INTRODUCTION

Caring for a morbidly obese patient presents physicians with a host of challenges, and one of the most daunting is safe and efficient airway management. The physiological changes associated with excess body weight are responsible for both derangements in pulmonary mechanics and increased oxygen consumption. Obesity increases the volume of soft tissue surrounding the pharyngeal airway, while at the same time decreasing lung volumes [1]. These mechanical and anatomical changes in the upper airway can easily lead to airway obstruction when the patient’s respiratory drive, airway reflexes, and resting pharyngeal muscle tone are abolished on the induction of anesthesia. Morbidly obese patients will have a reduced time until the onset of hypoxia if ventilation by facemask is difficult or impossible, due to reduced functional residual capacity and increased oxygen consumption. This justifies a conservative approach to airway management in the morbidly obese, but we must acknowledge that endotracheal intubation, failure of which may lead to death and hypoxic brain damage if ventilation is not ensured, is no longer as difficult as it used to be. This is thanks to technological advances, widespread application of indirect visualization devices, improved airway management algorithms, and skilled practitioners [2]. In addition, the widespread availability and implementation of supraglottic ventilation devices such as the laryngeal mask airway (LMA) have made it easier to ventilate many patients when facemask ventilation is difficult or impossible, and to establish a reliable means of ventilation when the attempt at endotracheal intubation fails.

While technological improvements in airway management have provided anesthesiology clinicians with a wider variety of options, and likely increased perioperative safety, recent investigations have called into question the longstanding assumption that obesity and sleep apnea are de facto indicators of difficult airway management. In addition to providing a review of this literature, the following chapter provides a strategy for anticipating, preparing, and executing an effective upper airway management plan for the morbidly obese, a plan that utilizes basic clinical strategies, pharmacological adjuncts, and the latest in technological advances.

PREPROCEDURE EVALUATION

It is ideal for patients with morbid obesity to have an anesthesiology consultation well in advance of their scheduled procedure. This allows for a full physical examination, assessment of comorbid conditions, and review

KEY POINTS

- Difficult laryngoscopy and difficult mask ventilation are not as cleanly correlated with elevated BMI as once generally believed. Other patient factors play a significant role in determining how challenging these essential tasks might be.
- Proper preinduction positioning improves preoxygenation and ease of mask ventilation and laryngoscopy in morbidly obese patients.
- Effective coupling of a well-planned assortment of modern airway equipment with a comprehensive set of difficult airway management skills can result in very low morbidity and mortality secondary to airway management in morbidly obese patients.
of old medical records. A history of prior difficult intubation, difficult mask ventilation, or difficult extubation may thus be identified. A complete anesthetic record will also document the Cormack–Lehane view obtained on direct laryngoscopy (Cormack–Lehane and Mallampati class) (see Figure 7.1). The preanesthetic visit also affords an opportunity to refer the patient for evaluation of presumptive obstructive sleep apnea (OSA). A recent practice advisory published by the American Society of Anesthesiologists (ASA) provides an assessment tool for gauging the likelihood that a given individual has OSA based on a constellation of physical and historical characteristics [3]. Alternatively, a simple questionnaire (Snoring, Tiredness, Observed apnea, and high Blood Pressure) combined with Body mass index (BMI), Age, Neck circumference, and Gender – called the STOP-BANG assessment – is very sensitive in identifying patients with moderate to severe OSA [4]. Finally, the preoperative evaluation is an opportunity to educate the patient about their trip to the surgical suite. Some individuals will benefit from counseling about the procedures involved with airway management, particularly if awake fiberoptic intubation (AFOI) is anticipated.

AIRWAY EXAMINATION

While the preprocedure evaluation has numerous objectives, the overarching principle is to identify factors that work independently or synergistically with other patient characteristics to increase anesthetic risk. One obvious focus has been on airway assessment, with conventional wisdom generally dictating that morbid obesity and OSA were more likely to be associated with a “difficult airway.” Recent investigations, however, reveal a more nuanced and not entirely consistent picture. Siyam and Benhamou reported an association with sleep apnea syndrome and difficult intubation [8], while in the same year Brodsky et al. reported no specific association with obesity alone and difficult laryngoscopy [9]. Neligan et al. reported findings consistent with the Brodsky study in 2009, failing to identify a correlation between OSA and difficult intubation while at the same time identifying high Mallampati class and male gender as difficult laryngoscopy predictors [10]. Ezri et al. also found no association with difficult laryngoscopy and obesity, but did identify an association with high Mallampati class, OSA, and abnormal front dentition [11]. A large retrospective study published by Lundstrom et al. also failed to show a strong correlation between elevated BMI and failed laryngoscopy [12]. See Table 7.1 for a list of factors associated with difficult laryngoscopy.

