Airway Management for Pediatric Emergencies

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The most immediate concern in the management of any pediatric resuscitation or medical emergency is an assessment of the airway and respiratory function with assisted or controlled ventilation as needed. Regardless of the etiology of respiratory failure, further attempts at resuscitation or treatment of the underlying condition will fail if airway control and restoration of ventilation/oxygenation is delayed or ineffective. This is the case regardless of the etiology of respiratory failure: status asthmaticus, status epilepticus, or sepsis. Emergency airway management may be fraught with difficulties as there may be limited time to prepare for the problem, thereby emphasizing the need for prior preparation and appropriate training of all essential personnel.¹

Airway management in the trauma setting is somewhat different from the nontrauma setting. While immediate airway control and assisted ventilation are necessary, protection of the cervical spine is mandatory. It should be assumed that all pediatric trauma patients have a cervical spine injury until proven otherwise. While a thorough physical examination and radiologic investigation are helpful in excluding an injury, in the emergent setting, there may be inadequate time to embark on such investigations. Therefore, the airway is managed with the assumption that there is an injury, and techniques are used to control the airway and intubate the trachea that will not be harmful if an injury is found during the subsequent evaluation. The issues of airway management in the trauma setting, the radiologic evaluation of the cervical spine, and the techniques used to prevent...
cervical spine injury during airway management are reviewed elsewhere. This article reviews the techniques of airway management for medical emergencies in children.

AIRWAY MANAGEMENT

Regardless of the setting, the goals of airway management remain the same: to relieve anatomic obstruction, to prevent the aspiration of gastric contents, and to promote adequate gas exchange. All emergency patients should receive 100% oxygen (delivered by a nonrebreathing system) until the initial assessment of respiratory function is made. Airway management may be as simple as relieving soft-tissue obstruction of the airway by proper positioning of the head. Several factors predispose the pediatric patient to airway obstruction. Airway obstruction most commonly occurs because the tongue or pharyngeal soft tissues collapse into the airway. Alterations in the level of consciousness, related to closed head injury or cardiovascular compromise with inadequate cerebral perfusion, can lead to relaxation of pharyngeal musculature with soft-tissue obstruction of the airway. The proportionately larger head of the child, when compared with the rest of the body, promotes neck flexion. The oral cavity is relatively small, and the tongue is relatively large. All of these factors make upper airway obstruction a likely occurrence in children.

Simple measures to relieve airway obstruction include proper positioning of the head with avoidance of neck flexion, anterior displacement of the mandible (jaw thrust maneuver), or placement of an oral airway. The latter two maneuvers are best avoided in combative or semiconscious patients because they may be poorly tolerated and lead to vomiting. The head tilt is avoided in the trauma setting because of the possibility of aggravating a cervical spine injury.

Decisions regarding endotracheal intubation include the route (oral versus nasal) and awake versus anesthetized. These decisions are based on the assessment of the normalcy of the airway and the ability to successfully perform endotracheal intubation. In most cases, the preferred route for endotracheal intubation is oral. Attempts at nasal intubation can result in bleeding, which can obstruct visualization and make further attempts at endotracheal intubation impossible. Awake nasal intubation can lead to significant increases in intracranial pressure and is contraindicated in patients with closed head injuries. Nasal intubation also is contraindicated in patients with evidence of facial trauma, cerebrospinal fluid leaks, or suggestion of basilar skull fracture (e.g., Battle's sign, raccoon eyes, and hematotympanum). Any of these are suggestive of disruption of the cribiform plate and the usual barrier between the nasopharynx and the intracranial vault.

