Ventilation

Pea Ridge Fire Department

EMS Refresher Program

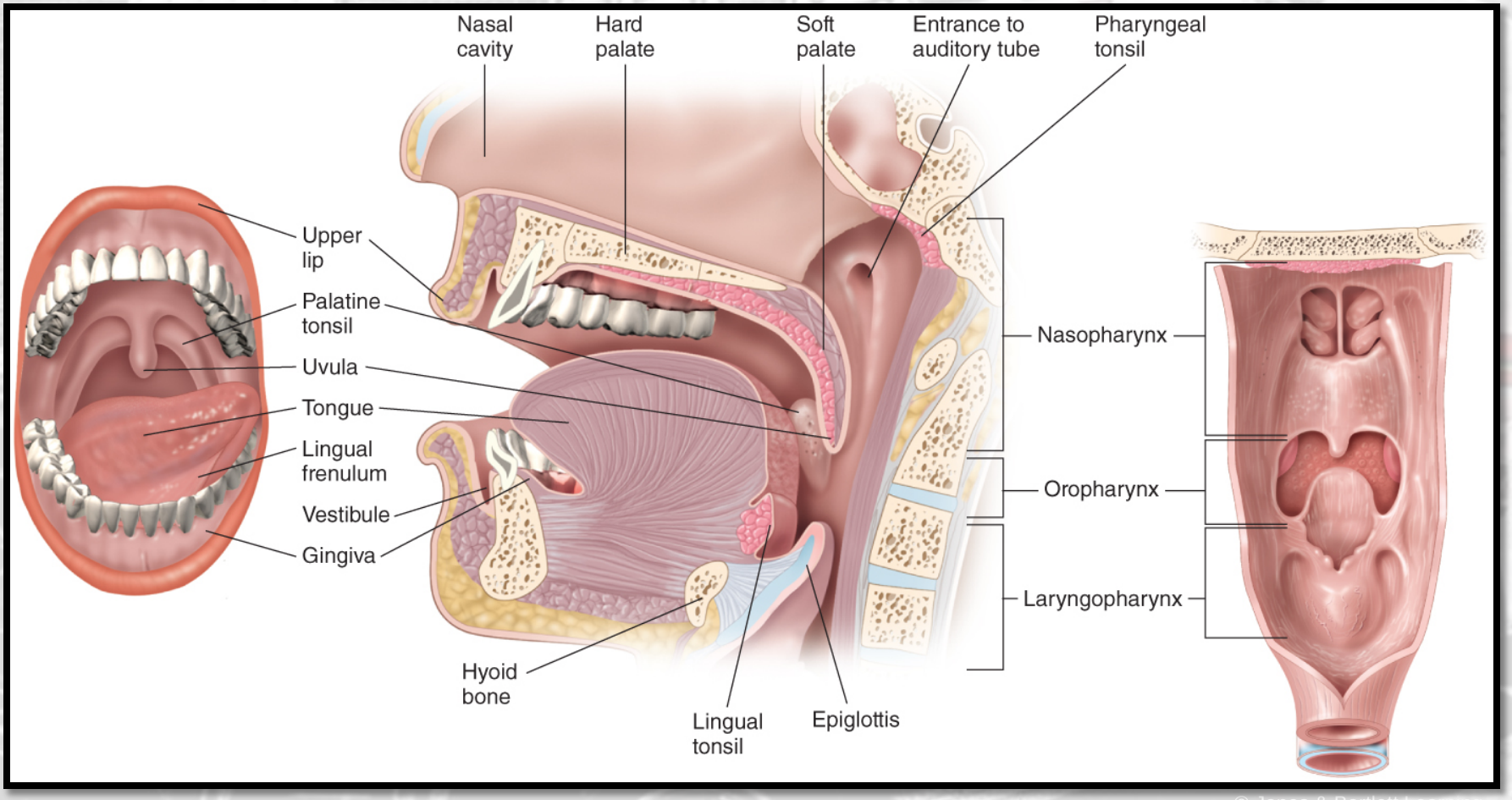
Introduction

- Establishing and maintaining a patent airway and ensuring effective oxygenation and ventilation are vital to patient care.
  - The human body needs a constant supply of oxygen.

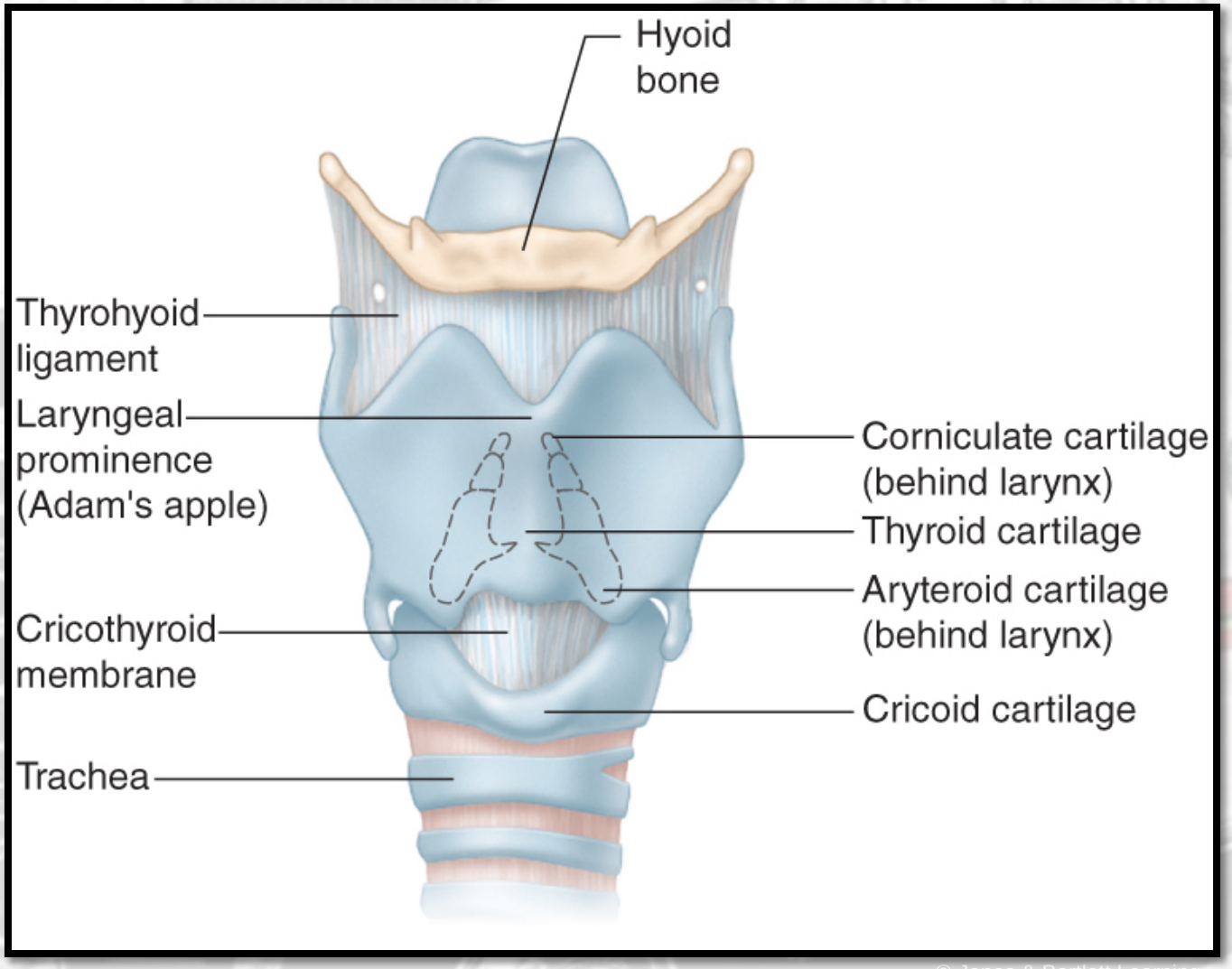
Introduction

- Appropriate airway management
  - Open and maintain patent airway.
  - Recognize, treat obstructions.
  - Assess ventilation, oxygenation status.
  - Administer oxygen.
  - Provide ventilatory assistance.