The relationship between obesity and difficult mask ventilation (as opposed to difficult laryngoscopy) is also not completely straightforward. The presence of a beard, BMI > 26, lack of teeth, age > 55, and a history of snoring were identified as risk factors for difficult mask ventilation [13]. A large, retrospective study endorsed several of the above predictors, with limited jaw protrusion and
Chapter 7

thick neck anatomy as additional risk factors for grade 3 or 4 mask ventilation. In short, certain characteristics associated with elevated BMI such as OSA, high Mallampati class, and thick neck circumference may be associated with both difficult mask ventilation and laryngoscopy. See Table 7.2 for a list of factors associated with difficult mask ventilation.

Table 7.1 Factors associated with difficult laryngoscopy.

- Retrognathia
- Macroglossia
- Prominent incisors
- Inability to protrude the mandible
- Cervical hump (fat pad) limiting neck extension
- Prior facial or airway surgery
- Head and neck radiation
- Head, neck, and mediastinal masses
- Thermal and chemical burns
- Head, neck, or facial trauma
- Cervical collar or other cervical spine immobilizers
- Chipped front teeth (question of prior difficult intubations)
- Pregnancy
- Preeclampsia
- Congenital diseases (Treacher Collins, Goldenhar, Trisomy 21, etc.)

Table 7.2 Factors associated with difficult mask ventilation.

- Presence of a beard
- BMI > 26 kg/m²
- Edentulous
- Age > 55
- History of snoring
- Mallampati class III or IV
- Male gender
- Airway masses
- Changes associated with neck radiation

PREPARING THE OPERATING ROOM

An essential component of operating room (OR) preparation is having drugs in the proper dosages close at hand. Many agents have altered volumes of distribution in morbidly obese patients and require dosage adjustments based on presumed lean body mass versus total body weight (TBW) \[14], \[15]. The pharmacokinetics of opioids is more complex. Fentanyl, the most commonly used lipophilic opioid in current clinical practice, requires an adjustment in dosing from TBW. Shibutani et al. introduced the concept of “pharmacokinetic mass,” which more accurately guides the dosing of fentanyl downward from what might be administered by TBW \[16]. An important factor to keep in mind as one considers the entire anesthetic from induction to emergence is that nondepolarizing neuromuscular blockers are generally effective when dosed on ideal body weight rather than TBW. To dose these medications based on TBW may mean prolonged time to recovery and difficulty with timely emergence and safe extubation at the end of the case.

Communication with the surgical team regarding their preferences for endotracheal tube (ETT) type, placement, and position should be done in advance. Prior communication with the OR nursing staff is also an essential component of caring for the morbidly obese patient. In addition, establishing the availability of anesthesia technician support or other skilled assistance in advance will help ensure the smooth execution of the task at hand. Management of the difficult airway has advanced significantly over the past decade, and a modern operating suite must have easy access to fiberoptic bronchoscopy, some type of indirect visualization device such as a videolaryngoscope or a Glidescope (trademark), and intubating and nonintubating LMAs. It is typical to concentrate equipment for difficult airway management in easily portable carts. The exact contents of the cart should be planned by the anesthesiology clinicians who will be using it, and the carts must be well-stocked and well-maintained.

Even when direct laryngoscopy is the primary plan for securing the airway, quick access to a difficult airway...
cart in case of failure should be ensured. Airway adjuncts such as oral airways, nasal trumpets, bougies, LMA's, and surgical airway kits should be immediately available.