Prior preparation is an absolute requirement to ensure that endotracheal intubation is accomplished in an expedient manner. The available equipment should include a resuscitation bag and oxygen source (it is important to double-check that the oxygen flow is turned on), appropriate sized masks, laryngoscopes, endotracheal tubes, styles, suction, and drugs. Various sizes and shapes of laryngoscopes are available, but they can be classified as either having straight (Miller) or curved blades (Macintosh). During laryngoscopy, the straight blade is placed on the laryngeal side of the epiglottis while the curved blade is placed on the pharyngeal side of the epiglottis in the vallecula. The author's preferences is to use straight blades for children who weigh ≤ 15 kg and curved blades for older patients. Suggested sizes and types of laryngoscopes are listed in Table 1. The appropriate-sized endotracheal tube is based on the patient's age. A 3-mm or 3.5-mm endotracheal tube should be used in a term neonate while a 4-mm endotracheal tube is appropriate for an infant 2 to 6 months of age. Beyond 6 months of age, the appropriate-sized tube (mm) can be estimated using the rule:

\[
\text{Age (years)} + 16 + 4
\]

Another method of estimating endotracheal tube size is to use an endotracheal tube whose outside diameter approximates that of the patient's little finger. The formulas used to estimate endotracheal tube size are only starting guidelines, the real test is during laryngoscopy and passage of the endotracheal tube through the glottis. Excessive force must be avoided. The endotracheal tube should pass through the cords easily without undue force. Following placement, there should be minimal air leak with inflating pressures of 20 to 30 cmH2O.

While cuffed endotracheal tubes are not recommended for patients younger than 6 to 8 years of age, it should be remembered that it is the pressure from cuff inflation and not the cuff that causes the damage. If a cuffed endotracheal tube is used, a half-size smaller tube should be chosen and the cuff inflated with the least amount of air necessary to prevent an excessive air leak.

The appropriate equipment and drugs should be prepared prior to the patient's arrival. It is frequently best to have a specific dedicated area or room in
which all emergencies are handled. This allows for the collection of all of the appropriate equipment in one area.

An additional issue with emergency patients is that they are at risk for aspiration during intubation. Unlike endotracheal intubation performed for elective surgical cases in the operating room, patients who present with acute medical emergencies frequently do not have an empty stomach. During sedation and paralysis for endotracheal intubation, passive or active regurgitation of stomach contents may occur. Trauma, pain, and anxiety all delay gastric emptying; therefore, regardless of when the patient last ate, he or she is still considered to have a “full stomach.” Therefore, techniques to minimize the risks of regurgitation of stomach contents should be used.\textsuperscript{3,4} The risks of pulmonary damage following acid aspiration are related to both the volume and pH of the fluid. The risks are greatest with volumes >0.4 mL/kg and a pH <2.5. With emergency airway management, there is not adequate time for pharmacologic management of either the volume or the pH of the fluid. The techniques used to prevent acid aspiration include cricoid pressure and rapid neuromuscular blockade/anesthesia (rapid sequence induction and intubation). Attempts at emptying the stomach with an orogastric tube are not recommended since it does not effectively empty the stomach and may induce vomiting.

The goal of a rapid sequence intubation is to secure the airway while protecting the lungs from acid aspiration. Cricoid pressure is a technique that prevents the passive regurgitation of stomach acid. The upper esophagus is compressed against the cervical vertebral column by applying anteroposterior pressure on the cricoid cartilage. The cricoid cartilage is the only complete ring of the trachea and can be used to compress the esophagus without interfering with the ability to pass an endotracheal tube. Cricoid pressure should be maintained from the time consciousness is lost until proper placement of the endotracheal tube is confirmed or until the patient reawakens if intubation is unsuccessful.

The second key to a successful endotracheal intubation is the appropriate use of rapidly acting neuromuscular blocking agents and anesthetic agents. With rapid neuromuscular blockade and anesthesia, the possibility of vomiting at the time of intubation is reduced. Rapid sequence intubation should always be preceded by the administration of 100% oxygen via a tight-fitting face mask. With full desaturation, the typical adult, without pulmonary parenchymal disease or abnormalities of functional residual capacity, can sustain approximately 4 to 5 minutes of apnea without hypoxemia. The period of apnea to the development of hypoxemia may be significantly less in infants and children due to their increased metabolic rate of oxygen and decreased functional residual capacity.

