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# Emergency Airway Management in Infants and Children

The agitated, semiconscious infant or toddler with a compromised airway is a challenging, anxiety-provoking clinical problem. The ability to emergently manage a child's airway is one of the most important life-saving skills an emergency physician can possess. This lecturer will teach the latest methods of rapid sequence intubation, the correct drug dosages and tube dimensions for children at various stages of development, and other useful airway tips.

- Identify the appropriate management of pediatric patients with airway problems.
- Describe the issues and risks associated with pediatric rapid sequence intubation techniques.
- Identify the indications for and use of mechanical ventilation for children in the emergency department.

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**FACULTY**

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## *Emergency Airway Management in Infants and Children*

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**COURSE DESCRIPTION:**
The agitated, semiconscious infant or toddler with a compromised airway is a challenging, anxiety-provoking clinical problem. The ability to emergently manage a child's airway is one of the most important life-saving skills an emergency physician can possess. This lecturer will teach the latest methods of rapid sequence intubation, the correct drug dosages and tube dimensions for children for various stages of development, and other useful airway tips.

**OBJECTIVES:**
1. Identify the appropriate management of pediatric patients with airway problems.
2. Describe the issues and risks associated with pediatric rapid sequence intubation techniques.
3. Identify the indications for and use of mechanical ventilation for children in the emergency department.

**CASE SCENARIOS:**
1. 8 month-old-male BIB paramedics after aspirating "food at picnic": paramedics performing BVM on arrival in ED. Patient with agonal respirations, pulse rate 140, unconscious...
   *What are your management priorities?*
   *What method can be used to remove the foreign body and/or secure the airway?*
   *What additional methods could be used?*

2. 4 year-old-male is silent while running with a "superball" in his mouth. Paramedics find the child in respiratory arrest but with a pulse.
   *Which airway management options are available to the field provider?*
   *What method would be chosen to maintain the airway once the child is brought to the ED?*

3. 5 year-old-male status post auto versus pedestrian accident. Child was struck by fast moving automobile and thrown 50 feet. Child is unconscious, diaphoretic and pale at the scene - GCS= 8; HR=150; BP=70 mm Hg. You are working in the ED.
   *What are your management priorities?*
   *What medication choices would you make in performing RSI for this patient?*

4. 16 month old female is BIB paramedics after suffering a seizure; temperature is >39.9°C; respiratory rate is 12 and shallow.
*What are your management priorities?*
*What method would be chosen to maintain the airway?*
*What additional methods could be used?*

5. 9 month-old-male with rapid breathing and stridor. History of fever yesterday and today. No obvious drooling, but child poorly interactive and sitting in a tripod position.
*What are your management priorities?*
*When is it appropriate to call for consultants?*
*What additional methods to secure the airway could be used?*

***PEDIATRIC AIRWAY MANAGEMENT***
**ANATOMICAL CONSIDERATIONS:**

- Neonate is < 1 month of age; an infant is defined as < 1 year of age; and a child is > 1 year of age.
- **Pediatric airway differences in anatomy -**
  - relatively larger tongue which can obstruct the airway
    - most common cause of airway obstruction in children
    - may necessitate better head positioning or use of airway adjunct (oropharyngeal (OP) or nasopharyngeal (NP) airway)
  - larger mass of adenoidal tissues may make nasotracheal intubation more difficult
    - NP airways may also be more difficult to pass in infants < 1 year of age
  - epiglottis is floppy and more U-shaped
    - necessitates use of a straight blade in children up to 8 years of age
  - larynx more cephalad and anterior
    - more difficult to visualize the cords; may need to get lower than the patient and look up at 45°angle or greater while intubating
  - cricoid ring is the narrowest portion of the airway
    - allows for use of uncuffed tubes in children up to size 6.0 mm or about 8 years of age
  - narrow tracheal diameter and distance between the rings, making tracheostomy more difficult
    - American Heart Association recommends a needle cricothyrotomy for the difficult airway versus a surgical cricothyrotomy for the same reason
  - shorter tracheal length (4-5 cm in newborn an 7-8 cm in 18 month old)
    - leading to intubation of right mainstem or dislodgement of the ET tube
  - large airways more narrow
    - leads to greater airway resistance ($R \propto 1/radius^4$)

