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Review

Airway management in obese patients: The need for lean strategies

Daniela Godoroja [a, b, *], Massimiliano Sorbello [c], Michael Margarson [d]

[a] Department of Anaesthesia and Intensive Care, Ponderas Academic Hospital Regina Maria, Bucharest, Romania
[b] University of Medicine and Pharmacy 'Carol Davila', Bucharest, Romania
[c] Anesthesia and Intensive Care, AOU Policlinico Vittorio Emanuele, Catania, Italy
[d] Department of Anaesthesia and Intensive Care, St Richard's Hospital, Chichester, West Sussex, United Kingdom

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ABSTRACT

Airway management is often the major concern of anaesthetists when presented with a morbidly obese patient for general anaesthesia. All anaesthetists are encountering increasing numbers of these patients, presenting for all types of surgery. With the particular experience gained from bariatric surgery worldwide, there is now a greater evidence base to support and guide our practice.

This review article aims to provide an update of the key points in safe airway management in the obese, with a focus on pre-operative airway assessment and intra-operative airway management.

Contents

* Corresponding author. Department of Anaesthesia and Intensive Care, Ponderas Academic Hospital Regina Maria, Bucharest, Romania
E-mail address: .daniela.godoroja@reginamaria.ro (D. Godoroja).

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1. When do things go wrong? Airway disasters and obesity

Body mass index (BMI), used to define obesity, is calculated by dividing weight (kg) by height squared (m^2) (kg/m^2) [10]. The World Health Organization defines obesity as an abnormal/excessive accumulation of fat presenting a risk to health, and they classify it as follows: Class 1, BMI = 30–35 kg/m^2; Class 2, BMI = 35–40 kg/m^2; and Class 3, BMI ≥40 kg/m^2. Class 3 is termed 'morbid', 'extreme', or 'severe' obesity [1].

In Morbid Obesity, the reduced oxygen reserves and increased basal oxygen requirement lead to rapid desaturation in the event of failure of ventilation. Loss of a patent airway will cause this and is one of the most feared complications for anaesthetists. Although anaesthesia-related airway complications have decreased over the past 30 years with the routine use of capnography and pulse oximetry and implementation of practice guidelines for the management of difficult airways [2], airway problems still account for over 25% of all anaesthesia-related deaths [3]. The 4th National Audit Project of the Royal College of Anaesthetists and the Difficult Airway Society (NAP4), conducted in the United Kingdom, identified 38 deaths and 146 cases of severe morbidity attributable to an airway event over a one-year period [4].

In the NAP4 report, obese patients were twice as likely to have a major airway complication, resulting in a permanent hypoxic brain injury or death. The risk increased four-fold in the morbidly obese. NAP4 recognised the following issues associated with obesity: lack of recognition and poor planning for potential airway problems, difficult mask ventilation (MV) and difficult emergency cricothyrotomy, particularly in patients with obstructive sleep apnoea (OSA) and high Mallampati classification. Two further factors were inappropriate use of SGDs with either airway failure or aspiration, and failure to use awake fibre-optic intubation when indicated. It was suggested that feasible alternatives to general anaesthesia (GA), such as regional anaesthesia, were often not considered. Because of the reduced safe apnoea time in the obese, when airway complications occurred, they did so rapidly and rescue procedures frequently failed. Adverse events occurred more frequently when inexperienced, junior anaesthetists conducted the procedures alone and out of hours, and particularly a markedly higher incidence of adverse outcomes in obese patients in the emergency and intensive care unit (ICU).

According to analyses based the American Society of Anesthesiologists (ASA) Closed Claims Analysis, failure to evaluate the airway and predict difficulty is the single most important factor leading to a failed airway. Anaesthesia training should thus focus on preventing and managing such airway emergencies, not on handling the consequences of an airway disaster [2].

2. Respiratory physiology

Obesity has significant effects upon the respiratory system. Functional residual capacity (FRC), mainly expiratory reserve volume (ERV), decreases as BMI increases. However, their lungs are not proportionally adapted. Obese patients, therefore, have a diminished total lung capacity and vital capacity due to decreased chest wall compliance, weight of the abdominal contents, and chest restricting diaphragmatic movement [5]. This mechanical constriction is worsened when the patient is supine and/or sedated, which causes a further reduction in the FRC.