<table>
<thead>
<tr>
<th>TABLE 2</th>
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<tbody>
<tr>
<td><strong>Intubating Drugs and Doses</strong></td>
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<tr>
<td><strong>Drug</strong></td>
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<tr>
<td><strong>Neuromuscular Blocking Agents</strong></td>
</tr>
<tr>
<td>Succinylcholine</td>
</tr>
<tr>
<td>Pancuronium</td>
</tr>
<tr>
<td>Vecuronium</td>
</tr>
<tr>
<td>Rocuronium</td>
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<tr>
<td><strong>Amnestic/Analgesic Agents</strong></td>
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<tr>
<td>Ketamine</td>
</tr>
<tr>
<td>Pentothal</td>
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<tr>
<td>Propofol</td>
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<tr>
<td>Etomidate</td>
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<tr>
<td>Midazolam</td>
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<tr>
<td><strong>Miscellaneous Medications</strong></td>
</tr>
<tr>
<td>Lidocaine</td>
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<tr>
<td>Atropine</td>
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<tr>
<td>Glycopyrrolate</td>
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</table>

The use of a pulse oximeter during endotracheal intubation provides an added margin of safety and alerts the physician performing the intubation when the attempt should be aborted and bag-mask ventilation started. In some children, gentle assisted ventilation with cricoid pressure may be necessary to maintain oxygenation until the onset of full neuromuscular blockade adequate for endotracheal intubation. The latter technique also may be used to provide hyperventilation prior to intubation in patients with altered intracranial compliance who are at risk for increases in intracranial pressure.

The Normal Airway

The use of sedative and neuromuscular blocking agents is contraindicated if the airway is judged to be abnormal. In that setting, other techniques to secure the airway are needed. If the airway is assessed as normal, one can proceed with the use of neuromuscular blocking agents and sedative/analgesic agents for endotracheal intubation (Table 2). However, these medications should never be used if there is any question about the possibility of successful tracheal intubation.

The neuromuscular blocking agent used may be either a depolarizing agent such as succinylcholine or a nondepolarizing agent (eg, pancuronium, vecuronium, or rocuronium). The advantages of succinylcholine include a rapid onset of action (30 to 45 seconds) and a short duration of action (4 to 5 minutes). The latter may be particularly important in patients with head trauma or suspected cervical spine injury so that immediate reassessment of their clinical status is possible. Extensive burns, crush injuries, and various neurologic and neuromuscular diseases remain contraindications to succinylcholine as an exaggerated
TABLE 3

Contraindications to Succinylcholine

- Hyperkalemia
- Muscular dystrophies
- Burns
- Metabolic acidosis
- Paraplegia/quadruplegia
- Dementia injury
- Metastatic rhabdomyosarcoma
- Parkinson’s disease
- Disuse atrophy
- Polyneuropathy
- Degenerative central nervous system diseases
- Purpura fulminans

TABLE 4

Nondepolarizing Muscle Relaxants

**Aminosteroid Compounds**

- Pancuronium
- Vecuronium
- Rocuronium
- Pipecuronium

**Benzylisoquinolinium Compounds**

- Tubocurarine
- Metocurine
- Atracurium
- Mivacurium
- Doxacurium

Hyperkalemic response may be seen (Table 3). Succinylcholine also is contraindicated in patients with open globe injuries since the contraction of the extraocular muscles may lead to expulsion of the intraocular contents and permanent loss of vision. Succinylcholine in patients with increased intracranial pressure is controversial. Although it has been demonstrated to cause a modest increase in intracranial pressure, the rapid onset of neuromuscular blockade allows endotracheal intubation to occur sooner with improvements in oxygenation and ventilation. The latter are the primary determinants of cerebral blood flow and intracranial pressure. In the emergency setting, regardless of the age of the patient, a small dose of an anticholinergic agent such as atropine (5 to 10 μg/kg up to 0.4 mg) is suggested prior to the administration of succinylcholine to prevent bradycardia.

