Airway Management in the Morbidly Obese Patient

**Introduction**

Evaluating and identifying the challenging airway is the beginning of airway management, which is a basic and essential skill of the anesthesiologist. As the incidence and prevalence of obesity increase around the globe, the anesthesia provider will be exposed to a variety of obese and morbidly obese patients presenting for procedures. Obesity does not necessarily equate with a difficult airway. Obstructive sleep apnea (OSA) may be the compounding factor that increases the challenge of any airway.

Obesity is a global and continually increasing problem that was first recognized as a disease in 1948 by the World Health Organization. According to the CDC, more than one-third of adults in the United States (39.8%) are affected by obesity, which afflicted 93.3 million U.S. adults in 2015-2016. Obesity can be measured by different methods:

- BMI, as used by the CDC and WHO for quantitative definition and categorization (Table);
- abdominal circumference; and
- body fat percentage.

The most accurate methods of fat mass measurement are:

- underwater weighing;
- dual-energy x-ray absorptiometry;
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**Airway Management in Obesity**

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The definition of the difficult airway is a clinical situation in which a conventionally trained anesthesiologist experiences difficulty with face mask ventilation of the upper airway, difficulty with tracheal intubation, or both.

Many studies have addressed the relationship between difficult mask ventilation (DMV) and difficult tracheal intubation (DTI) in the morbidly obese patient.
In a study of 576 patients, Yildiz et al showed that male gender, increasing age, Mallampati class IV and increased weight are considered independent factors for DMV. Langeron et al conducted a prospective study of 1,502 patients; DMV was reported in 75 patients, with one case of impossible ventilation. After multivariate analysis, five criteria were shown to be independent risk factors for DMV:

1. BMI greater than 26 kg/m²,
2. age older than 55 years,
3. presence of a beard,
4. a history of snoring, or
5. lack of teeth.

Another multicenter analysis involving four tertiary care centers showed 698 patients of 176,679 experienced DMV combined with difficult laryngoscopy. Independent predictors for the combination of DMV and difficult laryngoscopy were age of 46 years or more, BMI greater than 26 kg/m², male gender, Mallampati class III or IV, presence of a neck mass, prior radiation therapy, sleep apnea, presence of a beard, thick neck, limited jaw protrusion, and limited cervical spine mobility.

Obesity is a predictive factor for potential DTI when compared with the nonobese. In a cohort study of 91,332 patients by Lundstrom et al, the frequency of DTI was 5.2% after multivariate analyses adjusted for other covariates. A BMI of 35 kg/m² or greater is a weak but statistically significant predictor of difficult and failed intubation.

Saasouh et al analyzed the electronic health records of more than 67,000 adults undergoing elective noncardiac surgery requiring tracheal intubation between 2011 and 2015. They concluded that increasing BMI is associated with a greater likelihood of DTI compared with those with leaner weights. As BMI increased to greater than 30 kg/m², the chance of DTI remained elevated, but difficulty did not increase with still greater BMIs.

Preanesthesia Evaluation

Airway assessment in the preanesthetic period is of paramount importance, as it will give the anesthesia provider an opportunity to devise an airway management plan as well as alternative plans for airway management, if necessary. The airway assessment of the obese patient should include a review of electronic health records and documentation of previous airway management, if available. A history of chronic diseases that may affect airway management, such as collagen diseases and diabetes, should be noted. Any surgical history on the temporomandibular joint, cervical spine, or head and neck region should be noted.

A clinical examination should be undertaken of the patient’s mouth opening, presence of a beard, head and neck deformities or masses, temporomandibular joint mobility, dentition, and neck range of movement, with attention to the following.

Thyromental Distance and Sternomental Distance

Thyromental distance (TMD) is the distance between the tip of the thyroid cartilage and the tip of the mandible while the neck is extended, while the sternomental distance (SMD) is the distance from the suprasternal notch to the tip of the mandible.

Shailaja et al, using the Intubation Difficulty Scale, concluded that age older than 40 years and an SMD less than 12.5 cm are predictors of DTI in the obese. Kim et al concluded that the ratio of neck circumference and TMD (neck circumference/TMD) provides the greatest sensitivity, a negative predictive value, and the largest area under the curve among the various indexes used to predict difficulty of intubation in the obese.