Know The Anatomy

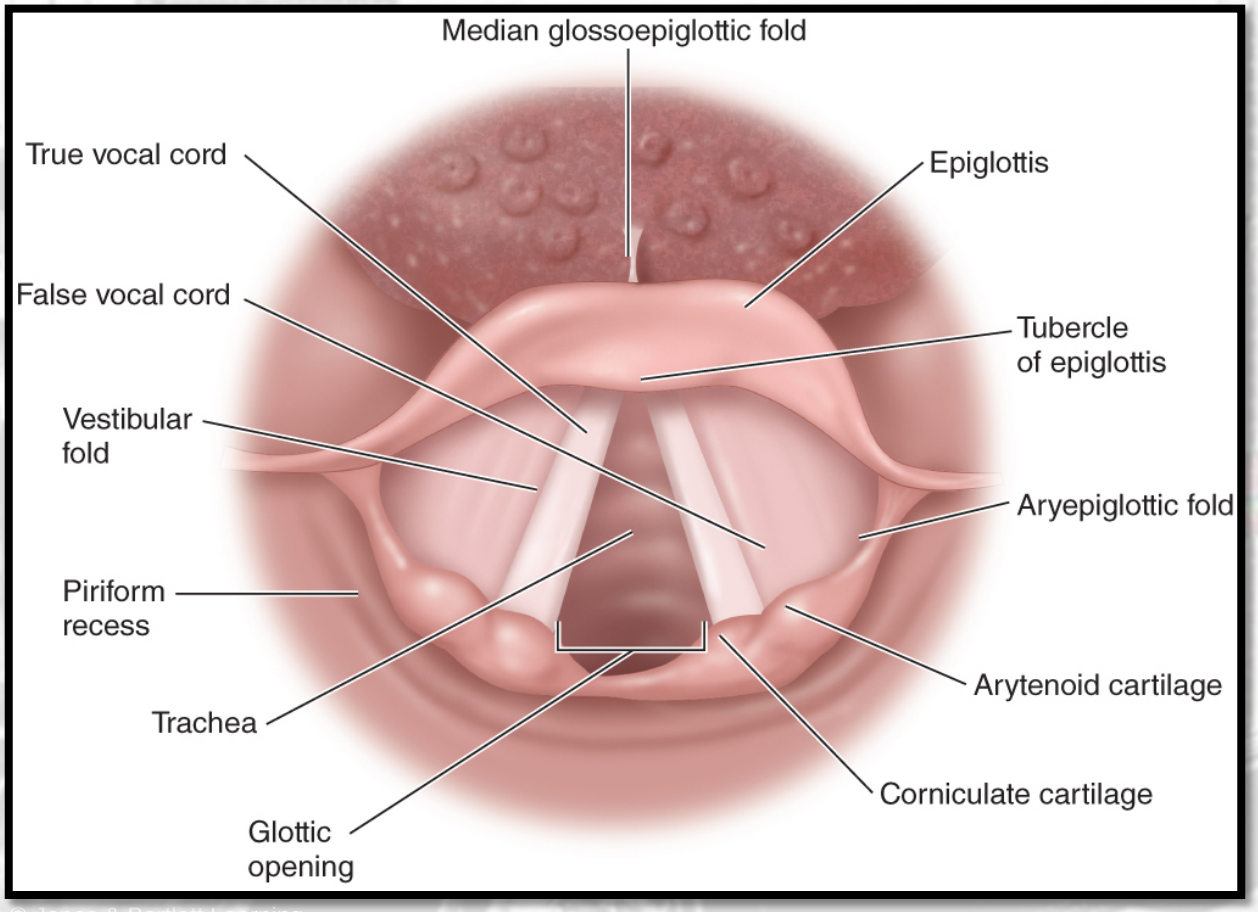


Larynx



Glottis

- Space between the vocal cords



Ventilation, Oxygenation, and Respiration

- Respiratory and cardiovascular systems work together.
  - Bring oxygen and nutrients to cells
  - Remove waste

Table 15-1 Ventilation, Oxygenation, and Respiration

Function	Definition
Ventilation	The physical act of moving air into and out of the lungs
Oxygenation	The process of loading oxygen molecules onto hemoglobin molecules in the bloodstream
Respiration	The exchange of oxygen and carbon dioxide in the alveoli and the tissues of the body

Ventilation

- Physical act of moving air into and out of lungs
  - Two phases
    - Inhalation (active, muscular part of breathing)
    - Exhalation (passive process)
- You must ensure adequate ventilation.

Oxygenation

- Process of loading oxygen molecules onto hemoglobin molecules in the bloodstream
- Requires adequate fraction of inspired oxygen (FIO_2)

Respiration

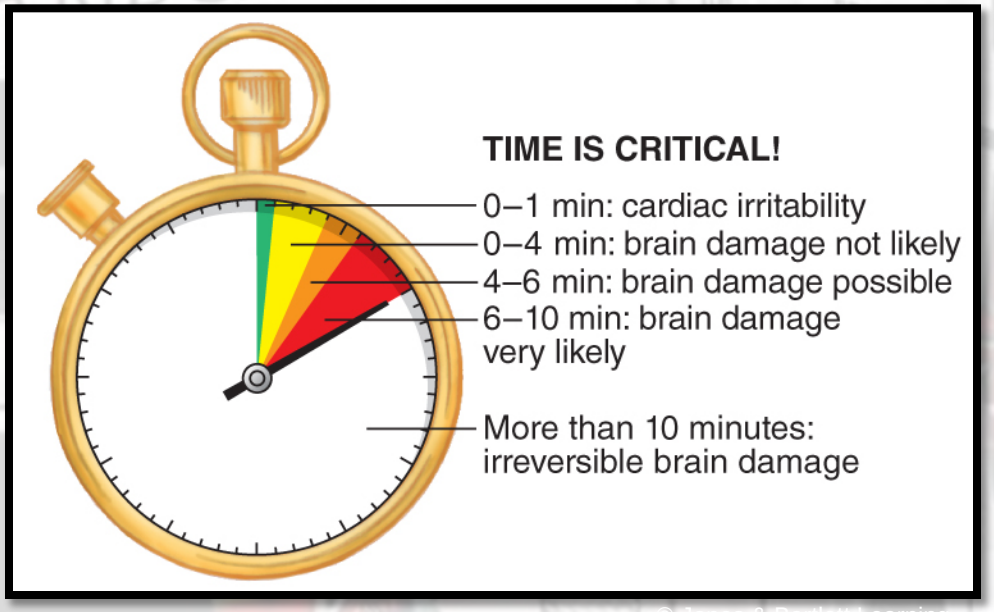
- Respiration: Process of exchanging oxygen and carbon dioxide
  - External
    - Exchange of O_2 and CO_2 between alveoli and blood in pulmonary capillaries
  - Internal
    - Exchange of O_2 and CO_2 between the systemic circulation and the cells

Pathophysiology of Respiration

- Disruption of pulmonary ventilation, oxygenation, and respiration causes immediate effects.
  - Must recognize and correct immediately.

