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Techniques and Procedures

HIGH-RISK AIRWAY MANAGEMENT IN THE EMERGENCY DEPARTMENT: DISEASES AND APPROACHES, PART II

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☐ **Abstract—Background: Successful airway management is critical to the practice of emergency medicine. Thus, emergency physicians must be ready to optimize and prepare for airway management in critically ill patients with a wide range of physiologic challenges. Challenges in airway management commonly encountered in the emergency department are discussed using a pearl and pitfall discussion in this second part of a 2-part series. Objective: This narrative review presents an evidence-based approach to airway and patient management during endotracheal intubation in challenging cases commonly encountered in the emergency department. Discussion: Adverse events during emergent airway management are common with postintubation cardiac arrest, reported in as many as 1 in 25 intubations. Many of these adverse events can be avoided by proper identification and understanding the underlying physiology, preparation, and postintubation management. Those with high-risk features including trauma, elevated intracranial pressure, upper gastrointestinal bleed, cardiac tamponade, aortic stenosis, morbid obesity, and pregnancy must be managed with airway expertise. Conclusions: This narrative review discusses the pearls and pitfalls of commonly encountered physiologic high-risk intubations with a focus on the emergency clinician. Published by Elsevier Inc.**

☐ **Keywords—airway; aortic stenosis; cardiac tamponade; elevated intracranial pressure; morbid obesity; postintubation cardiac arrest; pregnancy; trauma; upper gastrointestinal bleed**

INTRODUCTION

Successful airway management is a critical skill in emergency medicine (1,2). Most emergent and unplanned intubations in emergency departments (EDs) are managed by emergency physicians using rapid-sequence intubation, with success rates as high as 99% (2–4). However, emergency physicians must be able to prepare for and manage critically ill patients with a wide range of physiologic challenges in the peri-intubation setting.

First-pass success is a priority in any attempt at endotracheal intubation, but especially in physiologically challenging airways, because multiple attempts are associated with an increase in adverse events (5,6). Severe complications occur in 24–28% of endotracheal intubation in patients who are critically ill, most commonly hypoxemia and hypotension (6,7). Many of the preintubation risks for decompensation can be recognized, prevented, or mitigated with proper preparation and evaluation (7–13).

This second article in a 2-part series will focus on the latest literature, recommendations, and underlying

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physiologic considerations for airway preparation in high-risk patients, including patients with trauma, elevated intracranial pressure (ICP), upper gastrointestinal (GI) bleed, cardiac tamponade, aortic stenosis, morbid obesity, and pregnancy. Each condition will be discussed through pitfalls and pearls (Table 1).

DISCUSSION

Trauma and Hemorrhagic Shock

Pitfall: Failure to resuscitate before intubation. There are several anatomic and physiologic challenges that should be considered while managing the airway of the sick trauma

Table 1. Pearls and Pitfalls in the Management of High-Risk Airways

High-Risk Airway	Pitfalls	Pearls
Trauma and hemorrhagic shock	1. Failure to resuscitate before induction 2. Failure to prepare for the traumatized airway	1. Aggressively resuscitate those with hypotension or a shock index* of >0.8–0.9 before induction and reduce the dose of induction agent 2. Be prepared for a difficult glottic view and have backup methods prepared and ready
Elevated intracranial pressure	1. Allowing a second insult to the injured brain from hypercapnia, hypoxemia, or hypotension	1. Avoid hypotension and target higher mean arterial pressure >80 mm Hg to ensure an adequate cerebral perfusion pressure 2. Preoxygenate, target normocapnia, and avoid inadvertent hyperventilation and hypoventilation
Upper gastrointestinal bleed	1. Not preparing for blood obscuring the glottic view 2. Failure to adequately resuscitate before induction	1. Aggressively resuscitate those with hypotension or a shock index* of >0.8–0.9 before induction 2. Have adequate suction available and consider intubation in an upright position
Cardiac tamponade	1. Intubation before pericardiocentesis 2. Failure to hemodynamically optimize	1. Perform a pericardiocentesis, if able, before an intubation attempt 2. Administer a 250–500 mL fluid bolus before an intubation attempt and consider an awake intubation
Aortic stenosis	1. Failure to optimize the preload prior to intubation 2. Failure to maintain a normal heart rate 3. Failure to anticipate or treat hypotension	1. Give a small fluid bolus and use induction agents that do not reduce the preload 2. Treat brady- and tachydysrhythmias before intubation 3. Have push-dose vasopressor and an infusion available and use a hemodynamically neutral induction agent/dose
Obesity	1. Failure to preoxygenate 2. Ineffective bag-mask ventilation 3. Failure to position appropriately during laryngoscopy 4. Failure to use a supraglottic airway in the event of a difficult airway	1. Sit the patient up for preoxygenation and use noninvasive positive pressure ventilation 2. Use a 2-handed V-E mask technique and have a supraglottic airway available 3. Positioning the patient to align the external auditory meatus into horizontal alignment with the sternal notch is recommended 4. Have a supraglottic airway device available to use in the event of difficulty with intubation or mask ventilation of the obese patient
Pregnancy	1. Failure to prepare for a difficult airway (≤8% of intubations) 2. Failure to position appropriately	1. Use a smaller endotracheal tube (e.g., 7 mm); have backup methods and a supraglottic airway readily available 2. Position with the head up around 20°, preoxygenate, and displace the uterus to the left

