37 Tracheal Intubation

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Tracheal intubation is a common, high-risk procedure. Risks associated with intubation in critically ill patients remain high and include prolonged hypoxemia, hemodynamic instability, cardiac arrest, and death. Over the past decade, significant improvements in patient safety have been reported for this procedure by employing skilled operators, a systematic approach to airway management, and advanced airway tools. The goal of this chapter is to provide a common, systematic approach using best evidence to maximize the success and safety of tracheal intubation in the intensive care unit (ICU).

AIRWAY MANAGEMENT CHALLENGES IN THE CRITICALLY ILL

Reported complication rates from tracheal intubation in the critically ill range from 4.2% to 22% and remain unacceptably high in comparison to operating room procedures.[1-5] Emergent ICU airway management cases leave little time to perform a thorough airway assessment and less time to plan when high-risk anatomic features are present. Cardiopulmonary disease makes preoxygenation more difficult, providing less apneic time during intubation before hypoxemia develops.[6] Hemodynamic instability can limit the choice and dose of induction and paralytic agents that, combined with upper airway secretions, edema, and loss of muscle tone, can decrease glottic visualization. Other coexisting comorbidities, including obesity, increased intracranial pressure, and acute coronary syndrome can further complicate management of the critically ill during tracheal intubation.

TRAINING

Current airway management training is highly variable, even among anesthesia providers.[7-10] A recent meta-analysis suggested that the level of training, as opposed to specialty, was the key factor for optimizing proper airway management.[11,12] The appropriate volume and scope of airway training required, however, remains a topic in need of further research. Novices can obtain reasonable competence with direct laryngoscopy after 30 to 50 cases and may accelerate their skills using video-assisted instruction, but performance continues to improve even after 100 intubations.[13-15] Box 37-1 provides a suggested list of airway management topics for training, but these recommendations are expert opinion only.[16] The development of a vast array of advanced airway management devices has only complicated efforts to standardize training and approaches to ICU airway management. In a national survey of 180 American ICU and anesthesiology directors, only 70% had a difficult airway cart in their ICU, and 60% of the respondents reported that they had not been trained in the use of such equipment.[17]

INDICATIONS FOR TRACHEAL INTUBATION

Tracheal intubation is most commonly performed in critically ill patients with active or impending respiratory failure due to inadequate oxygenation and/or ventilation or for airway protection due to an inability to maintain a patent airway. Artificial airways can also facilitate secretion clearance and hyperventilation in the setting of an intracerebral herniation syndrome and can enhance the safe performance of procedures requiring conscious sedation in the setting of significant cardiopulmonary disease.

MAXIMIZING PATIENT SAFETY DURING TRACHEAL INTUBATION

The American Society of Anesthesiologists recommends that an airway assessment be performed before all intubations and emphasizes a systematic approach that maximizes oxygen delivery and considers an awake procedure, a variety of noninvasive techniques, and preservation of spontaneous ventilation.[18] Other recent studies have also underlined the importance of a systematic approach to airway assessment, patient and equipment preparation, and procedure planning to maximize intubation success. Jaber et al. demonstrated that implementation of a protocolized ICU intubation bundle (Box 37-2) reduced complications by 25%.[19] Improved patient safety and reduced need for emergent surgical airways have been achieved through implementation of a standardized, team-based approach that includes proactive identification of patients with known difficult airways, ready availability of advanced airway equipment, simulation-based airway skills and teamwork training, a mandatory bedside procedure checklist, and post-event debriefs.[20,21] The APPROACH mnemonic (Box 37-3) is one structured checklist tool to ensure that these standardized interventions are consistently performed.[22]

Airway Assessment

Common methods of airway assessment are limited in their ability to correctly identify difficult airways (positive predictive value, 4%-27%).[23,24] The MACOCHA score, a seven-item validated prediction tool for the critically ill, is perhaps the most valuable tool for identifying high-risk patients.[25,26]

