Emergency Department Management of the Airway in Obese Adults

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Airway management in obese adults can be challenging, and much of the literature on this subject focuses on elective surgical cases, rather than acutely ill patients. In this article, we review the emergency department evaluation of the airway in obesity, discussing anatomy, physiology, and pharmacology. In addition, we describe techniques and devices used to improve intubating conditions in the obese patient. After our review of the relevant literature, we conclude that research in this particular area of acute care remains in its infancy. [Ann Emerg Med. 2010;56:95-104.]

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BACKGROUND

It is estimated that more than 30% of the adult population is obese, and this number seems to be increasing.[1,2] The World Health Organization defines overweight as a body mass index (BMI) of 25 kg/m^2 or higher, obesity as a BMI of 30 kg/m^2 or higher, and extreme (morbid) obesity as a BMI of 40 kg/m^2 or higher.[1] Surprisingly, obese patients do not visit the emergency department (ED) more frequently than patients of normal weight.[3,4] However, critically ill obese patients have higher morbidity and mortality than nonobese patients, which may be related to the effects of obesity on the respiratory system.[5] In addition, obesity is associated with an increased risk of diabetes mellitus, hypertension, dyslipidemia, coronary artery disease, congestive heart failure, and obstructive sleep apnea.[5,6] Morbid obesity can also pose challenges in obtaining vascular access and accurately monitoring blood pressure and oxygen saturation.[6] Airway management in obese patients can be problematic for a number of reasons, including difficulty with mask ventilation, rapid oxygen desaturation, and altered pharmacokinetics. Here we review the available literature on the ED management of the airway in obesity and emphasize the need of further research in this field.

ANATOMIC AND PHYSIOLOGIC CONSIDERATIONS

Pulmonary Physiology

Obesity profoundly affects airway anatomy and pulmonary physiology. An understanding of these physiologic changes, which may be exaggerated in the acutely ill patient, is necessary for proper airway management. The increased mortality in critically ill obese patients compared with nonobese patients can be attributed in part to the effect of obesity on the respiratory system.[5] Diminished total lung capacity and vital capacity in obesity result from decreased chest wall compliance and increased abdominal cavity contents.[7] Airway resistance is also increased in obesity.[7-9] Obese individuals without significant obstructive lung disease or other underlying lung disease have a relatively high incidence of resting room air hypoxemia and hypercapnia,[10] the cause of which is multifactorial.

Diminished expiratory reserve volume from collapse of the small airways results in decreased ventilation of the relatively well-perfused lung bases, causing ventilation-perfusion mismatch and hypoxemia.[5,11] Ventilation-perfusion mismatching is exacerbated in the supine position and with sedation and paralysis, likely because of further alveolar collapse.[9] In addition, functional residual capacity declines exponentially as BMI increases, resulting in a smaller oxygen reserve and more rapid oxygen desaturation during periods of apnea.[8,9] Obese individuals also have increased oxygen consumption and carbon dioxide production because of the metabolic activity of excess body tissue[8,12-14] and increased work of breathing.[9] Finally, obesity is associated with inefficient respiratory muscles, as evidenced by increased oxygen consumption during exercise compared with that of nonobese individuals.[8] In addition to impaired pulmonary function, obese patients have alterations in gastrointestinal physiology that may affect airway management.

Gastrointestinal Physiology

Obese patients have increased intraabdominal pressure, increased incidence of hiatal hernia and gastroesophageal reflux disease,[15] larger gastric volume, and lower pH of gastric contents. Because lower gastric pH and larger gastric volumes have been shown to be predictive of lung injury after aspiration, obese patients have traditionally been considered high risk for aspiration pneumonitis during airway management. However, others have challenged the idea that obesity increases the risk for aspiration in patients without hiatal hernia or gastroesophageal reflux disease.[16] Despite conflicting data, some anesthesiologists still advocate the use of antacids and rapid sequence intubation even in elective surgical cases to minimize the risk of aspiration pneumonitis.[8] The use of rapid sequence intubation increases the first-pass success rate during emergency airway management and therefore may reduce the risk of aspiration by decreasing the need for mask ventilation and the potential for gastric insufflation and regurgitation.[17]

PREDICTING THE DIFFICULT AIRWAY

The American Society of Anesthesiologists' Practice Guidelines for Management of the Difficult Airway define a difficult airway "as . . . difficulty with face mask ventilation of the upper airway, difficulty with tracheal intubation, or both."[18] Predicting difficult mask ventilation and tracheal intubation allows for appropriate preparation for airway management. Obesity may not necessarily predict difficult tracheal intubation, and other specific indicators may be more important than BMI itself in anticipating challenges in laryngoscopy and tracheal intubation. In contrast, mask ventilation is predictably difficult in obese patients.