**OUT-OF-HOSPITAL:**

- Scope of practice of out-of-hospital providers varies from one EMS system to another.
- Level of providers available:
  First Responders: < 40 hours of training; no defined pediatric curricula; mouth to mask ventilation
  EMT-Basic: 110 hours of training; Department of Transportation has defined pediatric objectives; placement of oral (OP) and nasopharyngeal (NP) airways and bag-valve mask ventilation (BVM); option for endotracheal intubation (editorial comment - I feel this should NOT be an option)
  EMT-Intermediate: wide variation in training between systems; includes basic and advanced pediatric airway management; BVM and endotracheal intubation (ETI), use of pediatric Magill forceps to remove foreign bodies
  EMT-Paramedic: 1000 hours + of training; includes basic and advanced pediatric airway management; varies widely between EMS systems → BVM, ETI, cricothyrotomy, use of neuromuscular blockers (succinylcholine)
  - ➢ Study from Seattle, Washington addressed use of succinylcholine in out-of-hospital setting; retrospective, so unable to determine success rates - complication rate 22.6% (aspiration 15.6%; pneumothorax 3.3%, esophageal intubation 1.9%; mainstem bronchus intubation 12.6%; oral trauma 0.7%)

- Researchers at Harbor UCLA Medical Center and the Los Angeles and Orange Counties, California EMS agencies have completed a large, prospective randomized study of the effect of out-of-hospital pediatric intubation on patient outcome.
  - 830 patients were enrolled in a study where patients were randomized (even/odd calendar days) to receive either BVM or BVM followed by ETI
  - Results indicate no difference in outcome of pediatric patients treated with BVM versus ETI; potential for mortal complications with ETI are high
  - No benefit of endotracheal intubation in any subgroup
  - Results reported at Society for Academic Emergency Medicine Conference may, 1998 (manuscript in press)

**EMERGENCY DEPARTMENT:**
**Indications for Airway Management:**

- Respiratory failure or impending respiratory failure
  - Rates < 12-20 or > 60 plus nonpurposeful or unresponsive to painful stimuli
- Cardiopulmonary failure
- Shock - to decrease work of breathing
- Neurologic resuscitation: modified GCS ≤ 9 absolute indication; would consider it in any patient with GCS < 12 and declining mental status; remember with hyperventilation keep $PCO_2$ about 30 mm Hg; do not over hyperventilate - "more is not better"
  - In children, the cerebral vasculature is very responsive to changes in $PCO_2$, if the patient is hyperventilated too much, the cerebral vessels may constrict to such a degree as to cause focal areas of ischemia and decreases cerebral blood flow which ultimately can lead to cell death
- Protection of the airway

**Bag-valve-mask Ventilation (BVM):**

- Correct mask size is key: measure from the bridge of the nose to the cleft of the chin
- “C”-grip with index and thumb over mask to keep mask pressure; avoid the eyes (vagal stimulus); 3rd finger on angle of jaw in infants and 3rd, 4th and 5th on angle of jaw in children - fingers from an “E”.
  - Can remember placement of the hand for BVM as EC-clamp (avoid pushing on submental area - can cause airway obstruction)
- Bag size ≥ 450 cc for any infant or child < 5 years of age; after this time use 750 cc or adult bag
- Ventilation rate no greater than 30/min in infants; no greater than 20/min in children
- Say "squeeze, release release" to keep bagging rates down; **Squeeze** bag until chest rise is just initiated then begin release the bag as you say **release, release**; this will help to decrease gastric insufflation
- Complications: gastric insufflation, vomiting, aspiration, hypoxemia

