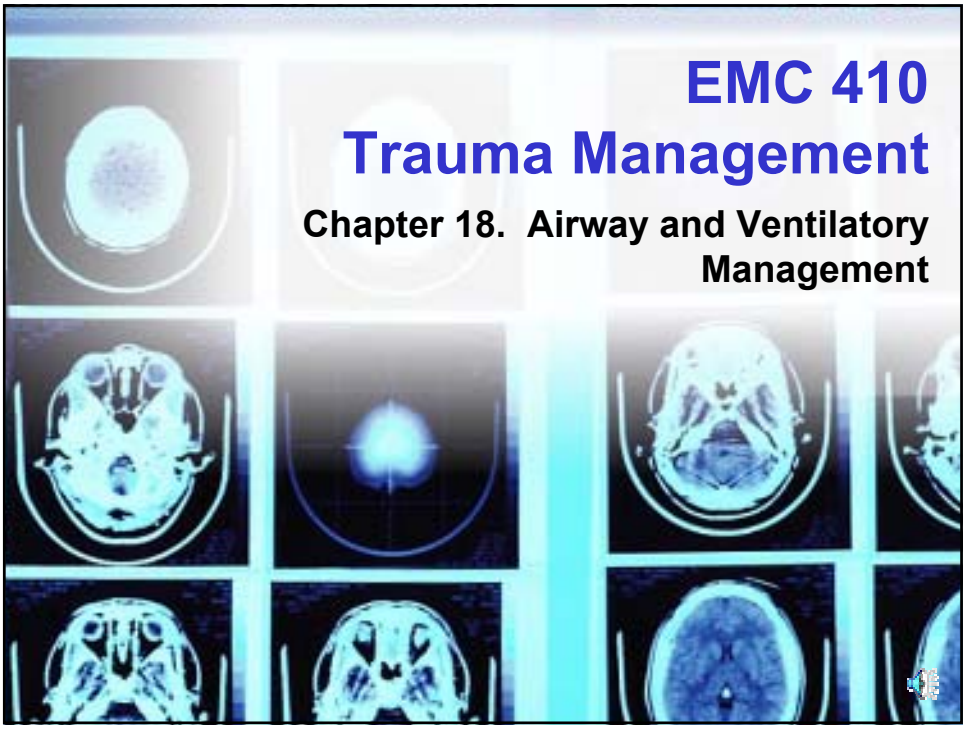


EMC 410
Trauma Management

Chapter 18. Airway and Ventilatory Management

Unit Objectives

- **Upon completion of this chapter, you should be able to:**
  - Describe the anatomy and physiology of the respiratory system.
  - Describe the 5 major types of airway and respiratory pathologies.
  - Discuss methods for maintaining airway patency in the patient with cervical spine injuries.
  - Explain the basic interventions in airway and ventilatory management.
  - Describe the advanced methods of airway control and list the indications, advantages, and disadvantages for each.
  - Discuss the indications, contraindications, and procedures for surgical airway control.
  - Explain the indications, contraindications, and procedures for rapid sequence intubation.

Unit Objectives continued

- Describe in detail the dosage, mechanisms of action, and side effects of the neuromuscular blocking agents most commonly employed in the prehospital setting.
- Discuss the setup and operation of chest drainage systems.
- List and describe the ventilator modes most commonly used in the management of trauma patients.
- Determine the initial settings for mechanical ventilation.
- Describe the techniques used to assess patient response to mechanical ventilation.
- Explain the physiological responses to intubation and mechanical ventilation.
- Explain the procedure for obtaining arterial blood gas samples.
- Discuss the interpretation of arterial blood gas values.
- Discuss the interpretation of end-tidal carbon dioxide monitoring.

Anatomy Review

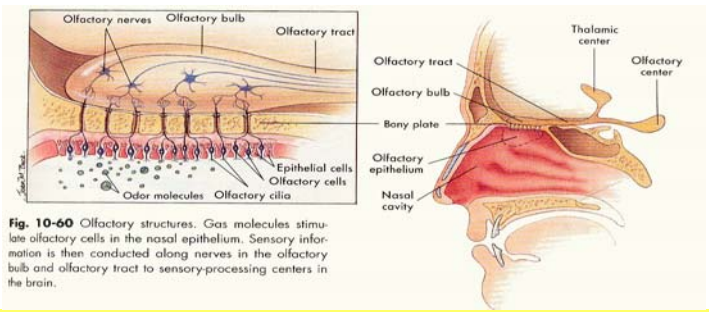
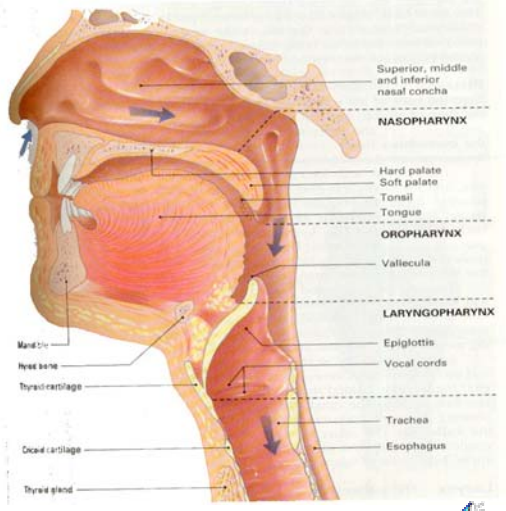


Fig. 10-60 Olfactory structures. Gas molecules stimulate olfactory cells in the nasal epithelium. Sensory information is then conducted along nerves in the olfactory bulb and olfactory tract to sensory-processing centers in the brain.

- **Nose**
  - Receives blood supply from internal and external carotids.
  - Sensation via trigeminal nerve (CN V).
  - Olfactory reception via olfactory nerve (CN I).
  - Functions as a conduit, humidifier, heat exchanger, voice resonator, and filter.
  - These functions are bypassed in the intubated patient in which cool, dry, unfiltered air is delivered to the lower respiratory system.

