Learning Objectives

• Describe the anatomy of the airway and respiratory structures.
• Distinguish between respiration, pulmonary ventilation, and external and internal respiration.

Learning Objectives

• Explain the mechanics of ventilation and respiration.
• Explain the relationship between partial pressures of gases in the blood and lungs to atmospheric gas pressures.

Airway Anatomy

• Upper airway
  – All structures above glottis
• Lower airway
  – All structures below glottis
Upper Airway

• Two openings
  – Nose
  – Mouth

• Nasopharynx
  – Air passes through from nose
  – Superior part of the pharynx

Upper Airway

• Oropharynx
  – Air passes through from mouth
  – Extends to level of epiglottis

• Uvula
  – Where nasopharynx ends, oropharynx begins
Upper Airway

• Laryngopharynx (hypopharynx)
  – Extends from tip of epiglottis to glottis and esophagus
  – Opens into larynx, which lies in anterior neck

Larynx

• Consists of outer casing of nine cartilages
  – Connect to each other by muscles, ligaments
  – Six of nine are paired
  – Three are unpaired
**Larynx**

- **Unpaired cartilages**
  - Thyroid cartilage
    - Largest, most superior of cartilages
    - Also know as Adam’s apple
  - Cricoid cartilage
    - Most inferior cartilage
    - Only complete cartilage ring in larynx
  - Epiglottis

- **Paired cartilages**
  - Stacked in two pillars between cricoid cartilage and thyroid cartilage
  - Arytenoid cartilages
  - Corniculate cartilages
  - Cuneiform cartilages
Larynx

- Hyoid bone
  - U-shaped
  - Located beneath mandible
  - Helps support airway by anchoring muscles to jaw
- Thyroid membrane
  - Joins hyoid bone and thyroid cartilage
    - Known as cricothyroid membrane

Larynx

- Vocal cords
  - Regulate flow of air to and from lungs for production of voice sounds
  - Endotracheal tube passed through during ET intubation
- Pyriform sinus
  - Recess located on either side of larynx
  - Foreign materials can become lodged there

Lower Airway

- Trachea
  - Lies anterior to esophagus
  - Air passage from larynx to lungs
  - Begins at border of cricoid cartilage
  - Ends where it bifurcates into right and left main bronchi
    - Bifurcation at level of jugular notch
    - Composed of 16 to 20 incomplete cartilaginous rings
      - Open posteriorly to prevent trachea from collapsing
Lower Airway

- Carina of trachea
  - Downward and backward projection of last tracheal cartilage
  - Forms ridge that separates opening of right and left main stem bronchi
  - Occurs at sternal angle (angle of Louis)

Lower Airway

- Right and left main bronchi
  - Pass from bifurcation of trachea to lungs to form bronchial tree
  - Further branch into secondary bronchi
  - Divide again into tertiary segmental bronchi, finally terminal bronchioles
- Bronchioles
  - Smallest airways without alveoli
  - Divide into respiratory bronchioles, then alveolar ducts
Lower Airway

- Alveoli
  - Functional units of the respiratory system
  - Majority of lung tissue
  - Where majority of respiratory gas exchange takes place
  - About 300 million exist in two lungs
  - Each surrounded by fine network of blood capillaries
  - Capillaries arranged so air within alveolus is separated from blood by thin respiratory membrane
  - Coated with pulmonary surfactant, thin film produced by alveolar cells, prevents collapsing

Lower Airway

- Lungs
  - Large, paired, spongy organs
  - Attached to heart by pulmonary arteries, veins
  - Separated by mediastinum
    - Heart
    - Blood vessels
    - Trachea
    - Esophagus
    - Lymphatic tissue
    - Vessels

Lower Airway

- Lungs
  - Each lung shaped like a cone, with base resting on the diaphragm
  - Left lung is smaller than right and divided into two lobes
  - Right lung has 3 lobes
  - Lobes are divided into lobules
    - 9 lobules in left lung
    - 10 lobules in right lung
Lower Airway

- Lungs
  - Both lungs are surrounded by a separate pleural cavity
  - Two layers of pleura
    - Visceral and parietal
    - Separated by a serous fluid
    - Serous fluid acts as lubricant to allow pleural membranes to slide past each other during breathing
- Primary function is respiration
  - Exchange of $O_2$ and $CO_2$ between an organism and environment

Airway Support Structures

- Thoracic cage
  - Protects vital organs
  - Prevents thorax collapse during ventilation
- Contents
  - Thoracic vertebrae
  - Ribs
  - Associated costal cartilages
  - Sternum
Airway Support Structures

• Ventilation muscles
  – Intercostal muscles
    • Used only during exercise, exertion, distress along with accessory muscles, not used during quiet breathing
  – Diaphragm
    • Most important for ventilation
    • When contracted, abdominal contents are pushed downward, intercostal muscles move ribs upward AND outward, which increases volume and decreases pressure in the thoracic cavity

Airway Support Structures

• Phrenic nerves
  – Mostly motor nerve fibers that produce diaphragm contractions
  – Provide sensory innervation for many components
    • Mediastinum
    • Pleura
    • Upper abdomen
    • Liver
    • Gallbladder
Airway Support Structures

• Phrenic nerves
  – Right phrenic nerve
    • Passes over brachiocephalic artery, posterior to subclavian vein, crosses root of right lung anteriorly
    • Leaves thorax, passing through opening in diaphragm
    • Never passes over right atrium
  – Left phrenic nerve
    • Passes over pericardium and left ventricle
    • Enters diaphragm separately

• Mediastinum
  – Thoracic cavity central compartment
  – Supporting structure of respiratory system
  – Lies between right and left pleura in near and sagittal plane of chest
  – Extends from sternum in front to vertebral column behind
  – Continuous with loose connective tissue of neck, extends inferiorly onto diaphragm
  – Contains all thoracic viscera except lungs
Mechanics of Respiration

- O₂
  - Essential nutrient for living organism to produce energy
- CO₂
  - Byproduct of energy production
  - Must be removed from body

Mechanics of Respiration

- Pulmonary ventilation
  - Mechanical process of gas exchange
    - Air must move freely in/out of lungs
    - Brings O₂ into lungs, removes CO₂

Respiration Phases

- External respiration
  - Transfer (diffusion) of O₂ and CO₂ between inspired air and pulmonary capillaries
- Internal respiration
  - Transfer (diffusion) of O₂ and CO₂ between capillary red blood cells and tissue cells
Think of two medical conditions that could impair external respiration and internal respiration.

Pressure Changes and Ventilation
- Gas flows from area of higher to lower pressure or concentration
  - Pressure gradient needed for gas to flow into lungs
    - Produced by differences between atmospheric pressure, intrapulmonic pressure, and intrathoracic pressure (intrapleural pressure)

Pressure Changes and Ventilation
- Atmospheric pressure
  - Pressure of gas around us
  - Varies with differences in altitude
    - At sea level, is 760 mmHg
Pressure Changes and Ventilation

- Intrapulmonic pressure
  - Pressure of gas in alveoli
  - Depending on size of thorax, varies a little above and below 760 mmHg
  - Depends on whether it is measured during inspiration or expiration

Pressure Changes and Ventilation

- Intrathoracic pressure
  - Pressure in pleural space
  - Normally less than atmospheric pressure (usually 751 to 754 mmHg)
  - May exceed atmospheric pressure during coughing or straining during bowel movements

Pressure Changes and Ventilation

- Inspiration
  - Chest wall expands
  - Increases size of thoracic cavity and expands lungs
    - Expansion results from muscle movement and negative pressure in pleural space
  - As thorax expands, lung space increases
    - Causes drop in intrapulmonic pressure of about 1 mmHg below atmospheric pressure
Pressure Changes and Ventilation

• Inspiration
  – Pressure gradient results in gas flow into lungs
  – At end of inspiration:
    • Thorax and alveoli stop expanding
    • Intrapulmonic pressure becomes = atmospheric pressure
    • Gas no longer moves into lungs

Pressure Changes and Ventilation

• Expiration
  – Chest wall
  – Muscles of ventilation are at rest
  – Process of inspiration reverses
  – Elastic recoil causes thorax and lung space to decrease in size
    • Increases intrapulmonic pressure
Pressure Changes and Ventilation

• Expiration
  — Pressure gradient created in thoracic cavity
    • Produces decrease in alveolar volume and increases intrapulmonic pressure about 1 mmHg over the atmospheric pressure
    • Results in gas flow out of lungs
  — At end of expiration
    • Opposing forces and pressures become equal
    • Thoracic volume no longer decreases
    • Intrapulmonic pressure becomes = atmospheric pressure
    • Gas movement out of lungs stops

Ventilation Muscles

• Lung and thorax expansion caused by movement of diaphragm and internal/external intercostal muscles
• On inspiration
  — Diaphragm contracts
  — Dome of diaphragm flattens
    • Increases superior–inferior dimension of chest cavity
    • Internal/external intercostal muscles contract
    • Raises the ribs
    • Increases front-to-back (anterior-posterior) and side-to-side dimensions of chest cavity
Ventilation Muscles

- Expiration is passive motion
- During expiration
  - Relaxation of diaphragm and internal intercostal muscles allows elastic recoil properties of lungs to decrease size (or volume) of thoracic cavity
**Ventilation Muscles**

- Compliance
  - Ease with which lungs and thorax expand during pressure changes
  - Greater the compliance, easier the expansion
  - Diseases that decrease compliance will increase energy required for breathing
    - Asthma
    - Bronchitis
    - Pulmonary edema

**Ventilation Muscles**

- Compliance
  - Some diseases break down elastic fibers that surround lung tissue
    - Increase lung compliance
    - Can inflate lungs, but difficult to exhale

**Work of Breathing**

- Energy needed for normal, quiet breathing
  - Healthy people = 3 percent of total body expenditure
  - Factors that increase
    - Loss of pulmonary surfactant (e.g., from smoke inhalation)
    - Increase in airway resistance (e.g., from asthma)
    - Decrease in pulmonary compliance (e.g., from cystic fibrosis)
    - Can increase energy requirement to as much as 1/3 of total body expenditure
Work of Breathing

- Pulmonary alveoli have tendency to collapse, result of
  - Recoil caused by elastic fibers
  - Surface tension of alveolar walls
    - Created because water molecules are attracted to each other in the alveolar membrane
  - Pulmonary surfactant lowers surface tension
    - Intermingles with water molecules to reduce cohesive force
    - Helps to prevent collapse of alveolus at end of expiration

Work of Breathing

- Surfactant
  - Composed of lipoproteins that reduce surface tension of pulmonary fluids
  - Constantly being replenished by certain alveolar cells
  - Production stimulated by normal ventilation
    - If production decreases, very high ventilation pressures may be needed to produce lung expansion

Work of Breathing

- Elastic forces of lung oppose lung expansion
- Viscous and frictional forces play central role in impeding airflow into/out of lungs
**Work of Breathing**

- Resistance to airflow is provided by upper airways of the respiratory tract
  - Nasal passages cause about 50 percent of total airway resistance during nose breathing
  - Mouth, pharynx, larynx, and trachea account for approximately 20 to 30 percent of airway resistance during quiet mouth breathing
    - May increase to about 50 percent during times of increased ventilation (e.g., during vigorous exercise)

- Airway resistance
  - Falls as bronchial tree continues to branch toward alveoli
  - Increased with presence of airway secretions or bronchiolar constriction
  - Factors may occur separately
  - More often, they occur at same time (e.g., as in asthma)
  - When resistance to airflow increases, the usual pressure gradient needed for ventilation is inadequate
    - Muscular effort is needed to create a larger pressure gradient

- Increased work
  - Structural changes in lungs or thorax as result of trauma or disease
  - Usually obvious from use of accessory muscles during labored breathing
    - Scalenes
    - Sternocleidomastoid
    - Posterior neck and back muscles
    - Abdominal muscles
How will interruption of the chest wall from a stab wound change the mechanics of breathing?