**Endotracheal intubation (ETI):**

- Correct tube size needs to be determined:
  - Newborn 3.0 mm or if large newborn 3.5 mm tube
  - Up to 6 months of age 3.5-4.0 mm tube (note should measure child with the length-based resuscitation tape - measure from top of head to infant or child's heel)
  - At one year of age approximately 4.0-4.5 mm tube
  - Greater than 1 year of age - can calculate tube size:
    1. based on age: (16 + age (years))/4
    2. measurement/length-based resuscitation tape

4. width of the child's little finger nail or size of nostril

- Depth of tube placement in cm can be calculated as 3 X size of tube: (example: 3.5 mm tube would be placed at 10.5 cm at the lip)
  - Depth can also be determined by use of a length-based resuscitation tape or by use of an illuminated endotracheal tube

- Blade size: Utilize length-based resuscitation tape
  - Miller 0 (Premature newborn and newborn)
  - Miller 1 (Newborn to about 2-3 years)
  - Miller 2 (> 3 years)

- Confirmation: Clinical assessment: listen 2 breaths over the stomach (air meeting water (fluid) causes bubbling which implies the tube is in the esophagus) **NOTE: you will probably hear breath sounds in the stomach, this is probably normal do not pull the tube but complete your assessment**; listen for 2 breaths on the right 3rd ICS midaxillary line and compare to 2 breaths on the left 3rd ICS midaxillary line; next utilize an end tidal $CO_2$ monitor or colorimetric device ($CO_2$ detector); obtain a chest radiograph which can help with depth and placement but need to confirm clinically first.
  - Esophageal intubation detectors (syringe and bulb models) have been used to confirm placement - approved in children $\geq$ 20 kg bodyweight or $\geq$5 years

- Complications: esophageal intubation, right mainstem intubation, dislodgement, obstruction, barotrauma, incorrect tube size with inadequate ventilation, trauma to the airway and subglottic stenosis (late)
  - Dislodgement and esophageal intubation can be minimized by use of a colorimetric $CO_2$ detector or end tidal $CO_2$ monitor

- Nasal tracheal intubation may be problematic:
  - Must be done on a spontaneously breathing patient
  - Noxious and may result in more movement of the patient which could exacerbate a cervical spine injury; this was shown in a cadaver model
  - More difficult a procedure in children because of the small nares and large adenoids which may be lacerated and bleed; also risk of worsening a basilar skull fracture or insertion into the cranium

- Endotracheal drug delivery: Drugs that can be given endotracheally include (<u>LEAN</u>: lidocaine, epinephrine, atropine and narcan)
  - **Example:** 10 kg infant in cardiopulmonary arrest dose of epinephrine (0.1 mg/kg or 0.1 ml/kg); use 1:1,000 concentration to minimize volume; in this patient give 1 mg or 1 ml of 1:1,000 epinephrine add 1-2 ml of saline and squirt down endotracheal tube; then ventilate
  - A total volume of at least 2cc must be in the ETT to overcome surface tension of

the tube.

**Rapid Sequence Induction:**

- Goals: facilitate endotracheal intubation(ETI); reduce adverse effects (intracranial pressure (ICP), complications of intubation); control airway in combative patients
- Indications and clinical settings:
  - ➢ Facilitate intubation in patient difficult to intubate without paralysis
  - ➢ Head trauma patient in need of hyperventilation
    - blunt effects of intubation on ICP
  - ➢ Paralyze patient for special procedures (CT head, endoscopy, angiography, MRI)
  - ➢ Facilitate ventilation in combative patient or patient with severe bronchospasm

- Contraindications:
  - ➢ Abnormal airway anatomy (ie; major facial trauma)
  - ➢ Upper airway obstruction
  - ➢ Ruptured globe of the eye/history of paralysis/hyperkalemia (succinylcholine only)
  - ➢ Laryngeal fracture

Preparation: S-O-A-P-ME:

- ➢ Suction (assume patient has a full stomach)
- ➢ Oxygen
- ➢ Airway equipment:
  - Oral and nasal airways
  - BVM devices and masks
  - Endotracheal tubes and stylets
    - ➢ endotracheal tubes - two sizes available; appropriate size based on length or other calculation and ½ size smaller
  - Laryngoscope handles and blades
  - Magill forceps
  - Surgical airway equipment
  - Tracheostomy tubes
- ➢ Pharmacology:
  - Atropine
  - Lidocaine
  - Sedatives
  - Neuromuscular blocking agents
- ➢ Monitoring Equipment:
  - Cardiorespiratory monitor/pulse oximeter
  - End-tidal $CO_2$ detector or monitor

Other:

- ➢ Surgical airway available and physician who can perform it
- ➢ Individualize protocol to your patient

- Always have contingency plan in case unsuccessful with first attempt
- Consider head and neck surgeon and anesthesia standby in difficult cases

- Premedication:

  *Atropine* (0.02 mg/kg IV; 0.1 mg minimum dose; max single dose 0.5 mg for child; 1.0 mg for adolescent): to affect the bradycardia which is caused by vagal stimulus of ETI; used in infants < 1 year of age and in children < 5 years of age who receive succinylcholine

  *Lidocaine* (1.5 mg/kg IV): attenuate adrenergic response to laryngoscopy; decrease rise in ICP and intraocular pressure

- *Defasciculating dose of neuromuscular blocker:* Use in children > 5 years of age (controversial); I personally don't use a defasciulating dose in children – it is time consuming with very little added benefit

| | |
|---|---|
| Pancuronium | 0.01 mg/kg |
| Vecuronium | 0.01 mg/kg |
| Succinylcholine | 0.1 mg/kg |

- *Sedation*: choice is based on clinical state of patient and effects of medication

  *Thiopental*: (2-5 mg/kg IV) short acting barbiturate; ↓ ICP; may cause hypotension; respiratory depression; do not use in patients with asthma - use in patients with increased ICP (head trauma, meningitis)

  *Methohexital*: (1-1.5 mg/kg IV) short acting barbiturate; definitely causes respiratory depression; may cause seizures in high doses

  *Fentanyl*: (2-4 mcg/kg IV) potent narcotic; causes ↑ ICP, seizures, respiratory depression and chest wall rigidity; histamine release, reversible with naloxone (0.1 mg/kg); possible uses are normotensive trauma patient

  *Diazepam*: (0.1 -0.2 mg/kg IV) long acting; respiratory depression; do not use in patients with glaucoma

  *Lorazepam*: (0.1 – 0.2 mg/kg) antiepileptic; long acting; use in patients with status epilepticus

  *Midazolam:* (0.05 - 0.1 mg/kg IV) short acting and causes respiratory depression; does not increase ICP; antiepileptic; reversible with flumazenil; use in patients with status epilepticus

  *Propofol*: (1-2.0 mg/kg IV) may cause hypotension; can use as a drip

*Etomidate*: (0.2 - 0.4 mg/kg IV) short acting nonbarbiturate; ↓ ICP; may ↓ cortisol synthesis with one dose; may be drug of choice in hypotensive trauma patient

*Ketamine*: (1-2 mg/kg IV); dissociative anesthetic; ↑ bronchodilation/preferred in asthmatics; ↓ cerebral blood flow/ contraindicated in patients with head trauma; also causes ↑ secretions (atropine 0.01 mg/kg or glycopyrrolate 0.005 mg/kg) – (NOTE: I don't give atropine or glycopyrrolate routinely); and emergence reactions (↑ with increasing age)

- Neuromuscular Blocking Agents:
  - Depolarizing Agent:
    - *Succinylcholine*: (2 mg/kg IV, IM or IO); effects seen 15-30 sec; duration of action 3-5 minutes; ↑ muscle fasciculation resulting in ↑ICP, intraocular pressure and K+; also causes bradycardia and ↑ secretions which is treated with atropine (0.02 mg/kg); all these effects markedly increased with 2nd dose → switch to other agent if 2nd dose is needed; rare complication is malignant hyperthermia (treat with aggressive cooling and dantrolene 1 mg/kg q 1-5 min based on symptoms)

