical regional anesthesia in the ambulatory setting: an analysis of 9,038 blocks. *Anesthesiology* 2005; **102**: 181–7.
59. Ingrande J, Brodsky JB, Lemmens HJ. Regional anesthesia and obesity. *Current Opinion in Anesthesiology* 2009; **22**: 683–6.
60. Balki M, Lee Y, Halpern S, Carvalho CA. Ultrasound imaging of the lumbar spine in the transverse plane: the correlation between estimated and actual depth to

the epidural space in obese parturients. *Anesthesia and Analgesia* 2009; **108**: 1876–81.
61. Hamza J, Smida M, Benhamou D, Cohen SE. Parturient's posture during epidural puncture affects the distance from the skin to epidural space. *Journal of Clinical Anesthesia* 1995; **7**: 1–4.
62. Afshan G, Chohan U, Khan FA, Chaudhry N, Khan ZE, Khan AA. Appropriate length of epidural catheter in the epidural space for postoperative analgesia: evaluation by epidurography. *Anaesthesia* 2011; **66**: 913–8.
63. Carvalho B, Collins J, Drover DR, Atkinson Ralls L, Riley ET. ED(50) and ED(95) of intrathecal bupivacaine in morbidly obese patients undergoing cesarean delivery. *Anesthesiology* 2011; **114**: 529–35.
64. Broom MA, Slater J, Ure DS. An observational study of practice during transfer of patients from anaesthetic room to operating theatre. *Anaesthesia* 2006; **61**: 943–5.
65. Cook TM, Woodall N, Frerk C, on behalf of the Fourth National Audit Project. Major complications of airway management in the UK: results of the Fourth National Audit Project of the Royal College of Anaesthetists and the Difficult Airway Society. Part 1: Anaesthesia. *British Journal of Anaesthesia* 2011; **106**: 617–31.
66. Gander S, Frascarolo P, Suter M, Spahn DR, Magnusson L. Positive end-expiratory pressure during induction of general anesthesia increases duration of nonhypoxic apnea in morbidly obese patients. *Anesthesia and Analgesia* 2005; **100**: 580–4.
67. Collins JS, Lemmens HJM, Brodsky JB, Brock-Utne JG, Levitan RM. Laryngoscopy and morbid obesity: a comparison of the ''sniff'' and ''ramped'' positions. *Obesity Surgery* 2004; **14**: 1171–5.
68. Henderson JJ, Popat MT, Latto IP, Pearce AC. Difficult Airway Society guidelines for management of the unanticipated difficult intubation. *Anaesthesia* 2004; **59**: 675–94.
69. Taha SK, El-Khatib MF, Baraka AS, et al. Effect of suxamethonium vs rocuronium on onset of oxygen desaturation during apnoea following rapid sequence induction. *Anaesthesia* 2010; **65**: 358–61.
70. Benumof JL, Dagg R, Benumof R. Critical hemoglobin desaturation will occur before return to an unparalyzed state following 1 mg/kg intravenous succinylcholine. *Anesthesiology* 1997; **87**: 979–82.
71. Bisschops MMA, Holleman C, Huitink JM. Can sugammadex save a patient in a simulated 'cannot intubate, cannot ventilate' situation? *Anaesthesia* 2010; **65**: 936–41.
72. D'Anza B, Knight J, Greene JS. Does body mass index predict tracheal airway size? *Laryngoscope* 2014; http://onlinelibrary.wiley.com/doi/10.1002/lary.24943/full (accessed 04/03/2015).
73. Santesson J. Oxygen transport and venous admixture in the extremely obese. Influence of anaesthesia and artificial ventilation with and without positive end-expiratory pressure. *Acta Anaesthesiologica Scandinavica* 1976; **20**: 387–94.
74. Mulier JPJ, Dillemans B, Cauwenberge S. Impact of the patient's body position on the intraabdominal workspace during laparoscopic surgery. *Surgical Endoscopy* 2010; **24**: 1398–402.