* Calculated as heart rate/systolic blood pressure.

patient. Rapid sequence intubation (RSI) is ideal for the trauma patient because it mitigates the risks of aspiration, provides rapid control of the airway, and has high success rates (14,15). Although shock and hypoxemia may themselves be an indication for airway management in the trauma patient, resuscitation and preoxygenation should occur before RSI if time allows to prevent hemodynamic collapse or worsening hypoxemia (14,16,17). Studies suggest that preintubation hypotension and shock index ≥0.8–0.9 (heart rate/systolic blood pressure) are predictors of postintubation decompensation and cardiac arrest (8,13,18–22). Therefore, an unstable trauma patient with a shock index of ≥0.8–0.9 or hypotension should be aggressively resuscitated before induction. The induction medication will depend on local practices, but hemodynamically neutral and appropriately dosed induction agents such as ketamine and etomidate as discussed in part I of this series are optimal choices (14,23–26). Both high dose rocuronium (>1.0 mg/kg) and succinylcholine are appropriate neuromuscular relaxants for RSI in the trauma population (15).

> Pearl: Resuscitate and preoxygenate before induction, if time allows, and use a hemodynamically neutral and appropriately dose-reduced induction agent.

Pitfall: Failure to prepare for the traumatized airway and the anatomic challenges of head, face, and neck trauma. If a cervical spine injury is suspected, neutral alignment of the spine is recommended (27,28). This can be accomplished by having an assistant hold manual in-line stabilization while the anterior portion of the rigid collar is removed to free the mandible and allow mouth opening (17,28,29). However, in-line stabilization of the cervical spine may worsen the glottic view with direct laryngoscopy (27–29). Though the benefits are controversial in the literature, video laryngoscopy should be considered to improve glottic visualization with decreased spinal motion (14,27,28,30,31). Direct laryngoscopy with a bougie remains another option (17). There is also a risk of anatomic distortion and airway debris with head, facial, and neck trauma (17). Adequate suction should be available. Different airway techniques can be used, such as awake spontaneous breathing, fiberoptic intubation, or cricothyrotomy on a case by case basis (16). When performing RSI, the operator must be prepared, with equipment at the bedside, for an invasive surgical airway if unable to oxygenate or ventilate (14,16,32).

> Pearl: If cervical spine injury is suspected, use manual in-line stabilization while anticipating a difficult view; consider video laryngoscopy or direct laryngoscopy with a bougie. Be prepared for difficult anatomy and surgical airway if endotracheal intubation is unsuccessful in those with head, neck, and facial trauma.

Elevated Intracranial Pressure

Pitfall: Allowing a "second hit," such as hypercapnia, hypoxemia, or hypotension to the injured brain. Suboptimal airway management in the medical or trauma patient with suspected elevated ICP can lead to secondary brain injury, herniation, and poor neurologic outcomes (27,28,33). RSI with maintenance of normocapnia, oxygenation, and blood pressure with adequate induction sedatives and analgesia to prevent an increase in ICP is the recommended approach (27,28,34). A partial pressure of carbon dioxide ($PaCO_2$) of 35–45 mm Hg should be targeted because elevated $PaCO_2$ causes cerebral vasodilation and increased ICP (27,28). Quantitative end-tidal CO_2 ($ETCO_2$) can also be used to target and maintain normocapnia while avoiding inadvertent hypoventilation or hyperventilation (27,35). While the difference between $ETCO_2$ and $PaCO_2$ is usually ≤5 mm Hg, caution should be used while interpreting $ETCO_2$ in disease states known to increase the variability, such as shock, lung disease, or chest wall injuries (36,37). Hyperventilation should be reserved only for temporary treatment of an acute elevation in ICP resulting in herniation and neurologic decompensation (27,38). Hypoxemia is associated with poor neurologic outcomes and should be aggressively avoided (10,27). The goal oxygen saturation should be >94%, with preoxygenation and bag valve mask ventilation as needed (27). The head of the bed should only be flattened if needed and as briefly as possible; once the patient is intubated, the head of the bed should be placed at 30° or higher to facilitate cerebral venous drainage (27).

> Pearl: Maintain normocapnia PaCO2 of 35–45 mm Hg and oxygenation of >94%. Maintain head of bed elevation ≥30° and only lower briefly if needed for intubation.