  - Nondepolarizing Agents:
    - *Pancuronium*: (0.1-0.2 mg/kg); effects seen in 2-3 min; duration of blockade 45-90 min; causes ↑HR, BP

    - *Vecuronium*: (0.1-0.2 mg/kg); effects seen in 30-90 sec; ? causes myopathy in children on steroids; duration of blockade 25-60 min

    - *Rocuronium*: (0.6-1.2 mg/kg); effects in 30-60 sec; duration of blockade 25-60 min; cause increase in heart rate (may be current nondepolizer of choice)

    - *Atacurium*: (0.5 mg/kg); effects seen in 2-4 min; duration of blockade 25-40 min; associated with histamine release - flushing and hypotension

    - *Mivacurium*: (0.15-0.3 mg/kg); effects seen in 30-60 secs; duration of blockade 12-30 min; causes flushing and hypotension in some patients

- Reversal agents: only for nondepolarizing blockers; not complete
  *Edrophonium* (0.5-1.0 mg/kg) + atropine 0.02 mg/kg
  *Neostigmine* (0.04 mg/kg) + atropine 0.02 mg/kg

- **RSI algorithm for pediatric patients receiving succinylcholine:** will be dependent on the clinical state of the child; use agents that you are familiar with and are appropriate for the clinical setting

**Preoxygenate, prepare intubation equipment including suction**
**Place ECG monitor and pulse oximeter**
↓
**Premedicate**
↓

- **Lidocaine 1.5 mg/kg IV slow push for patients with increased ICP -give 2-5 min prior to intubation)**

- **Atropine (0.02 mg/kg IVP) for patients < 5 years of age - give 1-2 min prior to intubation)**

↓
**IV sedation**
↓
**Succinylcholine 2mg/kg IVP**
↓
**Apply cricoid pressure**
**Perform endotracheal intubation and confirm placement**
↓
**Continued sedation**
**Vecuronium or pancuronium (0.1 mg/kg) for continued paralysis**

- **Ventilator Management:**
  Ventilator settings are adjusted based on patients clinical status and results of pulse oximetry, end tidal $CO_2$ and blood gas measurements

  - Pressure-cycled ventilators:
    - used to deliver an indefinite volume of gas at a fixed pressure
    - used in children with uncuffed tubes (<6.0mm)
    - settings should be as follows and adjusted to achieve (1) adequate chest rise and (2) exhaled volume approximately 10-12 cc/kg
    - Peek inspiratory pressure (PIP) -20 cm water
    - Inspiratory time (I:E=1:2)
    - Peek end expiratory pressure (PEEP) 2-4 cm water
    - Rate normal for age
    - $FIO_2$ 100%; may decrease quickly using pulse oximetry and/or ABG as a guide

- Volume-cycled ventilators:
  - deliver a fixed volume of gas at a fixed maximum pressure
  - used in children >20 kg or those with cuffed tubes
  - note in some institutions all children who are intubated get cuffed tubes; therefore use weight > 20 kg or >5.5 mm tube as a guide)
  - settings are as follows and adjusted as needed
  - Rate normal for age (16-20)
  - $FIO_2$ 100%; may decrease quickly using pulse oximetry and/or ABG as a guide
  - Tidal volume 10-12 cc/kg
  - Inspiratory time (I:E=1:2)
  - Peek end expiratory pressure (PEEP) 2-4 cm water

**Laryngeal mask:**

- The laryngeal mask (LMA)- a device which consists of a large bore tube with a distal inflatable molded mask that is placed above the laryngeal inlet to direct gases into the lungs
  - Introduced in 1983 by Brain AIJ: *Br J Anaesthes*
  - Success on insertion rates (67-92%);
  - LMA has been used for neonatal resuscitation; possible limitations of its use: leaks with positive pressure ventilation; no route for suctioning or for delivering medications
  - Other complications include laryngospasm (1.6%); hypoxemia $PO_2$ < 90% on insertion
- Used in the operating room by anesthesiologists; unclear role for use in the ED