Preparing the OR table is the final step in readying the OR for the morbidly obese patient. A ramp created from folded blankets, a foam wedge, or by adjusting the configuration of the bed itself to create a sniffing position when the patient is supine will help optimize the view obtained when performing laryngoscopy (see Figures 7.2–7.5) [14,17]. Proper positioning will minimize the number of difficult glottic exposures during direct laryngoscopy encountered by the anesthesiology clinician.

Many patients will benefit from a modest dose of benzodiazepine before proceeding to the OR. Whenever a patient arrives from the emergency department, has received a neuraxial or peripheral nerve block placed for postoperative pain, or has come from an inpatient bed, it is prudent to confirm that other central nervous system (CNS) depressants or opioids have not been given recently. A quick survey assessing what medications were taken prior to arrival in holding may avert an unintended overdose.
Finally, before proceeding back to the operating suite, it is often helpful to arrange lifting assistance in advance and confirm that the bed being used will accommodate the anticipated weight. Many patients find the simple transfer from the gurney to the OR table challenging, and a shifting pannus can actually pull a person from a narrow table even when it appears that they are safely positioned.

**IN THE OPERATING ROOM**

Once the patient is safely and comfortably positioned, monitors are applied, and adequate intravenous access is assured, the patient may be preoxygenated and denitrogenated prior to induction. Preoxygenation in a reclined, rather than supine, position has been
reported to improve preinduction oxygenation [18]. This means the application of the mask with an adequate seal, demonstration of exhaled carbon dioxide, and an approach to equilibrium of inhaled and exhaled oxygen concentration. This technique will ensure the maximum amount of apneic time before desaturation begins to occur. The patient should be placed in a ramped position, with the chin above the chest, in a “sniffing” pose. Many practitioners will often employ a rapid sequence induction using a fast-acting sedative hypnotic agent in combination with succinylcholine, as these patients tend to quickly desaturate secondary to decreased functional residual capacity and increased oxygen consumption. A recent dose ranging study for succinylcholine in this population suggested that a dose of 1 mg/kg based on TBW provided satisfactory muscle relaxation [19]. When succinylcholine is contraindicated, a bolus dose of the ultra short-acting narcotic remifentanil in combination with propofol has been reported to provide satisfactory intubating conditions comparable to propofol and succinylcholine [20]. It should be noted that in the referenced trial, the subjects were lean and without substantial comorbidities, and experienced a significant degree of hypotension. Yet another alternative would be to use propofol, remifentanil, and low-dose rocuronium to achieve satisfactory intubating conditions similar to what might be obtained with propofol and succinylcholine alone [21]. The use of a video laryngoscope may improve the view beyond what might be expected with standard laryngoscopy [22].

The principles espoused in the ASA Difficult Airway management algorithm still apply. If an attempt at endotracheal intubation fails, something should be changed before another attempt (head position, operator, laryngoscope blade, direct laryngoscope for a videolaryngoscope). Each attempt at laryngoscopy can be expected to increase airway swelling, so the total number of attempts must be limited to avoid turning a “cannot intubate” scenario into a “cannot ventilate” scenario. If mask ventilation becomes difficult, a LMA can be inserted, and it may be possible to secure the airway through the LMA. If attempts to secure the airway are unsuccessful, spontaneous ventilation should be reestablished and the patient allowed to awaken.

If there is a question regarding how successful a standard induction will be, it may be possible to perform an “awake look” using a combination of midazolam and a single bolus dose of remifentanil [23]. With this technique, the patient is positioned in the standard fashion, preoxygenated, and a dose of 1–2 µg/kg of remifentanil is given. After approximately 90 seconds, it is possible to instruct the patient to open his or her mouth, and perform laryngoscopy in the usual fashion. If a reasonable view is obtained, the ETT may be placed, or induction may proceed while holding the view obtained. While this technique has not been validated in the morbidly obese population, it is an airway management option available in obese patients with unrestricted mouth opening.

**AWAKE FIBEROPTIC INTUBATION (AFOI)**

It is not uncommon for the preoperative physical examination of the morbidly obese patient to raise questions about whether or not the airway can be safely and swiftly secured using standard laryngoscopy. Under these conditions, AFOI might be the preferred option. As mentioned above, clear and concise communication with the OR nursing teams as well as anesthesia technician support will help set the stage for a smooth and safe procedure. In special circumstances, it may be reasonable to ask the operating surgeon to stand by while the airway is being secured in the event that a surgical airway is required.