Mask Ventilation

Obese patients do not tolerate apnea well, and there may be time enough for only one attempt at tracheal intubation before critical oxygen desaturation. Thus, the ability to mask ventilate the obese patient is of utmost importance because emergency physicians traditionally rely on this rescue technique after failed attempts at tracheal intubation.[19] Obesity has been demonstrated to predict difficult mask ventilation in the anesthesia literature. In a prospective study of more than 1,500 subjects undergoing elective surgery, a BMI greater than 26 kg/m^2 predicted difficulty in maintaining an oxygen saturation above 92% with mask ventilation during general anesthesia.[20] A combination of poor chest wall compliance, decreased diaphragmatic excursion, increased upper airway resistance, and redundant supraglottic tissues makes mask ventilation more difficult in obese patients. To our knowledge, obesity as a predictor of difficult mask ventilation has not been studied in the ED setting, but one might anticipate obese patients to be even more difficult to adequately ventilate and oxygenate in cases of respiratory failure when lung compliance is often reduced. In situations in which mask ventilation is required, technique should be optimized with the use of oral or nasal airways, appropriately fitting mask, a 2-person technique with a 2-handed bilateral jaw thrust, and proper positioning of the patient in the ramped position. The American Society of Anesthesiologists' Practice Guidelines for Management of the Difficult Airway suggest the use of a supraglottic airway device in cases of failed tracheal intubation and impossible or inadequate mask ventilation, and numerous studies support this practice in obese patients.[18,21-25] In contrast to mask ventilation, controversy exists in the literature about obesity and its predictive value in difficult tracheal intubation.

Tracheal Intubation

Although it seems intuitive that obese patients would be challenging to intubate, the literature on predicting difficult tracheal intubation in obesity is somewhat contradictory. In some studies, obesity has been associated with difficult tracheal intubation,[26-29] and in other cases increasing BMI has not predicted difficult tracheal intubation.[30-37] Part of this controversy stems from a lack of standardized criteria used to define difficult tracheal intubation. Some studies have used Cormack-Lehane laryngoscopy grade,[30,33] others have looked at a combination of laryngoscopy grade and tracheal intubation attempts,[28,31,35] and still others have used tracheal intubation difficulty scales.[26] In fact, difficult laryngoscopy and difficult tracheal intubation are not synonymous. Indeed, a poor laryngeal view may not translate to difficulty with tracheal intubation,[31] as defined by the need for multiple attempts to intubate the trachea.[18] For example, a patient with a Cormack-Lehane grade III view may be intubated easily on the first attempt, with the assistance of a tracheal tube introducer (bougie). Conversely, a patient with a grade I view and tracheal stenosis or obstruction may be difficult or impossible to intubate. The "sniffing" position, which involves 8 to 10 cm of head elevation, results in suboptimal positioning for laryngoscopy in an obese patient, and this may also confound results and falsely worsen graded views.[38] In addition, neck circumference,[31,32,39] abnormal upper teeth,[33,34] short neck,[27] obstructive sleep apnea,[33,40] Mallampati score evaluated with the neck held in extension, and diabetes mellitus[36] may be more predictive of difficult tracheal intubation than BMI. The effect of obesity on tracheal intubation success rates has not been well studied in the ED setting, but there is some indication that obese trauma patients are not more difficult to intubate than lean patients.[37] Studies about airway assessment in obese patients undergoing elective surgery should not be generalized to the ED because patients have poorer laryngoscopy views in the emergency setting.[41,42] In addition, tests used for predicting difficult tracheal intubation lack validation and utility in the emergency setting[43] and have poor interobserver reliability, particularly when patients are unable to follow directions or position themselves appropriately.[44] Furthermore, the use of BMI as predictor for difficult tracheal intubation has a limited role in the emergency setting because this measurement is not typically available to the emergency physician before attempts at tracheal intubation.

Further research is needed to determine predictors of difficult tracheal intubation that are clinically relevant and applicable during emergency airway management in the obese population. Even if obesity does not predict difficult tracheal intubation, the obese patient, owing to difficult mask ventilation, has by definition a potentially difficult airway. In addition, the shortened safe apnea time may further complicate attempts at laryngoscopy and tracheal intubation.