When considering hemodynamics in patients with brain injuries, cerebral perfusion pressure (equal to mean arterial pressure − ICP) should be kept >60 mm Hg (27). A decrease in systemic blood pressure can cause a secondary brain injury; there is a strong association with mortality and episodes of hypotension during early resuscitation of patients with brain injuries (10,27,39,40). Therefore, it is recommended to keep the mean arterial pressure >80 mm Hg to ensure adequate cerebral perfusion pressure (27).

> Pearl: Hypotension is associated with poor outcomes in patients with brain injury and should be aggressively avoided.

The noxious stimulus of laryngeal manipulation may cause a transient increase in ICP if there is inadequate sedation (27,28,41). Etomidate is hemodynamically neutral and a good option in the brain injured patient (7,24,42,43). When using etomidate or other agents without analgesic effects (i.e., propofol or

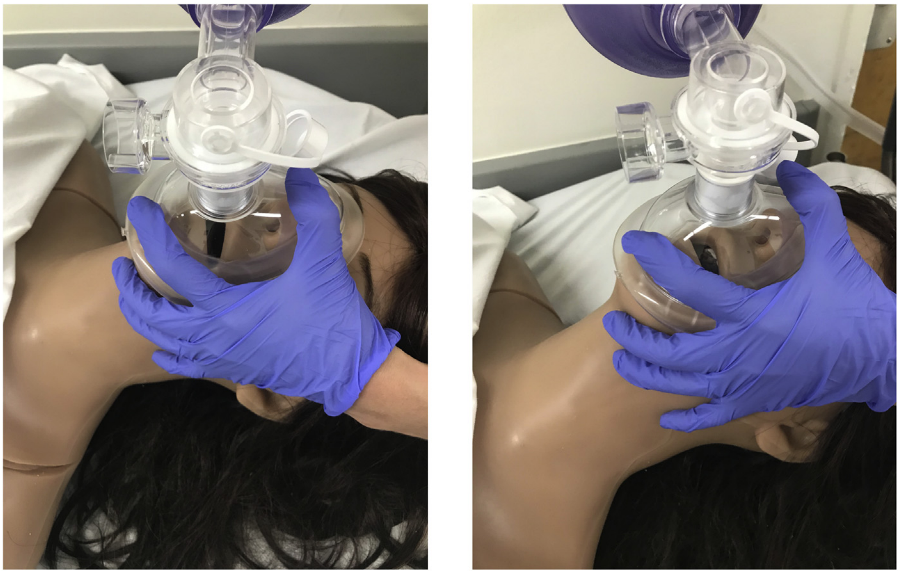

Figure 1. C-E technique.

benzodiazepines) consider analgesic pretreatment with fentanyl 2–3 μg/kg intravenously several minutes before induction in patients who are hypertensive or in those not at risk for hypotension. This may blunt the sympathetic response and potential increase in ICP associated with laryngoscopy (24,27,34,44). In patients with a brain injury, pretreatment with lidocaine 1.5 mg/kg intravenously 2–3 min before intubation was thought to mitigate the direct laryngeal reflex that can cause an increase in ICP. However, the evidence for efficacy in preventing increased ICP is poor, and lidocaine is not universally recommended (15,27,33,41,45–47). Propofol is an option for induction and sedation because it reduces ICP, but it should be used with caution because of the risk of associated hypotension and subsequent reduction in cerebral perfusion pressure (24,27,34,42,48). Ketamine was previously controversial for use in those at risk for elevated ICP, but recent evidence has shown it to be safe with a favorable hemodynamic profile (14,15,27,34,49–52). The most common choices for neuromuscular blockade in RSI include succinylcholine and rocuronium. Succinylcholine was thought to transiently increase ICP, but this has not been clearly demonstrated and is not regarded as clinically significant (27,53,54). Succinylcholine offers the benefit of rapid onset and short duration, allowing for an earlier neurologic examination (27,34). Rocuronium has no known effects on ICP and at high doses (>1.0 mg/kg) has a desirable short time of onset. Rocuronium, or an alternative nondepolarizing agent, should be used in those at risk for hyperkalemia (24,34,55). The duration of paralysis at high doses of rocuronium is >45 min and will obscure the neurologic examination during this time (24,34,55). If this is a factor, sugammadex may be administered if an examination is urgently needed shortly after intubation (56).

Pearl: Aggressively avoid hypotension, increased ICP, and decreased cerebral perfusion pressure during induction with proper selection of induction sedation, analgesia, and neuromuscular blocking agents.