**In holding**

After preparation of the OR, other preparatory steps may be undertaken. Many practitioners utilize glycopyrrolate as an antispasmodic. This medication should be used cautiously in patients who have known or suspected coronary artery disease, obstructive cardiac lesions, stenotic valves, or other conditions under which cardiac performance may suffer with tachycardia.

Topicalization of the airway is necessary to blunt the noxious stimulation of awake airway manipulation. The glossopharyngeal nerve provides sensory innervation of the posterior third of the tongue, the tonsillar pillars, and the oropharynx. The larynx is innervated by the superior and inferior laryngeal nerves, which are branches of the vagus. The application of local anesthetic to the mucous membranes will do much to accomplish effective anesthesia of the airway and can be achieved by several methods, including aerosolization by nebulizer, lidocaine jelly “lollipops,” or directly spraying the mucous membranes with an atomizer. Benzocaine spray may also be used, but may result in methemoglobinemia [24]. While the toxic dose of local anesthetic applied to the airway will vary
with the method of application, concentration of drug, total dose given, and the size of the patient, it is prudent to be mindful of the quantity of local anesthetic administered by any route. A superior laryngeal nerve block may also be applied by injecting 2 cc of local anesthetic close to the cornu of the hyoid bone bilaterally. Because of accumulation of adipose tissue around the neck, identification of appropriate landmarks may be difficult or impossible in some patients. Ultrasound has been used to identify the hyoid bone and subglottic structures in lean subjects [25], and may prove useful in the management of obese patients as well.

**In the OR**

In anticipation of AFOI, the operating table should be configured with the back elevated in a beach chair configuration to ensure comfort while monitors are applied and supplemental oxygen is administered. Drugs for induction and muscle relaxation should be immediately available. Additional topiicalization may be applied at this time, while intravenous sedation is started. While adequate topicalization of the tracheal mucosa below the vocal cords can be accomplished with nebulization, it may at times be necessary to inject local anesthetic through the cricothyroid membrane with a small-gauge needle.

The selective α-2 agonist dexmedetomidine has been used successfully as an adjunct to AFOI [26]. A loading dose of 1 µg/kg, given over 10 minutes, with an infusion of 0.7 µg/kg/hour, is generally sufficient. Smaller doses should be considered for patients over the age of 65. Side effects of dexmedetomidine include bradycardia, hypertension, hypotension, dizziness, and nausea. Rarely, sinus arrest has been reported. This medication provides excellent sedation with minimal impact on respiratory drive. The intraoperative use of this medication will also augment other anesthetics and reduce the need for both intraoperative and postoperative opioids [27].

Benzodiazepines, particularly midazolam, are also useful in this scenario. While midazolam has predictable activity at clinically effective doses and may be reversed with flumazenil in overdose, it works synergistically with other CNS depressants, increasing the potential for respiratory embarrassment.

The short-acting narcotic remifentanil has also been employed to sedate patients undergoing AFOI [28]. This medication, while having a significant impact on respiratory drive at higher doses, may be used both as a bolus [29] and as an infusion while the ETT is being secured. It is also useful when applying airway devices, such as nasal trumpets or oral airways, which are noxious when positioned. A bolus dose of 25–100 µg may be given intravenously before the infusion is started, generally at 0.05–0.1 µg/kg/minute, based on ideal body weight [30]. Smaller doses should be used in older patients, or in patients who have received other CNS or respiratory depressants. Chest-wall rigidity can occur at higher bolus doses. The advantages of remifentanil include its exceedingly short half-life and context-sensitive half-time, and its reversibility with naloxone.

Ketamine has also been used in conjunction with other agents for this indication [31]. This medication has been associated with dysphoria and increased airway secretions at higher doses, two side effects that limit its usefulness as a sole agent.

**Alternative methods**

On occasion, AFOI of the airway is either unsuccessful, or simply not an option because of patient factors such as a bleeding or obstructed airway. Under these circumstances, alternatives must be considered.