PREOXYGENATION AND NONINVASIVE VENTILATION

Preoxygenation

Obesity results in shorter time to oxygen desaturation during induction of anesthesia in patients undergoing elective surgery.[45-48] Part of the rapid oxygen desaturation observed in obesity results from a reduction in functional residual capacity, which provides continued oxygen supply during periods of apnea. Sedation and paralysis, as well as placing the patient in the supine position, further decrease functional residual capacity.[8,9] Increased oxygen consumption in obesity also contributes to rapid desaturation during apnea. Obese patients may undergo oxygen desaturation to 90% within 3 minutes compared with 6 minutes in normal-weight patients.[48] There is a strong negative linear correlation between time to desaturation and increasing obesity,[48] and in patients with a BMI greater than 60 kg/m^2, the time to desaturation may be less than 1 minute,[47] allowing for only one attempt at tracheal intubation before mask ventilation would be required. Preoxygenation during emergency airway management seems to be of little benefit in safeguarding against hypoxemia during laryngoscopy and tracheal intubation in critically ill patients.[49] Presumably, difficulties with preoxygenation and rapid oxygen desaturation occur even more frequently in critically ill obese patients, although this has not been well studied. Several techniques may improve preoxygenation of the obese patient, potentially allowing further time to safely secure the airway.

Proper positioning of the obese patient during preoxygenation is perhaps the easiest method of lengthening the duration of safe apnea. When compared with the supine position, preoxygenation with the patient's head elevated 25° to the horizontal prolongs the time to oxygen desaturation in obese patients undergoing elective surgery.[46] Application of 100% oxygen with continuous positive airway pressure (CPAP) set at 10 cm H_2O before tracheal intubation increases the duration of nonhypoxic apnea by 1 minute in obese patients undergoing elective surgery.[47] The favorable effect of CPAP in this study was attributed to a decrease in atelectasis and in increase in functional residual capacity.[47] Similar results were not observed when a CPAP of 7.5 cm H_2O was used for 3 minutes before tracheal intubation.[50] Although much of the literature on preoxygenation in obesity involves elective surgical cases, positive-pressure ventilation may also improve oxygenation and ventilation of obese patients in the acute setting.

Noninvasive Positive-Pressure Ventilation

In morbidly obese patients with acute respiratory failure, noninvasive positive-pressure ventilation may improve arterial blood gas parameters and prevent the need for tracheal intubation.[51,52] There are limited data comparing bilevel positive airway pressure and CPAP for acute respiratory failure in obesity, and one technique cannot be recommended over the other.[51] A case report describes the use of bilevel positive airway pressure to improve oxygen saturation from 90% to 99% in a morbidly obese patient before rapid sequence intubation for urgent surgery.[53] During noninvasive ventilation, inspiratory pressures exceeding 15 cm H_2O may be required to adequately assist in ventilation because of the high airway resistance. One potential risk of this technique would be gastric insufflation, resulting in increased risk of regurgitation and aspiration of stomach contents, particularly when insufflation pressure exceeds 25 mm Hg.[47]

Although potentially beneficial in preoxygenation and as a means of preventing tracheal intubation in obese patients, questions about the safety and efficacy of positive-pressure ventilation in the ED setting remain unanswered. In particular, the risk of aspiration related to noninvasive positive-pressure ventilation in obesity warrants further investigation.

PHARMACOLOGY OF AIRWAY MANAGEMENT

Drug Metabolism

Several factors related to obesity may influence the metabolism and elimination of medications commonly used during emergency airway management. As a result of increased renal blood flow, the clearance of certain drugs is increased.[8,14] The volume of distribution, particularly in lipophilic drugs, is increased in obese patients.[14] Despite a high frequency of liver enzyme abnormalities and histologic changes in the liver in obesity, there does not appear to be any change in hepatic metabolism of drugs.[8,14] The interaction of increased renal clearance, changes in volume of distribution, and other factors, such as abnormal protein binding, can make predicting pharmacokinetics in obesity difficult.[8,54] As a general principle, hydrophilic drugs should be dosed according to ideal body weight, and lipophilic drugs, owing to an increased volume of distribution, should be administered based on total body weight.[14,16,55] Unfortunately, the lack of published data on medication dosing in obesity precludes an evidence-based approach to pharmacokinetics in obesity in the acute setting, and dosing of many medications is often based on theoretical considerations.