Preoxygenation

Adequate preoxygenation is essential to maximize the time for intubation attempts. Use of a resuscitation bag, oral or nasal airway, positive end-expiratory pressure (PEEP) valve, high-flow nasal cannula system, or noninvasive positive pressure ventilation (NIPPV) can help improve and sustain patient oxygen saturation when standard bag-valve-mask ventilation proves challenging.[27,28] Head of bed elevation may be particularly helpful to sustain apneic normoxia in patients with obesity, atelectasis, or reduced lung compliance, but apneic oxygenation using a nasal cannula during intubation was recently shown not to be beneficial.[29-32]

Preparation and Teamwork

The Fourth National Audit Project of the Royal College of Anaesthetists and Difficult Airway Society (NAP4) found that preparation, equipment, and communication errors were the most common causes of complications during airway management in ICUs and emergency departments in the United Kingdom.[33] These data underline the importance of deliberate planning and preparation to maximize patient safety and procedure success.

Patient positioning is especially important in ICU patients. Common methods include placing the patient in a supine position, moving them close to the head of the bed, and raising their head to or just below the level of the operator's xiphoid process. Provided there is no concern for neck injury, the patient's head is placed in a sniffing

BOX 37-1 Fundamental Airway Knowledge and Skills

Face mask ventilation, airway positioning
Laryngeal mask airway (LMA, including intubating devices)
Oral endotracheal intubation (direct laryngoscopy, DL)
Simple maneuvers (positioning, BURP*) to improve DL
Use of stylet, gum elastic bougie
Rapid sequence induction
Fiberoptic intubation via conduit (oropharyngeal airway, LMA)
Percutaneous cricothyrotomy

**BURP*, Backwards, Upwards, and Rightwards Positioning.*
From Goldmann K, Ferson DZ. Education and training in airway management. Best Pract Res Clin Anaesthesiol 2005;19(4):717–732.

BOX 37-2 ICU Intubation Bundle Used in a Large Multicenter Study to Improve Patient Outcomes

PREINTUBATION

1. Presence of two operators
2. Fluid loading (isotonic saline [500 mL] or hetastarch [250 mL]) in the absence of cardiogenic pulmonary edema
3. Preparation of long-term sedation
4. Preoxygenation for 3 min with NIPPV in case of acute respiratory failure (Fio_2 100%, pressure support ventilation level between 5 and 15 cm H_2O to obtain an expiratory tidal volume between 6 and 8 mL/kg and PEEP of 5 cm H_2O)

DURING INTUBATION

5. Rapid sequence induction: etomidate (0.2-0.3 mg/kg) or ketamine (1.5-3 mg/kg) combined with succinylcholine (1-1.5 mg/kg) in the absence of allergy, hyperkalemia, severe acidosis, acute or chronic neuromuscular disease, burn patients for more than 48 hours, and major crush injury
6. Sellick maneuver

POSTINTUBATION

7. Immediate confirmation of tube placement by capnography
8. Norepinephrine if diastolic blood pressure remains <35 mm Hg
9. Initiate long-term sedation
10. Initial "protective ventilation": tidal volume 6-8 mL/kg of ideal body weight for a plateau pressure <30 cm H_2O

NIPPV, non-invasive positive pressure ventilation; *PEEP*, positive end expiratory pressure; *Fio_2*, inspired oxygen fraction.
From Jaber S, Jung B, Corne P, Sebbane M, Muller L, Chanques G, et al. An intervention to decrease complications related to endotracheal intubation in the intensive care unit: a prospective, multiple-center study. Intensive Care Med 2010;36:248–255.

position to align the oral, pharyngeal, and laryngeal axes for traditional direct laryngoscopy attempts. A rolled towel under the shoulders and a flat towel underneath the head can also help with alignment. Patients with known or suspected cervical injury should receive inline stabilization of the head and neck, which remain in a neutral position during intubation attempts.