Lung Volumes and Capacities

- Average adult, 12 to 24 breaths/minute
  - 20% of inspired air never reaches alveoli for gas exchange
  - Instead fills anatomical dead space
    - Upper respiratory tract and lower nonrespiratory bronchioles
  - Physiological dead space
    - Anatomical dead space + volume of nonfunctional alveoli
  - Spaces are nearly identical
    - Some respiratory diseases (emphysema), alveolar walls begin to degenerate
    - Wall destruction increases size of physiological dead space up to 10 times that of anatomical dead space
Lung Volumes and Capacities

- Lungs hold about eight times the amount of air brought in by normal resting inhalation
  - From first breath of life, lungs are never fully emptied
    - After forced expiration, residual volume air remains in alveoli, replenished slowly
    - At least 16 breaths are needed to renew residual volume

Lung Volumes and Capacities

- Tidal volume
  - Gas volume inhaled, exhaled during normal breath
  - Average 500 to 600 mL
    - 150 mL remains anatomical dead space, bronchi, bronchioles, other prealveolar structures until exhaled during next respiratory cycle
    - Therefore, 150 mL atmospheric gas inhaled in each respiration never reaches alveoli, moved into, out of airways
    - Observing rise, fall chest, indirectly observing tidal volume
Lung Volumes and Capacities

• Inspiratory reserve volume
  – Gas amount forcefully inhaled after inspiration of normal tidal volume
  – 2000 to 3000 mL

• Expiratory reserve volume
  – Gas amount forcefully exhaled after expiration of normal tidal volume
  – Less than inspiratory reserve volume, 1200 mL

• Residual volume
  – Gas remaining in respiratory system after forced expiration
  – 1000 to 1200 mL

• Maximum volume lungs can expand
  – Combined measurements of tidal volume, inspiratory reserve volume, expiratory reserve volume, residual volume
Lung Volumes and Capacities

• Pulmonary capacities
  – Sum of two or more pulmonary volumes
  – Inspiratory capacity
    • Tidal volume + inspiratory reserve volume
    • Reflects gas amount a person can inspire maximally after normal expiration
    • 3500 mL
  – Functional residual capacity
    • Expiratory reserve volume + residual volume
    • Reflects gas amount remaining in lungs at end of normal expiration
    • 2300 mL

Lung Volumes and Capacities

• Pulmonary capacities
  – Vital capacity
    • Gas volume that can move on deepest inspiration and expiration, or sum of inspiratory reserve volume, tidal volume, expiratory reserve volume
    • 4600 mL
  – Total lung capacity
    • Sum of vital capacity + residual volume
    • 5800 mL

Which respiratory volumes will be affected by a severe burn that encircles the chest?
Minute Volume

• Gas amount inhaled or exhaled in 1 minute
• Multiply tidal volume by respiratory rate
  – Example: Respiratory rate of 10 breaths/minute, resting tidal volume 500 mL
  • Average minute volume = 5 L/min

Minute Alveolar Ventilation

• Amount of inspired gas available for gas exchange during 1 minute
• Much gas inspired during breathing fills anatomical dead space before reaching alveoli
  – That air is unavailable for gas exchange
• Minute alveolar ventilation = (Tidal volume – Dead space) × Respiratory rate
Minute Volume

- If tidal volume or respiratory rate increases, minute volume increases
- If tidal volume or respiratory rate decreases, minute volume decreases
  - Note depth of breathing (tidal volume) and respiratory rate to determine whether respiratory status is adequate

Measurement of Gases

- Mixture of gases that make up atmosphere exerts a combined partial pressure
  - Pressure measured in millimeters of mercury, or torr (1 torr = 1 mmHg)
    - Based on percentage of particular gas

Measurement of Gases

- Mixture of gases that make up atmosphere exerts a combined partial pressure
  - Atmospheric pressure at sea level (760 mmHg) represents 100%
    - Nitrogen makes up about 78.62% of volume of dry atmospheric gas at sea level
    - Partial pressure that results from nitrogen is calculated by multiplying 78.62% by 760 mmHg = 597 mmHg or partial pressure of nitrogen (P_N2) of 597 torr
    - Oxygen accounts for 20.84% of volume of atmospheric gas
    - Partial pressure of oxygen (P_O2) is found by multiplying 20.84% by 760 mmHg = 159 mmHg, or P_O2 of 159 torr
Measurement of Gases

- Another partial pressure can be measured when gas comes into contact with water
  - Water molecules convert into gas, evaporate, and exert partial pressure
    - Water vapor pressure ($P_{H_2O}$)

Measurement of Gases

- Compositions of alveolar gas and dry atmospheric gas are not the same
  - Result of
    - Humidification of air entering respiratory system by body
    - Exchange of $O_2$ and $CO_2$ between alveoli and blood
    - Incomplete emptying of alveoli with expiration
Lesson 15.2
Pulmonary Circulation, Gas Transport, and Chemical Regulation

Learning Objectives

• Describe pulmonary circulation.
• Explain the process of exchange and transport of gases in the body.
• Describe voluntary, nervous, and chemical regulation of respiration.

Pulmonary Circulation

• Process of gas exchange in lungs
  — Opposite of what occurs in tissues throughout rest of body
  — As inspired gas enters lungs, respiratory system brings O₂ to blood, removes CO₂
  — Blood low in O₂ returns to heart from all parts of body
  • Passing through right side of the heart, blood flows into either lung through the pulmonary artery
  • Then flows into smaller pulmonary arterioles
  • Flows into capillaries that surround each of hundreds of millions of alveoli inside lungs
Pulmonary Circulation

- Alveoli
  - Now filled with high concentration of \( O_2 \) molecules and low concentration of \( CO_2 \) molecules as a result of inhaled air
  - Have pressure gradient required for gas exchange

Pulmonary Circulation

- \( O_2 \) molecules move into surrounding capillaries at the same time that \( CO_2 \) molecules move into alveoli to be exhaled
  - Blood is now rich in \( O_2 \)
    - Flows through pulmonary venules into pulmonary veins
    - Then flows into left atrium, then into left ventricle
    - Next, flows back out through aorta to body’s tissues
    - To supply enough \( O_2 \) to body tissues, alveolus fills and empties more than 15,000 times per day of normal breathing
Exchange and Transport of Body Gases

• Volume of O₂ taken up in lungs can be measured
  – Calculated from difference in amount of O₂ in inspired and expired air
  – Volume of CO₂ eliminated can be determined in same way

Exchange and Transport of Body Gases

• Metabolism
  – All chemical changes that occur in body
  – In a healthy body with a constant metabolism, relationship between tissue CO₂ production and O₂ consumption is fixed
  – Amount of O₂ taken up by capillary blood is greater than the amount of CO₂ released by blood to alveolar gas
  – Expired volume is less than inspired volume

Exchange and Transport of Body Gases

• At rest, combined consumption of all body cells = 200 mL of O₂/minute
• Same amount of CO₂ is produced by cells
  – Because about 20% of atmospheric gas is O₂, total O₂ inspired is 20% multiplied by 5 L, or about 1 L of O₂/minute
  • Of this, 200 mL crosses alveoli into the pulmonary capillaries
  • Remaining 800 mL is exhaled
Exchange and Transport of Body Gases

- 200 mL of O₂ is added to quantity of O₂ already in pulmonary capillaries
  - Then transported to body tissues by circulatory system
  - After body cells use necessary O₂, O₂ remaining in blood returns to heart and lungs.
    - This exchange of O₂ and CO₂ is carried out by diffusion
- Diffusion
  - Tendency for molecules in solution to move from an area of higher to lower concentration

Diffusion

- Molecules of gases are in constant, random motion
  - Motion fueled by collisions with other molecules
- If blood is divided by permeable barrier, gas molecules come into contact with and cross the barrier
  - More likely that highly concentrated molecules will strike and cross membrane than less concentrated molecules
    - Concentration of molecules on either side of a permeable membrane tends to equilibrate
Diffusion

- Diffusion of gases through liquid is determined by:
  - Pressure of gases
  - Solubility of gases in liquid
- When free gas comes into contact with liquid, the number of gas molecules that dissolve in liquid is directly proportional to pressure of gas.
  - When free gas pressure is greater than the pressure of gas in liquid, enough molecules dissolve in liquid to allow free gas pressure = dissolved gas pressure.