The diminished lung volume also reduces airway calibre. Obesity, a pro-inflammatory condition, may also cause airway hyper-reactivity and a tendency to asthma. Breathing at low lung volume promotes airway closure in dependent lung zones, causing decreased ventilation in the lung bases (atelectasis) with hypoventilation and ventilation–perfusion mismatch (shunt) [6,7]. All these factors pre-dispose to a baseline arterial hypoxaemia.

Obese patients have a high resting metabolic rate with increased oxygen demand. Oxygen consumption is increased due to increased work of breathing [8]. FRC is the capacity of the lung to hold extra oxygen, creating a reserve for patients to draw upon during hypoventilation or apnoea, such as when muscle relaxants are administered for rapid sequence intubation (RSI). This indicates that these patients will desaturate much faster than will those with ideal body weight. Healthy obese patients may desaturate to critical levels in half the time of non-obese patients (three versus 6 min), whereas critically ill obese patients will desaturate even faster [9].

3. Airway assessment: reliability of predictive testing?

A pre-operative airway assessment before administering conscious sedation or general anaesthesia to obese patients is an extremely important aspect of patient management.

3.1. Sleep-disordered breathing

Sleep-disordered breathing, most commonly Obstructive Sleep Apnoea (OSA), occurs in 10–20% of Obese patients with BMI 30–40, and is often undiagnosed. OSA is characterised by pauses in ventilation during a sleep cycle. It is caused by relaxation of the pharyngeal muscles during sleep phases, in patients with an anatomical predisposition to airway collapse, leading to obstruction [10].

OSA is associated with difficult face mask ventilation (FMV), difficult direct laryngoscopy (DL), and a tendency to upper airway obstruction following minimal sedation [11]. Sato et al. found one-handed FMV to be difficult in patients with OSA and obesity [12]. Patients with OSA may experience very rapid arterial oxygen desaturation during and immediately after induction of anaesthesia and in the postoperative period. Untreated OSA may progress to co-exist with obesity hypoventilation syndrome (OHS), a triad of obesity, daytime hypoventilation with hypercapnia, and hypoxaemia. Chronic hypoxaemia and hypercapnia cause increased sensitivity to the effects of residual anaesthetic agents and opioids, which can result in respiratory arrest in the early postoperative period [13].

The ASA and Society for Anaesthesia and Sleep Medicine recommend pre-operative screening of surgical patients for OSA, and treatment with continuous positive airway pressure (CPAP) during the peri-operative period when significant OSA is present. Overnight polysomnography is necessary to confirm an OSA diagnosis, but is expensive and often impractical [14,15]. The STOP-Bang Questionnaire [16] (Table 1) is a useful OSA screening tool. Room air pulse oximetry ($SpO_2 < 95\%$) [17], spirometry measurements (ERV < 0.5 l) [18], and serum bicarbonate concentration > 28 mmol/l [19], suggest OSA and can identify individuals at a risk of post-operative complications.

OSA risk is associated with body shape, rather than absolute BMI [20]. Men typically exhibit central or visceral obesity ('apple shape') with intra-abdominal, neck, and airway adipose distribution, while women usually have a predominantly peripheral fat distribution ('pear shape') and their airways are less commonly affected [21]. Simpson et al. found a significant association between central (male-type) obesity and OSA severity [22]. Patients identified as having OSA risk by the STOP BANG questionnaire are at an increased risk of postoperative complications. There should be a low threshold for the use of post-operative monitoring of oxygenation and ventilation in patients with higher scores [15].

Airway obstruction can occur due to relaxation of pharyngeal muscles during anaesthesia induction. De Jong et al. found that in the ICU, the incidence of difficult intubation (DI) in obese patients

Table 1
Mnemonics for airway management of the obese patient.