Neck Circumference

Neck circumference is measured just below the thyroid cartilage prominence. Many studies have concluded that neck circumference is an independent predictor of difficult intubation. Neck circumference less than 43 cm is highly sensitive for difficult intubation, but when neck circumference is combined with a high Mallampati score (i.e., III and IV), the specificity increases to 92%.

In the study by Brodsky et al, a neck circumference of 40 cm is associated with a 5% probability of a problematic intubation, and increases to 35% if the neck circumference is 60 cm. In addition to the increased risk for difficult intubation, the increased neck circumference is associated with OSA and metabolic syndrome, both of which can add to difficult intubation.

Obstructive Sleep Apnea

OSA is characterized by intermittent episodes of either complete or partial upper airway obstruction resulting in desaturation and recurrent arousal episodes from sleep. In the general population, the prevalence is 9% to 25%, with a higher prevalence in the bariatric surgical population. OSA is a comorbidity in the obese patient population. A retrospective study by Lopez et al showed that the incidence of OSA in patients presenting for gastric bypass surgery was greater than 70% (227/290 patients) and increases in incidence as BMI increases.
Palla et al found that OSA was present in 60% of a group of 101 patients with BMIs of at least 40 kg/m². They studied a group of 101 consecutive patients with a BMI greater than 40 kg/m² (33 men; age range, 20-80 years) whose symptoms of OSA were not known, and a validation group of 45 patients. It was found that OSA was present in 61 patients (60.4%); in 33.7% of those patients, OSA was of a severe degree. The study concluded that OSA was present in almost two-thirds of morbidly obese patients.

Because of the potentially serious adverse consequences associated with untreated OSA in the surgical population, the need for a reliable, concise and easy-to-use screening tool for patients with OSA has led to the development of the STOP-Bang questionnaire.

The questionnaire consists of eight dichotomous (yes/no) items related to the clinical features of sleep apnea. The total score ranges from 0 to 8, with a score of 0 to 2 classified as low risk, 3 to 4 as intermediate risk, and 5 to 8 as high risk. The questionnaire asks about Snoring, Tiredness, Observed apnea, high blood Pressure, BMI, Age, Neck circumference and male Gender.

Studies by Chung et al and Elkouny et al highlight the importance of screening obese patients in the preoperative setting using the STOP-Bang questionnaire to detect OSA. Chung’s study on patients who visited preoperative clinics concluded that a STOP-Bang score of 5 to 8 identified patients with a high probability of moderate to severe OSA. The study by Elkouny et al concluded that the updated STOP-Bang questionnaire was found to be a reliable tool to detect OSA risk and predict its perioperative implications.

Patients with OSA may present a challenge to the anesthesiologist during intubation. A narrative review by Chung et al included 10 studies that concluded the incidence of difficult intubation is higher in patients with OSA compared with non-OSA patients. A systematic meta-analysis review of articles in the period from 1946 to 2017 showed that patients with OSA have a higher risk for difficult intubation.

**Mallampati Score**

The Mallampati score was introduced in 1985 as a non-invasive bedside assessment of ease of intubation. The Mallampati score is inadequate if used alone to predict DTI. A meta-analysis involving 177,088 patients showed that the score has a poor prognostic value. A study by Juvin et al concluded that a Mallampati score of III to IV was the only independent risk factor for DTI in obese patients, but its specificity and positive predictive values were 62% and 29%, respectively. Gonzalez et al concluded that a Mallampati score greater than or equal to III is a useful bedside test to predict difficult intubation.

**Airway Management**

A strategy for airway management based on current and published guidelines should be adopted and individualized for each obese patient. Plans for management should be formalized with backup alternative solutions, with optimization of conditions for the first intubation attempt, including positioning. Several varieties of airway equipment should be ready and checked, and an experienced airway manager should be available and willing to assist, if needed.

**Positioning**

Lack of proper positioning of an obese or morbidly obese patient is a patient safety issue. Careful positioning is imperative for the care of obese patients, regardless of the primary airway management technique that is used. The goal of optimal positioning is the alignment of oral, pharyngeal and laryngeal axes to improve and facilitate first-pass intubation.

The ramping position or HELP (head-elevated laryngoscopy position; Figures 1 and 2) can achieve this alignment and offers the following benefits:

- improves ease of breathing;
- provides better preoxygenation; and
- allows easier mask ventilation of the patient.