Upper Gastrointestinal Bleed

Pitfall: Not preparing for an obscured glottic view by blood and not adequately resuscitating hemorrhagic shock. The patient with an upper gastrointestinal bleed presents several challenges, including the risk of hemorrhagic shock, aspiration, and obstruction of the glottic view by blood. As in all patients with shock, those with a shock index $\geq$0.8–0.9 and preceding hypotension are at risk for postintubation cardiac arrest and hypotension and should be optimized and resuscitated aggressively before induction (7,8,13,18,20–22). Prophylactic, routine intubation before endoscopy for upper gastrointestinal bleed is controversial and should be decided on a case by case basis because prophylactic intubation has been associated with adverse cardiopulmonary outcomes, most commonly pneumonia (57–60). If there is massive hematemesis, altered mentation with failure to protect the airway, or hemodynamic instability, intubation is recommended (57).

Pearl: Resuscitate before intubation. Prophylactic intubation is not needed in every patient and should be decided on a case by case basis.

In preparation for induction in the patient requiring intubation, positioning should be carefully considered.

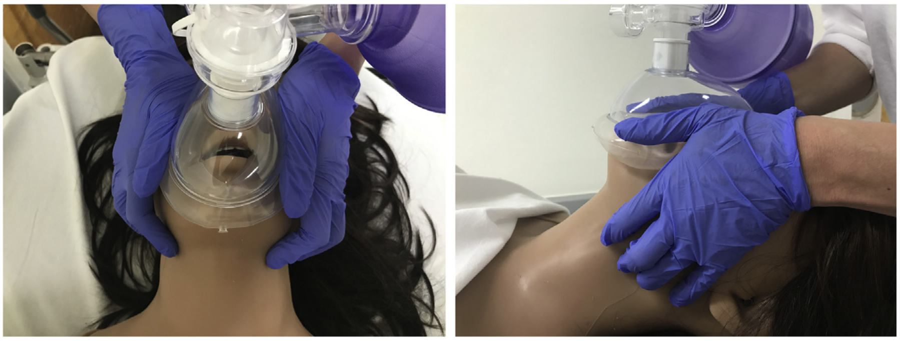

Figure 2. V-E technique.

An upright position may help reduce aspiration of blood during intubation attempts (61,62). All staff should wear full personal protective equipment to reduce the risk of exposure. At least 2 suction devices should be available, with consideration of nasogastric decompression before induction (61). There is risk of video obstruction by blood, and thus direct laryngoscopy or dual-purpose standard geometry video blade if available is recommended (i.e., C-MAC [Karl Storz GmbH & Co. KG, Tuttlingen, Germany]). If heavy bleeding is encountered, placing the suction catheter into the esophagus or using a suction-assisted laryngoscopy assisted decontamination technique may optimize intubating conditions (63).

> Pearl: Consider sitting the patient upright, have suction available, and anticipate airway contamination.

Cardiac Tamponade

Cardiac tamponade is a life-threatening condition caused by the buildup of fluid within the pericardial space (64). As fluid rapidly accumulates, the fibrinous, inelastic pericardium has limited ability to acutely expand, resulting in increased pericardial pressures and compression of cardiac chambers. Because of its lower pressure, the right side of the heart is affected first. Collapse of the right atrium and right ventricle (RV) impairs diastolic filling and reduces RV output, subsequently decreasing blood return to the left heart and, as a result, decreasing stroke volume. Though cardiac output and adequate blood pressure are initially maintained by compensatory increases in sympathetic tone, as pericardial pressures continue to rise, all chambers become compressed, and cardiac output is no longer able to maintain coronary and systemic perfusion, resulting in complete cardiovascular collapse (64).

Pitfall: Intubation before pericardiocentesis or failure to hemodynamically optimize before intubation. Intubation of the patient with cardiac tamponade is dangerous for several reasons. Medications administered for intubation blunt endogenous sympathetic tone, thereby removing compensatory tachycardia and vasoconstriction (65). Sedative agents may depress myocardial function and cause peripheral vasodilation (65,66). Positive pressure ventilation increases the intrathoracic pressure, which further decreases venous return and cardiac output (65–68). In the setting of tamponade, even small reductions in cardiac preload caused by positive pressure can precipitate cardiac arrest (67,68). When these factors are combined, patient hemodynamic compensation and cardiac arrest may occur. In unstable patients, rapid and immediate decompression of pericardial tamponade under local anesthesia should be performed before intubation (65,66,68). One author recommends delaying intubation, even in the setting of hypoxemia or severe neurologic impairment, until surgical intervention is readily available unless the patient becomes apneic or bradycardic (68). If respiratory failure is present, respirations should be assisted with gentle bag-mask valve and pericardiocentesis performed under local anesthesia if possible (65,66,68). Ketamine can provide adequate sedation while maintaining spontaneous respirations and avoiding the need for intubation (69).

> Pearl: Perform pericardiocentesis before intubation using local anesthesia if possible.