a. Preoperative Evaluation OSA Screening		b. Difficult Facemask Ventilation	
STOP-Bang Questionnaire		OBESE	
S **Snoring. Do you snore loudly (louder than talking or heard through a closed door?**		**O** **Obese**	**M** **Male Gender**
T **Tired** Do you often feel tired, fatigued or sleepy during the daytime? Do you fall asleep in the daytime?		**B** **B**eard	**M** Mask seal which is affected by beard or being edentulous
O **Observed** Has anyone observed you stop breathing or choking or gasping during your sleep?		**E** **E**dentulous	**M** Mallampati grade 3 or 4
P **Blood Pressure** Are you hypertensive or do you take medicine for blood pressure?		**S** **S**noring (OSA)	**M** Mandibular protrusion
B **BMI** BMI > 35 kg/m^2		**E** **E**lderly (>55yr)	**A** Age
A **Age** Age > 50 years			**S** Snoring and obstructive sleep apnoea
N Neck Circumference (measured around Adam's apple) > 43 cm (17 in) for males, > 41 cm (16 in) for females			K Kilograms (weight)
G **Gender** Male			

[a]The STOP-BANG screening questionnaire for obstructive sleep apnoea. One point is scored for each positive feature; a score ≥5 is a significant risk. (Chung at al.)
[b]Two mnemonics helpful for remembering patient factors that are associated with difficult mask ventilation [26].

was doubled, and severe life-threatening complications related to intubation increased 20-fold [23].

3.2. Airway risk assessment—advanced airway evaluation

The ASA defines a 'difficult airway' as the clinical situation in which a conventionally trained anesthesiologist experiences difficulty with facemask ventilation of the upper airway, difficulty with tracheal intubation, or both [3].

Conventional airway assessment includes both pre- and post-induction assessment, including mouth opening and Mallampati Classification, as well as assessment of the glottic view using the Cormack-Lehane score. Additionally, the incisors height, inter-incisor distance, thyromental distance, neck circumference, range of motion of the neck, and ability to push the jaw forward should be examined pre-operatively.

Difficult face mask ventilation (FMV) is defined as the inability to provide adequate FMV to maintain an oxygen saturation >92%, inadequate mask seal, and inadequate airway patency. Hagberg et al. describe predictors of difficult FMV, which include obesity and OSA as risk factors [24], in addition to male sex, OSA, a beard, Mallampati grade III/IV, and a neck circumference >50 cm. FMV in obese patients often requires two operators: one to hold the face-mask and another to squeeze the reservoir bag [25]. There are suggested simple mnemonics to help remember these predictors: **MMMMASK or OBESE** [26,27] (Table 1).

The Intubation Difficulty Score (IDS) [28] is used to measure intubation difficulty (Table 2). An IDS ≥5, indicating airway difficulty, was reported in 15.5% of obese patients compared to 2.3% of non-obese patients. A meta-analysis claimed a three-fold higher incidence of difficult intubation in obese patients [29]. Nevertheless, obesity *per se* is not a predictor of difficult intubation; 378 of 379 obese and morbidly obese patients in the four cited studies in that review were successfully intubated by DL. Conventional DL is successful in most morbidly obese patients, but male sex, Mallampati class III/IV, and large neck circumference (>60 cm) increased the probability of difficult intubation to 35% [30].

Pre-operative prediction of difficult airways continues to be difficult. In a large cohort study of the Danish database consisting of 3391 difficult intubations, only 25% were a genuine difficult intubation. Moreover, difficult FMV was unanticipated in 94% of the cases, and when anticipated, occurred only in 22%. The specificity and sensitivity of our current screening tools are poor [31].

4. Preparation for and induction of anaesthesia

4.1. Strategy

Pre-operatively, an individualised strategy for airway management should be prepared, based on published guidelines [3,33]. Difficult airway equipment should be checked in advance, and additional personnel with suitable experience (a senior anaesthetist and trained nurse) should be available if required. In case of SGD use or a history of gastric reflux history, some recommend that drugs to decrease gastric volume and increase gastric pH should be administered to reduce aspiration risk [32].

In general, sedative premedication should be avoided because of the risk of increased sensitivity to central respiratory-depressant effects.

The technique of choice in obese patients is tracheal intubation and controlled ventilation. The decision to proceed with standard anaesthetic induction, RSI, or awake intubation will depend on the

Table 2
Intubation difficulty scale (IDS).