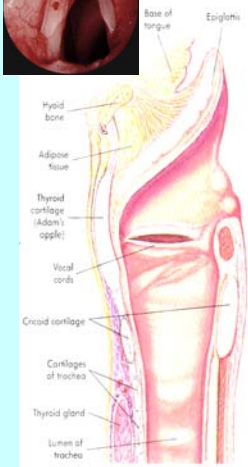
Anatomy Review continued

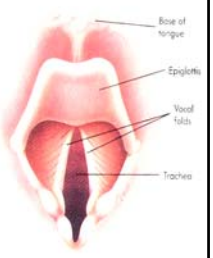
- **Mouth**
  - Tongue innervated by hypoglossal nerve (CN XII)
  - Airway obstruction may result when CN XII is impaired



Anatomy Review continued

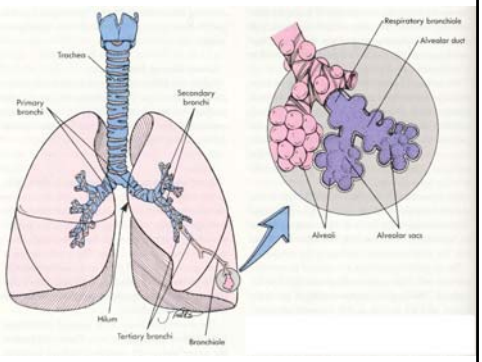
- **Larynx**
  - Forms boundary between upper and lower airway
  - Forms an open, partially closed, and closed valve
  - Extends from the tip of the epiglottis to the lower border of the cricoid cartilage
  - Corresponds with the C-3 to C-5 level of spinal column
  - Provides internal (epiglottis) and external (cricoid) landmarks
  - Cricoid cartilage is the only continuous cartilaginous ring
    - Sellick's maneuver used to enhance visualization and prevent aspiration
  - Laryngospasm





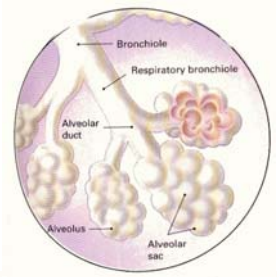
Anatomy Review continued

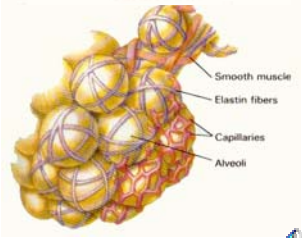
- **Trachea**
  - 9 to 16 mm in diameter and 10 to 15 cm from cricoid to carina
  - Formed by 16 to 22 C-shaped cartilaginous rings
  - Carina lies at sternomanubrial joint anteriorly and T-5 posteriorly
  - Right bronchus less angulated (25°) than left (45°)
  - A properly positioned ET tube rests at 18 to 22 cm at the incisors
  - Add 4 cm for nasotracheal tube (22 to 26 cm)



Anatomy Review continued

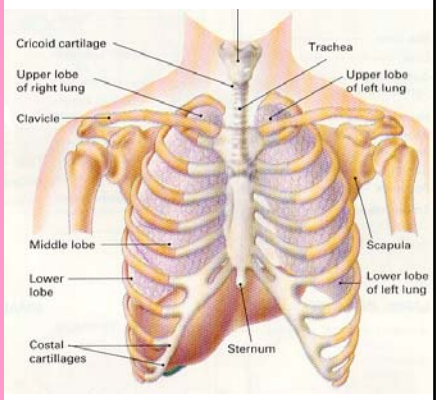
- **Bronchi**
  - Become smaller and increasingly muscular as they divide
  - Although the size of the airways become progressively smaller, the total area available for gas exchange increases





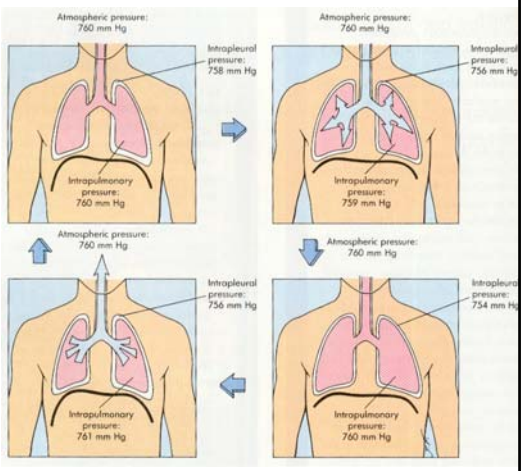
Anatomy Review continued

- **Lungs**
  - Extend from the diaphragm to just above the clavicles
  - Lie against the ribs both anteriorly and posteriorly
  - Primary bronchi and pulmonary vessels form the root
  - Contain 300 million alveoli with a surface area of 70 square meters
  - Parietal pleura lines the entire thoracic cavity, adhering to the internal surface of the ribs and the superior surface of the diaphragms
  - Pleural fluid creates cohesion between visceral and parietal pleura



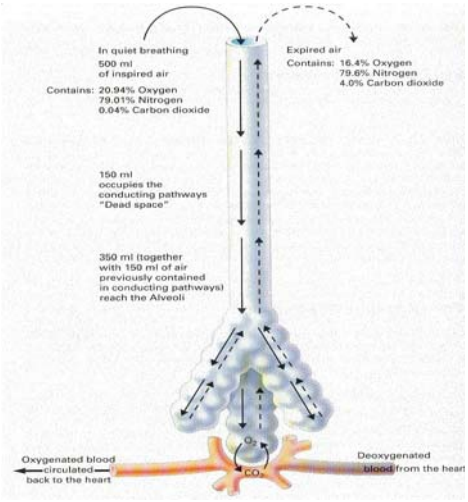
Physiology of Respiration

- **Consists of ventilation, pulmonary and cellular respiration**
  - **Ventilation**
    - Movement of diaphragm and intercostal muscles decreases intrathoracic pressure to 1 mm Hg below atmospheric pressure
    - Elasticity of chest wall, lungs and diaphragm permits passive exhalation
    - Minute ventilation = 12 (RR) x 500 ml (TV) = 6 liters per minute