Crew resource management principles important for an efficient airway management team include explicit role assignments, closed loop communication, and standardized equipment and medication preparation and positioning. Clear articulation of the primary and backup airway management plans and discrete oxygen cutoffs (which should prompt termination of intubation efforts and resumption of bag-valve-mask ventilation) provide shared situational awareness and guidance to maintain quality control and safety throughout the procedure. An empiric crystalloid bolus in the absence of decompensated heart failure and readily available vasopressors also reduce the risk of hypotension during intubation.[19]

Airway Pharmacology

Rapid sequence intubation is the standard of care in the emergency department due to its high rate of success.[34] Medication

BOX 37-3 The ACCP APPROACH to Airway Management

Assess the airway—it's all in your **HAND**
- **H**istory of difficult intubation
- **A**natomic considerations
  - 3-3-2 rule
  - Modified Mallampati Classification
  - Other risk factors for airway distortion, obstruction
- **N**eck mobility
- **D**ifficult airway should be considered if concerns with any of the factors above

Preoxygenate using 100% oxygen, bag-valve-mask with PEEP valve
Prepare
- Patient: Sniffing position, headboard off and patient head just below the intubator's xiphoid process
- Medications: Free-flowing IV, premedication, induction, paralytic, and vasopressor agents
- Right side: Suction, endotracheal tube with stylet and syringe attached
- Left side: Laryngoscope handle, blades, oral and nasal airways, end-tidal CO_2 detector

Review team member roles, primary and backup intubation plans
Oxygen cutoffs: Identify signals to abort, reinitiate bag-valve-mask ventilation
Administer medication, if indicated
Confirm endotracheal tube placement using two indicators (including end-tidal CO_2)
Hold endotracheal tube until secured

From American College of Chest Physicians Airway Management Program Curriculum, 2013.

BOX 37-4 Contraindications to Succinylcholine

History of malignant hyperthermia
Hyperkalemia
Upper, lower motor neuron lesions
Myopathy
Crush injury
Severe burns (>24 hours)
Prolonged immobility

administration in critically ill patients is more variable because of differences in provider comfort, hemodynamics, and concern for airway failure. Outside of a pulseless or unresponsive patient, however, selecting and preparing appropriate medications should be a routine part of intubation preparation and planning. Common agents, indications, and doses are summarized in Table 37-1.[35] Drugs administered before induction are particularly useful in the setting of severe exacerbations of obstructive lung disease and significant intraocular or intracranial hypertension. Initial induction agent doses should be reduced by 25% to 50% in the elderly and in patients with hypotension, hypovolemia, or significantly impaired cardiac function. Propofol provides the best glottic visualization at full induction doses but causes significant hypotension. Etomidate has less associated hypotension and myocardial depression. It reduces adrenal steroidogenesis, but single doses do not appear to increase mortality even in septic patients.[36] Ketamine increases heart rate, blood pressure, and cardiac output and has been shown to provide similar intubating conditions and outcomes to etomidate in a large, prospective randomized trial.[37] Its use in the setting of increased intracranial pressure (ICP) is controversial.[38,39]

The combination of an induction agent such as propofol with a paralytic has been shown to produce optimal intubating conditions.[40] The most commonly used agent is succinylcholine, a depolarizing muscle relaxant with a rapid onset of action and very short duration. In situations where succinylcholine may be considered unsafe (Box 37-4), rocuronium or atracurium will provide a similar onset of action but a much longer duration of paralysis. Use of rapid sequence intubation in the ICU remains controversial, but growing evidence suggests it is safe and effective when employed thoughtfully by an experienced operator.[41]

TABLE 37-1 Common Medications Used During Tracheal Intubation

PREINDUCTION MEDICATIONS

DRUG	DOSE, COMMON INDICATIONS	CAUTIONS
Fentanyl	2-3 micrograms/kg IV, 1-2 mins CAD, aneurysm, increased ICP	Hypotension Masseter, chest wall rigidity
Esmolol	2-3 mg/kg IV Neurosurgery, head injury	Bradycardia Hypotension, bronchospasm
Lidocaine	1.5 mg/kg IV, 2-3 min Asthma, COPD, increased ICP	Hypotension