Pathophysiology of Respiration

- Every cell needs a constant supply of oxygen to survive.
  - Perfusion: Circulation of blood in adequate amounts to meet cells' needs



Hypoxia

- Tissues and cells do not receive enough oxygen.
- Varying signs and symptoms
  - Early signs: Restlessness, irritability, tachycardia, and anxiety
  - Late signs: Mental status changes, a weak pulse, and cyanosis

Ventilation-Perfusion Ratio and Mismatch

- Air and blood flow must be directed to the same place at the same time.
  - Ventilation and perfusion must be matched.
- If not, V/Q mismatch results.
  - Blood passes over alveolar membranes without gas exchange.
  - Carbon dioxide is recirculated into bloodstream.

Factors Affecting Ventilation

- Patent airway is critical for the provision of oxygen to tissues.
- Intrinsic and extrinsic factors can cause an airway obstruction.

Factors Affecting Ventilation

- Intrinsic factors: Infection, allergic reactions, unresponsiveness
  - The tongue is the most common obstruction in an unresponsive patient.
  - Factors may not be directly part of the respiratory system.

Factors Affecting Ventilation

- Extrinsic factors: Trauma and foreign body airway obstruction
  - Trauma requires immediate intervention.
    - Blunt/penetrating trauma and burns can disrupt airflow into the lungs.
    - Trauma to the chest wall can lead to inadequate pulmonary ventilation.

Factors Affecting Ventilation

- Hypoventilation
  - Carbon dioxide production exceeds elimination.
- Hyperventilation
  - Carbon dioxide elimination exceeds production.

Table 15-2 Carbon Dioxide Balance

	Hypoventilation	Hyperventilation
Minute volume	↓	↑
CO_2 elimination	↓	↑
$PaCO_2$	↑ (hypercapnia)	↓ (hypocapnia)

Abbreviations: CO_2, carbon dioxide; $PaCO_2$, partial pressure of carbon dioxide

External Factors Affecting Oxygenation and Respiration

- Factors in ambient air
  - High altitudes: Partial pressure decreases
  - Closed environments: Oxygen decreases
- Toxic gases displace oxygen in the environment.

Internal Factors Affecting Oxygenation and Respiration

- Conditions that reduce surface area for gas exchange also decrease oxygen supply.
  - Nonfunctional alveoli inhibit diffusion.
  - Fluid in the alveoli inhibits gas exchange.
    - Submersion victims
    - Patients with pulmonary edema
    - Exposure to environmental conditions or occupational hazards

Internal Factors Affecting Oxygenation and Respiration

- Hypoglycemia
  - Oxygen and glucose levels decrease.
- Infection
  - Increases metabolic needs
  - Disrupts homeostasis
- Hormonal imbalances
  - May result in ketoacidosis

Circulatory Compromise

- Inadequate perfusion
- Oxygen demands will not be met.
  - Obstruction of blood flow is typically related to trauma.
    - Inhibits gas exchange at the tissue level

Circulatory Compromise

- Heart conditions reduce blood flow to tissues.
- Blood loss and anemia reduce the blood's oxygen-carrying ability.
- Shock: Oxygen is not delivered efficiently.
  - Poor tissue perfusion; anaerobic metabolism

Acid-Base Balance

- Can be disrupted by
  - Hypoventilation
  - Hyperventilation
  - Hypoxia
- May rapidly lead to deterioration and death

Acid-Base Balance

- Respiratory and renal systems help maintain homeostasis.
  - Tendency toward stability in the body
  - Requires balance between acids and bases
- Acid in the body can be expelled as carbon dioxide from the lungs.

Acid-Base Balance

- Acidosis can develop if respiratory function is inhibited.
- Alkalosis can develop if the respiratory rate is too high.
  - Respiratory acidosis/alkalosis
  - Metabolic acidosis/alkalosis

Patient Assessment: Airway Evaluation

- Quality of care depends on assessment.
- Assessing the airway
  - First determine if patient's airway is patent.
    - Snoring
    - Vomitus draining from the mouth
    - Gurgling sound heard during breathing
  - Secretions pooling in patient's mouth indicate depressed or absent gag reflex.

Patient Assessment: Airway Evaluation

- Adequate breathing
  - Patient is responsive, alert, able to speak.
  - Rate between 12 and 20 breaths/min
  - Adequate depth
  - Regular pattern of inhalation and exhalation
  - Clear and equal breath sounds

Table 15-3 Normal Respiratory Rate Ranges

Age	Range (breaths/min)
Adults	12 to 20
Children (ages 1 to 18 years)	12 to 37
Infants (ages 1 month to 1 year)	30 to 53

Pediatric data from: American Heart Association (AHA). Vital signs in children. In: *Pediatric Advanced Life Support.* Dallas, TX: AHA; 2015.

Recognizing Inadequate Breathing

- Breathing rate of less than 10 breaths/min or more than 30 breaths/min – Consider using BVM to control Ventilations
- Cyanosis: Indicator of low blood oxygen
- Preferential positioning
  - Upright sniffing (tripod) position
  - Semi-Fowler (semi-sitting) position

Recognizing Inadequate Breathing

- Potential causes:
  - Severe infection
  - Trauma
  - Brainstem insult
  - Noxious or oxygen-poor environment
  - Renal failure
  - Upper and/or lower airway obstruction
  - Respiratory muscle impairment
  - Central nervous system impairment

Recognizing Inadequate Breathing

- Airway management steps
  - Open the airway.
  - Clear the airway.
  - Assess breathing.
  - Provide appropriate intervention(s).
- Evaluation includes:
  - Observation
  - Palpation
  - Auscultation

Inadequate Breathing

- Note the following:
  - Position
  - Orthopnea
  - Chest rise/fall
  - Skin
  - Flared nostrils
  - Pursed lips
  - Retractions
  - Use of accessory muscles
  - Asymmetric chest wall movement
  - Quick breaths, long exhalation
  - Labored breathing

Inadequate Breathing

- Signs
  - Fewer than 10 or more than 30 breaths/min plus dyspnea
  - Irregular rhythm
  - Diminished, absent, or noisy sounds
  - Abdominal breathing
  - Reduced flow
  - Unequal chest expansion
  - Increased effort
  - Shallow breathing
  - Pale, clammy skin
  - Retractions
  - Staccato speech