Dosing of Induction Agents

Current available data on commonly used induction agents are summarized in the Table. Etomidate is lipophilic and theoretically should be administered according to total body weight. However, there is inadequate literature to support the safety and efficacy of this practice.[54] In contrast, there is more convincing evidence to support ketamine dosing according to lean body mass, which can be estimated by adding 20% to the ideal body weight.[56] When given as a single intravenous dose, benzodiazepines are likely to be most effective when administered according to total body weight.[16] However, other authors advocate using a dose between ideal body weight and total body weight,[57] and still others suggest using lean body mass.[14] The half-life of benzodiazepines is increased in obese patients, and subsequent doses and continuous infusions should be given according to ideal body weight to prevent prolonged sedation.[14,57,58] Propofol appears to be most efficacious when dosed according to total body weight, owing to the high

Table. Dosing of commonly used medications in airway management in the obese adult.*

Drug	Dosing	Comments
Etomidate	Total body weight	Based on theoretical considerations, lipophilicity of drug, and a single case report.
Ketamine	Lean body mass	Based on small pilot study of adult patients.
Midazolam	Total body weight	Prolonged half-life due to lipophilicity. Subsequent doses based on ideal body weight.
Propofol	Ideal body weight	Despite lipophilicity, conservative approach uses ideal body weight because of potential for cardiovascular depression.
Fentanyl	Total body weight	Total body weight overestimates dose requirement in patients >140 kg.
Succinylcholine	Total body weight	Dosing based on ideal body weight yields inadequate paralysis and poorer laryngoscopy view.
Vecuronium	Ideal body weight	Recovery may be prolonged when dosed based on total body weight.
Rocuronium	Ideal body weight	Prolonged duration of action when dosed according to total body weight.
Atracurium	Total body weight	Recovery not prolonged when dosed according to total body weight.

*Based on several references.[14,16,54,56,57,59,60,62-64,99]

lipophilicity, increased volume of distribution, and increased total clearance of the drug.[16,59,60] Because of the potential for cardiovascular depression with propofol, a more conservative approach would be to use ideal body weight for initial dosing and titrate until the desired effect is achieved.[14,57] Although the opiates are generally lipophilic, the pharmacokinetics of these medications are difficult to predict in obesity, and individual requirements for adequate analgesia vary significantly. Some have advocated dosing the opiates, such as fentanyl, according to total body weight.[14,54] Others recommend an initial dose based on ideal body weight, and subsequent doses can be adjusted according to individual patient response.[16,57]

Topical Anesthesia

In a study of 27 morbidly obese patients undergoing awake tracheal intubation using a flexible fiberoptic bronchoscope, the administration of 40 mL of 2% atomized lidocaine, in addition to sedation with midazolam and fentanyl, safely provided adequate topical anesthesia and acceptable intubating conditions without achieving toxic plasma levels.[61]

Dosing of Neuromuscular Blocking Agents

In contrast to sedative agents, there is more consistent evidence from the literature to guide the dosing of neuromuscular blocking agents in obesity (Table). When succinylcholine is administered according to ideal body weight, poorer laryngoscopic views and incomplete neuromuscular paralysis are achieved compared with dosing based on total body weight.[62] Inadequate sedation and muscle relaxation may predispose to aspiration during tracheal intubation.[63] Succinylcholine should be dosed according to total body weight,[14,54,62,63] and a dose of 1 mg/kg safely provides complete neuromuscular paralysis during rapid sequence intubation.[62] Nondepolarizing neuromuscular blocking agents such as rocuronium[64] and vecuronium[65] should be dosed according to ideal body weight because of their hydrophilicity.[14,57,59]

Medication dosing for airway management in obesity has not been well studied in the ED. This area deserves further investigation to determine the proper dosing of medications necessary to safely provide adequate sedation and paralysis during emergency airway management in obese patients. Because of the unpredictable nature of pharmacokinetics in the acutely ill obese patient, titration to the desired clinical response and careful monitoring for signs of drug toxicity are critical.

APPROACH TO AIRWAY MANAGEMENT

Preparation

Taking into consideration that unexpected difficulties may be encountered in the emergency setting, mask ventilation may be difficult or impossible, and the obese patient will rapidly undergo rapid oxygen desaturation during apneic periods, preparation and careful planning are fundamental to the approaching the airway in obesity. Figure 1 represents a strategy for emergency airway management in the obese patient. The approach may vary considerably, depending on the clinical situation, operator experience, and resources available. We review in detail below the different devices and techniques shown to be effective in managing the airway in obesity. Once the decision is made to intubate, positioning the obese patient is arguably the most underappreciated technique in improving laryngoscopic view and ensuring successful tracheal intubation.