Diffusion

- General gas law:
  - If liquid containing dissolved gas at high pressure is exposed to free gas at lower pressure, gas molecules leave liquid and enter free gas until the pressures become equal.
  - Underlying theme of gas exchange between cells and capillary blood throughout body.
Diffusion

• General gas law
  – Partial pressure of free gas (P_{O_2}) in lungs is greater than partial pressure of dissolved O_2 in bloodstream
  • O_2 diffuses from lungs to blood
  • Partial pressure of O_2 in blood is greater than that in peripheral tissues
  • O_2 diffuses from blood into tissues

Diffusion

• Solubility of gases in liquid affects behavior of gases
  – Ease with which gases dissolve determines absolute number of gas molecules that diffuse through liquid at given pressure
  – Example: liquid may be exposed to two different gases at the same pressure
  • Number of molecules of each gas that diffuse may not be the same because of differing solubilities of two gases

Diffusion

• Blood entering pulmonary capillaries is systemic venous blood that has been circulated to lungs via pulmonary arteries
  – P_{CO_2} is relatively high in this blood, P_{O_2} is low
  – Alveoli have greater concentration of O_2 than blood entering pulmonary capillaries
  • O_2 molecules diffuse from alveoli into blood
  • CO_2 moves from blood, where it is more concentrated, into alveoli, where it is less concentrated
Diffusion

• Respiratory membrane
  – Thin layer of tissue that separates blood flowing through pulmonary capillaries from alveolar air
  – Composition
    • Alveolar wall (surfactant, epithelial cells, basement membrane)
    • Interstitial fluid
    • Wall of pulmonary capillary (basement membrane and endothelial cells)

Diffusion

• Respiratory membrane
  – Differences in P_{O_2} and P_{CO_2} on two sides of membrane result in diffusion
    • O_{2} moves into blood and C_{O_2} into alveoli
    • Capillary blood P_{O_2} level rises
    • Capillary blood P_{CO_2} level falls
    • Diffusion stops when alveolar and capillary partial pressures equalize
  – In healthy people, this gas exchange occurs so quickly that blood leaving lungs to be pumped through arteries has nearly the same P_{O_2} (80 to 100 mmHg) and P_{CO_2} (35 to 40 mmHg) as alveolar air
**Diffusion**

- Gas diffusion at capillary-alveolar level affected by
  - Some respiratory diseases (e.g., emphysema) destroy and collapse the alveolar wall
    - Results in formation of fewer but larger alveoli
    - Reduces total area available for diffusion
  - In some diseases, alveolar-capillary membrane becomes thick or less permeable
    - Forces gas molecules to travel farther
    - Decreases rate of diffusion

**O₂ Content of Blood**

- O₂ present in blood in two forms
  - Physically dissolved in blood
  - Chemically bound to hemoglobin (Hb) molecules
- Compared with CO₂ and nitrogen, O₂ is relatively insoluble in water
  - Only 0.3 mL of O₂ can be dissolved in 100 mL of blood at normal alveolar and arterial P₀₂ of 100 mmHg
  - 197 mL of O₂ (about 98%) is carried in red blood cells
  - Is chemically bound to hemoglobin (oxyhemoglobin)
O₂ Content of Blood

• Hemoglobin
  – Can unload CO₂ and absorb O₂ 60 times faster than blood plasma
  – When fully converted to oxyhemoglobin (HbO₂), each hemoglobin molecule can carry 4 molecules of O₂
    • At this point, it is fully saturated
    • Nears full saturation at a Po₂ of 80 to 100 mmHg

O₂ Content of Blood

• Degree it combines with O₂ increases rapidly when Po₂ is 10 to 60 mmHg
  – Cause: about 90% of total hemoglobin is combined with O₂ when Po₂ is 60 mmHg
  – Further increases in Po₂ produce only small increases in amount of O₂ bound to hemoglobin
  – If Po₂ falls slightly, amount of oxyhemoglobin decreases only slightly
    • Still provides adequate oxygenation to tissues
    • Body adapts to higher Po₂ values
O₂ Content of Blood

• Venous blood entering lungs has a Po₂ of 40 mmHg and hemoglobin saturation of 75 percent
• O₂ diffuses from alveoli (because of its higher Po₂ of 100 mmHg) into plasma
  – This diffusion raises plasma Po₂
  – Produces increase in uptake of O₂ by hemoglobin molecules
  – In tissue capillaries, process is reversed
    • As blood enters capillaries, plasma Po₂ is greater than Po₂ in fluid surrounding capillaries
    • Causes diffusion across capillary membranes to cells of tissues

CO₂ Content of Blood

• CO₂ amount produced by body
  – Fairly constant
  – Determined by body’s rate and type of metabolism
  • If metabolic rate increases, more CO₂ is produced
  • As metabolic rate decreases, less CO₂ is produced
  • Certain types of metabolic processes also result in increased CO₂ production

CO₂ Content of Blood

• CO₂ is transported in blood in three major forms
  – Plasma
  – Blood proteins
  – Bicarbonate ions
• CO₂ solubility in water is very minimal
  – Accounts for 8 percent of CO₂ carried in plasma
  – 20 percent present in blood proteins (including hemoglobin)
  – 72 percent is in the form of bicarbonate ions
CO₂ Content of Blood

• When arterial blood flows through tissue capillaries, oxyhemoglobin gives up O₂ to tissues
  – At the same time, CO₂ diffuses from tissues into blood
    • Small amount of CO₂ dissolves in plasma

• Oxygen-free hemoglobin binds more readily to CO₂ than hemoglobin binds with O₂
  – Some of CO₂ that diffuses into red blood cells binds to hemoglobin to form carbaminohemoglobin (HbNHCOOH)
    • Remainder of CO₂ reacts with water to form carbonic acid
    • Bicarbonate is very soluble in water
    • Venous blood rich in CO₂ is returned to lungs
    • Because blood Pco₂ is greater than that in alveoli, CO₂ from blood diffuses into alveoli
    • From there it is exhaled and eliminated from body
Blood Oxygenation Factors

- Process of breathing
  - Fully oxygenates blood at alveolar-capillary level
  - Allows CO₂ to be eliminated
- Movement and utilization of O₂ in body to perfuse tissues can be described by Fick principle
  - Amount of O₂ lungs deliver to blood is directly related to amount of O₂ that body consumes

Blood Oxygenation Factors

- Movement and utilization of O₂ based on
  - Adequate amount of O₂ must be available to saturate hemoglobin on red blood cells as they pass by alveolar membranes in lungs
    - Requires adequate ventilation of lungs through patient’s airway
    - Requires high partial pressure of O₂ in inspired air (Fio₂)
    - Requires minimal obstruction to diffusion of O₂ across alveolar-capillary membrane
Blood Oxygenation Factors

- Movement and utilization of O₂ based on
  - Red blood cells must be circulated to tissue cells
    - Requires adequate cardiac function
    - Requires adequate volume of blood flow
    - Requires proper routing of blood through vascular channels

Blood Oxygenation Factors

- Movement and utilization of O₂ based on
  - Red blood cells must be able to load O₂ in pulmonary capillaries
    - Must be able to unload O₂ at site of peripheral tissue cells
    - Requires normal hemoglobin levels
    - Requires circulation of the oxygenated red blood cells to tissues in need
    - Requires close approximation of cells to capillaries to allow for diffusion of O₂ and ideal conditions of pH, temperature, and other factors

Blood Oxygenation Factors

- Hypoxemia
  - State of decreased O₂ content of arterial blood
  - May lead to hypoxia (decreased O₂ content at tissue level)
  - Some abnormal conditions can result in inadequate blood oxygenation
# Blood Volume Circulation Disturbances

- Disturbances in effective circulation of blood
  - Can affect body's ability to nourish tissues and maintain adequate cellular oxygenation
  - Can result from cardiac disease, trauma, problems with systemic vascular resistance
  - Heart rate must be capable of circulating blood through vascular system for adequate tissue perfusion

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- Disturbances in effective circulation of blood
  - Conditions that can negatively affect circulation include conduction disturbances, tachycardia, bradycardia, and inadequate preload that diminishes stroke volume
  - Role of autonomic nervous system and medications that affect alpha and beta stimulation of heart are also important for adequate cardiac function

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- Total peripheral resistance
  - Vascular resistance in systemic circulation
  - Must be adequate to maintain BP and cardiac output
  - Factors that affect
    - Capacitance of blood vessels (functioning precapillary arterioles)
    - Smooth muscle effects initiated by alpha and beta cholinergic receptors
    - Hypoxia, acidosis, and effectiveness of the buffer systems, temperature changes, neural factors, and catecholamines
Respiratory Regulation

• Respiration is controlled by a number of factors
  – When paramedics evaluate patient, key elements they must consider include various mechanisms responsible for rhythmic ventilation
  – Rate and depth of breathing are also crucial factors

Respiratory Voluntary Control

• Breathing is an involuntary process
  – Pattern of respiration can be consciously altered
  – Example: voluntary hyperventilation can lead to decrease in blood Pco2, vasodilation of peripheral blood vessels, decrease in BP, or a combination of these effects
    • Hyperventilation causes excessive loss of exhaled CO2, which produces hypocarbia, resulting in cerebral vascular constriction, reduced cerebral perfusion, paresthesia (tingling sensation), dizziness, even feelings of euphoria

Respiratory Voluntary Control

• Breathing can be affected by voluntary apnea
  – Arterial blood Pco2 increases, Po2 decreases
  – As apneic period continues, abnormal levels of Pco2 and Po2 trigger respiratory centers
    • Changes in levels override child's conscious control of breathing
    • If loss of consciousness occurs, respiratory center resumes normal function
Respiration Nervous Control

• Inspiratory muscles
  – Diaphragm and intercostal muscles
  – Composed of skeletal muscle
  – Cannot contract unless stimulated by nerve impulses
  – 2 phrenic nerves responsible for moving diaphragm originate from 3rd, 4th, and 5th cervical spinal nerves
  – 11 pairs of intercostal nerves originate from the 1st to the 11th thoracic spinal nerves
    • Nerve impulses that control these respiratory muscles originate in neurons of the medulla

Respiration Nervous Control

• Inspiratory muscles
  – Inspiratory and expiratory center
    • Influenced by pons, hypothalamus, reticular activating system (RAS), and cerebral cortex
    • Innervated by afferent activity in vagus, glossopharyngeal, and somatic nerves
What alteration in breathing would you anticipate in a patient who has an injury affecting the pons?