INDUCTION MEDICATIONS

AGENT	ONSET (SECONDS)	DURATION (MINUTES)	DOSE
Propofol	9-50	3-10	0.5-2 mg/kg
Etomidate	30-60	3-5	0.2-0.3 mg/kg
Ketamine	60-120	5-15	2 mg/kg

NEUROMUSCULAR BLOCKERS

AGENT	ONSET (SECONDS)	DURATION (MINUTES)	DOSE	OFF-LABEL DOSING
Succinylcholine	30-60	5-15	1.0-1.5 mg/kg	Manufacturer's recommendation 0.6 mg/kg
Rocuronium	45-60	45-70	0.6-1.2 mg/kg	
Atracurium	60-90	35-70	0.4-0.5 mg/kg	

From Reynolds SF, Heffner J. Airway management of the critically ill patient. Chest 2005;127:1397–1412.

INTUBATION TECHNIQUES

Recent years have seen the development of a wide array of commercially available airway equipment, with mixed availability and familiarity in many ICUs.[17] Most experts recommend the selection of a limited list of airway tools most appropriate for a given ICU population to facilitate familiarity and training.

Direct Laryngoscopy

Current Macintosh and Miller blades are designed for rapid endotracheal tube placement. The Macintosh blade is broad and curved and includes a flange to displace the tongue to the left when the blade is introduced into the mouth from the right side (paraglossal approach). The blade is advanced toward midline, and the tip is directed into the vallecula once the epiglottis comes into view. Gentle blade traction will lift the epiglottis and expose the glottic aperture. The Miller blade is longer and straight with a slightly curved tip. It can be inserted using either a paraglossal or midline approach, and the distal end is used to directly lift the tip of the epiglottis. Care must be taken with both blades to apply caudal and anterior force, holding the laryngoscope handle near its base and keeping its angle less than 45 degrees to the patient to avoid dental damage. Blade sizes 3 or 4 are most appropriate for adult procedures. The broader surface of the Macintosh blade may provide better upward displacement of excess upper airway soft tissue, and the longer and narrower profile of the Miller blade may assist in the setting of narrow mouth opening or a long epiglottis. A stylet is generally used to help guide the ETT though the vocal cords and can be shaped with a distal bend to aid in tracheal placement.

Indirect Laryngoscopy Devices

Indirect laryngoscopy devices provide video or optical imaging using mirrors and prisms to improve glottic visualization in individuals in whom alignment of the airway axes is difficult. Some devices incorporate an acutely angulated blade (i.e., Glidescope, McGrath, C-Mac), while others incorporate a channel (i.e., AirTraq, Pentax) to facilitate endotracheal tube placement through a more anterior glottis with the head in a neutral position.[42]

Current literature suggests that indirect laryngoscopy offers little advantage in the average patient but affords high rates of intubation success in patients with difficult airway risk factors, obesity, or failed direct laryngoscopy attempts.[43-47] This advantage does not appear to be uniform; the Airtraq optical laryngoscope, for example, has performed less favorably in difficult airways in the prehospital setting.[48] Videolaryngoscopy can also accelerate training performance with novices and provides a high rate of first-time success in the hands of less experienced intubators.[49-51] Each device has unique technical considerations that operators must be familiar with to maximize their potential benefit.

THE DIFFICULT AIRWAY

The definition of a difficult airway is the presence of clinical factors that complicate ventilation or intubation.[18] The incidence of difficult airways encountered during emergent intubations is reported to be 10%.[2,3]

The best management approach to a difficult airway in the ICU is not well studied. Until the many complex variables present in ICU airway management can be more systematically analyzed, the following suggestions represent the consensus opinion of one group of experts based on available data.[52]

Emergency Airway Management: Extraglottic Airways and Cricothyroidotomy

Prolonged hypoxemia is the primary cause of most serious airway complications. If aggressive initial attempts to restore adequate oxygenation are not successful, early emergency airway management should be accomplished using either an extraglottic airway or cricothyroidotomy.