Preload must also be optimized by administering small (250–500 mL) boluses of intravenous fluid (67). One small study of unstable patients with cardiac tamponade showed significant increases in blood pressure and cardiac output with infusion of only 250–500 mL intravenous normal saline; larger volumes of infusion resulted in no added significant benefit (70). Though the literature regarding airway management in tamponade is scarce, it is recommended to maintain spontaneous respirations during the attempt using an awake intubation with a flexible intubating endoscope and topical lidocaine (66,69,71,72). Ketamine can be used to facilitate intubation because it maintains respiratory drive and augments sympathetic tone, attenuating the adverse hemodynamic consequences of intubation (71,73). Finally, because of the deleterious effects of positive pressure ventilation after intubation, ventilatory settings should be adjusted to low tidal volume and low positive end-expiratory pressure to minimize intrathoracic pressure (66,68).

Pearl: If intubation is unavoidable, optimize preload with judicious fluids and consider an awake intubation with ketamine sedation to maintain spontaneous respirations. After intubation, adjust ventilator settings to provide the minimum pressure required to maintain adequate ventilation.

Aortic Stenosis

Aortic stenosis is the most common valvular disease encountered in clinical practice, with an incidence that increases with older age, affecting approximately 10% of the population over 80 years of age (74). It stems from 1 of 3 primary pathways: age-related calcific degeneration of a normal tricuspid aortic valve, rheumatic heart disease, or stenosis of a congenitally abnormal bicuspid valve (75,76). Regardless of the etiology, the end result and pathophysiology include progressive stenosis of the aortic valve that results in gradually worsening obstruction to left ventricular outflow (75,76). The left ventricle (LV) with an obstructed outflow compensates for chronic pressure overload with concentric hypertrophy which, over time, results in a thickened, noncompliant ventricle, progressive ventricular hypertrophy, diastolic dysfunction, and increased LV filling pressure (76). The net effect is a heart that is both extremely susceptible to pulmonary congestion with excess volume while dependent on a high filling pressure from an adequate preload to maintain cardiac output. Increased LV mass also increases myocardial oxygen consumption while impairing myocardial capillary blood flow, resulting in a potential mismatch between supply and demand with subsequent risk of myocardial ischemia (75,77,78).

Hemodynamic goals in aortic stenosis include the maintenance of intravascular volume and preload, adequate systemic blood pressure and systemic vascular resistance, and normal sinus rhythm while avoiding tachycardia and bradycardia (79,80). Though these principles should be applied to all patients with aortic stenosis, they become crucial when intubating critically ill patients with aortic stenosis because the hemodynamic perturbations induced by intubation can cause cardiovascular collapse.

Pitfall: Failure to optimize preload before intubation. Patients with aortic stenosis depend on an adequate preload to provide the elevated filling pressure necessary to maintain a cardiac output. Through both the vasodilatory effects of induction agents and the decrease in systemic venous return from positive pressure ventilation, intubation results in an acute drop in preload that can precipitate hemodynamic collapse (81). This effect can be compounded if intravascular volume depletion related to an acute illness is already present. Subsequently, hypotension should be corrected and preload optimized before intubation with the administration of a crystalloid fluid bolus (75,78).

Pearl: Optimize preload before induction with a small fluid bolus and use induction agents that avoid a decrease in preload.

Pitfall: Not maintaining a normal heart rate. Maintenance of normal sinus rhythm is essential in patients with aortic stenosis. The hypertrophied LV depends on the left atrial kick for ventricular filling, which accounts for 30–40% of end diastolic volume (79). In addition, both tachycardia and bradycardia are poorly tolerated in aortic stenosis. Tachycardia decreases diastolic filling time and increases myocardial oxygen demand, thereby impairing ventricular filling and promoting myocardial ischemia, respectively. Subsequently, tachydysrhythmias, such as atrial fibrillation with rapid ventricular response, can result in hemodynamic deterioration and should be aggressively managed with beta-blockers, digoxin, or calcium channel blockers, while avoiding significant bradycardia (75,79,82). Cardioversion before intubation is recommended for dysrhythmias, particularly if the patient is hemodynamically unstable. Compared with tachycardia, bradycardia increases diastolic time, improving LV filling (78). However, bradycardia is poorly tolerated because it can result in decreased cardiac output across the fixed aortic valve, precipitating hypotension and congestive heart failure (75,76,81). Bradycardia subsequently should also be corrected before intubation (75).

Pearl: Aggressively manage brady- and tachydysrhythmias before intubation.