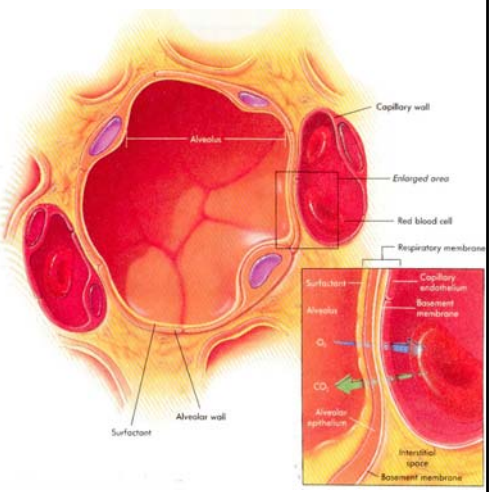
Physiology of Respiration continued

- **Consists of ventilation, pulmonary and cellular respiration continued**
  - **Ventilation continued**
    - First airways hold 150 ml that do not participate in gas exchange (anatomic dead space)
    - Anatomic dead space + pathologic dead space = physiologic dead space; Normally physiologic dead space = anatomic dead space
    - Pathologies pneumothorax, hemothorax, flail chest, obstruction



Physiology of Respiration continued

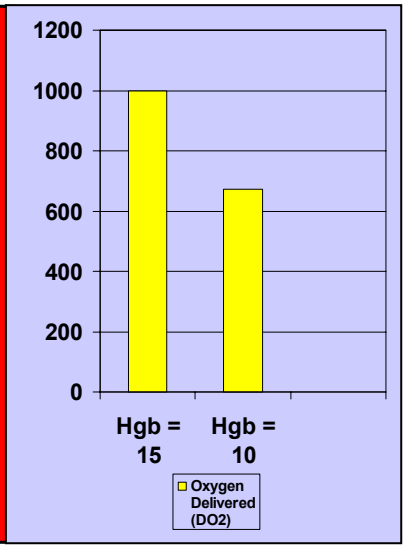
- **Pulmonary respiration**
  - **Gas exchange**
    - Oxygen and carbon dioxide diffuse across A-C membrane
    - Once across A-C membrane, oxygen is dissolved in plasma
    - Normal PaO_2 declines 3 - 4 mm Hg per decade after 2nd or 3rd decade
    - Each fully saturated gm hgb carries 1.34 ml O_2
    - Each mm hg of PaO_2 represents only 0.0031 ml of dissolved oxygen in blood
    - CaO_2 = [hgb x 1.34 x (SaO_2/100)] + (PaO_2 x 0.003)
    - Must have an adequate hemoglobin, SpO_2, and PaO_2



Physiology of Respiration continued

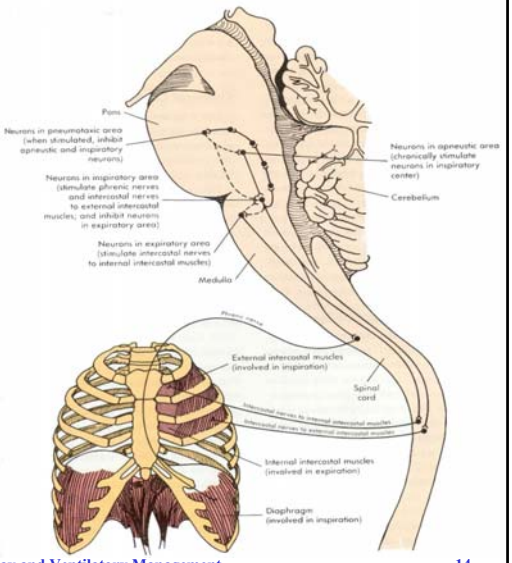
- **Pulmonary respiration continued**
  - **Gas exchange continued**
    - To prevent hypoxia, must deliver oxygen to the tissues
    - $DO_2 = (10 \times CaO_2) \times CO$
    - Example: hgb = 15 g/dl, PaO_2 = 100 mm hg, CO = 5 lpm, SpO_2 = 98%

      $DO_2 = [(10 \times 15 \times 1.34 \times 0.98) + (100 \times 0.003)] \times 5 = 1000$ ml/min
    - If hgb drops to 10 g/dl, DO_2 decreases to 672 ml/min
    - If any other of the parameters drops, so does DO_2
    - Emphasizes importance of ABCs



Physiology of Respiration continued

- **Regulation of respirations**
  - Inspiratory center and expiratory center (usually passive)
  - Baroreceptors (Hering-Breuer reflex)
  - Chemoreceptors
    - Medulla sensitive to carbon dioxide
    - Carotid and aortic bodies sensitive to pH and oxygen



Measuring Respiratory Function

- **History and Physical Exam**
- **Arterial Blood Gases**
  - $PaCO_2$ reflects ventilatory status
  - PaO_2 reflects oxygenation status
  - Limitations of ABGs
    - Snapshot
    - Measure serum partial pressures
    - CO and cyanide impair oxygen use
    - Temperature, pH, and $PaCO_2$ impair oxygen release

Measuring Respiratory Function

- **Alveolar-arterial oxygen gradient**
  - $P(A\text{-}a)O_2 = PAO_2 - PaO_2$
- **Alveolar oxygen tension**
  - $PAO_2 = (Pb - PH_2O) \times FiO_2 - (PaCO_2/R)$
- **Calculations**
  - PaO_2 from ABG
  - Pb = 760 mm Hg at sea level
  - PH_2O = 47 mm Hg
  - R = 0.8 (may be eliminated when $FiO_2 > 0.6$)
  - FiO_2 = fraction of inspired oxygen

Measuring Respiratory Function

- **Interpretation**
  - Normal P(A-a)O_2 is < 4 mm Hg for every 10 years of age on room air. On 100% oxygen, every 50 mm Hg difference approximates 2% shunt

Results of Respiratory Function Calculations	Pathology	Corrective Actions
↓ PaO2, ↑P(A-a)O2	Diffusion defect, V/Q mismatch, or shunt	Improve oxygenation, correct mismatch or shunt
↓ PaO2, ↑PaCO2, normal P(A-a)O2	Hypoventilation	Improve ventilation

Airway and Respiratory Pathologies

- **Airway obstruction**
  - Tongue
  - Foreign body
  - Trauma (blunt, penetrating, Le Forte fractures)
  - Laryngeal spasm and edema