Extraglottic airways (EGAs, such as the Laryngeal Mask Airway and King tube) can be placed into the upper airway to reestablish adequate oxygenation and ventilation without significant technical expertise in many cases. Intubation through EGAs has proven successful following failed direct laryngoscopy and as a more rapid primary approach in patients with a predicted difficult airway.[53,54] A number of current EGAs also provide the option of one-step intubation through

the device (Ambu Aura-i, CookGas LLC Air-Q/ILA, LMA Fastrach, and Classic Excel, i-Gel).

Surgical cricothyroidotomy is reserved for the emergency airway situation when an extraglottic airway cannot be effectively employed due to upper airway abnormalities, blood, or secretions that obviate proper placement and function. Cricothyroidotomy can be performed most rapidly using a rapid four-step technique.[55] Using a bougie through the neck incision to serve as an ETT guide has been shown to be successful even in the hands of the novice nonsurgeon.[56] A cricothyroidotomy kit that uses a Seldinger approach is also available but has been associated with longer time to placement.[57] Major complications include esophageal perforation, subcutaneous emphysema, and bleeding.

The Role of Advanced Airway Tools in Difficult Airway Management

If initial stabilization and oxygenation is possible, a rapid clinical airway assessment is essential to plan an appropriate and effective management strategy. Cooperative patients with slowly progressive respiratory failure and predicted difficult airways can be considered for awake intubation. More unstable or uncooperative patients can be managed with indirect laryngoscopy, gum elastic bougie, or an extraglottic airway.

Awake intubation provides the opportunity to preserve spontaneous respiration and prolong the available time for intubation attempts. Upright fiberoptic-assisted intubation through a Williams or Ovassapian intubating airway is a common and effective approach. Patients typically require a combination of nebulized or atomized lidocaine directed at the base of tongue and tonsillar pillars. Antisialogues are frequently employed to aid visualization, and low-dose narcotics such as remifentanyl appear to be superior to dexmedetomidine when combined with low-dose midazolam for sedation.[58] Unfortunately, the 20-30 minutes required for appropriate airway preparation can be challenging in critical care practice, limiting broad-based application of this technique.

In the setting of a predicted difficult airway, indirect optical devices and videolaryngoscopes provide better glottic visualization and maximize the opportunity of intubation success. In one large single institution study, a gum elastic bougie was the preferred method to successfully manage patients with incomplete glottic visualization and those for whom glottis intubation is not possible.[2] An intubating extraglottic airway is also an appropriate primary or rescue strategy.

CONCLUSION

Tracheal intubation in the ICU remains a high-risk procedure, and a systematic approach that emphasizes planning, preparation, and teamwork is necessary to maximize its outcome and safety. Although intensivists should maintain facility with direct laryngoscopy, there are growing data supporting the use of indirect laryngoscopy as both a primary and rescue technique in the ICU. In the setting of an emergency airway, an extraglottic airway or surgical airway should be rapidly employed. If oxygenation and ventilation can be reestablished, a wider variety of techniques can be considered. Until better evidence is available, ICU directors must apply these general principles to develop a safe and effective airway management program in their institution.

DISCLAIMER

The views expressed in this review are those of the author and do not reflect the official policy or position of the Department of the Army, Department of Defense, or the U.S. government.

KEY POINTS

1. A systematic approach that emphasizes planning, preparation, and teamwork is the best proven method to reduce risks associated with airway management in the ICU.
2. An extraglottic airway should be employed early in the patient with inadequate oxygenation and ventilation.

References for this chapter can be found at expertconsult.com.

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