75. McKay RE, Malhotra A, Cakmakkaya OS, Hall KT, McKay WR, Apfel CC. Effect of increased body mass index and anaesthetic duration on recovery of protective airway reflexes after sevoflurane vs desflurane. *British Journal of Anaesthesia* 2010; **104**: 175–82.
76. Extubation algorithm. Difficult Airway Society. 2011. http://www.das.uk.com/content/das-extubation-guidelines (accessed 24/02/2014).
77. Awad S, Carter S, Purkayastha S, et al. Enhanced recovery after bariatric surgery (ERABS): clinical outcomes from a tertiary referral bariatric centre. *Obesity Surgery* 2014; **24**: 753–8.
78. *Venous Thromboembolism Prevention Quality Standard*. National Institute for Health and care Excellence (NICE), 2010. https://www.nice.org.uk/guidance/qs3 (accessed 24/02/2015).
79. Rowland S, Dharmarajah B, Moore H, et al. Inferior vena cava filters for prevention of venous thromboembolism in obese patients undergoing bariatric surgery. *Annals of Surgery* 2015; **261**: 35–45.
80. Haematology, Anticoagulation and Thrombosis Committee. Medicines Q&As, 2010. http://vteprevention-nhsengland.org.uk/images/Thromboprophylaxis%20and%20extreme%20weight.doc (accessed 14/10/2014).
81. Wool DB, Lemmens HJM, Brodsky JB, Solomon H, Chong KP, Morton JM. Intraoperative fluid replacement and postoperative creatine phosphokinase levels in laparoscopic bariatric patients. *Obesity Surgery* 2010; **20**: 698–701.
82. Academy of Medical Royal Colleges. *Safe Sedation Practice for Healthcare Procedures. Standards and Guidance*. London: Academy of Medical Royal Colleges, 2013.
83. National Confidential Enquiry into Perioperative Outcome and Death. *Peri-operative Care: Knowing the Risk*. London: NCEPOD, 2011. www.ncepod.org.uk/2011poc.htm (accessed 08/01/2015).
84. Chung F, Mezei G, Tong D. Pre-existing medical conditions as predictors of adverse events in day-case surgery. *British Journal of Anaesthesia* 1999; **83**: 262–70.
85. Davies KE, Houghton K, Montgomery JE. Obesity and day-case surgery. *Anaesthesia* 2001; **56**: 1112–5.
86. Verma R, Alladi R, Jackson I, et al. Day case and short stay surgery: 2. *Anaesthesia* 2011; **66**: 417–434.
87. Jones K, Montgomery J. Pushing the patient boundaries. In: Smith I, McWhinnie D, Jackson I, eds. *Day Case Surgery*. Oxford: Oxford University Press, 2012: 327–34.
88. Watkins BM, Ahroni JH, Michaelson R, et al. Laparoscopic adjustable gastric banding in an ambulatory surgery center. *Surgery for Obesity and Related Diseases* 2008; **4**: S56–62.
89. Dunsire MF, Patel AG, Awad N. Laparoscopic gastric banding for morbid obesity in the day surgical setting. *Journal of One-Day Surgery* 2007; **17.3**: A19.
90. Cobourn C, Mumford D, Chapman MA, Wells L. Laparoscopic gastric banding is safe in outpatient surgical centers. *Obesity Surgery* 2010; **20**: 415–22.
91. Centre for Maternal and Child Enquiries (CMACE). *Maternal Obesity in the UK: Findings from a National Project*. London: CMACE, 2010.
92. Obstetric Anaesthetists' Association. Advice to OAA Members from the OAA Committee: Re: CMACE Report 'Maternal obesity in the UK: findings from a national

project' (2010). 2011. http://www.oaa-anaes.ac.uk/assets/_managed/editor/File/CMACE/OAA_response_to_obesity_report.pdf (accessed 08/01/2015).
93. Callaway LK, Prins JB, Chang AM, McIntyre HD. The prevalence and impact of overweight and obesity in an Australian obstetric population. *Medical Journal of Australia* 2006; **184**: 56–9.
94. Duckitt K, Harrington D. Risk factors for pre-eclampsia at antenatal booking: systematic review of controlled studies. *British Medical Journal* 2005; **330**: 565.
95. Vahratian A, Zhang J, Troendle JF, Savitz DA, Siega-Riz AM. Maternal prepregnancy overweight and obesity and the pattern of labor progression in term nulliparous women. *Obstetrics and Gynecology* 2004; **104**: 943–51.
96. Chu SY, Kim SY, Schmid CH, et al. Maternal obesity and risk of cesarean delivery: a meta-analysis. *Obesity Reviews* 2007; **8**: 385–94.
97. Myles TD, Gooch J, Santolaya J. Obesity as an independent risk factor for infectious morbidity in patients who undergo cesarean delivery. *Obstetrics and Gynecology* 2002; **100**: 959–64.
98. Cnattingius S, Villamor E, Johansson S, et al. Maternal obesity and risk of preterm delivery. *Journal of the American Medical Association* 2013; **309**: 2362–70.
99. Blomberg M. Maternal obesity, mode of delivery, and neonatal outcome. *Obstetrics and Gynecology* 2013; **122**: 50–5.
100. Bamgbade OA, Khalaf WM, Ajai O, Sharma R, Chidambaram V, Madhavan G. Obstetric anaesthesia outcome in obese and non-obese parturients undergoing caesarean delivery: an observational study. *International Journal of Obstetric Anesthesia* 2009; **18**: 221–5.
101. Hood DD, Dewan DM. Anesthetic and obstetric outcome in morbidly obese parturients. *Anesthesiology* 1993; **79**: 1210–8.
102. Perlow JH, Morgan MA. Massive maternal obesity and perioperative cesarean morbidity. *American Journal of Obstetrics and Gynecology* 1994; **170**: 560–5.
103. Royal College of Obstetricians and Gynaecologists. Reducing the Risk of Thrombosis and Embolism During Pregnancy and the Puerperium. 2009. https://www.rcog.org.uk/globalassets/documents/guidelines/gtg37areducingriskthrombosis.pdf (accessed 08/01/2015).
104. Kumar G, Majumdar T, Jacobs ER, et al. Outcomes of morbidly obese patients receiving invasive mechanical ventilation: a nationwide analysis. *Chest* 2013; **144**: 48–54.
105. Akinnusi ME, Pineda LA, El Solh AA. Effect of obesity on intensive care morbidity and mortality: a meta-analysis. *Critical Care Medicine* 2008; **36**: 151–8.
106. Ventilation with lower tidal volumes as compared with traditional tidal volumes for acute lung injury and the acute respiratory distress syndrome. The Acute Respiratory Distress Syndrome Network. *New England Journal of Medicine* 2000; **342**: 1301–8.
107. Dickerson RN. Hypocaloric, high-protein nutrition therapy for critically ill patients with obesity. *Nutrition in Clinical Practice* 2014; **29**: 786–91.
108. Vanden Hoek TL, Morrison LJ, Shuster M, et al. Part 12: cardiac arrest in special situations: 2010 American Heart Association Guidelines for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care. *Circulation* 2010; **122**: S829–61.

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