Airway and Respiratory Pathologies

- **CNS dysfunction**
  - Head and spinal cord injury
    - Impaired respiratory drive
    - Obstruction
    - Paralysis of respiratory muscles
  - Toxins

Airway and Respiratory Pathologies continued

- **Mechanical dysfunction**
  - Pneumothorax
  - Tension pneumothorax
  - Diaphragmatic rupture
  - Hemothorax
  - Rib fractures
  - Flail segments
  - Chest wall compression

Airway and Respiratory Pathologies continued

- **Aspiration**
  - Occurs in up to 50 percent of emergency intubations
  - Pregnancy, hiatal hernia, obesity, NG tubes, paralytic agents, and BVM ventilation all predispose patients to aspiration
  - Results in chemical pneumonitis, obstruction by food, infection
  - Mortality related to volume, distribution and pH of aspirate
  - 0.4 ml/kg of aspirate is clinically significant (≈30 ml in adult)
  - pH 2.5 = 40% mortality, nearly 100% mortality with pH of 1.8
  - Prevention is key (Sellick maneuver, proper BVM, limit intubation attempts)
  - If aspiration occurs, immediately intubate and perform endotracheal suctioning

Airway and Respiratory Pathologies continued

- **Toxic inhalation**
  - Airway edema
  - Laryngospasm
  - Pulmonary edema
  - Disruption of A-C membranes
  - Interference with oxygen absorption/release

Airway and Respiratory Pathologies continued

- **Ventilation-perfusion (V/Q) mismatch**
  - Ventilation
    - Hemothorax, pulmonary edema, near-drowning, flail segment, hypoventilation
  - Perfusion
    - Shock or injuries to the pulmonary vasculature

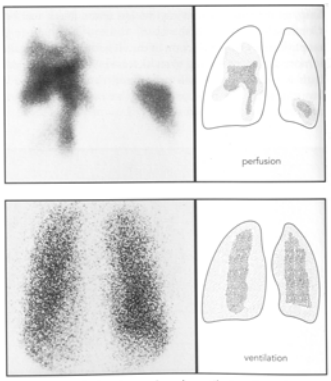


Fig. 5.18 Perfusion (upper) and ventilation (lower) scans in pulmonary emboli. Note the multiple perfusion defects but the normal ventilation pattern.

Airway Management

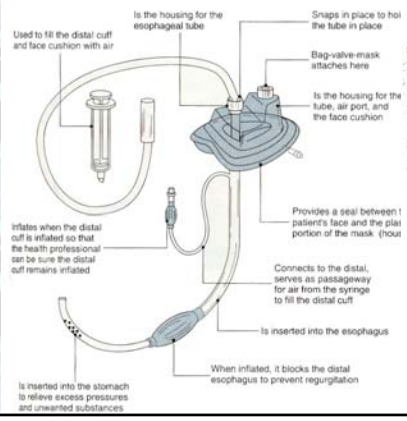
- **Cervical spine injury and airway management**
  - Estimated incidence of 1% to 21% in blunt trauma and MVC
  - Field clearing criteria rarely apply to patients who require intubation
  - Chin lift and TJT are standard of care, despite increasing disc space by 5 mm in surgically created C5-C6 lesion in cadaver model
  - Only 2 mm posterior subluxation noted in cadaver model during BNI
  - Orotracheal intubation acceptable with manual stabilization
  - Spinal movement during cricothyrotomy has not been investigated

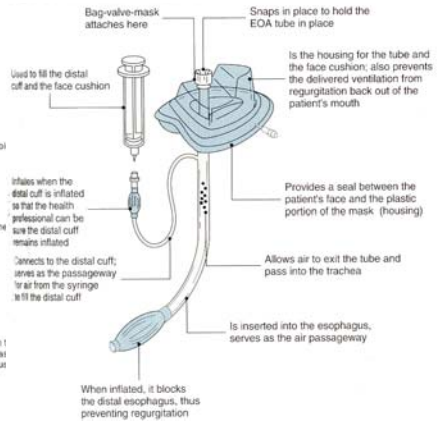
Airway Management continued

- **Basic airway management**
  - Trauma jaw thrust (TJT)
  - Trauma chin lift (TCL)
- **Basic adjuncts**
  - Oropharyngeal airway (OPA)
  - Nasopharyngeal airway (NPA)
- **BVM**

Airway Management continued

- **Advanced airway adjuncts**
  - EOA/EGTA





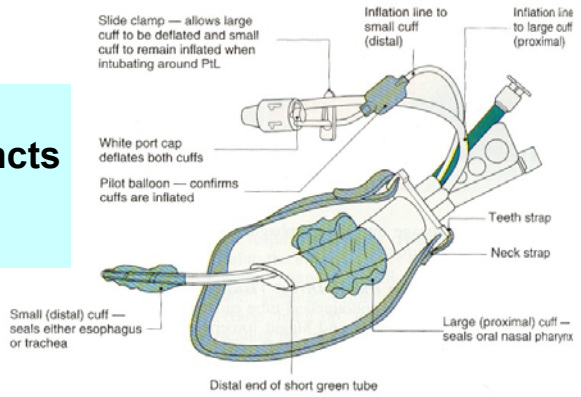
Airway Management continued

Advanced airway adjuncts
EOA/EGTA continued

Indications	Advantages	Disadvantages	Contraindications
1. Failure of other techniques of airway control 2. Inability to visualize anatomical landmarks due to blood or vomitus 3. Inability to visualize landmarks due to traumatic disruption	1. Blind procedure 2. Requires less technical skill than ETI 3. Requires less time to perform than ETI 4. Does not require manipulation of the head for insertion 5. Provides access for gastric decompression (EGTA only) 6. Once inserted, serves as an esophageal marker for ETI	1. Less effective means of ventilation compared to ETI 2. Requires proper seal between face and mask 3. Does not protect lungs from aspirating blood and foreign bodies from upper airway 4. Esophageal injury and perforation 5. Restrictions on patient size	1. Less than 16 years of age 2. Greater than 7 feet in height 3. Less than 5 feet in height 4. Esophageal injury 5. Preexisting esophageal disease 6. Ingestion of caustic substances 7. Presence of a gag reflex 8. Massive facial trauma that would preclude adequate interface between face and mask