Nondepolarizing muscle relaxants are used in situations or underlying conditions that contraindicate succinylcholine. Several different nondepolarizing agents are available (Table 4). Their primary differences include onset and duration of action, metabolic fate, and cardiovascular effects. Significant histamine release can occur with several of the agents including curare, atracurium, and mivacurium, thereby limiting their use in the emergency setting. Pancuronium (0.15 mg/kg) will provide acceptable conditions for intubation in 90 to 120 seconds with paralysis lasting from 45 to 90 minutes. Mild histamine release and an increment in heart rate related to its vagolytic effects may be seen. Pancuronium is primarily (70% to 80%) dependent on renal excretion with a significantly prolonged effect in patients with renal insufficiency or failure. A more rapid onset of paralysis can be achieved with either vecuronium or rocuronium. As vecuronium is devoid of cardiovascular effects, increased doses can be used to speed the onset of neuromuscular blockade. Doses of 0.3 mg/kg will provide acceptable conditions for endotracheal intubation in 60 to 90 seconds with a duration of blockade of 60 to 90 minutes. Priming also may be used to speed the onset of vecuronium. For this, 0.01 mg/kg is administered followed in 2 to 3 minutes by the remainder of the intubating dose of 0.15 mg/kg. In the emergency setting, a priming dose generally is not recommended because it may induce significant amounts of neuromuscular blockade. It is also generally recommended that the intubating dose be given 2 to 3 minutes after the priming dose. This delay may not be practical during emergency airway management. Due to these problems, this practice is not recommended for emergent airway management.

The problem of the delayed onset with nondepolarizing muscle relaxants has been alleviated somewhat with the introduction of rocuronium. Acceptable intubating conditions are achieved within 60 seconds in the majority of patients, making it the most rapidly acting of the nondepolarizing neuromuscular blocking agents. Like vecuronium, it is relatively devoid of cardiovascular effects. The duration of action following an intubating dose of 0.6 to 1.2 mg/kg is 30 to 60 minutes.

The second decision pertains to the drugs used to provide amnesia/analgesia during rapid sequence induction (Table 2). The drugs chosen are based on two factors: the patient’s hemodynamic status and the presence or absence of increased intracranial pressure (Table 5). In the hemodynamically stable patient (with or without a closed head injury), standard induction doses of thiopental (4 to 6 mg/kg) or propofol (2 to 3 mg/kg) can be used. In addition to providing anesthesia for endotracheal intubation, both agents also will provide central nervous system protection. Both propofol and thiopental decrease the cerebral metabolic rate for oxygen, leading to reflex cerebral vasoconstriction and a lowering of intracranial pressure. The administration of lidocaine (1.5 mg/kg) 1 to 2 minutes prior to endotracheal intubation also can be used to blunt the rise in intracranial pressure during laryngoscopy.

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In the hemodynamically unstable patient without closed head injury, etomidate (0.2 to 0.3 mg/kg) or a small dose of ketamine (0.5 to 1 mg/kg) may be used to provide amnesia/analgesia. Neither agent will significantly affect cardiovascular function. Although ketamine has direct negative inotropic properties, it causes a release of endogenous catecholamine that generally overshadows its direct effects on myocardial contractility, resulting in an increase in heart rate and mean arterial pressure. Ketamine increases intracranial pressure and therefore is contraindicated in patients with significant closed head injury. Ketamine is the drug of choice for endotracheal intubation of patients with increased airway reactivity. The release of endogenous catecholamines may be beneficial in patients with bronchospastic disorders. In the hemodynamically unstable patient with a closed head injury, etomidate can be used to provide amnesia and lower intracranial pressure without deleterious effects on cardiac output and systemic vascular resistance. Etomidate, like propofol and thiopental, decreases intracranial pressure.

Once endotracheal intubation is accomplished, correct tube placement can be confirmed by one of several means, including direct visualization of the tube passing through the vocal cords, auscultation, mist in the tube, the presence of carbon dioxide in the exhaled gases, fiberoptic documentation of tracheal rings, or subsequent chest radiograph. Capnography or documentation of end-tidal CO₂ (ETCO₂) serves as a useful adjunct to endotracheal tube placement and should be considered routine in any setting in which endotracheal intubation occurs. Once correct endotracheal tube placement is identified, the tube is taped securely in position, bilateral breath sounds are auscultated again (after taping the endotracheal tube), and a chest radiograph is obtained. Once the endotracheal tube is secured, the stomach is decompressed with an orogastric or nasogastric tube.