Pitfall: Not preparing for intubation-related hypotension. Hypotension, even for brief periods, can be deadly in patients with severe aortic stenosis. The hypertrophied LV, with an increased LV end-diastolic pressure (LVEDP), requires normal to elevated aortic blood pressure to maintain coronary perfusion (coronary perfusion pressure = diastolic aorta pressure − LVEDP). A decrease in systemic vascular resistance reduces coronary perfusion pressure by a reduction in systemic blood pressure, potentially precipitating myocardial ischemia, which further reduces cardiac contractility and increases

LVEDP (78). Because of fixed flow across the stenotic valve, the heart is unable to increase its stroke volume to compensate for a decreased systemic vascular resistance, furthering hypotension (81). Hypotension should therefore be avoided. Adequate fluid resuscitation is recommended both before and after intubation. If vasopressors are used, phenylephrine is the agent of choice for its pure alpha-agonism, which provides afterload support without the associated risk of tachycardia and tachydysrhythmias (80,83). Initiation of a vasopressor before induction should be considered. During induction, medications that cause vasodilation and myocardial depression should be avoided. Though there are no randomized controlled trials comparing agents, the anesthesia literature recommends using medications with a hemodynamically neutral profile, such as opioids, midazolam, or etomidate (78–80). The use of ketamine as a solo induction agent is controversial because of the risk of tachydysrhythmias, but small studies have shown it be safe when used in small doses and in combination with propofol, benzodiazepines, or opioids (78,79,84).

Pearl: Have a push-dose vasopressor (i.e., phenylephrine) and a vasopressor infusion ready before intubation to treat and prevent postintubation hypotension. Use a hemodynamically neutral induction agent in appropriate doses.

Morbid Obesity

Approximately 40% of Americans are currently obese, and the incidence is expected to increase (85). There are several consequences of obesity pertaining to airway management. Excess adipose tissue in the pharyngeal tissues decreases the posterior airway space, obscuring airway view and increasing upper airway resistance. Excess adipose tissue increases intrathoracic and intra-abdominal pressure, resulting in a restrictive lung disease with decreased functional residual capacity (FRC), impaired lung compliance, and alveolar hypoventilation with V/Q mismatch. The net effect of these physiologic changes includes difficulty with mask ventilation and laryngoscopy as well as rapid oxygen desaturation because of limited oxygen reserve (86,87).

Pitfall: Failure to position appropriately during preoxygenation. Obesity decreases FRC, which normally functions as an oxygen reserve. This occurs in large part because of compression of the diaphragm and lungs by the increased inward pressure of the abdominal and chest wall, an effect that is exaggerated in the supine position. Before intubation, obese patients should be maintained in a head-elevated position to improve lung expansion, thereby increasing FRC and an available reserve of oxygen. Numerous studies from the anesthesia literature have shown that simply positioning the patient in a 25° "heads up" or reverse trendelenburg position during preoxygenation delays the onset of hypoxemia and increases the duration of apnea without desaturation during intubation (12,88,89). One randomized controlled trial found that preoxygenation in the 25° head-up position compared with supine increased the average time to desaturation after apnea from 155 to 201 s (88). Another study showed that in obese patients, preoxygenation in a 90° sitting position compared with supine position increased the period of apnea without desaturation by an average of 50–60 s; subsequently, the 90° sitting position has been recommended as the ideal position for preoxygenation in the obese patient with obstructive sleep apnea undergoing bariatric surgery (90,91). Though the aforementioned studies were performed in patients who were well and who were undergoing general anesthesia for elective surgery, the principles of preoxygenation in an upright position are likely applicable to the critically ill obese patient requiring emergent intubation.

Pearl: Sit the obese patient to ≥25° for preoxygenation.

Pitfall: Failure to use noninvasive positive pressure ventilation for preoxygenation. Obese patients are at risk of rapid desaturation after induction of anesthesia because of limited FRC and oxygen reserve. In addition to preoxygenating in a head-elevated position, the use of noninvasive positive pressure ventilation (NIPPV) can improve preoxygenation and prolong the time to desaturation after induction in obese patients (86,87,89). One study of 28 morbidly obese patients undergoing general anesthesia found that 5 min of preoxygenation with NIPPV resulted in more rapid achievement of goal end-tidal O2 of 95% compared with spontaneous ventilations (92). Gander et al. found that application of 10 mm Hg positive end-expiratory pressure before and during the induction of anesthesia in morbidly obese patients increased time to desaturation after apnea by 50% (93). Recently, the PREOPTIPOP randomized trial compared preoxygenation via high-flow nasal cannula (HFNC) or NIPPV in 100 obese patients undergoing scheduled surgery (94). NIPPV resulted in lower rates of desaturation compared to HFNC (12% vs. 30%, relative risk 2.5) (94). This difference occurred despite the HFNC group receiving continued apneic oxygenation via HFNC throughout intubation, while the NIPPV group received no apneic oxygenation, further supporting the superiority of NIPPV for preoxygenation (94).

Pearl: Preoxygenate obese patients with NIPPV.