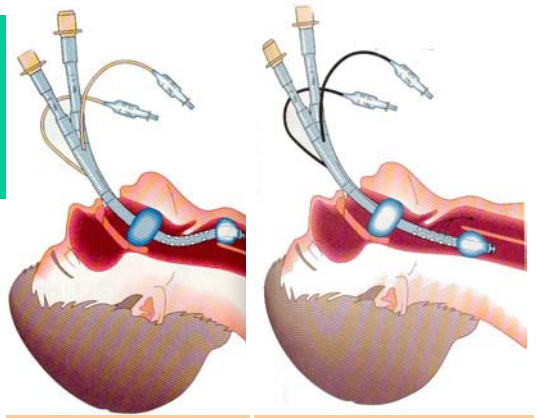
Airway Management continued

- **Advanced airway adjuncts continued**
  - PTLA



Airway Management continued

- **Advanced airway adjuncts continued**
  - Combitube



Tracheal Position | Esophageal Position

Airway Management continued

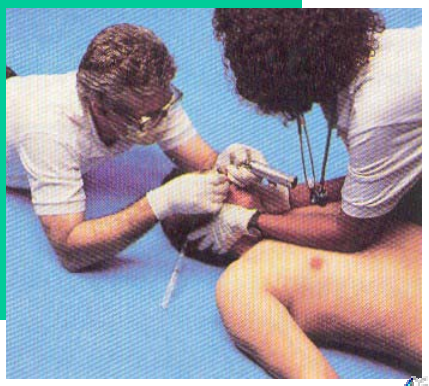
Advanced airway adjuncts continued

Combitube and PTLA

Indications	Advantages	Disadvantages	Contraindications
1. Same as EOA/EGTA	1. Blind procedure 2. Requires less skill to perform than ETI 3. Requires less time to perform than ETI 4. Does not require manipulation of the head for insertion 5. Provides access for gastric suctioning 6. Functional airway regardless of whether it is placed in the trachea or the esophagus 7. Possibility of spontaneous respirations through unused lumen incase of undiagnosed misplacement (Combitube only) 8. Less likely to produce esophageal rupture than EOA/EGTA 9. Improved ventilation over EOA/EGTA 10. Does not require a face mask.	1. Inadequate seal of pharyngeal balloon has been reported with PTLA 2. Difficult to pass endotracheal tube around these devices 3. Esophageal rupture possible 4. Lethal complications with misdiagnosed placement 5. Infrapharyngeal bleeding may be obscured by balloon and go undetected	1. Less than 14 years of age 2. Esophageal injury 3. Preexisting esophageal disease 4. Ingestion of caustic substances 5. Presence of gag reflex

Airway Management continued

- **Advanced airway adjuncts continued**
  - Orotracheal intubation

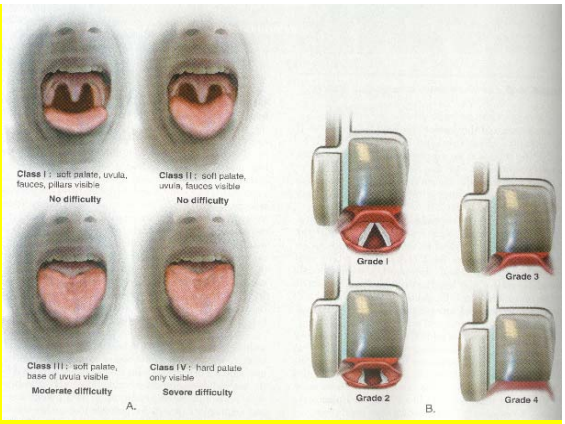


Airway Management continued

- **Advanced airway adjuncts continued**
  - Seated Orotracheal intubation

Airway Management continued

- **Advanced airway adjuncts continued**
  - Orotracheal intubation continued
    - Evaluating Difficulty of Intubation



Mallampati Classification **Grades of Difficulty**

Airway Management continued

- **Advanced airway adjuncts continued**
  - Orotracheal intubation continued
    - Endotrol

Airway Management continued

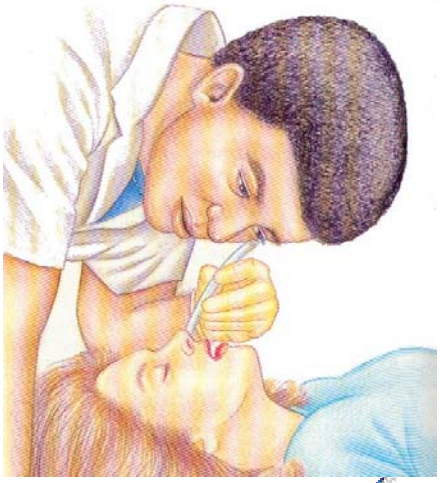
Advanced airway adjuncts continued

Orotracheal intubation

Indications	Advantages	Disadvantages	Contraindications
1. First choice of airway control when basic maneuvers fail 2. Unable to ventilate with BVM 3. Loss of pharyngeal (gag) reflex 4. Head injury with GCS o≤ 8 5. Prevention of aspiration 6. Correct hypoxia and hypercarbia 7. Obstructed airway 8. Pulmonary toilet in near-drowning and toxic inhalations	1. Most familiar technique among paramedics 2. Rapidly performed 3. Can be performed in a variety of patient positions 4. High success rate 5. Requires minimal equipment	1. Produces some movement of cervical spine 2. Visualization more difficult due to need for neutral alignment 3. Requires 2 clinicians 4. Requires laryngoscopy 5. Potential for trauma to teeth and oropharynx 6. Increased ICP 7. Vagal stimulation and bradycardia 8. Laryngospasm	1. Predicted difficult orotracheal intubation (Mallampati III/IV) 2. Major maxillofacial trauma 3. Inability to control cervical spine during procedure 4. Laryngeal trauma (relative contraindication)

Airway Management continued

- **Advanced airway adjuncts continued**
  - Nasotracheal intubation
    - Blind



Airway Management continued

- **Advanced airway adjuncts continued**
  - Nasotracheal intubation continued
    - Stylet

A 

B 

C 

D 

E 

F 

G 

H 

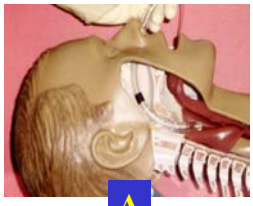
Airway Management continued

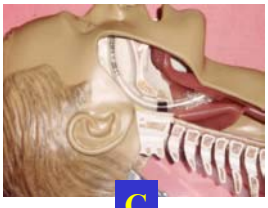
- **Advanced airway adjuncts continued**
  - Nasotracheal intubation continued
    - Stylet

Movie Clip Coming soon to a Power Point Near you!!