Inadequate Breathing

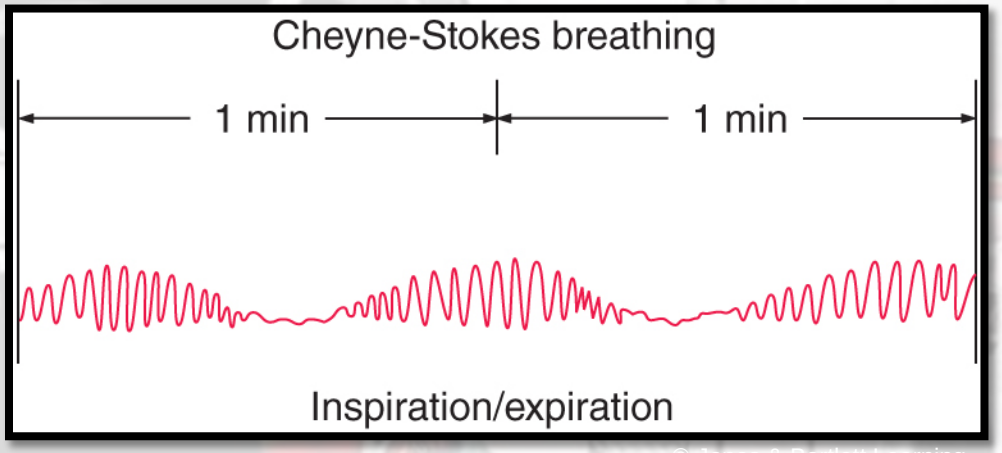
- Evaluate protective reflexes.
  - Coughing, sneezing, gagging
    - Gag reflex (eyelash reflex)
  - Sighing
  - Hiccupping

Inadequate Breathing

Table 15-4	Abnormal Respiratory Patterns
Cheyne-Stokes respirations	Gradually increasing rate and depth of respirations followed by a gradual decrease of respirations with intermittent periods of apnea; associated with brainstem insult Figure 15-5.
Kussmaul respirations	Deep, rapid respirations; seen in patients with diabetic ketoacidosis.
Biot (ataxic) respirations	Irregular pattern, rate, and depth of breathing with intermittent periods of apnea; results from increased ICP.
Apneustic respirations	Prolonged, gasping inhalation followed by extremely short, ineffective exhalation; associated with brainstem insult.
Agonal gasps	Slow, shallow, irregular, or occasional gasping breaths; results from cerebral anoxia. Agonal gasps may be seen when the heart has stopped but the brain continues to send signals to the muscles of respiration.

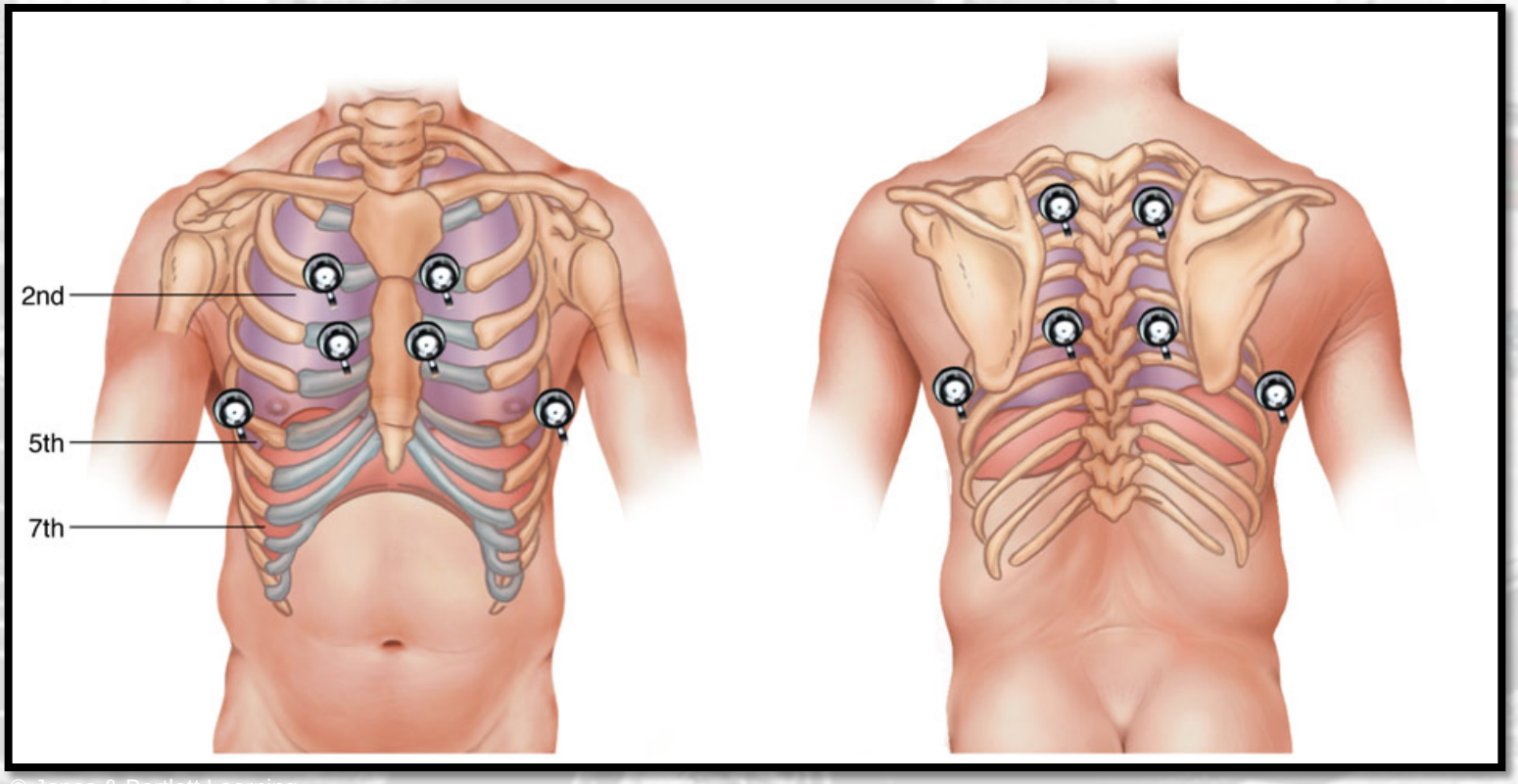
Abbreviation: ICP, intracranial pressure

Data from: Fontanarosa PB, Christiansen S. Units of measure. Table 2: Selected laboratory tests, with reference ranges and conversion factors. In: American Medical Association, ed. *AMA Manual of Style: A Guide for Authors and Editors.* 10th ed. New York, NY: Oxford University Press; 2007:798-815.



Assessment of Breath Sounds

- Auscultate breath sounds with stethoscope.
  - Should be clear and equal



Assessment of Breath Sounds

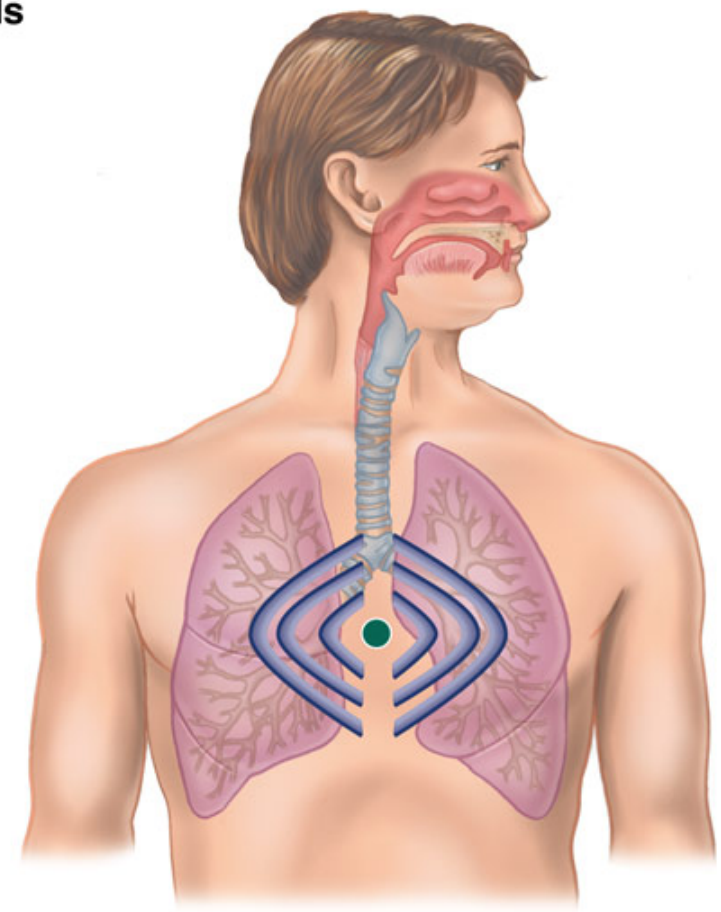
"Normal" Breath Sounds

Tracheal. Inspiratory and expiratory sounds are both loud.