It has been suggested that the optimal intubation position can be achieved by ensuring an imaginary
horizontal line connecting the patient’s sternal notch and external auditory meatus.33

In a prospective, unblinded study of 189 adult patients whose ASA physical status was class I to III, an anesthesiologist performed and graded two laryngoscopies: one in the ramp position and one in the sniffing position.34 The results showed that the ramping position provided significantly better or equal laryngoscopic views compared with patients in the sniffing position.

Collins et al conducted a study of 60 patients that showed the ramping position is superior to the standard sniffing position for direct laryngoscopy in morbidly obese patients.35

**Preoxygenation**

Studies have demonstrated that, following preoxygenation with tidal volume breathing for three minutes, the time required for oxygen saturation (SpO2) to fall to 90% during apnea is markedly less in morbidly obese patients compared with nonobese patients. These findings are attributed to increased volume of oxygen and decreased functional residual capacity.36,37

The supine position enhances the decrease in functional residual capacity because of cephalic displacement of the diaphragm. Placing obese patients in a 25-degree head-up position during preoxygenation has been shown to prolong the time of desaturation by approximately 50 seconds.38

Several techniques are available to achieve effective optimal preoxygenation in a noninvasive manner.

**Apneic diffusion oxygenation**

This technique is an effective method for increasing safe apneic time.39,40 Oxygen enters the lung by diffusion through a pressure gradient between the upper airway and alveoli. Apneic diffusion oxygenation is dependent on achieving maximal preoxygenation before apnea, maintaining airway patency, and the existence of a high functional residual capacity to body weight ratio.

Andrew et al conducted a randomized controlled trial of buccal RAE (Ring-Adair-Elwyn) tube oxygen administration on 40 obese patients who were randomly assigned to standard care (n=20) or buccal oxygenation (n=20) during induction of total IV anesthesia.41

The patients had ASA physical status classifications of I and II and BMIs of 30 to 40 kg/m². Clinically important prolongation of safe apnea times—750 and 296 seconds, respectively—can be achieved delivering buccal oxygen to obese patients on induction of anesthesia.41

**Bilevel positive airway pressure**

This technique combines the benefits of pressure support ventilation and continuous positive airway pressure (CPAP). The alveoli are “stented” open during the entire cycle of respiration. Intrapulmonary shunting may decrease and safe apnea time increase.42

A device that can achieve positive airway pressure in the perioperative period is the SuperNO2VA (Vyaire; Figure 3). It is a sealed nasal positive airway pressure mask that can deliver high fractional inhaled oxygen and titratable positive pressure.

Dimou et al conducted a prospective observational study that included 56 patients who presented for esophagogastroduodenoscopy under heavy sedation before bariatric surgery.43 Airway management was instituted using a nasal cannula (n=30) or the SuperNO2VA (n=26). The SuperNO2VA group had higher BMIs and higher ASA classifications, and were more likely to have OSA. The desaturation events were significantly lower in the SuperNO2VA group than the nasal cannula group.43

A case series of 10 patients by Kozinn et al demonstrated deep sedation for several procedures in which nine of 10 patients were obese with BMIs greater than 34.4 kg/m². All patients were high risk for or diagnosed with OSA. The SuperNO2VA was used in all patients, either connected to an anesthesia circuit or a hyperinflation bag. Airway patency was maintained in all patients. The lowest SpO2 was 98%, and there were no interrupted procedures and no tracheal intubations.44

**Transnasal humidified rapid insufflation ventilatory exchange**

This technique involves the insufflation of humidified oxygen, which is better tolerated, up to 70 L per minute via a nasal cannula. It combines the benefits of apneic oxygenation and CPAP with reduction in carbon dioxide (CO₂) levels through gaseous mixing and flushing of the dead space. It can produce a CPAP pressure of 7 cm H₂O, which “splints” open the upper airways and reduces shunting. The high flow delivered by this system washes out anatomic dead space, which avoids an increase in CO₂.45

**Face Mask Ventilation**

An audit of a sequential group (n=48) of obese patients (BMI, 45.936.6 kg/m²) undergoing bariatric surgery, presented at the Difficult Airway Society 2008 conference, found all patients were easy to ventilate or manageable when ventilated with a face mask.46 However, other studies have shown a high incidence of DMV in obese patients.47,48 The possibility of DMV must always be borne in mind.