Airway Management continued

- **Advanced airway adjuncts continued**
  - Nasotracheal intubation continued
    - Inflated cuff technique





Airway Management continued

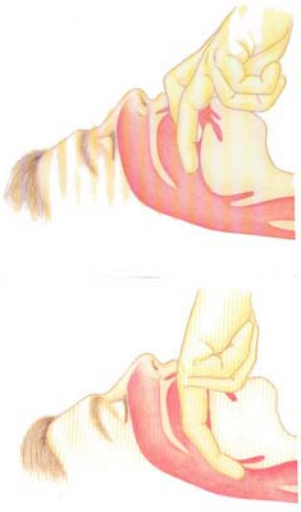
Advanced airway adjuncts continued

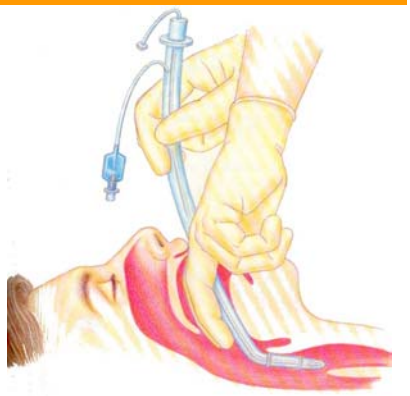
Nasotracheal intubation

Indications	Advantages	Disadvantages	Contraindications
1. Inaccessible oral cavity (trismus, seizures, wired jaws, trauma) 2. Sniffing position contraindicated 3. Difficult direct laryngoscopy 4. Need for long-term ventilation 5. Paralytics contraindicated 6. Patients in awkward positions 7. Conscious or semiconscious patients requiring intubation (e.g., burns, overdose)	1. Patient unable to bite tube 2. Better tolerated in conscious patient 3. Requires minimal equipment 4. Does not require laryngoscopy 5. No cervical spine manipulation 6. Reduced oropharyngeal secretions	1. Prone to nasopharyngeal trauma and epistaxis 2. Necrosis of nares 3. Potential for retropharyngeal perforation 4. Potential for esophageal intubation due to blind procedure	1. Apnea (relative) 2. Severe maxillofacial trauma (relative) 3. Obstruction of the nasopharynx 4. Upper airway foreign body

Airway Management continued

- **Advanced airway adjuncts continued**
  - Digital intubation





Airway Management continued

Advanced airway adjuncts continued

Digital intubation

Indications	Advantages	Disadvantages	Contraindications
1. Comatose patients with head and neck trauma 2. Obese or short-necked patients 3. As a back-up procedure during rapid sequence intubation (RSI) 4. Facial trauma where anatomical disruption prevents visualization 5. When suctioning is unable to adequately remove blood or vomitus 6. When other methods have failed	1. Does not require laryngoscopy 2. Minimal manipulation of C-spine 3. Can be performed under less than ideal circumstances such as poor lighting, cramped space, and awkward position	1. Blind procedure requires diligence in confirming correct placement 2. Risk of trauma to intubator's hand	1. Patients with small mouths 2. Intubators with oversized or undersized hands 3. Patients with intact gag reflexes

Airway Management continued

- **Advanced airway adjuncts continued**
  - Transillumination intubation

Airway Management continued

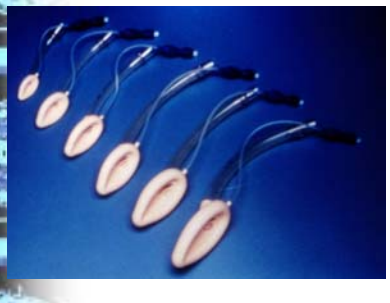
Advanced airway adjuncts continued

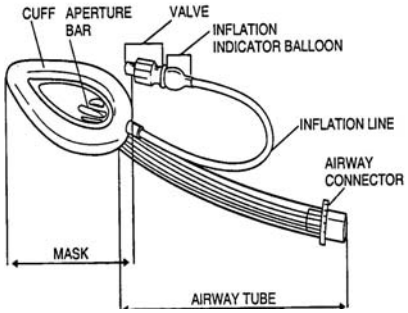
Transillumination intubation

Indications	Advantages	Disadvantages	Contraindications
1. Suspected cervical spine injury 2. Facial trauma 3. Difficult direct laryngoscopy 4. Patients in awkward positions 5. Patients immobilized on spine boards 6. Confirmation of tube placement in intubated patients	1. Rapidly performed 2. Can be performed in a variety of positions 3. High success rate 4. No manipulation of cervical spine 5. Does not require laryngoscopy	1. Difficult to visualize glow from stylet in environments with high intensity ambient light 2. Potential for esophageal intubation due to blind technique	1. Similar to oral intubation

Airway Management continued

- **Advanced airway adjuncts continued**
  - LMA





Airway Management continued

- **Advanced airway adjuncts continued**
  - LMA

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Airway Management continued

Advanced airway adjuncts continued

Laryngeal Mask Airway

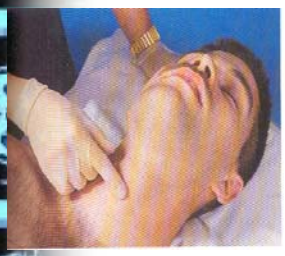
Indications	Advantages	Disadvantages	Contraindications
1. Inability to intubate using standard techniques	1. Requires minimal training	1. Does not protect against aspiration or regurgitation	1. Gross obesity
2. Suspected C-spine injury	2. Ease of insertion	2. Potential for malpositioning	2. Inability to open the mouth wider than 1.5 cm
	3. Rapidly inserted (< 15 seconds)		3. Pregnancy
	4. Blind insertion technique avoids the need for special equipment		4. Recent ingestion of opiates
	5. Endotracheal intubation can be achieved through the LMA		5. Decreased pulmonary compliance
	6. Manipulation of the head and neck is not necessary		6. Subglottic obstruction
	7. Less negative cardiovascular response as compared with ETI		
	8. Less soft tissue trauma as compared with ETI		
	9. No danger of inadvertent passage of LMA into a mainstem bronchus		
	10. Can be inserted with the patient in a variety of positions		