Parameter		Score	Rules for calculating
Number of attempts > 1		N_1	Every additional attempt adds 1point
Number of Operators > 1		N_2	Every additional operator adds 1point
Number of Alternative Techniques		N_3	Every alternative technique adds 1 point
Cormack Grade = 1		N_4	Successful blind intubation $N_{4=0}$
Lifting forced required	Not Applied	$N_5 = 0$	
	Applied	$N_5 = 1$	
Laryngeal pressure	Not Applied	$N_6 = 0$	Sellick's manoeuvre adds no point
	Applied	$N_6 = 1$	
Vocal cord mobility	Abduction	$N_7 = 0$	
	Adduction	$N_7 = 1$	
Total IDS = sum of scores		$N_1 - N_7$	

IDS Score >5 = Moderate-Major Difficulty.

patient's history and comorbidities, as well as a thorough pre-operative airway examination.

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 [32].

Difficulty or failure of DL intubation should be managed promptly, according to difficult airway algorithms. The number and duration of DL attempts should be limited, to prevent airway trauma and progression to a 'cannot intubate/cannot oxygenate' (CICO) situation [33].

4.2. Position

Pulmonary mechanics are markedly altered in supine patients because the increased intra-abdominal pressure causes diaphragmatic upward shift, thereby reducing FRC and total lung capacity, and impairing the capacity to tolerate apnoeic episodes. Their safe apnoea period (SAP), i.e. the time between apnoea onset and desaturation ($SpO_2 \leq 90\%$), is very short. Placing the operating room table in a 30° reverse Trendelenburg position prolongs the time to desaturation [34,35].

Direct laryngoscopy is usually performed on a supine patient in the "sniffing the morning air" (pillow under the head) position. The conditions for laryngoscopy and Cormack–Lehane view during DL are significantly improved in obese patients in the 'ramped' position, when the patient's head, upper body, and shoulders are significantly elevated above the chest with the head extended, aligning their ear level and sternal notch [36]. This head-elevated laryngoscopy position (H.E.L.P.) can be achieved in several ways: using pillows, folded blankets, pre-manufactured foam elevation pillows, or inflatable pillows under the upper body, head, and neck [37]. Currently, there are a number of commercially available devices to place a patient in the ramped position, including Rapid Airway Management Positioner (RAMP - Airpal Inc., Center Valley, PA), Oxford Head Elevating Laryngoscopy Pillow (Alma Medical, Oxford, UK) and Troop Elevation Pillow (Mercury Medical, Clearwater, FL, USA) [32,38].

The combination of H.E.L.P. and reverse Trendelenburg decreases dependent atelectasis by reducing mass-loading on the chest, increasing SAP, and improving the laryngoscopic view by aligning the oral, pharyngeal, and laryngeal axes [36,37]. (Fig. 1).

4.3. Pre-oxygenation

Normally, patients are pre-oxygenated with 100% oxygen via a tight-fitting facemask for 3 min at tidal volume ventilation, or with 8 vital capacity breaths within 60 s with a non-rebreathing mask at an oxygen flow of 10 l/min [39]. These manoeuvres increase SAP to 8–10 min in non-obese patients, but by only 2–3 min in obese patients. Obese patients should thus be pre-oxygenated by mask until their end-tidal oxygen is > 0.9. In a randomised controlled trial (RCT) of morbidly obese patients undergoing laparoscopic gastric banding ($BMI > 40\ kg/m^2$), oxygen tension and SAP following 3 min of pre-oxygenation were measured in either the supine or 25° head-up position. The head-up group achieved a 23% higher pre-induction oxygen tension compared with the supine group (442 ± 104 vs. 360 ± 99 mmHg, $P = 0.012$), with a higher SAP to reach 92% oxygen saturation (201 ± 55 vs. 155, $P = 0.023$) [35].

SAP can be increased by passive oxygenation during the apnoeic period ('apnoeic oxygenation'). Besides standard pre-oxygenation and FMV, oxygen supply via a nasal cannula is helpful. 'Nasal Oxygenation During Efforts of Securing A Tube' (NODESAT) [40] is achieved by delivering oxygen using a simple nasal cannula with flow rates of 5–15 l/min [40]. Modifying a 3.5-mm Ring-Adair-Elwyn (RAE) tube to deliver oral oxygen at 10 l/min during laryngoscopy also significantly increases SAP in obese patients [41]. NODESAT or buccal oxygenation increases the SAP and maintains higher SpO_2 levels during prolonged intubation attempts [41,42].

Comparing pre-oxygenation in morbidly obese patients undergoing bariatric surgery, one study compared those who received standard continuous positive airway pressure (CPAP) (10 cm H_2O) versus the use of high flow nasal oxygen devices, which deliver humidified oxygen at rates of >50 l/min. These authors demonstrated that high-flow nasal oxygen was superior to CPAP for pre-oxygenation [43].