![Figure 3. SuperNO2VA mask.](https://example.com/figure3.png)
**Supraglottic Devices**

Supraglottic airway devices have been used for airway management in patients without increased risk for aspiration. Supraglottic devices can be used to facilitate tracheal intubation, or for the management of unanticipated difficult airways. The use of supraglottic devices in obese patients may increase the risk for aspiration, as gastroesophageal reflux is a common association with this patient population.

A systematic Cochrane database review by Nicholson et al compared supraglottic airway devices with tracheal intubation during general anesthesia in obese patients undergoing laparoscopic surgery.\(^49\) It was concluded that the LMA ProSeal (Teleflex) required a few seconds longer for insertion; there was a failure rate of insertion of 3% to 5%; there was improvement in oxygenation both during and after surgery; and there was a reduction in postoperative coughing. The study authors stated that they did not have adequate information to make conclusions about safety.\(^49\)

A randomized controlled study of 60 obese patients, all of whom were mechanically ventilated and had BMIs greater than 30 kg/m\(^2\), compared the LMA Classic (Teleflex) and LMA ProSeal. The study found that both laryngeal masks could be used for mechanical ventilation in obese patients, with the LMA Classic requiring greater cuff pressure and the LMA ProSeal drainage tube requiring frequent checks for patency.\(^50\)

Cheon et al found that in patients anesthetized using laryngeal mask airways, the overall incidence of intraoperative ventilatory complications, such as difficult ventilation and laryngospasm, increased when the patient’s BMI was greater than 30 kg/m\(^2\), age was greater than 46 years, or the LMA Supreme Airway (Teleflex) was used rather than the LMA ProSeal.\(^51\)

**Direct Laryngoscopy**

Use of Macintosh and Miller blades to intubate the trachea requires optimization of conditions that facilitate success on the first intubation attempt. Preoxygenation, proper positioning, blade size and a detailed airway examination are all components for successful intubation.

A maneuver that aids in improving the laryngeal view is BURP (backward, upward, rightward pressure).\(^52,53\) A randomized comparison by Abdallah et al of 105 patients (with BMIs between 30 and 50 kg/m\(^2\)) requiring tracheal intubation for elective surgeries assigned tracheal intubations using either a Macintosh blade No. 4 or the Pentax AWS (airway scope) laryngoscope. Intubation success rate, time to intubation, ease of intubation, and the occurrence of complications were recorded. They concluded that intubations using the Macintosh blade were significantly faster than the Pentax AWS device. The first-attempt tracheal intubation success rate was 92% with the Macintosh blade, which was higher than that for the Pentax AWS device, at 86%.\(^54\)

**Indirect Laryngoscopy**

Morbidly obese patients have decreased functional residual capacity, which shortens the anesthesiologist’s time for successful tracheal intubation. In this population, there may be a need for a device that can help optimize the first attempt at intubation and help improve visualization of the larynx.

Direct laryngoscopy techniques are limited by the direct line-of-sight approach, and the requirement that the laryngoscopist visualizes beyond the tip of a laryngoscope blade for successful laryngeal visualization. This has led to the development of a variety of devices that overcome this limitation. Video laryngoscopes are divided into:

- Integrated channel laryngoscopes: LMA CTrach (Teleflex); Pentax AWS (Hoya Corp.); and Airtraq (Prodol Meditec; Figure 4)
- Video stylets: Bonfils (Karl Storz)
- Rigid-blade laryngoscopes: V-MAC and the newer C-MAC (both Karl Storz), GlideScope (Verathon) and McGrath MAC (Medtronic)\(^55\)

A study of video laryngoscopy in 100 bariatric cases reported that 98 patients were intubated on the first attempt and two patients on the second.\(^56\) A randomized study compared direct and video laryngoscopy (using the C-MAC) in 80 patients with BMIs greater than 35 kg/m\(^2\). The study showed equal time to intubation.