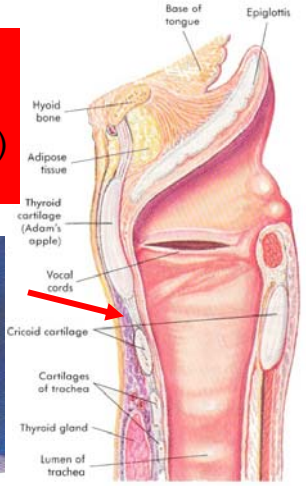
Airway Management continued

- **Surgical airways**
  - Translaryngeal jet insufflation (TJI)

Airway Management continued

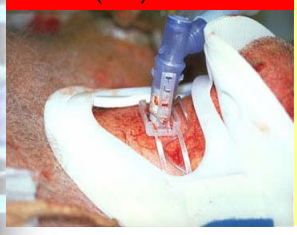
- **Surgical airways**
  - Translaryngeal jet insufflation (TJI)

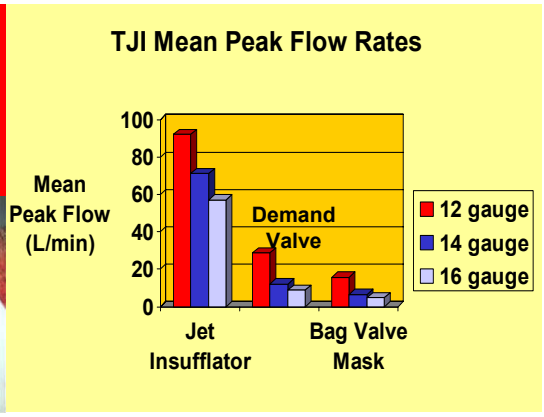




Airway Management continued

- **Surgical airways**
  - Translaryngeal jet insufflation (TJI)





Airway Management continued

Advanced airway adjuncts continued

Translaryngeal Jet Insufflation

Indications	Advantages	Disadvantages	Contraindications
1. Inaccessible oral cavity (trismus, seizures, trauma, wired jaws) 2. Difficult direct laryngoscopy 3. Severe facial trauma 4. Supralaryngeal obstruction 5. Anatomical disruption of upper airway 6. Failure of standard techniques	1. Less invasive than surgical cricothyrotomy 2. Paramedics more comfortable with IV catheter than scalpel 3. Provides a temporary airway while other methods are attempted	1. Potential for subcutaneous emphysema and pneumothorax with misdirected cannula 2. Relatively poor air exchange 3. Temporizing procedure 4. Barotrauma 5. Potential esophageal perforation 6. Requires specialized equipment 7. Does not protect against aspiration 8. Permits accumulation of CO_2	1. Inability to locate cricothyroid membrane 2. Total airway obstruction at or above the level of the vocal cords (complete expiratory obstruction) 3. Infralaryngeal obstruction 4. Primary laryngeal injury 5. Children less than 5 years of age

Airway Management continued

- **Surgical airways**
  - Retrograde tracheal intubation

Airway Management continued

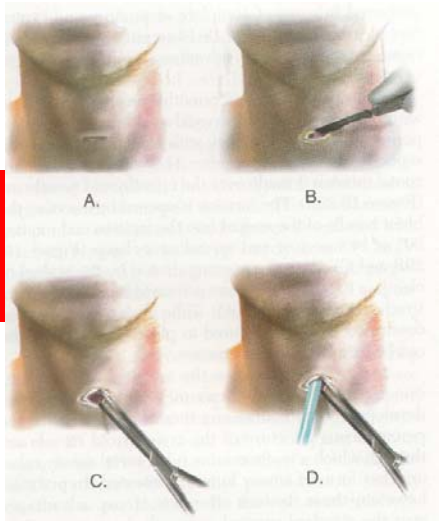
Advanced airway adjuncts continued

Retrograde Tracheal Intubation

Indications	Advantages	Disadvantages	Contraindications
1. Same as for crico-thyrotomy	1. Same as for cricothyrotomy 2. Less invasive than cricothyrotomy	1. Requires specialized equipment 2. Potential for bleeding, infection, and subglottic stenosis 3. Requires more time to perform than cricothyrotomy 4. More steps in procedure than cricothyrotomy 5. Potential esophageal perforation	1. Inability to locate cricothyroid membrane 2. Infralaryngeal obstruction 3. Inability to open mouth for catheter removal 4. Coagulopathy 5. Expanding hematoma of the neck 6. Preexisting subglottic stenosis

Airway Management continued

- **Surgical airways**
  - Cricothyrotomy



Airway Management continued

Advanced airway adjuncts continued

Cricothyrotomy

Indications	Advantages	Disadvantages	Contraindications
1. Poor visualization of oral cavity (trismus, trauma, wired jaws)	1. Improved ventilation over TJI	1. Potential for subcutaneous emphysema and pneumothorax with misdirected ET tube	1. Inability to locate cricothyroid membrane
2. Supralaryngeal obstruction	2. Prevents aspiration	2. Potential esophageal perforation	2. Infralaryngeal obstruction
3. Difficult direct laryngoscopy	3. Longer term airway when compared to TJI	3. Requires specialized equipment	3. Supralaryngeal obstruction
4. Severe facial trauma	4. Access to lungs for drug administration or pulmonary toilet	4. Paramedics less comfortable suing scalpel	4. Primary laryngeal injury
5. Anatomical disruption of upper airway	5. Does not require laryngoscopy	5. Invasive procedure	5. Children less than 10 years of age
6. Failure of standard techniques	6. High success rate	6. Potential for bleeding, infection, and subglottic stenosis	6. Preexisting subglottic stenosis
7. Back-up procedure during RSI	7. Does not require manipulation of the neck		7. Coagulopathy
			8. Expanding hematoma of the neck

Airway Management continued

- **Confirming tube placement**
  - Visualization
  - Chest excursion
  - BBS
  - Tube fogging
  - End-tidal CO2 detector
    - Sensitivity
    - Specificity
    - False readings
  - Syringe/bulb aspirator
    - Sensitivity
    - specificity

Airway Management continued

- **Confirming tube placement**
  - Capnography

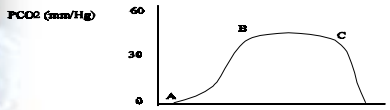


Figure 19-36a. Normal Capnogram

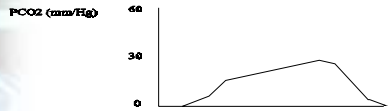


Figure 19-36b. Capnogram indicating airway obstruction.