Positioning

Repositioning the morbidly obese patient after failed attempts can be difficult and time consuming, and proper positioning should be achieved before any attempts at laryngoscopy. In the morbidly obese patient, the head and shoulders should be elevated above the chest such that the external auditory canal is parallel with the sternal notch to optimize view during laryngoscopy.[66,67] Multiple folded blankets placed under the head, shoulders, and neck may be required to achieve the so-called ramped position (Figure 2). The ramped position improves laryngoscopic view over the standard “sniff” position in obese patients.[67] The ramped position may also improve mask ventilation and provide easy access to the neck for application of cricoid pressure and attempts at surgical airways. While properly positioning and preoxygenating the obese patient, the emergency physician must simultaneously decide the best approach to securing the airway.

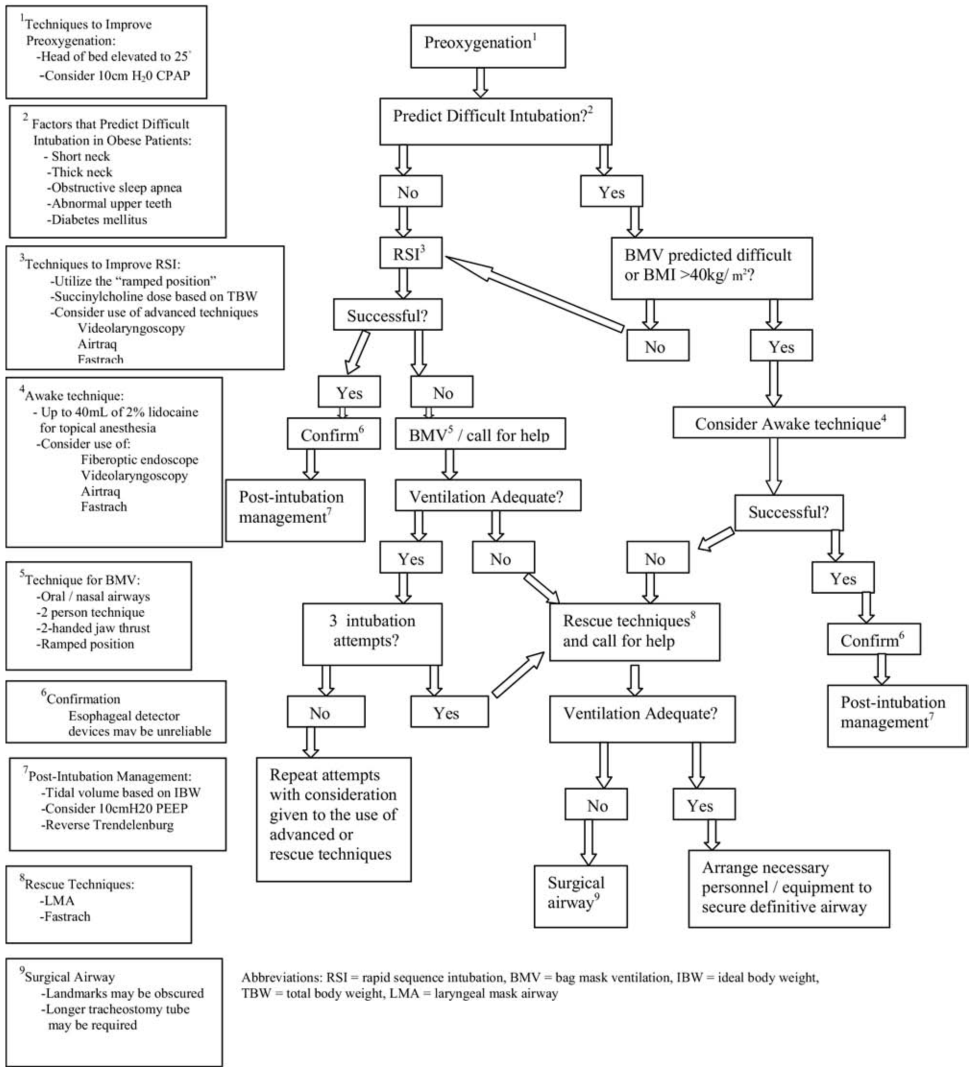

Figure 1. Approach to the management of the airway in obese adults.