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**Figure 4. Airtraq.**

Photo courtesy of Prodol Meditec.
between the two techniques but showed the risk for failed intubation was higher with direct laryngoscopy.\textsuperscript{57} Kaplan's randomized study of 865 patients showed that the use of video laryngoscopy significantly improved visualization of the larynx.\textsuperscript{58}

**Flexible Fiber-Optic Intubation**

Awake fiber-optic tracheal intubation is the gold standard for management of predicted difficult intubation. The flexible fiber-optic bronchoscope can be used in a patient with limited mouth opening and a history of difficult mask airway management. Use of flexible fiber-optic intubation in conjunction with the intubating laryngeal mask can be a viable intubation technique in the morbidly obese patient.

Abdellatif et al tested the hypothesis that intubation using GlideScope video laryngoscopy (GVL) will provide significant advantages over fiber-optic bronchoscopy (FOB). Sixty-four morbidly obese patients undergoing laparoscopic bariatric surgery with predicted difficult airways were randomly assigned to receive awake oral intubation by either GVL or FOB. After topicalization of the airway and use of target-controlled remifentanil infusion, the two devices were compared for time to intubate, successful intubation on first attempt, glottic view, hemodynamic response of the patient to the scope, patient satisfaction, and incidence of postoperative sore throat and hoarseness. The intubation time, success of first-attempt intubation, and the highest remifentanil target concentration to maintain sedation during intubation was 2.4±0.6 ng/mL and 2.2±0.8 ng/mL for FOB and GVL, respectively. The study authors concluded that GVL can be used as a useful alternative to FOB in morbidly obese patients with predicted difficult airway.\textsuperscript{59}

**Jet Ventilation**

Jet ventilation was first introduced to allow continuous ventilation with unobstructed surgical access through a rigid bronchoscope. The technique evolved to include stand-alone, nondistensible catheters that can be used without a laryngoscope or bronchoscope. Types of jet ventilation are delineated by frequency—high frequency (100–600 breaths per minute) and low frequency (approximately 15 breaths per minute)—and access route, which includes subglottic, supraglottic or transtracheal.

Obesity has been associated with an alteration of gas exchange in jet ventilation cases and an increased risk for complications, specifically barotrauma.\textsuperscript{51-64}

Philips et al retrospectively reviewed charts from 46 patients with tracheal or subglottic stenosis who underwent endoscopic surgery with jet ventilation between March 2014 and January 2017. Twenty-nine of these cases involved obese patients, nine of whom were morbidly obese. One patient required alternative airway management. Two cases had intra- and postoperative complications, including laryngospasm (1/29) and tachycardia (1/29). The study authors concluded that jet ventilation can be done successfully on obese patients, and complications are similar between obese and nonobese patients.\textsuperscript{64}

**Flow-Controlled Ventilation**

An emerging ventilation technique that linearizes expiratory flow is called flow-controlled ventilation (FCV), which is provided by a new ventilator, Evone (Ventinova). This device provides a constant positive flow during inspiration and negative flow during expiration. As a result, the pressure is linearly increased during inspiration and linearly decreased during expiration. Linearizing the expiratory flow improves lung recruitment, the homogeneity of lung aeration, and gas exchange.\textsuperscript{65-67}

A randomized controlled, interventional crossover trial of 23 obese patients, all of whom had BMIs greater than 30 kg/m\textsuperscript{2} and were undergoing elective bariatric surgery, compared respiratory system mechanics and regional ventilation for seven minutes using FCV and volume-controlled ventilation (VCV). FCV was achieved by the application of the Evone ventilator.

Even after this short application of FCV, lung recruitment was improved, as demonstrated by a significantly reduced intraoperative loss of both end-expiratory lung volume and mean lung volume, compared with VCV. These effects might be attributable to the increased mean tracheal pressure caused by the linearized decline of pressure during FCV. The study concluded that the recruiting effect was probably caused by the elevated mean tracheal pressure, which can be attributed to the decline of linearized expiratory pressure during FCV, and which may help prevent atelectasis and hypoxemia during mechanical ventilation in obese patients.\textsuperscript{68}

**Conclusion**

With the increasing incidence of obesity among surgical patients, management of the airway in these patients is of paramount importance to the anesthesiologist. We stress the fact that successful airway management depends on formulating a plan that relies on a thorough airway assessment in the preoperative period, and the application of the many families of airway adjuncts appropriately based on patient anatomy, pathology, and the skills of the user.

Every patient should have an individualized management plan that relies on techniques familiar to the airway manager as well as an armamentarium of backup devices.
References