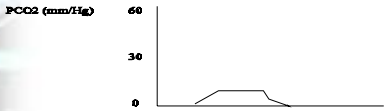
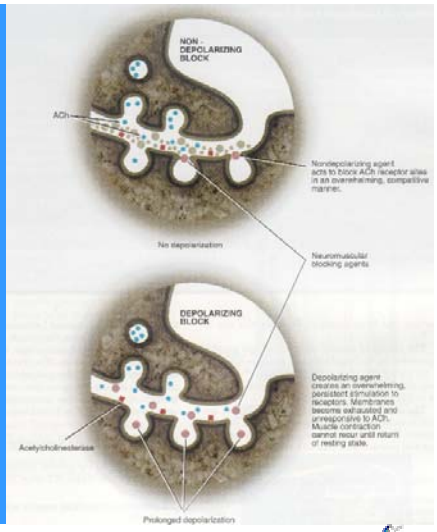


Figure 19-36c. Capnogram indicating esophageal intubation.

- **Confirming Tube Placement**
  - Capnography continued

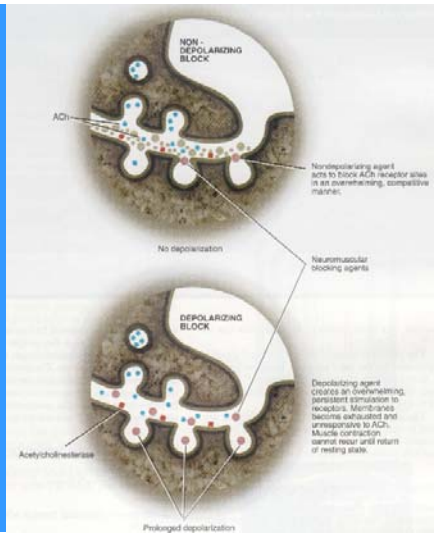
Airway Management continued

- **Rapid sequence intubation**
  - Depolarizing (succinylcholine)
    - Mimic the effect of acetylcholine
    - 1.5 mg/kg
    - Fasciculations
    - Rapid onset (30 - 60 seconds)
    - 5 to 10 minute duration
    - Non-reversible
    - Increases ICP and intraocular pressure
    - Bradycardia or asystole in children
    - Premedicate with lidocaine and atropine



Airway Management continued

- **Rapid sequence intubation**
  - Non-depolarizing (pancuronium, vecuronium)
    - Compete with acetylcholine for receptor sites
    - Tachycardia and increased PVR
    - Reversible with neostigmine
    - Onset in 2 - 5 minutes
    - Longer duration (60 - 90 minutes)
  - Procedure
    - Hyperventilate
    - Cardiac monitor
    - Sedative/hypnotic for conscious patient
    - Premedicate with lidocaine/atropine
    - Intubate



Advanced Topics

- **Mechanical ventilation**
  - Modes
    - Controlled mandatory ventilation (CMV)
      - Preset tidal volume, preset rate
      - No patient input
      - Used in unconscious, tetanus, seizure, chest wall injury
    - Assist control ventilation (ACV)
      - Similar to CMV but patient may increase the rate
    - Intermittent mandatory ventilation (IMV)
      - Preset rate and volume
      - Fresh gas supply for spontaneous, unassisted breaths
      - Potential for breath-stacking and barotrauma

Advanced Topics continued

- **Mechanical ventilation continued**
  - Modes continued
    - Synchronized intermittent mandatory ventilation (SIMV)
      - Synchronizes spontaneous and mandatory breaths
      - Spontaneous breaths are not assisted if above mechanical rate
  - Initial ventilator settings
    - 15 ml/kg IBW tidal volume
    - FiO_2 1.0
    - 12 RR for adult
    - Inspiratory pressure alarm at 15 cm/H_2O above PIP
    - PEEP starts at 5 cm/H_2O

Advanced topics continued

- **Mechanical ventilation continued**
  - Assessment of mechanical ventilation
    - Elevated $PaCO_2$ indicates poor ventilation and requires increasing respiratory rate

$$new\ respiratory\ rate = \frac{original\ rate\ x\ present\ PaCO_2}{desired\ PaCO_2}$$

    - Other means of improving ventilation
      - Replace ET with a larger one
      - Cut off excess ET tube
      - Use low compliance ventilator circuit
      - Increase tidal volume

Advanced topics continued

- **Mechanical ventilation continued**
  - Assessment of mechanical ventilation continued
    - Decreased PaO_2 indicates poor oxygenation and requires adjusting FiO_2
      - Step 1: Calculate PAO_2 needed

$$PAO_2\ needed = \frac{PaO_2\ desired}{\frac{PaO_2}{PAO_2}}$$

      - Step 2: Determine FiO_2 needed

$$FiO_2\ needed = \frac{(PAO_2\ needed + 50)}{713}$$

      - Other methods to improve oxygenation
        - » PEEP
        - » Restore C.O. to normal
        - » Improve hemoglobin levels

Advanced topics continued

- **Mechanical ventilation continued**
  - Physiologic response to intubation and ventilation
    - Intubation
      - Bradycardia, tachycardia, ICP, and hypertension
    - Ventilation
      - Decreased cardiac output, SV, hypotension, decreased blood flow to vital organs, barotrauma

Advanced topics continued

- **Chest Drainage System**
  - Indicated to remove fluid or air from pleural space