**Failed Endotracheal Intubation**

If the trachea cannot be intubated after paralysis and sedative agents have been given, an immediate decision must be made as to how to handle the failed intubation. A second attempt at intubation may be tried after changing the patient's head position, the laryngoscope blade, or adding pressure on the larynx to help visualize the glottis. If these maneuvers fail, 100% oxygen should be administered through a tight-fitting face mask and assisted ventilation initiated. Cricoid pressure should be maintained until the patient awakens. At this point, the alternatives to be considered should follow the algorithm provided by the American Society of Anesthesiologists (ASA) for failed intubation (Figure). If bag-mask ventilation is successful, there is time to consider alternative routes of securing the airway such as fiberoptic intubation, performance of a tracheostomy using local anesthesia, or retrograde intubation techniques. Such techniques should be performed only by physicians skilled in pediatric airway management. If the trachea cannot be intubated, but bag-mask ventilation is adequate, the most prudent maneuver is to allow the effects of the neuromuscular blocking/sedative agents to dissipate and for the patient to resume spontaneous ventilation. It should be remembered that dyspnea is better than asphyxia.

If bag-mask ventilation cannot be accomplished, one must move quickly along the ASA algorithm to prevent the central nervous system sequelae of hypoxemia. One of two options should be considered at this point: needle cricothyrotomy or placement of a laryngeal-mask airway. Needle cricothyrotomy is accom-

<table>
<thead>
<tr>
<th>ICP Status</th>
<th>CV Status</th>
<th>Agent</th>
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<tbody>
<tr>
<td>Normal</td>
<td>Normal</td>
<td>Pentothal; propofol</td>
</tr>
<tr>
<td>Normal</td>
<td>Abnormal</td>
<td>Ketamine</td>
</tr>
<tr>
<td>Increased</td>
<td>Normal</td>
<td>Pentothal; propofol</td>
</tr>
<tr>
<td>Increased</td>
<td>Abnormal</td>
<td>Etomidate</td>
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</tbody>
</table>

Abbreviations: ICP = intracranial pressure and CV = cardiovascular function.
TABLE 6

<table>
<thead>
<tr>
<th>Mask Size</th>
<th>Patient Weight (kg)</th>
<th>Internal Diameter (mm)</th>
<th>Cuff Vol (mL)</th>
</tr>
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<tbody>
<tr>
<td>1</td>
<td>&lt;6.5</td>
<td>5.25</td>
<td>2 to 5</td>
</tr>
<tr>
<td>2</td>
<td>6.5 to 20</td>
<td>7.0</td>
<td>7 to 10</td>
</tr>
<tr>
<td>2.5</td>
<td>20 to 30</td>
<td>8.4</td>
<td>14</td>
</tr>
<tr>
<td>3</td>
<td>30 to 70</td>
<td>10.0</td>
<td>15 to 20</td>
</tr>
<tr>
<td>4</td>
<td>70 to 90</td>
<td>10.0</td>
<td>25 to 30</td>
</tr>
<tr>
<td>5</td>
<td>&gt;90</td>
<td>11.5</td>
<td>30 to 40</td>
</tr>
</tbody>
</table>

plished by inserting a 14- or 16-ga intravenous catheter through the cricothyroid membrane into the trachea. The catheter is advanced through the skin into the trachea with a syringe that is filled with air or air and saline. Constant pressure is maintained on the plunger as the syringe is advanced; air bubbles will be seen in the saline when the trachea is entered. The plastic catheter then is advanced into the trachea. An alternative means includes the use of a syringe and needle as previously described, but with the passage of a guidewire into the trachea followed by a dilator and a catheter. The latter may ensure that the catheter is not advanced off the needle into a false tract. Jet ventilation through a catheter that is not in the trachea is disastrous as subcutaneous emphysema and distortion of the anatomy may preclude further airway maneuvers. The importance of ensuring that the catheter is in the trachea prior to instituting jet ventilation cannot be overemphasized. Identification of the trachea and correct catheter placement may be difficult in younger patients. Misplacement of the catheter can result in death. A more recently described technique for ensuring the intratracheal location of the catheter includes the attachment of an ETCO$_2$ detector to the syringe or needle. As the trachea is entered, CO$_2$ will be detected.