Bronchial. Inspiratory sounds are shorter than expiratory sounds, and both are loud.

Bronchovesicular. Inspiratory and expiratory sounds are about the same, and of medium intensity.

Vesicular. Inspiratory sounds last longer than expiratory sounds, and both are faint.



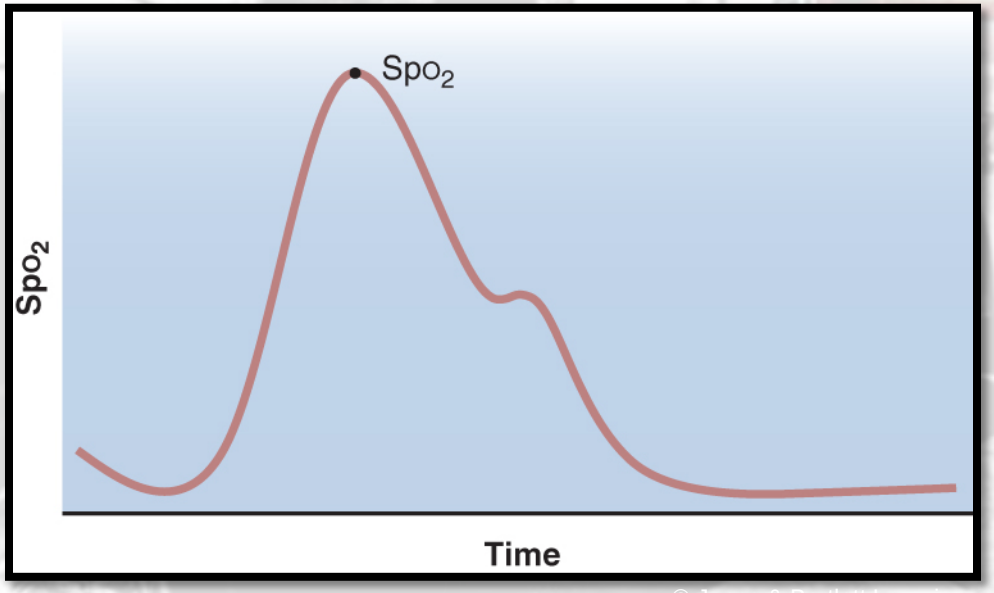
The thickness of the bars shows intensity (loudness) of the breath, and slope correlates with pitch (steeper slope, higher pitch).

Abnormal Breath Sounds

- Wheezing
  - Continuous, high-pitched
- Rhonchi
  - Continuous, low-pitched
- Crackles
  - Discontinuous
- Stridor
  - Loud, high-pitched, heard during inspiration
- Pleural friction rub
  - Surfaces of visceral and parietal pleura rub together.

Pulse Oximetry

- Pulse oximeter: Measures oxygen saturation of hemoglobin (Hb)
  - Normal: SpO_2 of greater than 95%



Pulse Oximetry

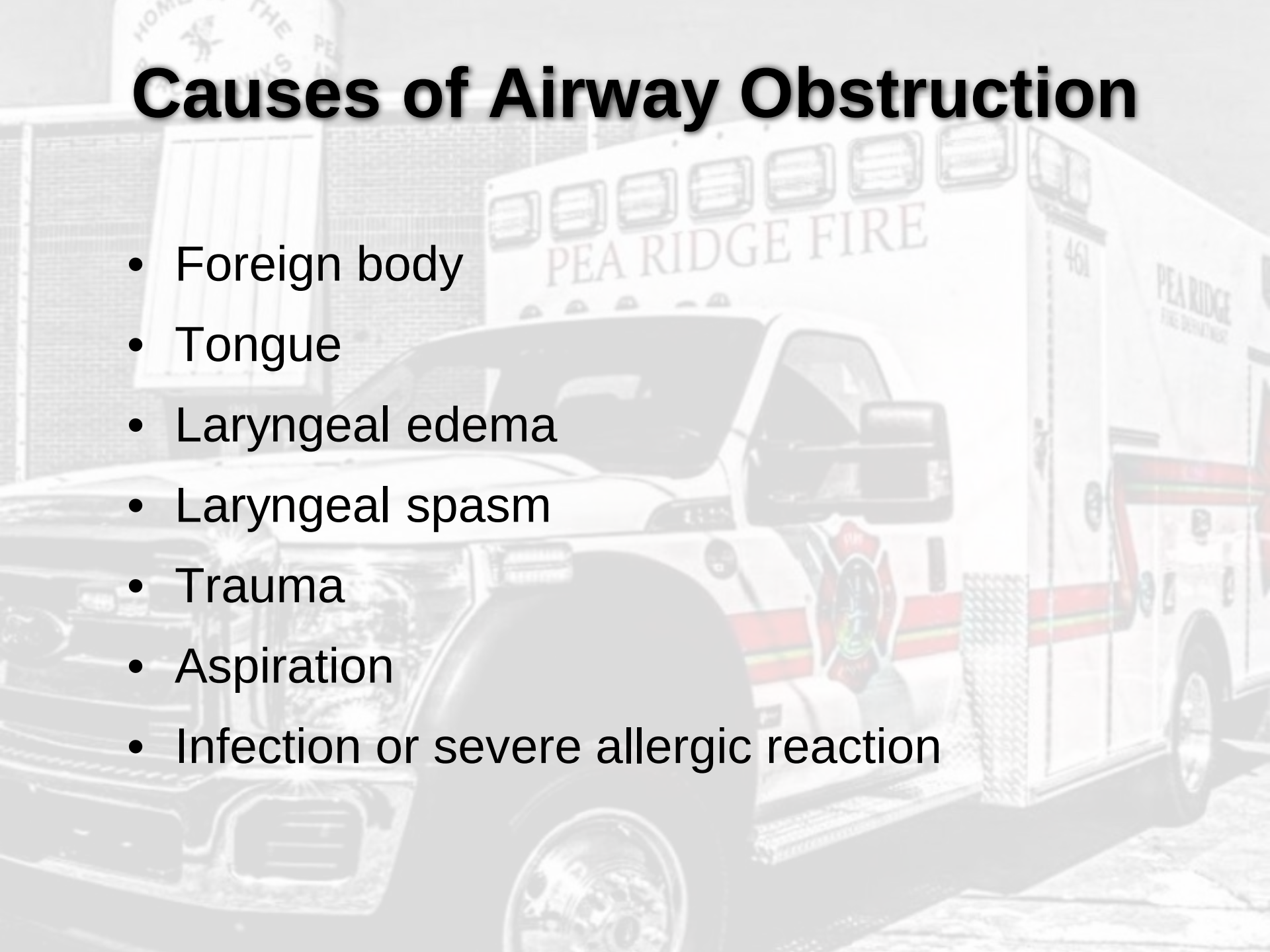
- Types of hemoglobin
  - Oxyhemoglobin (HbO_2)
  - Reduced hemoglobin
- CO-oximeter
  - Determines HbO_2 saturation (percentage of oxygenated Hb compared with total hemoglobin)