Respiration Nervous Control

• Inspiratory center neurons
  – Spontaneously active
  – Exhibit a pattern of activity followed by fatigue and then activity again
  – When active, send impulses along spinal cord to phrenic and intercostal nerves
    • Stimulate muscles of inspiration

Respiration Nervous Control

• Expiratory center
  – Inactive during quiet respiration
  – Exact nervous system mechanisms that control activity are unknown
    • Appears to be stimulated when the activity of the inspiratory center increases
    • When activated, counters inspiratory center, responding to forceful inspiration with forceful expiration
### Respiration Nervous Controls

- **Hering-Breuer reflexes**
  - One of two neural mechanisms responsible for basic respiratory rhythm established by inspiratory and expiratory centers
  - Vagus nerve conveys sensory information from thoracic and abdominal organs
  - Some vagus nerve fibers end in stretch or inflation receptors in walls of bronchi, bronchioles, lungs

### Respiration Nervous Control

- **Hering-Breuer reflexes**
  - When stretch receptors are stimulated by expansion of lungs, information is communicated by vagus nerve to medulla
    - Medulla produces discharges of inhibitory impulses, causes inspiration to stop (inflation reflex)
    - Followed by expiration or deflation of lungs
    - As expiration continues, stretch receptors are no longer stimulated
    - Allows inspiratory center to become active again (deflation reflex)
    - Hering-Breuer reflexes limit inspiration and prevent overinflation of lungs

### Respiration Nervous Control

- **Pneumotaxic center**
  - Located in pons above respiratory center in medulla
  - Has inhibitory effect on inspiratory center
  - When activity of inspiratory center stops, inhibitory impulses from pneumotaxic center stop
    - Then the inspiratory center is free to send impulses to initiate inspiration again
  - Appears to be active only in labored breathing
  - In quiet breathing, stretch receptors are the main control mechanisms for rhythmic breathing
Respiration Nervous Control

- Apneustic center
  - Located in lower portion of pons
  - Nerve impulses from this area stimulate inspiratory center
  - Center neurons are constantly active during normal respiratory rates
    - Overridden by pneumotaxic center when demand for increased ventilation arises

Respiration Chemical Control

- Activities of respiratory centers
  - Determined by changes in O₂ and CO₂ concentrations
  - Determined by hydrogen ion concentration (pH) of body fluids.
    - Partial pressure of CO₂ is major factor that controls respiration

Respiration Chemical Control

- Chemoreceptive area in medulla has neurons sensitive to changes in CO₂ and pH
  - Increase or decrease in plasma Pco₂ is accompanied by changes in pH
    - Increase in Pco₂ and resulting decrease in pH adversely affect cellular metabolism
    - Excess CO₂ must be eliminated to return the pH to normal
    - Decrease in Pco₂ inhibits ventilation
    - CO₂ created by normal metabolism is allowed to accumulate and return Pco₂ to normal
Respiration Chemical Control

- $O_2$ plays a fairly small part in regulating respiration
  - If $Po_2$ levels in arterial blood fall and pH and $Pco_2$ are held constant, ventilation increases

Respiration Chemical Control

- Chemoreceptors monitor arterial $Po_2$
  - Located in medulla and peripherally at bifurcation of common carotid arteries and in arch of aorta
    - Peripheral receptors are known as carotid and aortic bodies
- Carotid and aortic bodies
  - In intimate contact with arterial blood of great vessels
    - Their blood supply is greater than their use of $O_2$
    - $Po_2$ of their tissues is very close to that of arterial blood
    - Nerve fibers from these bodies enter brainstem
    - They synapse with neurons of medulla and initiate respiratory response
Respiration Chemical Control

• Respiration regulators
  – CO₂ and hydrogen ion concentrations
  – Reduced Po₂ in arterial blood
  – When patient is hypotensive (e.g., in shock), Po₂ in arterial blood may fall to low levels, which stimulates sensory receptors in carotid and aortic bodies
  • Leads to increased rate and depth of ventilation
  • Can occur without significant change in blood Pco₂
  • Usually accompanied by metabolic acidosis that occurs secondary to anaerobic metabolism

Respiration Chemical Control

• Po₂ plays a role in respiratory regulation at high altitudes
  – Barometric pressure is low
  • Causes Po₂ in arterial blood to drop
  • Low Po₂ levels stimulate carotid and aortic bodies
  • Does not affect body’s ability to eliminate CO₂
  • Increase in ventilation (triggered by the lowered arterial Po₂) results in drop in CO₂ levels in blood

Respiration Chemical Control

• Severe emphysema or chronic bronchitis causes chronically elevated Pco₂ levels
  – May rely on low Po₂ as stimulus for ventilation (hypoxic drive)
  – Chemoreceptors become less sensitive to high CO₂ level, fail to be stimulated
  – Over time, hypoxia becomes only remaining respiratory drive
Other Factors for Respiration Control

• Body temperature
  – Increase can affect respiratory center neurons
  • May be caused by febrile illness or increase in physical activity
  • Can cause increase in ventilation
  – Major decreases can lower the ventilation rate

Other Factors for Respiration Control

• Drugs and medications
  – Some stimulate ventilation
  • Promote cellular metabolism during stressful events and vigorous exercise
  – Drugs such as diazepam and morphine may decrease ventilations
  – Overdose of narcotics or barbiturates can become apneic

Other Factors for Respiration Control

• Pain
  – May produce reflex stimulation of ventilation
• Emotions
  – Require increase in movement of air into and out of lungs
  – Fear and anger cause rapid breathing
• As body’s activity and metabolism slow, so does formation of impulses to stimulate respiratory centers
  – Decreased activity decreases ventilation
**Modified Forms of Respiration**

- Cough and sneeze reflex are protective mechanisms
  - Function is to dislodge foreign matter or irritants from respiratory passages
  - Coughing generally is preceded by inspiration of greater than normal force (about 2.5 L of gas)
    - Glottis then closes, and muscles of thorax contract forcibly
    - Causes increase in intrapulmonic pressure
    - Pressure change in lungs increases to about 100 mmHg
    - When this pressure is reached, vocal cords part, and air escapes from lungs at high velocity, carries foreign materials and particles of mucus out of lungs

- Sneezing is violent expulsion of gas
  - Gas is forced or directed through nasal cavity
  - May occur as result of nasal irritants, stimulation of fifth cranial nerve (trigeminal nerve) in nose, or exposure to bright lights
  - Uvula and soft palate are depressed to direct air through both nasal passages and oral cavity

- Other forms of modified respiration include sigh and hiccup
  - Sighing is slow, deep inspiration followed by prolonged expiration
  - Thought to be protective reflex to hyperinflate lungs and to reexpand alveoli that might have been collapsed (atelectasis)
## Modified Forms of Respiration

- Hiccough results from spasmodic contraction of diaphragm with sudden inspiration cut short by closure of glottis
  - Serves no known useful physiological purpose
  - Ceases with time
  - May indicate pathological condition

## Older Patient Considerations

- Pulmonary changes decrease vital capacity
- Increase physiological dead space
- Ventilation–perfusion mismatching also tends to increase
  - Leads to a gradually lowered Po₂

## Older Patient Considerations

- Changes in pulmonary physiology include
  - Alterations in lung and chest wall compliance
  - Increased thoracic rigidity
  - Decreased elastic recoil
  - Enlarged alveolar ducts and sacs
  - Fewer alveoli
  - Less alveolar surface for gas exchange
Older Patient Considerations

- Changes in body’s ventilatory control mechanisms
  - Body’s arterial Po2 falls, yet no significant change in arterial Pco2 occurs
- Methods to calculate expected Pco2
  - Person who is 70 years old expected to have a Po2 of 70 mmHg
    - Using this value as baseline, expected change is 1 mmHg decrease in Po2 for every year over 70 or a 1 mmHg increase in Po2 for every year under 70

Older Patient Considerations

- Functioning of body’s chemoreceptors declines with age
  - Results in diminished ventilatory response to hypoxia, hypercapnia, and similar conditions
  - May predispose older individual to respiratory failure
  - Older patients with respiratory compromise from any cause must receive immediate intervention, oxygenation, and ventilatory support
Lesson 15.3
Obstruction, Aspiration, Assessment, and Supplemental Oxygen

Learning Objectives

- Discuss the assessment and management of airway obstruction.
- Describe risk factors and preventive measures for pulmonary aspiration.
- Outline assessment of airway and breathing.
- Describe the indications, contraindications, and techniques to deliver supplemental oxygen.

Upper Airway Obstruction

- Common cause of poor ventilation
- In conscious, caused by
  - Inhalation of food
  - Foreign body
  - Fluid (vomitus, saliva, blood, neutral liquids)
- Establishing and maintaining clear airway in any patient with poor ventilation from any cause are most critical lifesaving maneuvers paramedics can perform
  - Should always be first-order priority of patient care
Upper Airway Obstruction

- Factors in preventing unnecessary deaths from airway compromise
  - Early detection
  - Early intervention
  - Education of general public in basic life support measures

Foreign Body Airway Obstruction

- About 3,000 deaths each year
- Immediate removal of obstruction might have prevented the resulting hypoxemia, unconsciousness, or cardiopulmonary arrest that caused these deaths

Conscious Person Airway Obstruction

- Meat is most common cause of foreign body airway obstruction in conscious adults
- Factors associated with choking
  - Large, poorly chewed pieces of food
  - Elevated blood alcohol level
  - Poorly fitting dentures
- Patient often is middle aged or older
Conscious Person
Airway Obstruction

• Partial obstruction
  – Usually can speak
  – Can usually cough forcefully in effort to expel object
  – If air exchange is adequate, rescuer should not intervene
  – Monitor patient closely
  – Encourage patient to persist with spontaneous coughing and breathing efforts

Conscious Person
Airway Obstruction

• If obstruction persists or air exchange becomes severe, manage as complete airway obstruction
  – Silent cough
  – Wheezing
  – Increased respiratory difficulty
  – Decreased air movement
  – Cyanosis

Conscious Person
Airway Obstruction

• Complete airway obstruction
  – Signs:
    • Cannot speak (aphonia)
    • Cannot exchange air
    • Cannot cough
    • Often grasp neck between thumb and fingers (universal sign of choking)
Conscious Person Airway Obstruction

- Complete airway obstruction
  - Need immediate rescuer intervention
  - Causes hypoxemia
  - Can lead to an acute MI in patients with atherosclerotic cardiovascular disease
  - Leads to cardiac arrest in all patients if not corrected within minutes

Unconscious Person Airway Obstruction

- More often obstruction is caused by unconsciousness and cardiopulmonary arrest
  - Primary source is the tongue
  - Attached to the mandible by muscles that form floor of mouth
  - Normal tone allows air exchange by keeping posterior pharynx open
  - Unconsciousness causes relaxation of muscles
  - May cause airway to be blocked by tongue

Unconscious Person Airway Obstruction

- Airway obstruction by the tongue is common in
  - Cardiac arrest
  - Trauma
  - Stroke
  - Intoxication with alcohol, barbiturates, or psychotropic drugs
  - Paralysis caused by muscle relaxants
  - Myasthenia gravis
  - Fractured facial and nasal bones
Laryngeal Spasm and Edema