Transnasal humidified rapid-insufflation ventilatory exchange (THRIVE) combines the benefits of apnoeic oxygenation with continuous positive airway pressure (maximum PEEP of 5–7 cm H_2O) and gas exchange using high-flow, warmed, humidified oxygen at a flow rate of up to 70 l/min. The ability of high flow nasal oxygenation (HFNO) to extend apnoea time in patients with difficult airways was demonstrated by the THRIVE study [44]. This trial involved evaluation of 25 patients with difficult airways who received general anaesthesia for hypopharyngeal or laryngotracheal surgery. Twelve patients were obese; although THRIVE may increase SAP, the authors recognised groups of patients in whom the apnoea time was limited, such as obese patients that are predisposed to airway collapse and airway obstruction. The safe upper limit of apnoea time in the presence of morbid obesity was found to be 5 min, but this needs to be confirmed. It is important to point out that these patients were managed supine. The importance of posture – a head up angle of 45° or more – cannot be overstressed. Work to elucidate the relative importance and interaction of position and pre-oxygenation techniques in obesity remains to be done.

These results are supported by a prospective observational study conducted by Badiger et al. [45] who used Optiflow to maintain oxygenation during awake fibreoptic intubation (AFOI) in 50 patients; the patients maintained spontaneous ventilation under conscious sedation throughout the procedure. They found no occurrences of desaturation below baseline values, despite an average procedure time of 18 min. We can conclude that THRIVE maintains oxygenation in spontaneously breathing obese patients during awake intubation and sedation procedures. It is clear that THRIVE cannot rescue patients who have total airway obstruction.

Application of traditional CPAP during general anaesthesia induction increases SAP by 50% in obese patients [46, 47]. The optimal CPAP level to prevent collapse of the upper airway appears to be around 10 cmH_2O [48]. Non-invasive ventilation (NIV) improves alveolar recruitment and delays oxyhaemoglobin saturation. A recent meta-analysis that included 11 studies on 798 obese patients, showed that NIV was associated with significantly improved oxygenation before tracheal intubation, compared with standard pre-oxygenation. Postoperatively, NIV was associated with a decreased risk of respiratory complications, but there was no reduction in rates of reintubation or of unplanned intensive care unit admission [49].

4.4. Aspiration risk

Some authors and many centres still advocate rapid sequence induction (RSI) with cricoid pressure in all morbidly obese patients, although the necessity of this practice is now questioned. The incidence of peri-operative aspiration is similar between obese fasting patients and lean patients undergoing elective surgery and there now appears to be a consensus that RSI is not necessary in every obese patient [50]. However, obese patients with active