Once the catheter is placed in the trachea, oxygenation is maintained by intermittent jets from a high-pressure system. An oxygen line and toggle valve originating at a 50 psi oxygen source can be attached directly to the intravenous catheter. If this is not readily available, the small end of the 15-mm adapter from a 3-mm endotracheal tube will fit into the end of the intravenous catheter. Alternatively, the small end of a 7-mm endotracheal tube can be inserted into the barrel of a 3-mL syringe and the Luer lock end attached to the catheter. The 15-mm adapter allows connection to the oxygen supply such as a standard resuscitation bag. Any of the above mentioned techniques can be used to provide oxygenation. Their efficacy in providing ventilation and CO$_2$ removal is limited.

A recent addition to airway management is the laryngeal-mask airway. The laryngeal-mask airway is available in six sizes to accommodate all patients from infancy through adults (Table 6). The author recently has reviewed the use of the laryngeal-mask airway in the emergency department. The laryngeal-mask airway is designed to sit in the hypopharynx directly over the glottis. It is passed without direct visualization into the oropharynx until resistance is felt. Placement can be accomplished with the neck in a neutral position, making it suitable for use in the trauma patient. Following placement, the cuff is inflated and the 15-mm adapter is connected to an Ambu bag or the anesthesia circuit and either spontaneous or positive pressure ventilation is possible. While the laryngeal-mask airway will have limited use in the emergency setting, it may have a role in the "cannot intubate/cannot ventilate" scenario prior to proceeding to transtracheal jet ventilation (Figure). The laryngeal-mask airway also can be used as a guide for endotracheal intubation.

The Abnormal Airway

Occasionally, the airway of an emergency patient is such due to an underlying condition (ie, Pierre-Robin sequence) to suggest that endotracheal intubation may be difficult. Other clues noted on physical examination that suggest direct laryngoscopy and endotracheal intubation may be difficult are listed in Table 7. In these situations, alternatives to standard rapid sequence intubation with muscle paralysis/anaesthesia are required to ensure patient safety. An attempt at blind nasal intubation may be indicated in patients without facial trauma, signs of basilar skull fracture, and normal intracranial pressure.

Awake intubations are generally difficult in younger patients due to the their age, level of understanding, and ability to cooperate. In older patients, awake endotracheal intubation may be attempted. Awake intubation (of any route) is contraindicated in patients with increased intracranial pressure, penetrating neck wounds, and open globe injuries.

In the cooperative patient with a suspected difficult airway, there is generally nothing to lose by attempting a careful awake intubation. Awake intubation may be made easier by the combination of small doses of intravenous sedation (midazolam 0.03

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TABLE 7

Physical Features Suggestive of Difficult Intubation

<table>
<thead>
<tr>
<th>Feature</th>
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<tbody>
<tr>
<td>Short neck</td>
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<tr>
<td>Limited neck mobility</td>
</tr>
<tr>
<td>Limited mouth opening</td>
</tr>
<tr>
<td>Micrognathia</td>
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<tr>
<td>Large tongue</td>
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<tr>
<td>Small mouth</td>
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to 0.5 mg/kg) and topical anesthesia of the airway with a local anesthetic solution. This may be accomplished by aerosolizing a local anesthetic, topical application of local anesthetic to the mucosa of the oropharynx, or the direct blockade of the innervation of the airway. The latter techniques of direct blockade of airway innervation should be attempted only by those trained in these techniques. A review of such techniques is provided elsewhere. Consultation with a pediatric anesthesiology or other subspecialist trained in difficult airway management is suggested when confronted with such patients.