The Masimo Rad-57™ Pulse CO-Oximeter™ courtesy of Masimo Corporation (www.masimo.com)

Oropharyngeal (Oral) Airway

Nasopharyngeal (Nasal) Airway

Causes of Airway Obstruction



- Foreign body
- Tongue
- Laryngeal edema
- Laryngeal spasm
- Trauma
- Aspiration
- Infection or severe allergic reaction

Laryngeal Spasm and Edema

- Laryngeal spasm
  - Spasmodic closure of vocal cords
  - Completely occludes airway
  - Causes include:
    - Intubation trauma
    - Extubation
- Laryngeal edema
  - Glottic opening narrows or totally closes
  - Causes include:
    - Epiglottitis
    - Anaphylaxis
    - Inhalation injury

Laryngeal Spasm and Edema

- May be relieved by:
  - Aggressive ventilation
  - Forceful upward jaw pull
- May be relieved by muscle relaxants
- May recur; transport patient to hospital for evaluation

Aspiration

- Increases mortality
  - Can obstruct the airway
  - Destroys bronchiolar tissue
  - Introduces pathogens into the lungs
  - Decreases patient's ability to ventilate
- Have suction readily available

Recognition of an Airway Obstruction

- Mild obstruction
  - Patient is responsive, able to exchange air.
  - Usually has noisy respirations and coughing
  - Should be left alone
  - Closely monitor the patient's condition.
  - Be prepared to intervene.

Recognition of an Airway Obstruction

- Severe obstruction
  - Inability to breathe, talk, or cough
  - May grasp at throat, turn cyanotic, make frantic movements
  - Cough is weak, ineffective, or absent.
  - Weak inspiratory stridor and cyanosis

Emergency Medical Care for Foreign Body Airway Obstruction

- If patient becomes unresponsive, position supine, begin chest compressions.
  - 30 chest compressions
  - 15 with two rescuers or infant/child
- Open airway, remove any visible object.
- Attempt rescue breath, look for chest rise

Emergency Medical Care for Foreign Body Airway Obstruction

- If techniques do not work, proceed with direct laryngoscopy.
  - If you see the foreign body, remove it with Magill forceps.

Ventilatory Support

- Patient who is not breathing needs artificial ventilation and 100% supplemental oxygen.
  - Indications include signs of:
    - Altered mental status
    - Inadequate minute volume

Normal Ventilation Versus Positive Pressure Ventilation

- Normal ventilation
  - Diaphragm contracts.
  - Negative pressure in chest cavity draws in air.
- Positive pressure ventilation
  - Generated by a device
  - Forces air into the chest cavity from the external environment

Normal Ventilation Versus Positive Pressure Ventilation

Table 15-10 Normal Ventilation Versus Positive Pressure Ventilation

	Normal Ventilation	Positive Pressure Ventilation
Air movement	Air is sucked into the lungs due to the negative intrathoracic pressure created when the diaphragm contracts.	Air is forced into the lungs by means of mechanical ventilation.
Blood movement	Normal breathing facilitates venous return, thus maintaining preload.	Intrathoracic pressure is increased, which impairs venous return (and preload); as a result, stroke volume and cardiac output are reduced.
Airway wall pressure	Not affected during normal breathing	More volume is required to have the same effects as normal breathing. As a result, the walls are pushed out of their normal anatomic shapes.
Esophageal opening pressure	Not affected during normal breathing	Air is forced into the stomach, causing gastric distention that could result in vomiting and aspiration.
Overventilation	Not typical of normal breathing	Forcing volume and rate results in increased intrathoracic pressure, gastric distention, and decreased cardiac output (hypotension).

Normal Ventilation Versus Positive Pressure Ventilation

- With positive pressure ventilation, more air is needed to achieve the same effects of normal breathing.
  - Increases overall intrathoracic pressure
  - Blood flow is decreased.

Normal Ventilation Versus Positive Pressure Ventilation

- Cardiac output is a function of stroke volume multiplied by the pulse rate.
- Normally, when a person breathes, air enters the trachea.
  - Ventilations that are too forceful can cause gastric distention.

Assisted Ventilation

- Place the mask over the patient's nose and mouth.
- Squeeze the bag each time the patient inhales.
- After 5 to 10 breaths, slowly adjust the rate.
- Adjust the rate and tidal volume to maintain adequate minute volume.

Artificial Ventilation

- Begin artificial ventilation immediately if patient is not breathing.
- Methods include:
  - Mouth-to-mask technique
  - One-, two-, or three-person bag-mask device technique

Mouth-to-Mask Ventilation

- Plastic barrier placed in patient's face
- One-way valve to prevent the backflow of secretions
- Can use both hands

Mouth-to-Mask Ventilation

Mouth-to-Mask Ventilation

- Provide correct number of breaths per minute for patient's age.

Table 15-11 Ventilation Rates by Age

Adult	Apneic with a pulse: 10 to 12 breaths/min ▪ With or without an advanced airway in place (eg, ET tube, LMA, i-gel supraglottic airway) Apneic and pulseless: 10 breaths/min ▪ After an advanced airway has been inserted
Infant (ages 1 month to 1 year) and child (ages 1 to 17 years)	Apneic with a pulse: 12 to 20 breaths/min ▪ With or without an advanced airway in place (eg, ET tube, LMA, i-gel supraglottic airway) Apneic and pulseless: 10 breaths/min ▪ After an advanced airway has been inserted

Abbreviations: ET, endotracheal; LMA, laryngeal mask airway
Avoid hyperventilating any patient; hyperventilated lungs may "squeeze" the heart, thus impeding venous return and subsequent cardiac output. Hyperventilation also increases the risks of regurgitation and aspiration.

Data from: Kleinman ME, Brennan EE, Goldberger ZD, Swor RA, Terry M, Bobrow BJ, Gazmuri RJ, Travers AH, Rea T. Part 5: adult basic life support and cardiopulmonary resuscitation quality: 2015 American Heart Association Guidelines Update for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care. *Circulation*. 2015;132(suppl 2):S414-S435; Link MS, Berkow LC, Kudenchuk PJ, Halperin HR, Hess EP, Moitra VK, Neumar RW, O'Neil BJ, Paxton JH, Silvers SM, White RD, Yannopoulos D, Donnino MW. Part 7: adult advanced cardiovascular life support: 2015 American Heart Association Guidelines Update for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care. *Circulation*. 2015;132(suppl 2):S444-S464; Atkins DL, Berger S, Duff JP, Gonzales JC, Hunt EA, Joyner BL, Meaney PA, Niles DE, Samson RA, Schexnayder SM. Part 11: pediatric basic life support and cardiopulmonary resuscitation quality: 2015 American Heart Association Guidelines Update for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care. *Circulation*. 2015;132(suppl 2):S519-S525; and de Caen AR, Berg MD, Chameides L, Gooden CK, Hickey RW, Scott HF, Sutton RM, Tijssen JA, Topjian A, van der Jagt E, Schexnayder SM, Samson RA. Part 12: pediatric advanced life support: 2015 American Heart Association Guidelines Update for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care. *Circulation*. 2015;132(suppl 2):S526-S542.