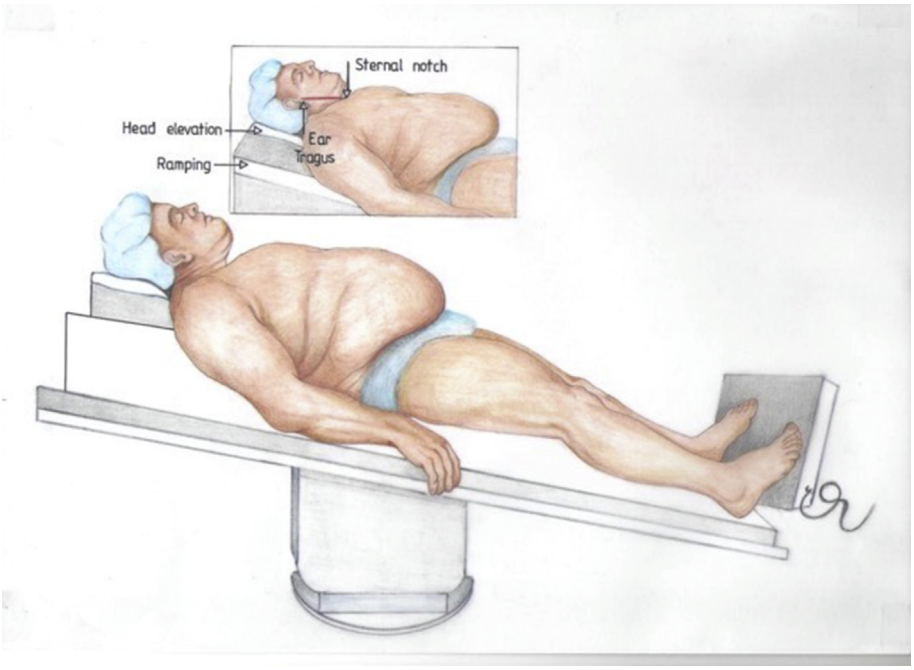

Fig. 1. Position for Tracheal Intubation in the Obese Patient Ramped Position (Head Elevation Laryngoscopy Position) with patient's ear level aligned with sternal notch, and operating table in Reverse Trendelenburg. This increases SAP and improves the view during DL by aligning the oral, pharyngeal, and laryngeal axes.

gastro-oesophageal reflux disorder and those with an inflated gastric band in situ are at increased risk for aspiration [32].

Recently, bedside ultrasound has been used to evaluate gastric content and volume to assess perioperative aspiration risk and guide anaesthetic management [51]. As a new diagnostic tool, gastric sonography appears to be reliable in patients, including those with morbid obesity, to evaluate the risk of aspiration [52].

Placement of a cuffed tracheal tube is standard practice and the best protection against aspiration [32]. Any induction agent can be used. In terms of paralysis, both suxamethonium and rocuronium achieve acceptable intubating conditions during RSI, although both must be dosed at adequate levels to achieve this early – suxamethonium at 1 mg/kg of total body weight, and rocuronium at a minimum of 0.9 mg/kg of lean body weight [53]. However, suxamethonium-induced muscle fasciculations increase oxygen consumption and muscle contraction may reduce the functional residual capacity; both of which would reduce the time before desaturation [54]. Rocuronium has a further theoretical advantage, in that it can be rapidly antagonised with sugammadex if intubation fails.

Cricoid pressure is controversial but remains standard practice in many countries. During FMV cricoid pressure may increase inspiratory pressures, reduce tidal volumes, and if badly applied cause complete airway obstruction and laryngeal displacement, increasing the frequency of failed intubations [55,56]. Garrard et al., showed a significant reduction in lower oesophageal sphincter pressure during the application of cricoid force in anaesthetised patients. They concluded that as no significant change occurred in gastric pressure, this resulted in a significant reduction in oesophageal barrier pressure that is independent of consciousness and occurs when the patients are anaesthetised and paralysed. Any manoeuvre, which leads to a reduction in barrier pressure, must be recognised as having the potential to increase the risk of gastro-oesophageal reflux [57].

Gentle FMV, with or without CP, has been recommended during anaesthesia induction in obese patients to prolong SAP [33].

5. Airway techniques

5.1. Direct vs video laryngoscopy

Direct Laryngoscopy (DL) refers to the use of a laryngoscope to directly visualise the patient's larynx and vocal cords. Intubation by DL in morbidly obese may require aids that include bougies and stylets, external laryngeal manipulation—backward, upward, and rightward pressure—and laryngoscopy blades of various shapes and sizes. The most common blade used is the curved Macintosh blade, designed by Robert Macintosh in 1943. Short laryngoscope handles are useful to avoid interference if a prominent chest wall and breast tissue interferes with placement of the laryngoscope blade in the mouth.

DL remains the most commonly used technique to intubate obese patients. However, videolaryngoscopy (VL) improves the view of the larynx [58] and some devices might be superior to others in obese patients [59]. The GlideScope® VL (GVL- Verathon Inc, Bothell, WA, USA) has improved intubation conditions in morbidly obese patients as compared with DL. A recent randomised controlled trial reported that both the C-MAC® VL (KARL STORZ–Tuttlingen, Germany) and Glideslope required fewer intubation attempts than a standard DL or the McGRATH™ MAC- VL (Medtronic, Minneapolis, MN, USA) [59].

Videolaryngoscopy may reduce the number of failed intubation attempts. By improving the glottic view, successful intubation may be achieved sooner, thus avoiding hypoxaemia. Reduced lifting force avoids airway trauma, with less hemodynamic response than seen with DL. VL provides a view of the airway anatomy and passage of the tracheal tube to both the operator and the assistant. VL is associated with a high rescue intubation success rate after DL and is more commonly used than other rescue techniques [60].