Pitfall: Ineffective bag-mask ventilation. Obesity increases the risk of difficult mask ventilation because of challenges in maintaining an effective face seal, airway obstruction by oropharyngeal tissues, and elevated airway pressures (86,95,96). Studies have shown that an elevated body mass index and a history of snoring or obstructive sleep apnea are independent predictors of difficult mask ventilation (95,96). Proper mask ventilation technique is critical in obese patients and should be performed using a 2-person, 2-handed technique if possible, which results in superior ventilation compared with the traditional 1-handed “C-E” technique (97–99). This can be done either via the 2-handed C-E technique or by the newer “V-E” thenar-grip technique, in which the thumbs and thenar eminence are placed over the sides of the mask while the rest of fingers lift the mandible, effectively performing a jaw thrust (Figures 1 and 2). Though some studies have shown equivalent ventilation with either 2-handed technique, others have shown the V-E technique to be superior, specifically in novice providers and in morbidly obese patients (97,99–101). In 1 small study of mask ventilation in morbidly obese patients, all subjects who received the modified V-E technique were effectively ventilated, and those who failed mask ventilation with the C-E technique were effectively ventilated with the V-E technique (100).

Pearl: Anticipate a difficult mask and use a 2-handed V-E mask technique.

Pitfall: Failure to position appropriately for laryngoscopy. Head elevation is also another method that is traditionally recommended to improve laryngoscopic views during intubation (91,102,103). In the obese patient, this can be accomplished by ramping, in which the upper back, head, and neck are elevated with blankets or pillows, bringing the external auditory meatus into horizontal alignment with the sternal notch (103). Compared with the traditional “sniffing” position, ramping has been shown to improve glottic views during direct laryngoscopy and is recommended by some experts as the ideal induction position in obese patients (91,102,103). Despite several studies showing improved views and first-pass success with ramping, others have failed to show any benefit (91,102–105). A multicenter randomized controlled trial of 260 critically ill adults undergoing intubation in the intensive care unit found that ramping worsened glottic views compared with a sniffing position (105). However, most patients included in this study were nonobese (average body mass index 26–27 kg/m^2 in both groups); therefore, these findings may not be applicable to obese patients. Recently, the National Emergency Airway Registry investigators published a retrospective analysis comparing supine vs. nonsupine positioning in adult obese patients intubated in the ED across 25 institutions (104). The investigators found no difference with regard to first-pass success between groups but higher rates of adverse events, including hypoxemia and hypotension, with nonsupine positioning. There were several limitations, including retrospective reporting of data, with subsequent recall bias and incomplete data sets, combining a head-up positioning with ramping into 1 “nonsupine” group, and the absence of a uniform definition for nonsupine positioning (104).

Pearl: Positioning the patient to align the external auditory meatus into horizontal alignment with the sternal notch is recommended, but the evidence for a ramping position is conflicting.

Pitfall: Failure to use a supraglottic airway in the event of a difficult airway. Placement of a rescue supraglottic airway device (SAD) is the recommended next step before surgical airway in patients who are unable to be intubated and cannot be ventilated by face mask per the American Society of Anesthesiologists “Practice Guidelines for Management of the Difficult Airway” (32). In obese patients with a difficult airway, SAD can be used as both a rescue, temporizing measure to provide oxygenation and ventilation pending more definitive airway management or, in the case of an intubating laryngeal mask airway (LMA), as a conduit to facilitate endotracheal intubation (106). Despite being recommended in difficult airway guidelines, supraglottic devices are likely underused in clinical practice. One retrospective study of almost 5000 patients found to have a difficult airway during general anesthesia found that a SAD was only used 18% of the time with a success rate of 65% (107). Of the 455 patients with a “cannot intubate cannot ventilate” situation, SAD was only attempted in 86 (19%), suggesting underuse, but yielded a 62% success rate (107). Once successfully placed, SADs have been shown to result in adequate oxygenation and effective ventilation, superior to mask ventilation, in obese patients undergoing general anesthesia (108–110). One small study found easier and improved quality of ventilation with the LMA supreme compared with mask ventilation in novice providers (109). Another study of 834 morbidly obese patients undergoing bariatric surgery found that SAD was the preferred method of ventilation after induction of anesthesia in very morbidly obese patients and a neck circumference >49.5 cm (110). Intubating LMA is another option to facilitate endotracheal intubation in obese patients with difficult airways, with approximately a 96% success rate of intubation reported in obese patients undergoing general anesthesia (111,112).

Pearl: Have a supraglottic airway device ready and available to use in the event of difficulty with intubation or mask ventilation of the obese patient.

Pregnancy

Intubation of the pregnant patient is challenging, with several studies from the anesthesia literature showing significantly higher rates of failed intubations with the obstetric population compared with nonobstetric patients (113). Many physiologic and anatomic changes in pregnancy are responsible for this difficulty. Estrogen-mediated fluid retention results in upper airway mucosal edema and swelling, which can obscure visualization of the glottis by laryngoscopy and makes passage of an endotracheal tube difficult (11,114). Accordingly, Mallampati scores increase as pregnancy progresses (11,115). Weight gain and breast enlargement in pregnancy further increase difficulty with laryngoscopy, an effect that is compounded in the setting of pre-existing obesity (114,116). Airway edema and increased vascularity increase the risk of bleeding with minor manipulation as occurs during intubation (11). In addition, as occurs in obese patients, increased abdominal girth from a gravid uterus displaces the diaphragm cephalad, thereby lowering FRC. This decreases the oxygen reserve, which when combined with increased oxygen consumption during pregnancy, places these patients at high risk for rapid oxygen desaturation during intubation with adverse effects on both the mother and fetus (117). Lastly, pregnant patients have low esophageal sphincter tone and delayed gastric emptying, increasing the risk of aspiration.