The structures of the oropharynx can be anesthetized quickly by topical spray (4% lidocaine or benzocaine). A second option is the use of a nebulizer (same as that used for nebulizing beta agonists) for the administration of 3 to 5 mL of 2% or 4% lidocaine depending on the size of the patient. The total dose of lidocaine should not exceed 5 to 7 mg/kg (0.25 to 0.35 mL/kg of a 2% solution). Either of the two choices will provide adequate anesthesia of the airway above the level of the vocal cords. More distal anesthesia may be obtained with the aerosolized administration of lidocaine; however, this is not necessary to blunt the response to laryngoscopy.

Following the achievement of topical anesthesia of the airway, several options exist for airway management. The first is direct laryngoscopy with oral endotracheal intubation. Despite the anticipation of difficult oral endotracheal intubation, this technique is frequently successful. The technique can be performed safely in patients with documented or suspected cervical spine injuries. Meschino et al. noted no exacerbation of neurologic injury in their series of 165 trauma patients who underwent awake, oral endotracheal intubation.

In addition to direct laryngoscopy with oral endotracheal intubation, other options exist for oral endotracheal intubation in the awake patient including the Bullard laryngoscope, the light wand, fiberoptic-guided endotracheal intubation, and wire-guided retrograde intubation. The majority of experience with any of these techniques has been in the adult population, and their use in the awake state, as with awake oral endotracheal intubation, requires an alert, cooperative patient. The Bullard laryngoscope (Circon ACMi, Stanford, Connecticut) is an anatomically shaped laryngoscope that uses fiberoptic technology to view the larynx. As such, direct visualization is not required, and the need for lining up the oropharynx and larynx is eliminated. The blade is in the shape of a curved L. Once the blade has been rotated around the base of the tongue, force is applied superiorly (in a plane perpendicular to the axis of the patient) to visualize the larynx. While visualization of the larynx is usually excellent, passage of the endotracheal tube into the glottis may be difficult. The current design has an intubating stylet that is incorporated into the laryngoscope and lies along the right posterolateral aspect of the blade in an attempt to correctly align the endotracheal tube and the airway. The Bullard laryngoscope can be used in the awake patient or following the induction of general anesthesia and provision of neuromuscular blockade. As there is limited movement of the cervical spine with both placement and subsequent use, it has been recommended as a useful tool for managing the airway in patients with suspected or confirmed cervical spine injury.

The light wand is a malleable illuminating stylet that can be used for blind oral intubation. The illuminating stylet can be inserted into an endotracheal tube ≥5 mm. As such, the technique is limited to patients who are at least 5 to 6 years of age. The distal end of the stylet and endotracheal tube are bent 90° to facilitate entry into the trachea. The preparation of the patient for awake oral intubation using the light wand is the same as for other awake techniques and can include topical anesthesia or direct nerve blockade. The patient is instructed to protrude the tongue, and the stylet with the endotracheal tube is inserted blindly into the oropharynx. As the device passes around the posterior aspect of the tongue and into the larynx, the light can be visualized in the anterior aspect of the neck at the level of the thyroid cartilage. Observation of the light may be facilitated by turning down the room lights. The light can be followed into the suprasternal notch if entry into the trachea occurs, while the light disappears if the tube passes into the esophagus. Once the endotracheal tube enters the trachea, the usual procedure is followed to confirm correct positioning. Successful use of the technique has been described in patients with normal and abnormal airways, in children, and in the trauma setting. Because neck movement is not required for successful placement, it can be used in patients with cervical spine injuries and also has been suggested as a back-up or alternative means of intubating the trachea when direct laryngoscopy fails.

Recent advances in technology have significantly improved the quality of fiberoptic devices as well as decreasing their size, making them suitable adjuncts to airway management in children. Fiberoptic-guided
endotracheal intubation may be used via the oral or nasal route to aid in endotracheal intubation of the difficult airway. However, certain problems exist surrounding their use in the pediatric trauma center. Most importantly, significant practice and experience may be required to become facile with these techniques, especially in smaller children. Once learned, ongoing practice is required to maintain the skills. Blood or secretions in the airway can significantly interfere with airway visualization. In addition, fiberoptic techniques can be time consuming or impossible in the uncooperative patient.