A Cochrane systematic review comparing VL *vs* DL [61] concluded that overall, VL improved the views and reduced difficulty in intubation. They identified two RCT studies [62,63] that included 200 obese participants. The authors were unable to

perform subgroup analysis against studies with non-obese participants but concluded that failed intubations were reduced with increased operator experience, highlighting the importance of being familiar with the VL before using it in an urgent or emergency clinical situation.

Both the ASA Guidelines for Management of the Difficult Airway and the Difficult Airway Society's guidelines suggest VL as the default procedure for an anticipated difficult intubation [3,33]. Due to the increased risk of hypoxaemia in MO, considering the first intubation attempt as the best one would be sensible. VL should always be available and used when DL fails or used for the initial intubation attempt when the patient is at risk of difficult intubation.

5.2. Supraglottic airway devices

An endotracheal tube should be the default airway used in most obese patients, although SGDs can be used for minor elective procedures in overweight and moderately obese patients and where the head can remain elevated and easily accessible [32]. The choice of SGD size is based on predicted body weight, and not total weight. Second-generation SGDs with gastric channel drainage and higher sealing pressures that usually allow higher peak inspiratory pressures, offer more aspiration protection because of the presence of a gastric port; and the general consensus is that they should be used as the preferred device [64]. The major limitation of SGD usage, is that the lungs of obese patients require higher airway pressures to ventilate, and ventilation can fail if a leak occurs. In NAP4, pulmonary aspiration was found to be a major complication of first generation SGD use in obese patients [65]. Recommendations made following the publication of NAP4 suggest caution with the SGD in patients with even modest levels of obesity: the UK Society for Obesity and Bariatric Anaesthesia recommends that an endotracheal tube should be the default in all patients with a BMI >35 kg/m^2, and several manufacturers of devices use the same cut-off. Whilst anaesthetists with extensive bariatric experience are able to judge risk and may utilise a SGD in patients with significantly higher BMIs, but with fat distributions and other factors suggesting low risk of airway problems, this is currently outside generally accepted practice, and the authors would advise adhering to the current guidelines.

An SGD can also function as an alternative to BMV prior to tracheal intubation, and as a rescue device if ventilation and intubation fail. Intubation using an SGD should be performed with the assistance of a fibrescope, with or without an airway exchanger catheter (Aintree catheter) [66].

5.3. Awake tracheal intubation

Awake intubation is performed whenever the anaesthetist considers it to be the safest method for securing the airway with an endotracheal tube, with the patient fully conscious or minimally sedated and spontaneously breathing [3,33]. In the obese, who often have increased airway sensitivity, topical anaesthesia for the pharynx, larynx and trachea, is essential. Sedation should be used with caution as the risks of respiratory depression or airway obstruction are high – these can lead to rapid desaturation or technique failure [67].

Depending on the patient's anatomy, transtracheal and bilateral superior laryngeal nerve blocks can be attempted. Intubation with the patient in the sitting or ramped position is performed with a FOB or VL, while oxygen is administered via a nasal cannula, a buccal tube, or by THRIVE.

Recent studies suggest VL vs awake fibreoptic intubation (AFOI) have comparable success rates in obese patients. Both may be challenging because of airway narrowing by fatty tissue [68,69]. First-attempt success rates >70% without serious complications have been reported for VL [70]. The National Audit Project 4 highlighted cases in which obesity was a factor and AFOI was not appropriately performed. A high rate of failure (60%) was also reported; because of airway obstruction, excessive sedation, and (probably most importantly) a lack of practitioner skill [65]. Videolaryngoscopy may in the future replace AFOI as the first choice for awake intubation in high-risk patients, but currently anaesthetists should be familiar with both techniques [68,69].

5.4. Twist and shout: the unanticipated difficult airway

Algorithms to manage the unanticipated difficult airway in surgical patients have been published by the Difficult Airway Society in the UK [33]. However, in an obese patient, the exact strategy used will depend on local guidelines, experience of the anaesthetist and equipment available.

Case reports on emergency intubation and/or unanticipated difficult airway in morbidly obese patients exist. The intubating laryngeal mask airway has been used for rescue oxygenation and tracheal intubation in morbidly obese patients in an out-of-hospital location [71]. If intubation fails, then it is important to perform oxygenation, either with a supraglottic airway device or face mask ventilation [33]. If this rescue procedure is successful, then the decision to wake the patient up must be considered. If this rescue procedure fails, then emergency front-of-neck access (FONA, a surgical cricothyroidotomy) should be performed.