Bag-Mask Device

- Can deliver nearly 100% oxygen
- Can provide adequate tidal volume when used by an experienced paramedic
  - Depends on mask seal integrity

Bag-Mask Device

- Technique (cont.)
  - Hold the mask in place while your partner squeezes the bag until the chest visibly rises.
  - Squeeze every 5 to 6 seconds for adults, 3 to 5 seconds for infants and children.

Bag-Mask Device

- Technique (cont.)
  - If alone, hold your index finger over the lower part of the mask and your thumb over the upper part.
  - Observe for gastric distention, changes in compliance, and changes in status.

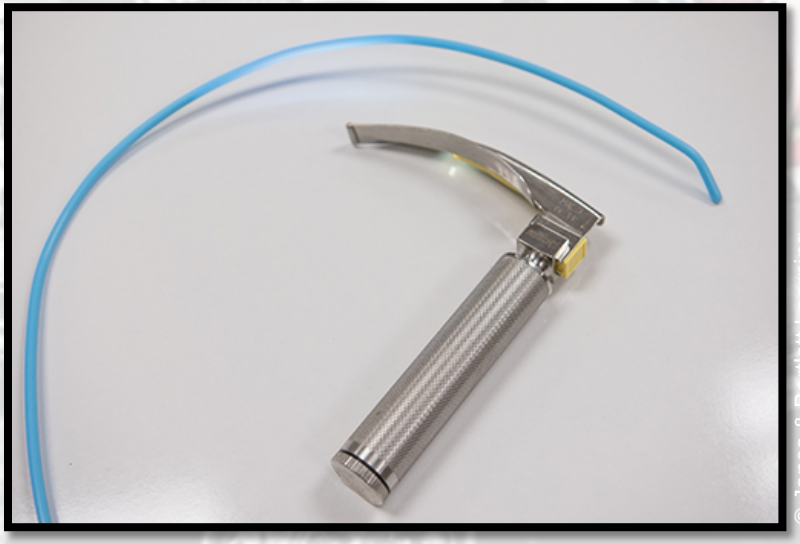
Automatic Transport Ventilators

- Steps for using:
  - Attach to wall-mounted oxygen source.
  - Set tidal volume and ventilatory rate.
  - Connect to fitting on ET tube or airway device.
  - Auscultate breath sounds and observe chest rise.

Courtesy of Impact Instrumentation, Inc.

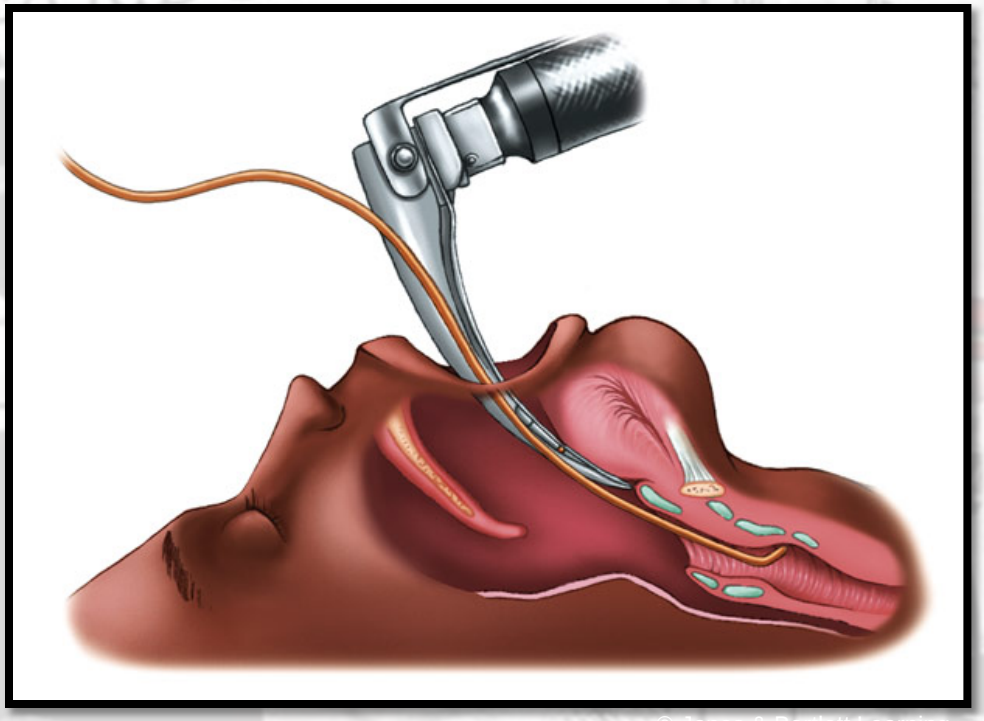
Visualization of the Glottic Opening

- Gum elastic bougie
  - Flexible device
  - Approximately 5 mm in diameter, 70 cm long
  - Used in epiglottis-only views to facilitate intubation



Visualization of the Glottic Opening

- Gum elastic bougie (cont'd)
  - Insert through the glottic opening under direct laryngoscopy.
  - Once placed, it becomes a guide for the ET tube.



ET Tube Insertion

- Pick up ET tube.
  - Hold it near connector as you would a pencil.
- Insert tube from the right corner of mouth through the vocal cords.
  - Continue until the proximal end of the cuff is 1 to 2 cm past the vocal cords.
  - *If you cannot see the vocal cords, do not insert the tube.*

ET Tube Insertion

- Do not pass the tube down the barrel of the laryngoscope blade.
  - Will obscure your view of the glottic opening

Ventilation

- After you have seen the ET tube cuff pass roughly 1 to 2 cm beyond the vocal cords:
  - Gently remove the blade.
  - Secure tube with right hand.
  - Remove stylet from tube.

Ventilation

- Inflate the distal cuff with 5 to 10 mL of air, then detach the syringe from the inflation port.
- Have your assistant attach the bag-mask device to the ET tube; continue ventilation.
  - Ensure that the patient's chest rises with each ventilation.

Ventilation

- Listen to both lungs and to the stomach.
  - You should hear equal breath sounds and a quiet epigastrium.
- Ventilation should be dictated by age.
  - Adult with a pulse: 10 to 12 breaths/min
  - Infant/child with a pulse: 12 to 20 breaths/min
  - Patient in cardiac arrest: 8 to 10 breaths/min

Confirmation of Tube Placement

- Visualize ET tube passing between the vocal cords.
- Auscultate.
  - Unequal or absent breath sounds suggest:
    - Esophageal placement
    - Right mainstem bronchus placement
    - Pneumothorax
    - Bronchial obstruction

Confirmation of Tube Placement

- Auscultate (cont'd)
  - Bilaterally absent breath sounds or gurgling over the epigastrium: Esophagus was intubated
    - Immediately remove ET tube.
    - Be prepared to suction the airway.

Confirmation of Tube Placement

- Auscultate (cont'd)
  - Breath sounds only on right means tube has been advanced too far.
    - Reposition the tube.

Confirmation of Tube Placement

- With proper tube position:
  - Bag-mask device should be easy to compress.
  - You should see corresponding chest expansion.
- Increased resistance may indicate:
  - Gastric distention
  - Esophageal intubation
  - Tension pneumothorax

Confirmation of Tube Placement

- Continuous waveform capnography plus clinical assessment
  - Most reliable method of confirming placement
  - Attach capnography T-piece when bag-mask device is attached to the ET tube.