Awake Tracheal Intubation

Given that the obese patient may be difficult to mask ventilate and rapid oxygen desaturation may occur after the ablation of spontaneous ventilation, consideration should first be given to an awake technique,[8,18] particularly in patients with a BMI greater than 40 kg/m^2.[20] Although flexible fiber optic endoscopy has historically been used for tracheal intubation in spontaneously breathing adults, a variety of new imaging devices, such as the GlideScope (Verathon Inc., Bothel, WA) or Airtraq (King Systems Corporation, Noblesville, IN), potentially can be used, depending on the effectiveness of topical anesthesia and sedation. Providing adequate topical anesthesia for an awake, oral tracheal intubation can be challenging in patients who are too tachypneic to gargle aqueous lidocaine or are unable to take deep enough breaths to distribute nebulized lidocaine throughout the airway. In this case, an atomizer can be used to directly spray the accessible areas of the mouth, oropharynx, and hypopharynx. Local anesthetic can then be sprayed into the larynx and trachea through the working channel of a fiber-optic scope. An awake technique requires patient cooperation, and the view obtained with fiberoptic devices may be obscured not only by blood and secretions but also by the redundant upper airway tissue of obese patients. Furthermore, this approach may precipitate oxygen desaturation or aspiration of stomach contents during prolonged attempts at tracheal intubation. If an awake approach is not feasible, rapid sequence intubation should be considered, with immediately available rescue techniques for ventilation and tracheal intubation. Rapid sequence intubation will optimize conditions for mask ventilation and reduce the risk of aspiration.[17] In addition, rapid sequence tracheal intubation optimizes intubating conditions for standard laryngoscopy and facilitates the insertion of supraglottic airway devices or a video laryngoscope or other imaging device.

Figure 2. Proper positioning of the patient in the ramped position before larygoscopy.The external auditory canal is parallel to the sternal notch. (Reproduced with permission from Levitan RM, Kinkle WC. *Airway Cam Pocket Guide to Intubation*. 2nd ed. Wayne, PA: Airway Cam Tech: 2007.)

ADVANCED TECHNIQUES

The American Society of Anesthesiologists Practice Guidelines for the Management of the Difficult Airway recommend limiting the number of conventional attempts at laryngoscopy to 3 and advocate the use of advanced airway techniques in lieu of repeated attempts with the same technique.[18] Indeed, greater than 2 attempts using conventional laryngoscopy are associated with an increased rate of hypoxemia, esophageal tracheal intubation, regurgitation, aspiration, and cardiovascular complications.[68] There is increasing evidence in the literature that advanced airway techniques, such as the GlideScope, the Airtraq optical laryngoscope, and the Fastrach intubating laryngeal mask airway (LMA North America Inc., San Diego, CA) may facilitate tracheal intubation of the obese adult.

Fiber-Optic and Optic Guidance and Video Laryngoscopy

A flexible fiber-optic endoscope may be used to facilitate tracheal intubation, using an awake technique through the nasal or oral route. If the oral route is used, a specially designed intubating oral airway of adequate size, such as the Berman or Ovassapian airway, can facilitate fiber-optic tracheal intubation by facilitating passage of the endoscope through redundant oropharyngeal tissue. The use of nasal CPAP provided a pneumatic "splint" to assist nasotracheal tracheal intubation through the contralateral naris in a 393-kg man with acute respiratory failure.[69] Although tracheal intubation using fiber-optic guidance may be attempted as a rescue technique after failed rapid sequence intubation attempts in lean patients with adequate mask ventilation, this approach can be time intensive and probably should not be relied on in obese patients who may have an obscured view because of redundant pharyngeal tissue and have shorter safe apnea times.

Several rigid or semirigid devices with fiber-optic technology on a stylet (Levitan FPS Scope, Clarus Medical, Minneapolis, MN) or laryngoscope blade (The Storz V-MAC, Karl Storz, Tuttlingen, Germany) have been used to improve direct laryngoscopy. A short optical stylet has been successfully used to assist with both rapid sequence intubation[70] and awake tracheal intubation[71] in morbidly obese patients with acute respiratory failure. A Bullard laryngoscope[72] has been used to successfully intubate a morbidly obese patient undergoing emergency cesarean section. The Storz V-MAC video laryngoscope provided a shorter tracheal intubation time and fewer attempts than the GlideScope Ranger and the McGrath video laryngoscope (LMA North America Inc., San Diego, CA) in morbidly obese patients undergoing elective surgery.[73]