In morbidly obese patients, excessive tissue and poor landmarks make FONA difficult or impossible. NAP 4 reported that failure of emergency surgical airways in anaesthesia or intensive care settings (where 50% of the patients were obese) were caused by decision-making delays, knowledge gaps, and equipment and technical failures. Two reported causes of failure were an inability to palpate the cricothyroid membrane (CTM) and difficulty in extending the neck [4,65]. During the pre-operative assessment of patients with impalpable landmarks at high risk for a difficult intubation, good practice involves attempting to identify the CTM by palpation and ultrasonography [72]. In a study involving obese patients assessed by novices who received one day of ultrasonography training, the success rate of CTM identification by ultrasound in 48 s was 83% [73].

The best approach for surgical placement of a cuffed tube during a “cannot intubate cannot oxygenate” (CICO) event is unclear. Anaesthetists should learn a basic technique. In patients with non-palpable landmarks, a surgical ‘scalpel-finger-bougie’ technique, with a large 10-cm skin incision and blunt dissection of the tissues for palpating the CTM is recommended [33]. A systematic approach to teaching emergency surgical airway skills for anaesthesia trainees and specialists should be developed, and regular standardised training should be provided to ensure skill retention [33,74].

5.5. Emergence from anaesthesia and post-anaesthesia care

Developing a plan for safe extubation and emergency re-intubation is crucial [75,76]. The obese patient should be extubated in a head-up position (‘sitting position’), and should ideally be fully awake, co-operative, and breathing with an adequate tidal volume to maintain normal end-tidal CO_2 and O_2 levels. In reality, tube intolerance usually develops before the patient achieves this but the extubation should be delayed as much as possible. Residual neuromuscular blockade must be avoided; therefore, neuromuscular monitoring is mandatory, and appropriate reversal agents should be used. A nasopharyngeal airway is recommended by

many, especially in OSA patients. The sitting position optimises respiratory mechanics, whilst being fully awake and co-operative post-extubation minimises the risk of developing airway obstruction, hypoventilation, or laryngospasm [77].

Postoperatively, patients should remain in the upright position and supplementary oxygen should be administered. The management in a level-2 high-dependency postoperative care unit should be considered for patients with severe OSA/OHS and serious co-morbidities and is strongly advised for patients who have undergone extensive surgical procedures requiring ongoing parenteral opioids. In the post-anaesthesia care unit (PACU), patients should be fully monitored, receive oxygen, and be in either a sitting or in a 45° head-up position. Whenever possible, opioid-sparing multimodal analgesia techniques should be used. Patients may require chest physiotherapy, incentive spirometry, and CPAP or non-invasive ventilation to maintain oxygenation. Obese patients experience frequent desaturations during the first 24 h post-surgery; hence, PACU management practices should be continued in the ward or until the patient has recovered completely and becomes ambulatory [77,78].

6. Key points

- Obesity-specific factors that predict difficulty for MV and DL are: OSA/OHS, in patients with increased upper body fat distribution, male sex, a large neck circumference, and Mallampati grade III/IV.
- Obese patients have a short safe apnoea period, so tracheal intubation must be accomplished rapidly:the first attempt should be the best one.
- Increasing the safe apnoea period can be accomplished by pre-oxygenation (including apnoeic oxygenation) with FMV, PEEP, and the patient ramped.
- An airway management strategy and back-up plans using difficult airway algorithms must be in place. These will involve VL use when conventional DL fails, or as a first choice when difficulty is anticipated. Limiting the number of attempts and having the immediate help from more experienced anaesthetists close to hand are crucial.
- The trachea should be extubated with the patient co-operative in a sitting or ramped position. Neuromuscular blockade must be completely reversed.
- Depressant drugs and opioids lingering postoperatively should be minimised by the use of short-acting anaesthetic agents and a low opioid analgesia protocol.

Originality

This paper has not previously been published by another journal or presented in any congress.

Contribution details

DG manuscript preparation and review, MS manuscript review, MM manuscript editing and review.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.tacc.2019.04.003.

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