Confirmation of Tube Placement

- Esophageal detector device
  - Syringe model: Plunger is withdrawn.
    - Tube in the trachea: Plunger does not move.
    - Tube in the esophagus: Plunger moves back.

Courtesy of Marianne Gausche-Hill, MD, FACEP, FAAP.

Confirmation of Tube Placement

- Esophageal detector device (cont'd)
  - Bulb model: Bulb is squeezed.
    - Tube in the esophagus: Bulb remains collapsed.
    - Tube in the trachea: Bulb briskly expands.

Courtesy of Marianne Gausche-Hill, MD, FACEP, FAAP.

i-gel

- Inserted in a manner similar to the LMA
- Seals pharyngeal, laryngeal, and perilaryngeal structures
  - While avoiding compression trauma

i-gel

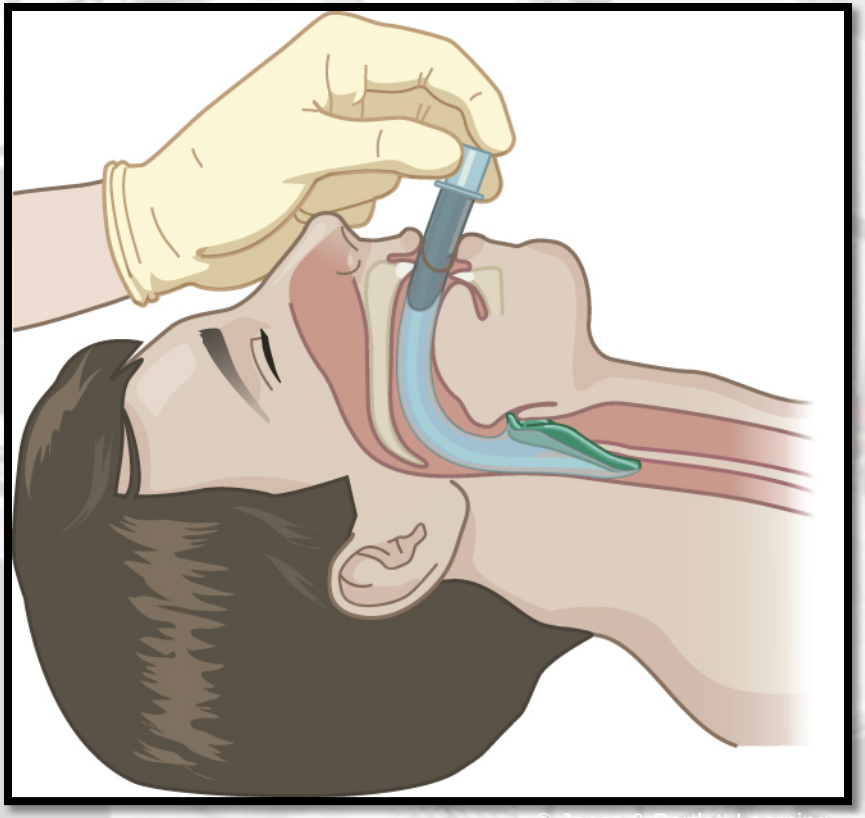
- Alternative when intubation is unsuccessful
- Features:
  - Integral bite block
  - Gastric access channel for passing a 12-Fr gastric tube
  - Supplemental oxygen inlet port for passive oxygenation
  - Support strap to secure i-gel in position

i-gel

Table 15-18 Sizes and Patient Criteria for Adult i-gel Supraglottic Airway

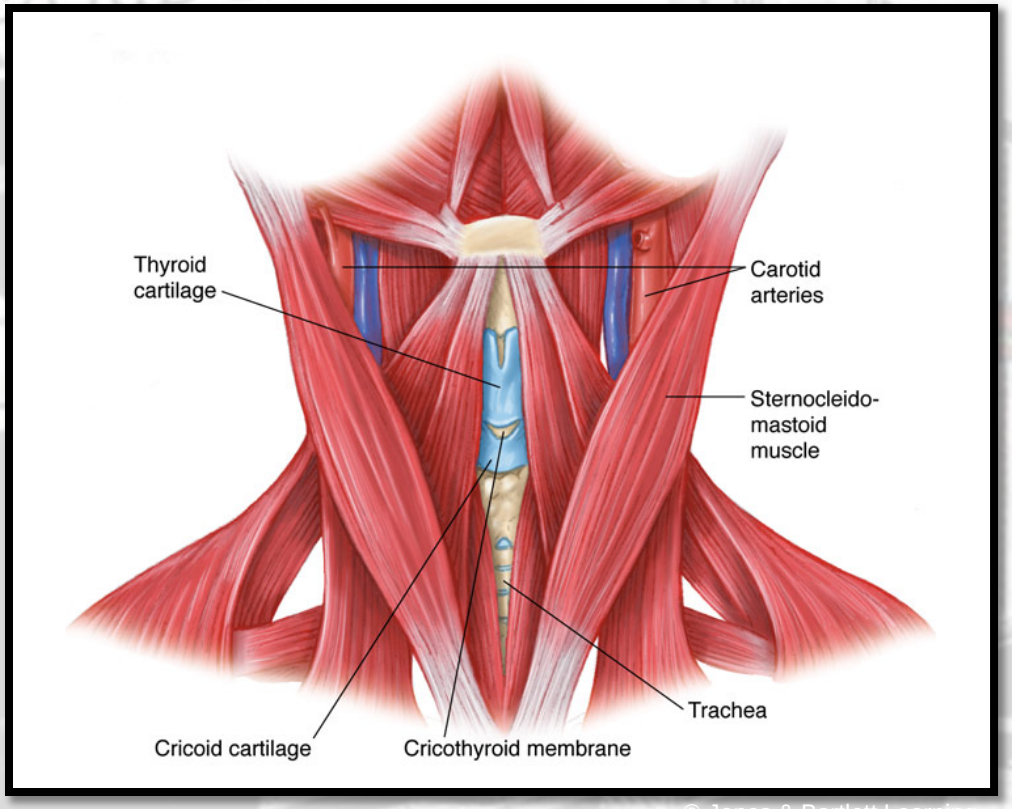
Size	Connector Color	Weight Criteria
3	Yellow	66–132 lb (30–60 kg)
4	Green	110–198 lb (50–90 kg)
5	Orange	>198 lb (>90 kg)

Data from: i-gel user guide. 9989 issue 1 01.10. Intersurgical Ltd website. http://docsinnovent.com/downloads/i-gel_User_Guide_English.pdf. Accessed February 21, 2017.



Surgical and Nonsurgical Cricothyrotomy

- Used when conventional techniques fail
- Be familiar with:
  - Anatomy of the anterior aspect of the neck
  - Important blood vessels in area



Open Cricothyrotomy

- Indications
  - Patent airway cannot be secured with conventional means.
    - Severe foreign body obstructions
    - Swelling of airway
    - Maxillofacial trauma
    - Inability to open mouth

Open Cricothyrotomy

- Contraindications
  - Ability to secure a patent airway
  - Inability to identify anatomic landmarks
  - Crushing injuries to the larynx and tracheal transection
  - Underlying anatomic abnormalities
  - Age younger than 8 years

Thank You

Move to the Next Section