**RESPIRATORY FUNCTION**

Following successful endotracheal intubation, confirmation of correct endotracheal tube placement is mandatory and should begin with the auscultation of bilateral breath sounds. No method of confirming the intratracheal location of an endotracheal tube is 100% sensitive except for the direct observation of tracheal rings when a bronchoscope is passed through the endotracheal tube. The availability of ETCO₂ is suggested whenever airway management is performed as an additional means of confirming correct endotracheal tube placement. The ETCO₂ monitor also may be useful during transport as an additional monitor to identify inadvertent endotracheal extubation should it occur and to ensure that the desired arterial CO₂ range is maintained. The latter may be particularly important if hyperventilation is instituted as a means of controlling ICP.

Once endotracheal intubation is performed and confirmed, one's attention should focus on providing oxygenation and ventilation. Initial tidal volumes of 10 to 15 mL/kg are suggested with respiratory rates adjusted according to the patient's age and the desired arterial CO₂. The initial F₁O₂ should be 1. Moderate periods of time even up to 10 to 12 hours of high F₁O₂ will not be detrimental to pulmonary function. An F₁O₂ of 1 generally is continued during the initial stabilization and transport of the patient. An adequate oxygen supply must be ensured prior to starting transport. An extra tank should be brought along if the transport time will be prolonged.

If poor ventilation and abnormal pulmonary compliance is noted, an immediate evaluation is necessary. The first step should be auscultation of breath sounds to rule out mainstem intubation. This is more likely to be a problem in younger patients. A suction catheter should be passed through the endotracheal tube to ensure that the endotracheal tube is not kinked or that secretions/blood have not blocked the tube. A chest radiograph is indicated to rule out a pneumothorax. If a pneumothorax is suspected, either because of lack of movement of the chest wall or absence of breath sounds, needle aspiration should be carried out followed by thoracostomy tube placement. There may not be time to obtain a chest film if the child's ventilatory or cardiovascular function is deteriorating. Even with adequate airway management and effective ventilation, there may still be hypoxia and arterial desaturation due to pathologic right-to-left shunting through damaged pulmonary tissue, acid aspiration, pneumonia, or lung contusion. Although these latter problems will require subsequent evaluation and treatment, the initial approach is the same: secure the airway and maintain adequate ventilation with 100% oxygen.

**SUMMARY**

Several factors increase the difficulty and urgency of airway management in children in the emergency setting. Early and appropriate airway management are of prime importance in improving the outcome of such patients. The major decision points of airway management include one's assessment of the airway and ability to perform endotracheal intubation. If the airway is judged to be normal, oral endotracheal intubation following sedation and neuromuscular blockade is suggested. Rapid sequence intubation to prevent acid aspiration should be used. While the medications for airway management generally are administered intravenously, it should be kept in mind that intranasal access is an acceptable alternative for the administration of several different agents, including those used for endotracheal intubation.

If the airway cannot be secured following the administration of anesthetic and neuromuscular blocking agents, the ASA algorithm for the "cannot intubate/cannot ventilate" scenario should be followed (Figure). When the airway is judged to be abnormal, one of the above described awake techniques may be used. While there is ample literature concerning these techniques in adults, their use in children has been limited. Most importantly, considerable practice may be required to become and stay facile with many of these "alternative techniques" of airway management. In certain circumstances, surgical cricothyrotomy should be considered as an alternative to airway management.

Regardless of the technique chosen, appropriate personnel and preparation are mandatory to ensure the safe and effective management of the airway in the pediatric trauma patient. Due to the various skills and expertise of different subspecialists, a multidisciplinary approach to such patients is recommended. Such an approach may include pediatricians, emergency room physicians, surgical subspecialists, anesthesiologists, and critical care physicians.
REFERENCES