In a randomized study of 106 morbidly obese patients undergoing general anesthesia, the time to successful tracheal intubation was significantly shorter with the Airtraq versus Macintosh laryngoscope. In addition, the Airtraq group had a decreased incidence of failure to intubate within 2 minutes and reduced incidence of oxygen desaturation.[74] In another large study of morbidly obese patients undergoing bariatric surgery, the Airtraq allowed for a 2-fold shorter time to tracheal intubation compared with the standard Macintosh laryngoscope.[75] The Airtraq optical laryngoscope has also been used to successfully intubate morbidly obese patients undergoing emergency cesarean section.[76] Difficulty may be encountered in placing the Airtraq laryngoscope in the pharynx of some obese patients. Insertion of the device 180° opposite to that recommended, followed by rotation back to the conventional position once inside the pharynx, reduces the time to tracheal intubation and decreases the incidence of upper airway trauma in morbidly obese patients.[77]

Video laryngoscopy has been shown to improve visualization of the larynx and reduce the time to tracheal intubation in obese patients undergoing elective surgery.[78] In a subgroup of 30 patients with a BMI greater than 40 kg/m^2 who were undergoing general anesthesia, the GlideScope yielded a Cormack-Lehane grade I or II view in 93% of cases, and all but one patient were successfully intubated.[79] The GlideScope was also used to successfully intubate 3 morbidly obese patients, using an awake technique with midazolam for sedation and lidocaine for topical anesthesia.[80] Although the initial experience with video laryngoscopy for elective tracheal intubation of obese patients has been promising, its efficacy in the acute setting warrants further investigation.

Tracheal Tube Introducer (Bougie)

The tracheal tube introducer (bougie) may be used to facilitate tracheal intubation when there is a restricted view of the glottis and only the epiglottis or the epiglottis and arytenoids are visualized, or when the operator encounters a large, floppy epiglottis during direct laryngoscopy. Indeed, the bougie is commonly cited as an effective technique during elective surgical cases when only the epiglottis is visualized in morbidly obese patients.[25,33] In addition, the bougie proved effective as a rescue device in 7 obese patients with difficult tracheal intubations in the out-of-hospital setting.[81] However, to our knowledge, the safety and efficacy of the bougie have not been studied rigorously in obese patients.

Supraglottic Devices

The American Society of Anesthesiologists Practice Guidelines for the Management of the Difficult Airway suggest the use of a supraglottic device, such as the LMA, when attempts at mask ventilation are inadequate.[18] The LMA has been shown to be an effective device for ventilation of morbidly obese patients undergoing elective surgery[24,25] and as a rescue device after failed attempts at tracheal intubation.[25] The Fastrach (LMA North America, Inc., San Diego, CA) intubating LMA appears to be as safe and effective in morbidly obese as in lean patients,[23] even in cases of poor visualization during laryngoscopy.[24] An intubating LMA also has been used successfully in a morbidly obese patient as a rescue device in the out-of-hospital setting after direct laryngoscopy and bougie and mask ventilation all failed.[23] In a case series, the LMA CTrach, an I-LMA (intubating laryngeal mask airway) that provides a fiber-optic image of the laryngeal inlet to guide endotracheal tube placement, proved effective in securing the airway by using an awake technique in morbidly obese patients with difficult airways.[82] In a randomized, prospective study of 104 morbidly obese patients undergoing bariatric surgery, the LMA CTrach provided better visualization and improved oxygenation during tracheal intubation.[83] The Aintree tracheal intubation catheter (Cook Critical Care, Bloomington, IN) has been shown to facilitate tracheal intubation through the LMA-ProSeal.[84] This technique, which was used to successfully intubate a 980-lb patient, involves passing a fiber-optic bronchoscope through the Aintree catheter and then passing both devices through the LMA-ProSeal into the trachea, under visual guidance.[85] The fiberoptic scope and LMA-ProSeal are then removed, and the endotracheal tube can be "railroaded" over the Aintree catheter. The Fastrach is an attractive rescue device in obese patients owing to its capabilities in resolving difficulties in oxygenation, ventilation, and tracheal intubation.