- Spasmodic closure of vocal cords often caused by aggressive intubation technique
  - May occur during extubation (removal of the endotracheal tube), especially if patient is semiconscious

Laryngeal Spasm and Edema

- Laryngeal spasm
  - Best managed with aggressive ventilation and forceful upward pull on jaw
  - May require use of muscle relaxants
  - Maintaining steady pressure against cords with endotracheal tube sometimes overcomes spasmodic closure

Laryngeal Spasm and Edema

- Swelling of glottic and subglottic tissues of airway can close off larynx
  - Edema may result from inflammatory or mechanical causes
    - Epiglottitis
    - Croup
    - Allergic reaction
    - Thermal injuries
    - Strangulation
    - Blunt trauma
    - Drowning
Laryngeal Spasm and Edema

- Swelling of glottic and subglottic tissues of airway can close off larynx
  - Associated swelling may partly or completely obstruct airway
  - Aggressive airway management (including consideration for cricothyrotomy) required for patient’s survival

Fractured Larynx

- Most common cause of external trauma to larynx is motor vehicle crash
- Indications for larynx fracture
  - Localized laryngeal pain on palpation or swallowing
  - Stridor
  - Hoarseness
  - Difficulty with speech (dysphonia)
  - Hemoptyis (coughing up blood)

Fractured Larynx

- Laryngeal injury can result in lack of support for vocal cords
  - May cause them to collapse into tracheal–laryngeal opening, thereby obstructing airway
Fractured Larynx

• Signs for impending airway obstruction as result of fracture
  – Subcutaneous emphysema
  – Dysphagia (difficult swallowing)
  – Throat discomfort that increases with coughing or swallowing
  – Paramedic should remain alert to possibility of laryngeal fracture
  – Important because laryngeal edema can rapidly close off airway

Fractured Larynx

• Certain types of injury may cause laryngeal fracture
  – Clothesline injury
  – Blunt trauma to the neck
• Requires rapid intervention
  – Cricothyrotomy may be required
  – Must secure open airway before laryngeal edema and hemorrhage cause complete closure

Tracheal Trauma

• Trauma to trachea is rare but serious
  – Most common site is area bordered by cricoid cartilage and third tracheal ring
  – Seldom occurs as an isolated event
  – More often associated with injuries to surrounding esophagus and cervical spine
  – CNS injuries and abdominal and thoracic trauma also usually accompany tracheal injury
Aspiration by Inhalation

- Aspiration
  - Active inhalation of food, a foreign body, or fluid (e.g., vomitus, saliva, blood, neutral liquids) into airway
  - May cause
    - Spasm
    - Mucus production
    - Atelectasis
    - Change in pH (if substance is acidic)
    - Coughing

Aspiration by Inhalation

- Aspiration
  - Prevention is far superior to any known treatment
    - Control and maintain airway
    - Be prepared for chance of aspiration in patients with a diminished level of consciousness

Aspiration by Inhalation

- 80 percent of 3,000 deaths each year from foreign body aspiration occur in children
- Risk factors
  - Running with food or other objects in mouth
  - Seizures
  - Forced feeding
  - Hot dogs and peanuts
  - Dental or nasal surgery
  - Loss of consciousness
  - Swallowing of poorly chewed food
  - Alcohol intoxication
Aspiration by Inhalation

• Large food particles and other foreign bodies can block airway
  – May cause hypoventilation of lower lung segments
  – Size of particle determines which airway is obstructed and to what extent
    • 60 percent found in right mainstem bronchus
    • 19 percent in left
    • 21 percent at larynx or vocal cords
  – When larynx or trachea is completely obstructed, victim can die from asphyxiation within minutes

Aspiration by Inhalation

• Average adult stomach has capacity of 1.4 L
  – Manufactures additional 1.4 L of gastric juices in each 24-hour period
  – Hydrochloric acid is manufactured by special cells in the gastric mucosa
    • With assistance of protein-dissolving enzyme (pepsin), helps break down large pieces of food into smaller ones

Aspiration by Inhalation

• Vomitus
  – Contains partly digested food particles and acidic gastric fluid
• Saliva
  – Watery, slightly acidic fluid
  – Secreted in mouth by major salivary glands
  – Secreted in smaller salivary glands in mucous membranes that line mouth
  – Contains digestive enzyme amylase
    • Helps break down carbohydrates
Aspiration by Inhalation

• Saliva
  – Contains a number of other substances
    • Minerals (e.g., sodium, calcium, and chloride)
    • Proteins
    • Mucin (principal constituent of mucus)
    • Urea
    • White blood cells
    • Debris from the lining of the mouth
    • Bacteria

Aspiration by Inhalation

• Consequences of aspiration of neutral liquids (liquids that are neither acidic nor basic)
  – Easier to reverse with supportive therapy than consequences of aspiration of acids or bases
  – Aspiration of large volume of neutral liquids is also associated with high mortality rate

Aspiration Pathophysiology

• Two conditions associated with high risk of aspiration
  – Diminished level of consciousness
  – Mechanical disturbances of airway and GI tract
Aspiration Pathophysiology

- Diminished level of consciousness causes
  - Trauma
  - Alcohol or other drug intoxication
  - Seizure disorder
  - Cardiopulmonary arrest
  - Stroke

Aspiration Pathophysiology

- Diminished level of consciousness causes
  - CNS dysfunction
    - Common element of these conditions is depression or loss of the gag reflex, with or without a full stomach
    - Gag reflex is normal neural reflex triggered by touching soft palate or posterior pharynx

Aspiration Pathophysiology

- Iatrogenic obstructions
  - Those caused by medical procedures
  - Common type of mechanical obstruction
  - Results from use of various devices to control upper airway problems
    - Removal of certain airway devices (risk of vomiting on removal)
    - Placement of nasogastric tube
    - Intubation
    - Requires adequate seal at tracheal orifice to prevent aspiration
Aspiration Pathophysiology

• Other mechanical or structural problems with high risk
  – Tracheostomy and esophageal motility disorders
    • Hiatal hernia
    • Esophageal reflux
  – Intestinal obstructions
  – Those being fed by gastric tube

Aspiration Pathophysiology

• Chances increase whenever vomiting occurs
• Vomiting follows stimulation of vomiting center of medulla
  – Can result from irritation anywhere along the GI tract from
    • Information passed to medulla from frontal lobes of brain
    • Disturbances in balance mechanism (vestibular system) of the inner ear

Aspiration Pathophysiology

• Once center is stimulated, the following events occur:
  – Deep breath taken
  – Hyoid bone and larynx are elevated
    • Opens preesophageal sphincter
  – Opening of larynx closes
  – Soft palate is elevated, closing posterior nares
Aspiration Pathophysiology

- Once center is stimulated, the following events occur
  - Diaphragm and abdominal muscles contract forcefully
    • Compresses stomach and increases intragastric pressure
  - Lower esophageal sphincter relaxes
    • Stomach contents are propelled into lower esophagus
  - If patient is unconscious or unable to protect airway, pulmonary aspiration may occur

Pulmonary Aspiration Effects

- Severity depends on
  - pH of aspirated material
  - Volume of aspirate
  - Whether particulate matter (e.g., food) and bacterial contamination are present in aspirate

Pulmonary Aspiration Effects

- Mortality rates
  - When pH level of aspirated material is less than 2.5, severe pulmonary damage occurs
  - When pH is less than 1.5, patient usually dies
  - Mortality rate among patients who aspirate grossly contaminated material (as occurs in bowel obstruction) approaches 100 percent
Pulmonary Aspiration Effects

- Toxic effects on lungs from gastric acid (which has pH less than 2.5) can be equated with those of chemical burns
  - Severe injuries that produce pulmonary changes
    - Destruction of surfactant-producing alveolar cells
    - Alveolar collapse and destruction
    - Destruction of pulmonary capillaries

- Permeability of capillaries increases with massive flooding of alveoli and bronchi with fluid
  - Resulting pulmonary edema creates areas of hypoventilation, shunting, and severe hypoxemia
  - Massive fluid shift from intravascular area to lungs may also produce hypovolemia severe enough to require volume replacement

Airway Ventilation
Essential Parameters

- Essential parameters of airway evaluation
  - Rate
  - Regularity
  - Effort
  - Recognition of airway problems that might indicate respiratory distress
Rate, Regularity, Effort

- Normal respiratory rate in resting adult = 12 to 24 breaths/minute
- Regularity is steady inspiratory and expiratory pattern
  - Breathing at rest should be effortless
  - Should be marked only by subtle changes in rate or regularity

Rate, Regularity, Effort

- Positions used by those in respiratory distress
  - Upright sniffing position
    - Sitting upright with head tilted back
  - Tripod position
    - Leaning forward on arms
  - Semi-Fowler’s position
    - Lying down with head and thorax slightly elevated (semi-Fowler’s position)
  - All frequently avoid lying flat, or supine

Why would lying in the supine position likely worsen respiratory distress?
Airway Problems Recognition

- Respiratory distress may be caused by
  - Upper or lower airway obstruction
  - Inadequate ventilation
  - Impairment of respiratory muscles
  - Ventilation–perfusion mismatching
  - Diffusion abnormalities
  - Impairment of nervous system

Observation Techniques

- Visual clues can aid recognition of airway problems
  - Note patient’s preferred position to facilitate breathing
  - Assess rise and fall of patient’s chest
  - Gasping for air
  - Cyanosis
  - Nasal flaring
  - Pursed-lip breathing
  - Retraction of intercostal or substernal muscles, suprasternal notch, and supraventricular fossa during respirations
Auscultation, Palpation, and Percussion Techniques

- Air movement evaluated by
  - Listening to respirations without using stethoscope
  - Using stethoscope to assess bilateral lung fields
- Palpation of chest wall helps determine
  - Presence or absence of paradoxical (contrary) motion of chest wall, inspiration, expiration, and any retraction of accessory muscles
- Percussion may be helpful
  - Used to help determine the presence of air or blood in chest cavity when diminished breath sounds or unequal chest wall movement are present

Other Respiratory Distress Signs

- Resistance or changing compliance when assisting or delivering respirations with bag-valve-mask
- Presence of pulsus paradoxus
History

• Determine progression and duration of dyspneic event
  – Ask whether event was sudden in onset or occurred over time
  – If occurred over time, length of that period should be determined
  – Did any known causes or triggers initiate difficulty breathing?
  – Is respiratory distress continuous or recurring?
  – What makes it better?
  – What makes it worse?