When the airway is bloody or obscured by other material, making the use of video equipment impossible, it may be reasonable to attempt a retrograde wire technique. With this method, a needle is placed just into the trachea at the level of the cricothyroid membrane. A wire or catheter is then fed cephalad through the needle until it emerges from the mouth or nose. The ETT or ET tube exchanger can then be guided into the trachea in a Seldinger-type fashion. When the tip of the tube reaches the level of the wire’s insertion site, the wire may be removed and the ETT advanced. A recent case report documents a retrograde technique utilizing a gum elastic bougie in a morbidly obese trauma patient with head and facial injuries [32].

Occasionally, awake tracheostomy is the only feasible option for successfully managing what would otherwise be an impossible airway. Under these conditions, careful coordination between the surgical and anesthetic teams is essential. Transportation of these patients even from the intensive care unit (ICU) or the emergency department can be perilous. Preoperative sedating medications should be used with caution. Once the patient is positioned on the bed in the OR, judicious use of sedatives and opioids may be employed as the skin superficial to the tracheostomy site is anesthetized. Once the tracheostomy is secured and end-title carbon dioxide is observed, induction agents and muscle relaxants can be given safely.
EXTUBATION

When the plan is to extubate the patient in the OR at the end of the procedure, it is wise to have available the same equipment for airway management that was present at the beginning of the case. Some practitioners will place nasal and oral airways prior to emergence. Full reversal of neuromuscular blockade is essential to ensure adequate airway protection and adequate ventilation once the ETT is removed. The patient should be awake and following commands prior to extubation, with unambiguous demonstration of purposeful movement. Once the ETT has been removed, a few minutes of observation in the OR prior to transfer to the recovery room is prudent. In some circumstances, particularly when airway swelling or difficult ETT replacement is anticipated, extubation over a tube exchanger may be advantageous. In the event the patient fails the extubation attempt, an ETT can be reinserted over the in situ tube exchanger.

In the postanesthesia care unit, careful communication with the recovery room nurses will minimize complications. While adequate control of postoperative pain is essential, significant respiratory depression must be avoided. When patients receive neuraxial analgesic techniques, peripheral nerve blocks, or infiltration of the surgical site with local anesthetic, opioid requirements will be altered, and may be dynamic as those measures dissipate. The use of other analgesics, including NSAIDS, acetaminophen, pregabalin, and dexmedetomidine, may reduce the need for postoperative opioids.

CONCLUSION

While caring for individuals with morbid obesity presents a constellation of medical challenges, the safe and smooth management of the airway can reliably be achieved with careful preprocedure evaluation, meticulous attention to detail in positioning the patient, a cautious and stepwise approach to airway management, and the intelligent application of now widely available airway management techniques and tools. Indirect visualization devices such as video laryngoscopes provide an additional degree of flexibility and safety by allowing much easier access to anterior glottic openings than is possible with standard direct laryngoscopy. For patients who require it (limited mouth opening, very difficult or impossible mask ventilation, need for maintenance of spontaneous ventilation), fiberoptic intubation via either a nasal or an oral route is a safe and widely practiced option. Given the epidemic of obesity worldwide, a consistent and reliable process for taking care of these individuals should be part of every medical center’s armamentarium.

BEST PRACTICE TIPS

1. Preanesthetic evaluation may help risk-stratify patients with elevated BMI before they present to the operating suite. This evaluation provides an important opportunity to educate patients about special airway maneuvers that may be needed to optimize their safe care.
2. Proper OR preparation is essential. Clear communication with OR staff, anesthesia technician support, and the surgical team is critical. Assurance that the OR table will accommodate the patient’s weight prior to transfer is mandatory.
3. Proper positioning of the patient in a “ramped” configuration prior to induction improves oxygenation, conditions for mask ventilation, and intubating conditions.
4. Ideal pharmacological adjuncts to AFOI include those medications that have minimal adverse effects on respiratory drive, such as dexmedetomidine, or have pharmacological antagonists, such as short-acting opioids and benzodiazepines.
5. Prior to extubation of the morbidly obese patient, return of muscle strength, adequate airway reflexes, and purposeful movement must be confirmed.

REFERENCES

12 Lundstrom LH, Moller AM, Rosenstock C, Astrup G, Weterslev 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 Feb;110(2):266–74.