SURGICAL AIRWAYS

In the "cannot intubate, cannot ventilate" scenario, percutaneous and open surgical access to the airway may be difficult when landmarks are obscured by excess soft tissue and a short neck.[70] Obesity and a short neck have been associated with difficult transtracheal needle ventilation and retrograde tracheal intubation.[54,86] Surprisingly, in elective surgical airway management, cricothyroidotomy has been shown to be technically feasible even in patients with difficult neck anatomy caused by obesity.[87] In addition, elective percutaneous tracheostomy has been shown to be safe in morbidly obese patients.[88,89] Longer tracheostomy tubes with more acute angles may be required in patients with excessive soft tissue in the anterior neck.[90] A 6-mm-inner-diameter endotracheal tube passed through a cricothyroidotomy incision may serve as a temporizing measure until the proper size of tracheostomy tube can be located.[91] There is a paucity of literature about the success rates of surgical airways in obese ED patients. However, even under ideal circumstances, cricothyroidotomy requires greater than 100 seconds to achieve ventilation,[86] and the procedure is rarely performed in the ED.[92]

POSTTRACHEAL INTUBATION MANAGEMENT

Confirmation

Reliance on indirect clinical tests alone, such as chest and gastric auscultation, chest excursions, endotracheal tube condensation, and oxygen saturations, to detect esophageal tracheal intubation contributes to hypoxemia, regurgitation, aspiration, and cardiovascular complications during emergency airway management.[93] Obesity may further diminish the utility of clinical findings to confirm endotracheal tube placement. Auscultation can be challenging because of excess chest wall tissue, and pulse oximetry may be inaccurate because of poor light-wave transmission through increased soft tissue in the fingers.[54] The use of devices such as capnography, disposable carbon dioxide detectors, and esophageal detectors has been advocated during emergency airway management to hasten the detection of and reduce the complications associated with esophageal tracheal intubation.[93] However, esophageal detector devices may be less effective in morbidly obese patients.[94] Interpretation of chest radiography can prove challenging as well, owing to poor penetration of radiographs through excess soft tissue. After confirmation of endotracheal tube placement, the clinician must next consider safe and effective mechanical ventilation techniques for obese patients.

Mechanical Ventilation

Respiratory mechanics and gas exchange are impaired in sedated and paralyzed obese patients undergoing mechanical ventilation.[9] Because of the low functional residual capacity in obesity, high tidal volumes were once advocated as a means of improving lung mechanics, oxygenation, and ventilation.[6,14] However, tidal volumes above 13 mL/kg of ideal body weight offer no advantage over lower tidal volumes in terms of oxygenation, but rather increase the plateau pressure, placing the patient at risk for lung injury.[95] It has also been demonstrated that obese patients benefit from lower tidal volume ventilation strategy in acute lung injury.[96] Even when a low tidal volume strategy is used for acute lung injury, clinicians still tend to overestimate lung size for obese patients and base tidal volumes on total body weight, rather than ideal body weight, resulting in higher airway pressures. When difficulties with mechanical ventilation arise, several techniques may improve ventilation and oxygenation in obese patients.

The addition of positive end expiratory pressure allows for the recruitment of atelectatic alveoli, thus improving respiratory mechanics and oxygenation.[9] The addition of positive end expiratory pressure of 10 cm of H_2O improves respiratory mechanics and oxygenation in obese patients compared with normal-weight patients.[97] The use of increasing levels of positive end expiratory pressure can have deleterious effects on cardiac output.[8] The reverse Trendelenburg position may also improve ventilation in obesity by preventing excess abdominal content from impairing diaphragmatic excursion.[98] High alveolar-arterial gradient in obesity may prevent the use of capnography to assess the adequacy of ventilation; blood gas analysis is preferred.[8,16]

CONCLUSIONS

Airway management in obese patients can be challenging because of the anatomic and physiologic changes associated with this condition. Several techniques may help to optimize airway management of the obese patient, including the use of CPAP during preoxygenation, proper positioning in the "ramped" position, and dosing of succinylcholine according to total body weight. The indications for tracheal intubation, the skills and experience of the operator, and the resources (equipment and consultants) available will often dictate the technique used to secure the airway. When circumstances permit, consideration should be given to an awake approach to tracheal intubation in obese patients because facemask ventilation may be exceedingly difficult and oxygen desaturation may occur precipitously after the ablation of spontaneous ventilation. The relative risks and benefits of an awake approach must be weighed against the merits of rapid sequence intubation, including improved intubating conditions, reduced risk of aspiration, and ease of insertion of advanced and rescue airway devices. During rapid sequence intubation, the chance for first-pass success should be optimized through the use of advanced airway devices, such as video or mirror laryngoscopes. Supraglottic rescue devices that have been shown to be effective in obesity, such as an intubating LMA, should be readily available because surgical access to the airway may be difficult. After a review of the relevant literature, we conclude that further research is necessary to determine the most effective approach to successful emergency airway management in obesity, including predictors of difficult tracheal intubation, techniques for preoxygenation, proper medication dosing, and the most effective means of securing the airway.

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