• Determine progression and duration of dyspneic event
  – Do any other symptoms occur at the same time (e.g., cough, chest pain, fever)?
  – Has any treatment with drugs been attempted?
  – Has the patient taken all medications and treatments as prescribed?
  – Crucial to determine whether patient has been previously evaluated or hospitalized for the condition and whether person has ever been intubated because of respiratory problems

Respiratory Pattern Changes

• Breathing process should be
  – Comfortable
  – Regular
  – Performed without distress

• Abnormal respiratory patterns are commonly seen in ill or injured patients
  – Recognizing patterns may help paramedics determine proper patient care
Inadequate Respiration

- Inadequate respiration can occur when
  - Body cannot compensate for increased oxygen demand
  - Cannot maintain normal range of oxygen/carbon dioxide balance

- Factors for inadequate ventilation and respiration
  - Infection
  - Trauma
  - Brainstem injury
  - Noxious or hypoxic atmosphere
  - Patient with respiratory compromise may have a number of symptoms and various respiratory rates and breathing patterns
Supplemental Oxygen

• May be provided for two reasons
  – Enriched oxygen in atmosphere increases the oxygen content in pulmonary capillary blood
  – Allows patient to compensate without increasing the work of breathing

Oxygen Sources

• Most common form of oxygen used in prehospital setting is pure oxygen gas, delivered in liters per minute (LPM)
  – Stored under pressure in stainless steel or lightweight alloy cylinders
  – Color coded by U.S. Pharmacopeia to distinguish various compressed gases
  – Steel green and white cylinders have been assigned to all grades of oxygen
  – Stainless steel and aluminum cylinders are not painted
Oxygen Sources

• Oxygen cylinders are filled under pressure of 2000 to 2200 psi
  – Safety is critical when equipment is handled
  – Ensure that correct regulator is firmly attached before moving an oxygen cylinder
  – Cylinder should never be handled by neck assembly alone
  – Most oxygen cylinders are considered “empty” at 200 psi
    • As a rule, tanks with less than 500 psi are too low to keep in service

Liquid Oxygen

• Liquid oxygen (LOX) has been cooled to its aqueous state
  – Converts to a gaseous state when warmed
• Used by some air medical services and by other EMS agencies when weight and space that standard oxygen systems occupy must be considered

Liquid Oxygen

• Advantage of LOX is that much larger volume of gaseous oxygen can be stored in an aqueous state
• Disadvantages of LOX
  – Cost
  – Generally requires upright storage
  – Special requirements are necessary for large-volume storage and cylinder transfer
Regulators

• High-pressure regulators
  — Used to transfer cylinder gas from tank to tank
  — Attached to cylinder stems and allow cylinder gas to be delivered under high pressure

• Therapy regulators
  — Used to deliver a safe pressure of oxygen to patients
  — Attached to cylinder stem
  — Work through regulator mechanism whereby 50 psi escape pressure is reduced (“stepped down”) to 30 psi for safe delivery to patient

Flowmeters

• Control amount of oxygen delivered to patient
  — Connected to pressure regulator
  — Adjusted to deliver oxygen at set number of liters/minute

• Some EMS agencies attach disposable humidifiers
  — Provide moisture to dry oxygen coming from supply cylinder
  — Desirable for long-term oxygen administration and for patients with croup, epiglottitis, or bronchiolitis

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Oxygen Delivery Devices

- Patients with spontaneous respirations can receive supplemental oxygen through several different delivery devices
  - Nasal cannula
  - Simple face mask
  - Partial rebreather mask
  - Nonrebreather mask
  - Venturi mask

Nasal Cannula

- Delivers low-concentration oxygen
  - By way of two small plastic prongs placed into nostrils
- Should not be used for
  - Poor respiratory effort
  - Severe hypoxia
  - Apnea
  - Patients who are primarily mouth breathers
- Well tolerated, but does not deliver high-volume/high-concentration oxygen
Nasal Cannula

- Difficult to obtain oxygen concentrations greater than 30 to 35 percent
  - Because patient continues to mouth breathe during oxygen administration
    - Reduces concentration of oxygen inspired through nose
  - Ineffective if patient’s nose is blocked by blood or mucus

- Use limited to patients who would benefit from low-concentration oxygen delivery
  - May include some patients with chest pain and patients who have chronic pulmonary disease
  - Maximum oxygen flow rate for nasal cannula is 6 L/min

Simple Face Mask

- Soft, clear plastic mask
  - Conforms to patient’s face
  - Small perforations in mask allow atmospheric gas to be mixed with oxygen during inhalation
    - Permit patient’s exhaled air to escape
Simple Face Mask

- O₂ concentrations of 25 to 60 percent can be delivered with flow rate of 6 to 10 L/min
  - Flow rate of more than 6 L/min can produce accumulation of CO₂ in mask
    - O₂ delivery through any face mask should always exceed this minimum
    - Flow rates above 10 L/min do not enhance O₂ concentration
- All masks must be well fitted to patient’s face for optimal benefit
  - Leaks reduce the O₂ concentration

Partial Rebreather Mask

- Has attached O₂ reservoir bag
  - Should be filled before patient uses mask
  - Has vent ports covered by one-way disks
    - Allow portion of patient’s exhaled gas to enter the reservoir bag and be reused
    - Remainder of the CO₂-loaded gas escapes into atmosphere
    - O₂ concentrations of 35 to 60 percent can be delivered with flow rate that prevents reservoir bag from collapsing completely on inspiration
Partial Rebreather Mask

- Should not be used in patients with apnea or poor respiratory effort
  - Delivery of volumes above 10 L/min does not enhance oxygen concentration

Nonrebreather Mask

- Similar in design to partial nonrebreather
  - Flutter valve assembly in mask piece stops patient's exhaled air from returning to reservoir bag
    - Delivers oxygen concentrations up to and above 95 percent
    - Flow rate must be adequate to keep reservoir bag partly inflated during inspiration
    - Paramedics should ensure that mask is seated firmly over patient's mouth and nose
    - Ensure reservoir bag is never less than 2/3 full
    - Most often used in patients who need high-concentration oxygen delivery (10 to 15 L/min)
    - Should not be used in patients with apnea or poor respiratory effort
What could happen if the oxygen source is disconnected from a nonrebreather mask?

**Venturi Mask**

- High-airflow
  - Delivers precise fraction of inspired oxygen (Fio₂) at typically low concentrations
  - Originally designed to deliver 30 to 40 percent concentrations
  - Has been adapted to deliver higher oxygen percentages
  - Uses “jet mixing” of atmospheric gas and oxygen to achieve desired mixture
Venturi Mask

• Color-coded adapters in various sizes are attached to mask to control the oxygen flow rate
  – Standard size adapters are 3, 4, and 6 L/min
  – Color codes and adapters state exact liter flow to use to obtain precise Fio₂
  – Choosing different liter flow greatly alters the Fio₂ delivered
• Various masks deliver 24 to 50 percent oxygen
  – Advised for patients who rely on hypoxic respiratory drive

Venturi Mask

• Allows precise regulation of Fio₂
  – Permits paramedic to titrate oxygen for patient with COPD so as not to exceed patient’s hypoxic drive while allowing enrichment of supplemental oxygen
• Care must be taken to match proper Fio₂ to correct flow rate
  – Otherwise, Venturi mask does not deliver the indicated Fio₂
Lesson 15.4
Augmenting Patient Ventilations

Learning Objective

- Discuss the methods of patient ventilation based on the indications, contraindications, potential complications, and use of each method.

Augmenting Patient Ventilations

- Patients with spontaneous breathing and having dyspnea or respiratory compromise need assistance to improve airflow and oxygenation
- Methods to improve patient's arterial oxygenation
  - Continuous positive airway pressure (CPAP)
  - Biphasic positive airway pressure (BiPAP)
Augmenting Patient Ventilations

• CPAP and BiPAP purpose
  – Improve oxygenation through positive pressure during ventilation
  – Reduce work of breathing
  – Prevent atelectasis
  – Allow for drug administration
  – May prevent need for intubation and risks and complications associated with invasive airway procedures

CPAP

• Transmits positive pressure into airways of spontaneously breathing patient throughout respiratory cycle
  – Increase in airway pressure allows for better diffusion of gases and reexpansion of collapsed alveoli
  – Results in improvement of gas exchange and reduction in work of breathing
  – Can be applied invasively in patient with spontaneous breathing (through endotracheal tube)

• Transmits positive pressure into airways of spontaneously breathing patient throughout respiratory cycle
  – Can be applied noninvasively through face or nose mask
  – Mask CPAP provided through tight-fitting face or nose mask
  – Facemask connected to battery-operated or oxygen-driven breathing circuit
  – Breathing circuit may have fixed or adjustable fraction of FiO₂ and fixed or adjustable pressure valve that delivers pressures of 5 to 10 cm H₂O or more
CPAP

• Lowers mean airway pressures
• May benefit patients who have obstructive airway disease

CPAP

• Patients who receive CPAP usually are quite anxious
  – 5 minutes after mask is applied, patient should be observed for signs and symptoms of improvement
    • Reduced effort of breathing
    • Increased ease in speaking
    • Slowing respiratory and heart rate
    • Increased PaO₂
**CPAP**

- Patients likely will require extensive coaching and reassurance from paramedic
- Use with standard drug therapy to treat pulmonary edema has been shown to reduce need for intubation

**BiPAP**

- Combines partial ventilatory support and CPAP
- Allows pressure to vary during each breath cycle
- Upon inhalation, pressure is similar to CPAP

**BiPAP**

- Upon exhalation, pressure drops, making it easier to breathe
- Applied by face or nose mask through noninvasive ventilator device with two settings
  - Device provides 5 cm H₂O pressure difference between inspiratory positive airway pressure (IPAP) and expiratory positive airway pressure (EPAP)
BiPAP

- **Leak-tolerant system**
  - Has ability to respond and adjust to leaks (CPAP does not)
  - Allows IPAP and EPAP settings to be titrated (adjusted) to reach desired PEEP range

- BiPAP may eliminate need for endotracheal (ET) intubation in patients with respiratory distress caused by
  - COPD
  - Pulmonary edema
  - Pneumonia
  - Asthma

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CPAP Procedure

- Methods to deliver continuous positive airway pressure will vary by device and manufacturer guidelines

- **General guidelines**
  - Treat patient’s underlying conditions as needed
  - Assess for indications and contraindications
  - Place patient in sitting position or similar position of comfort
  - Assess vital signs and lung sounds before and during therapy (systolic pressure should be above 90 mmHg), vital signs should be assessed every 5 minutes
  - Attach ECG and pulse oximeter
CPAP Procedure