Pitfall: Failure to prepare for a difficult airway. As discussed above, pregnancy increases the risk of a difficult airway, with 1 study showing an 8% incidence compared with 2.5% in the general population (114). Anesthesia-related complications are among the leading causes of maternal mortality, with airway disasters responsible for most of these deaths (116,118). Further complicating the matter is that standard bedside tests for airway assessment (neck circumference, thyromental distance, and Mallampati score) may fail to predict a difficult airway (119). Subsequently, the 2015 Obstetric Anaesthetists' Association and the Difficult Airway Society guidelines for obstetric anesthesia emphasize meticulous planning and preparation, with backup personnel and equipment readily available in case of failed or difficult airway (11). These guidelines provide standardized algorithms and best practices for intubation of the obstetric patient (11). Though these guidelines focus on intubation in the operative or labor and delivery setting, similar principles can be applied to the ED. Before intubation, preparation, preoxygenation, and positioning are imperative. Because of the risk of rapid desaturation during apnea, these patients should be adequately preoxygenated before induction. In addition, apneic oxygenation should be maintained after induction with nasal cannula (11,120). Displacement of the uterus to the left side to avoid compression of the inferior vena cava, and similar to non-obstetric obese patients, optimal positioning with head-of-the-bed elevation to 20–30°, can reduce the risk of peri-intubation decompensation. This position increases FRC, prolonging time to desaturation after apnea, may improve glottic visualization, and reduces gastroesophageal reflux (11). During intubation, because of underlying airway edema and friability in pregnancy, a small endotracheal tube (7.0 mm) should be used to reduce airway trauma and improve passage of the tube (11).

Pearl: Before intubation, prepare for the possibility of a difficult airway by having backup equipment and personnel available. Pregnant patients should be adequately preoxygenated and positioned with the head of the bed elevated to 20° and the uterus displaced to the left side. Intubation should be performed with a small endotracheal tube (7.0 mm) to minimize airway trauma and increase risk of success.

The guidelines also state that if 2 attempts at intubation are unsuccessful, one should declare a failed intubation and move to the "failed obstetric airway algorithm," as repeated attempts damage airway structures, worsening edema and increasing the risk of bleeding (11). In this situation, the management is similar to that of a failed airway in nonobstetric patients. Oxygenation should be maintained with facemask ventilation and a supraglottic airway placed with a maximum of 2 attempts. If this fails, then one should declare a "can't ventilate can't oxygenate scenario" and surgical front-of-neck access should be obtained (11).

Pearl: After 2 failed intubation attempts, call for assistance and move to a supraglottic airway. If unable to successfully place a supraglottic airway after 2 attempts, a surgical airway should be obtained.

CONCLUSIONS

Emergency clinicians are experts in airway management and routinely encounter critically ill patients with pre- and postintubation physiologic challenges associated with adverse events. Trauma patients should be resuscitated before induction. In those with head and neck trauma, a difficult airway should be anticipated, and in those at risk for cervical spine injury, manual in line stabilization should be maintained. Patients who are at risk for an elevated ICP should be carefully managed to avoid a secondary insult of hypoxemia, hypotension, or a sudden increase in ICP from inadequate sedation. Patients with a severe upper gastrointestinal bleed have a challenging airway because of contamination and hemodynamic instability. Cardiac tamponade should ideally be treated before intubation by pericardiocentesis, but if unavoidable, maintenance of preload and a low intrathoracic pressure are recommended. Aortic stenosis should have preload maintained and aggressive avoidance of systemic hypotension. In morbid obesity, careful attention must be paid to proper positioning and preoxygenation. Pregnant patients have difficult airways, and anatomic challenges should be anticipated. These considerations can assist emergency clinicians in optimizing intubation attempts.

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ARTICLE SUMMARY

1. Why is this topic important?

Critically ill patients present several physiologic challenges to emergency clinicians.

2. What does this review attempt to show?

This review provides an evidence-based approach to management of the physiologically challenging airway.

3. What are the key findings?

Peri-intubation complications can occur in emergent airways. High-risk scenarios including trauma, elevated intracranial pressure, upper gastrointestinal bleed, cardiac tamponade, aortic stenosis, morbid obesity, and pregnancy require consideration of several factors to optimize patient outcomes.

4. How is patient care impacted?

Knowledge of these scenarios can improve management of challenging physiologic scenarios.