- Procedure:
  1. Place patient in sniffing position
  2. Organize equipment for the procedure and have a back-up method, such as BVM ventilation and/or endotracheal intubation available.
  3. Determine the size of the laryngeal mask based on the following chart.

| **Size of LMA** | **Weight (kg)** | **Cuff volume (ml)** | **I.D. of endotracheal tube** |
|---|---|---|---|
| *1* | *<6.5* | *4* | 3.5 mm |
| *2* | *6.5-20* | *10* | 4.5 mm |
| *2.5* | *20-30* | *15* | 5.0 mm |
| 3 | 30-60 | 20 | 6.0 mm |
| 4 | 70-80 | 30 | 6.5 mm |
| 5 | >80 | 40 | 7.5 mm |

4. Deflate cuff of LMA while compressing the diaphragm portion against a flat surface
5. Lubricate the LMA with a water-soluble lubricant.
6. Insert the LMA into the mouth and flatten the diaphragm portion against the hard palate.
   - Note that failure to press the diaphragm portion of the LMA against the hard palate can cause the end to fold back on itself and prevent further insertion. If so, remove and begin again.
   - The curved portion of the LMA should be pointing toward the patient and away from health care provider.
7. Continue to press the LMA against the hard palate, past the tongue pushing downward with an index finger and stop when resistance is felt.
8. Inflate the cuff until the LMA protrudes slightly.
9. Attach bag-valve-mask device and begin ventilation look for chest rise.
10. A soft gauze bite block can be used to protect the LMA from the patient's teeth.
11. Tape the LMA in place similar to an endotracheal tube. Twice around the tube and then secure on the maxilla.
    - Note that a black line is located on the posterior surface of the LMA to aid in confirming correct positioning; the line if noted to be anterior or on the side means that the LMA has twisted into an incorrect position.

**Advanced Alternatives:**

- Flexible fiber optic scopes or lighted stylets; to guide nasal tracheal intubation and placement of surgical airways: need high level of skill and training; also often not available to the ED physician
  - Use of flexible bronchoscope or laryngoscope to assist in intubation can be done in larger children and by one with experience; takes time to get orientation in the airway which may be too long for critically ill or injured patient

- Retrograde intubation: percutaneous wire through cricothyroid membrane up into the oropharynx; tube slipped over the wire; when the tube is felt to be through the larynx and into the trachea, the lower wire is cut and the wire removed from the tube above; technically difficult because of the small size of the cricothyroid membrane in infants and children but possible

- Surgical airways:
  - Tracheostomy: recommended only in controlled circumstances, which is difficult in the ED, may be needed in cases of airway obstruction at the larynx or cricothyroid membrane; higher complication rates in children; complications include: incorrect tube placement; pneumothorax; pneumomediastinum; subglottic stenosis; carotid artery injury; subcutaneous emphysema; persistent tracheocutaneous fistula

  - Cricothyrotomy: used generally when ETI(+/-) RSI are not successful; complications rates are high (10-40%); age limit is unclear, probably could be performed on children > 8-10 years of age
    - Needle cricothyrotomy is recommended in younger children if a surgical airway is needed; the procedure is as follows:

      (1) identify cricothyroid membrane

      (2) cricothyroid membrane is located and air aspirated through a small needle (20 gauge); then a larger needle 12-14 gauge is used to puncture the membrane with the needle directed caudally at a 45° angle; once air is aspirated the catheter is left in place and the needle removed; a modification of this technique involves a wire inserted into the trachea followed by a dilator and then a 3.0 mm endotracheal tube threaded over the wire

      (3) ventilation by this technique is limited but the patient can be oxygenated; a 3.0 mm adaptor can be placed on the end of the catheter and a BVM device attached; this may not be as good as an actual jet ventilator device as described by Yamamoto.

**NOTES:**

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