• General guidelines
  – Explain procedure to patient
  – Anticipate and control anxiety (consider sedation with benzodiazepines, per protocol)
  – Provide coaching as needed
  – Connect CPAP to O₂ source; begin CPAP pressure at 5 to 7.5 cm H₂O

• General guidelines
  – Apply mask and check for air leaks; use head straps if needed and if tolerated by patient
  – Administer nebulized medications as indicated
  – Treatment should be given continuously throughout transport to emergency department

• CPAP therapy should be continued until arrival in emergency department
  – May be stopped if
    • Patient cannot tolerate mask
    • Airway requires suctioning or intervention
    • Respiratory distress worsens
    • Pneumothorax is suspected
CPAP Procedure

• Intermittent positive-pressure ventilation and/or intubation should be considered if patient is removed from CPAP therapy in prehospital setting
  – Even with CPAP therapy, some patients will require intubation in prehospital setting
  – Considerations for intubation
    • Deterioration of mental status
    • Increase of EtCO₂
    • Decline of SpO₂
    • Progressive fatigue
    • Ineffective tidal volume
    • Respiratory or cardiac arrest

PEEP

• Positive-end-expiratory pressure (PEEP)
  – Maintains degree of positive pressure at end of exhalation
  – Given to patients who have been intubated and who are receiving mechanical ventilation
  – Invasive procedure
• Positive pressure at end of exhalation keeps alveoli open and pushes fluid from alveoli back into interstitium or capillaries

PEEP

• In prehospital setting, ventilatory support with PEEP can be provided through PEEP valve
  – Hollow cylinders that contain weight in their lumens
  – Connected to expiratory port of a bag-valve device
  – Available in pressures of 5, 10, and 15 cm H₂O
  – Creates PEEP by forcing patient to exhale against weight of metal ball
  – Some transport ventilators have built-in PEEP controls
Rescue Breathing and Mechanical Ventilation

- Patient ventilation can be provided by
  - Rescue breathing (mouth to mouth, mouth to nose, mouth to stoma)
  - Mouth-to-mask breathing
  - Bag-mask devices
  - Automatic transport ventilators

Rescue Breathing

- Inspired air has $O_2$ concentration of about 21 percent
  - About 4 percent is used by body
  - Remaining 17 percent is exhaled
- Ventilation by rescue breathing can provide adequate oxygenation to a patient with respiratory insufficiency
Rescue Breathing

• Advantages
  – No equipment needed
  – Immediately available

• Disadvantages
  – Limitation of vital capacity of rescuer (about 500 to 600 mL is needed to ventilate an adult)
  – Low amount of O₂ delivered in expired air compared with other methods of ventilation with supplemental O₂
  – Difficult to force air past any obstructions in airway

Rescue Breathing

• Risks
  – Disease will be transmitted through direct body fluid contact
  – Transmission of unknown communicable disease at time of event

Rescue Breathing

• Complications common to all rescue breathing techniques
  – Hyperinflation of patient’s lungs
  – Gastric distention
  – Blood/body fluid contact concerns
  – Rescuer hyperventilation
Mouth-to-Mouth Method

• Guidelines
  – If no spinal injury is suspected, position patient with optimal head-tilt and chin-lift
  • If spinal injury is suspected, maintain in-line stabilization and maintain an open airway through jaw-thrust without head-tilt technique
  • If this technique does not open airway, use head-tilt-chin-lift maneuver
  • If necessary, clear airway of vomitus, body fluids, foreign objects
  – Pinch patient’s nostrils closed
  – Inhale normal breath

Mouth-to-Mouth Method

• Guidelines
  – Seal your mouth over patient’s mouth, which should be slightly open
  – Exhale into patient’s mouth over 1 second, until chest rises
    • Provide full ventilation of 500 to 600 mL of air

Mouth-to-Mouth Method

• Guidelines
  – Break contact with patient’s mouth and inhale another normal breath
  – Deliver another breath
  – Continue rescue breathing at rate of 10 to 12 breaths/min (1 breath every 5 to 6 seconds) as needed
    • If advanced airway is placed, reduce rate to 8 to 10 breaths/min (1 breath every 6 to 8 seconds)
### Mouth-to-Mouth Method

- Usually results in exchange of saliva between victim and rescuer
  - Transmission of hepatitis B virus (HBV) and human immunodeficiency virus (HIV) during rescue breathing has not been documented
  - Rare instances of herpes transmission during cardiopulmonary resuscitation (CPR) have been reported
  - When possible, use personal barrier protection devices

### Mouth-to-Nose Method

- Mouth-to-nose ventilation is very similar to technique described for mouth-to-mouth rescue breathing
- Differences in mouth-to-nose method
  - If no spinal injury is suspected, rescuer must keep one hand on patient’s forehead to maintain an open airway while using the other hand to close patient’s mouth
    - If spinal injury is suspected, jaw-thrust without head-tilt technique should be used
    - Rescuer’s cheek is used to seal patient’s mouth
  - Patient’s nose is left open

- Differences in mouth-to-nose method
  - Rescuer’s mouth is placed over patient’s nose with as tight a seal as possible
  - During passive exhalation by patient, rescuer’s mouth is removed from patient’s nose and patient’s mouth is opened for exhalation
    - Head-tilt or jaw-thrust position must be maintained to ensure open airway
Mouth-to-Nose Method

- Differences in mouth-to-nose method
  - May be appropriate for patients who have injuries to mouth and lower jaw and for patients with missing teeth or dentures
  - May overcome psychological barriers in having mouth-to-mouth contact with patient

Infant and Child Ventilation

- Use mouth-to-mouth-and-nose technique as described below
  - Position patient with slight head-tilt and chin-lift sufficient to open airway
    - Hyperextension of pediatric patient’s neck may block airway
    - Use spinal precautions as needed
  - During ventilation, rescuer’s mouth should cover both the mouth and nose of infant or small child up to 1 year of age

Infant and Child Ventilation

- Use mouth-to-mouth-and mouth-to-nose technique as described below
  - Exhale into patient’s mouth until chest rises
  - When allowing for passive exhalation, break contact with patient’s mouth and nose
  - Provide ventilations at a rate of 12 to 20 breaths/min (1 breath every 3 to 5 seconds)
    - When advanced airway has been placed, reduce rate to 8 to 10 breaths/min (1 breath every 6 to 8 seconds)
  - Deliver each breath over 1 second
  - Make sure chest rises
Mouth-to-Stoma Method

• Stoma
  – Temporary or permanent surgical opening in neck of patient who has laryngectomy or tracheostomy
  – Airway has been surgically interrupted
  – Larynx is no longer connected to trachea

Mouth-to-Stoma Method

• Stoma created by laryngectomy is large and round
  – Edge of tracheal lining can be seen attached to skin
• Stoma in tracheostomy patients is usually no more than several millimeters in diameter
  – Usually contains one or two concentric tubes (one fitting inside the other) made of plastic or metal
• Method of ventilating these patients is the same, regardless of type of stoma
Mouth-to-Stoma Method

• Stomas and breathing tubes may become clogged with secretions, encrusted mucus, and foreign matter, leading to inadequate ventilation
  – If cleaning is needed, wipe neck opening with gauze
  – If breathing tubes are clogged, can be removed or suctioned
    • Tracheostomy tube or stoma is suctioned by passing sterile suction catheter through external opening into trachea

Mouth-to-Stoma Method

• Do not insert catheter more than 7 to 12 cm (3 to 5 inches) into trachea
  – Once airway is partly open, begin ventilations by mouth-to-stoma method by using pediatric-size pocket mask over top of stoma or by securing airway with ET tube placed through stoma

Mouth-to-Stoma Method

• Technique for stoma ventilation is basically the same as for other methods of artificial ventilation
  – Patient’s head should be kept straight (rather than tilted back), with patient’s shoulders slightly elevated
    • Allows more effective ventilation
  – If patient’s chest does not rise or if air is heard to escape through patient’s upper airway, patient may be a “partial neck breather”
    • Able to inhale and exhale some air through nose and mouth
      • if this occurs, patient’s nostrils must be pinched closed and mouth sealed with palm of one hand during ventilation
Mouth-to-Mask Devices

- Used as alternative to mouth-to-mouth methods of ventilation
  - Masks are constructed of clear, flexible material
  - Available with one-way valves, bacterial filters, and ports for supplemental O₂ delivery
  - Made by a number of manufacturers, available in variety of sizes

Mouth-to-Mask Devices

- Advantages
  - Eliminate direct contact with patient’s mouth and nose
  - Provide more effective ventilation than mouth-to-mouth method or bag-valve-mask device
  - Reduce risk of disease transmission
  - Supplemental O₂ delivery is possible
  - One-way valve eliminates exposure to exhaled gases and sputum
  - Mask easy to apply

(1) Mouthpiece
(2) Non-rebreathing valve
(3) Tru-fit mask
(4) Exhalation port
Mouth-to-Mask Technique

• Can be used in patients with or without spontaneous respirations

• Steps
  – If no spinal injury is suspected, position patient with optimal head-tilt and chin-lift
    • Use of an oropharyngeal or nasopharyngeal airway is indicated in unconscious patients
    • If spinal injury is suspected, use spinal precautions

Mouth-to-Mask Technique

• Steps
  – Connect one-way valve to mask
    • O₂ tubing should be connected to inlet port with O₂ flow rate of 10 to 12 L/min
    • Using supplemental O₂ provides higher concentration of O₂ in inspired air
    • O₂ flow rate of 10 L/min, combined with rescuer ventilations, can supply O₂ concentration of 50 percent
Mouth-to-Mask Technique

• Position yourself at patient’s head (cephalic technique) or side (lateral technique)
• Clear airway of secretions, vomitus, and foreign objects

Mouth-to-Mask Technique

• Place mask on patient’s face and create an airtight seal
  – Using thumb side of palm with both hands, apply pressure to sides of mask
    • If using cephalic technique, apply upward pressure to mandible just in front of ear lobes using index, middle, and ring fingers of both hands while maintaining head-tilt
    • If using lateral technique, seal mask by placing index finger and thumb of hand closer to top of patient’s head along border of mask and place thumb of other hand along lower margin of mask
  – Place remaining fingers of hand closer to patient’s feet and lift jaw while performing head-tilt chin-lift

Mouth-to-Mask Technique

• Blow into opening of mask, observing chest rise and fall
• If available, second rescuer should apply cricoid pressure
  – Helps prevent gastric inflation during positive-pressure ventilation and reduces chance of regurgitation and aspiration
Mouth-to-Mask Technique
• Remove mask from patient’s face to allow for passive exhalation
  – If O₂ is not available, tidal volumes and inspiratory times for mouth-to-mask ventilation should be the same as for mouth-to-mouth breathing (500 to 600 mL delivered over 1 second)
  – If supplemental O₂ is used with face mask, provide a minimum flow rate of 10 to 12 L/min

Bag Mask Devices
• Consist of self-inflating bag and nonrebreathing valve
• Can be used with mask, an ET tube, or another invasive airway device

Bag Mask Devices
• An adequate bag-valve unit should have
  – Self-refilling bag that is disposable or easily cleaned or sterilized
  – Nonjam valve system that allows a minimum O₂ inlet flow of 15 L/min
  – Non-pop-off valve
  – Standard 15- and 22-mm fittings
  – System for delivering high-concentration O₂ through inlet port at back of bag or by O₂ reservoir
  – Nonrebreathing valve
Bag Mask Devices

- Device should perform in all common environmental conditions and under extremes of temperature
- Should be available in both adult and pediatric sizes

Bag Mask Devices

- When bag mask device is compressed, air is delivered to patient through one-way valve
  - Air inlet to bag is closed during delivery
  - When bag is released, patient’s expired gas passes through exhalation valve into atmosphere
    - Prevents patient’s exhaled air from reentering bag mask device
    - As patient exhales, atmospheric air and supplemental O₂ from reservoir refill bag
Bag Mask Devices

- Use of bag mask device with a mask is difficult
  - Problem of creating effective seal between mask and patient’s face while maintaining open airway
  - For this reason, it is recommended that two rescuers use device
    - One should hold mask and maintain airway while the second compresses bag with two hands
    - If three rescuers are available, one rescuer can be solely responsible for maintaining mask seal while providing spinal precautions as indicated

Bag Mask Devices

- Benefits
  - Rescuer can provide wide range of inspiratory pressures and volumes to adequately ventilate patients of varying sizes and underlying pathological conditions
  - Can be used to assist patients with shallow respirations
  - Performs adequately in extremes of environmental temperatures

Bag Mask Devices

- Benefits
  - O₂ concentrations ranging from 21 percent (room air concentration) to nearly 100 percent (using supplemental O₂ and reservoir) can be achieved
  - Manual compression of bag can give rescuer a sense of patient’s lung compliance, which is an advantage over mechanical methods of ventilation
Bag Mask Technique

- Guidelines
  - Ventilation with bag mask device is best accomplished when patient has been intubated with an ET tube or with a supraglottic device
  - If patient has not been intubated, bag mask device may be used with a mask

Bag-Mask Technique

- Guidelines
  - Rescuer is positioned at top of patient’s head
  - If no spinal injury suspected, place patient in optimal head-tilt chin-lift position, with patient’s head elevated in extension
    - If spinal injury is suspected, use spinal precautions
    - If jaw thrust maneuver does not produce open airway, use head-tilt-chin lift maneuver

Bag-Mask Technique

- Guidelines
  - Clear airway of secretions, vomitus, and foreign objects
    - If patient is unconscious, insert oropharyngeal or nasopharyngeal airway
    - Patient’s mouth should remain open under mask
  - Connect an O₂ source, flush reservoir with high-concentration O₂
Bag-Mask Technique

• Guidelines
  – Place mask on patient’s face, making tight seal
  • Place thumb on nose area and index finger on chin, spread remaining fingers along mandible
  • Maintain anterior displacement of mandible
  • To compress bag, rescuer’s other hand presses bag against his or her body (e.g., thigh) or another rescuer compresses bag with two hands as recommended by American Heart Association (AHA)
  • Compress bag smoothly, delivering approximately 500 to 600 ml for average adult over 1 second to produce visible chest rise

Pediatric Considerations

• Smaller bag mask devices are needed for infants and children
  – Helps to reduce chances of overinflation and barotrauma
  – Used mainly for pediatric patients who are in respiratory arrest
  – BVM devices equipped with a fish-mouth- or leaf-flap-operated outlet valve should not be used to provide supplemental O₂ to spontaneously breathing infant or child

Pediatric Considerations

• Smaller bag mask devices are needed for infants and children
  – If valve fails to open during inspiration, child receives only exhaled gases from within mask itself
  • Bag devices for ventilation of full-term neonates, infants, and children should have minimum volume of 450 to 500 mL
  • At least 10 to 15 L/min of O₂ flow is needed to maintain an adequate O₂ volume in reservoir of pediatric bag
Pediatric Bag Mask Technique

- Procedure
  - Ensure proper mask fit by using length-based resuscitation tape or by measuring from bridge of nose to cleft of chin

- Procedure
  - Ensure proper mask position and seal
  - Place mask over mouth and nose (avoid compressing eyes)
  - With one hand, place thumb on mask at apex and place index finger on mouth at chin (like a C clamp)
  - With gentle pressure, push down on mask to establish adequate seal
  - Maintain airway by lifting bony prominence on chin, with remaining fingers placed on mandible, forming an E
  - Avoid putting pressure on soft area under chin
Pediatric Bag Mask Technique

• Procedure
  – Provide ventilations at rate of 12 to 20 breaths/min
  – Deliver each breath in 1 second
    • Both rescuers should make sure it produces visible chest rise
  – Assess bag-mask ventilation by observing adequate rise and fall of chest, by listening for lung sounds at third intercostal space and midaxillary line, and by checking for improvement in skin color or heart rate, or both

Automatic Transport Ventilators

• Several time-cycled, gas-powered, automatic transport ventilators
  – Autovent is commonly used in prehospital emergency care
• Most automatic transport ventilators (ATVs) consist of a plastic control module
  – Module is connected by tubing to any 50 psi gas source
  – Exit valve of control module is connected by one or two tubes (based on model) to patient valve assembly to deliver selected tidal volumes (400 to 1200 mL for adults, 200 to 600 mL for children)

Automatic Transport Ventilators

• Most ATVs consist of a plastic control module
  – Another control selects respiratory rates from 8 to 22 breaths/minute for adults
    • Selects rates from 8 to 30 breaths/minute for children
    • Most ATVs are not to be used in children under 5 years of age
    • Most units provide 40 L/min flow of O₂
    • Flow remains constant despite changes in patient’s airway or lung compliance
Automatic Transport Ventilators

- Volume of gas delivered by automatic ventilator is determined by
  - Length of time manual trigger is depressed
  - Inspiratory effort of spontaneously breathing patient
- Most units are designed to limit inspiratory pressure to 60 to 80 cm H₂O
  - When this pressure is reached, an alarm sounds
    • Excess gas flow is vented off, preventing possible lung damage

Automatic Transport Ventilators

- ATVs allow paramedic to use both hands to obtain a tight face-to-mask seal on patient who has not been intubated
- Cricoid pressure also can be applied with one hand while the other hand seals mask on face
- Allow paramedic to perform tasks when ventilator is used on patient who has been intubated
Automatic Transport Ventilators

• Most ATVs should not be used in patients who
  – Are awake
  – Have an obstructed airway
  – Have increased airway resistance
    • Pneumothorax
    • Asthma
    • Pulmonary edema

Lesson 15.5
Airway Management and Confirmation Methods

Learning Objectives

• Describe the use of manual airway maneuvers and mechanical airway adjuncts based on knowledge of their indications, contraindications, potential complications, and techniques for each.
• Describe effective techniques to verify proper placement of endotracheal and peritracheal airway devices.
Airway Management

• Science and technology have produced many devices for providing airway management
  – Paramedic must not neglect basic airway management procedures
    • Better than a more technically difficult procedure.
• Airway management should progress rapidly from least to most invasive procedures and devices
  – Paramedics should also make sure they are always equipped with appropriate personal protective equipment for these procedures.

Manual Techniques

• Manual techniques of airway management
  – Head-tilt chin-lift method
  – Jaw-thrust
  – Jaw-thrust without head-tilt

Manual Techniques

• Do not use manual maneuvers to open airway in patients who are responsive or when attempts to open patient’s mouth are met with resistance
  – Hazardous if spinal injury is factor
• None of these maneuvers protects against aspiration
  – Using Sellick maneuver to reduce gastric distention should be consideration with manual airway techniques.
Manual Techniques

• Head-tilt chin-lift maneuver
  – Preferred for opening airway when spinal injury is not suspected
  – Performed by placing one hand on the victim’s forehead and applying firm backward pressure with palm to tilt head back
  – Fingers of other hand are placed under bony part of lower jaw (near chin) and lifted to bring chin forward
    • Fingers support jaw and help to maintain head-tilt position

Manual Techniques

• Jaw-thrust maneuver
  – Used to gain additional forward displacement of mandible if no spinal injury is suspected
  – Grasp angles of patient’s lower jaw and lift with both hands, one on each side
    • Displaces mandible forward while tilting head back
    • If unable to open airway with jaw-thrust maneuver, perform head-tilt chin-lift maneuver
    • Open airway remains highest priority, even for unresponsive trauma victim
Manual Techniques

- Jaw-thrust without head-tilt maneuver
  - Used if spinal injury is suspected
  - Patient’s head should be stabilized
  - Cervical spine should be immobilized with neutral, in-line stabilization
  - Jaw-thrust maneuver should then proceed without extension of neck
Suction

- Suction can be used to remove vomitus, saliva, blood, food, and other foreign objects that might block the airway or increase the likelihood of pulmonary aspiration by inhalation
  - Many factors can predispose person to aspiration
  - Every patient should be considered a possible aspiration victim

Suction Devices

- Fixed and portable mechanical suction devices are available through a number of manufacturers
- Fixed suction devices
  - Mounted in patient care areas of hospitals and nursing homes
  - Used in many emergency vehicles
  - Electrically operated by vacuum pumps or powered by vacuum produced by vehicle engine manifold
  - Furnish air intake of at least 40 L/min
  - Provide vacuum of more than 300 mmHg when tube is clamped
Suction Devices

- Portable suction devices may be
  - O₂ or air powered
  - Electrically powered
  - Manually powered
  - To operate effectively, should furnish air intake of no less than 20 L/min

Suction Catheters

- Suction catheters
  - Used to clear secretions and debris from oral cavity and airway passages
- Classifications
  - Whistle-tip suction catheters
  - Tonsil-tip suction catheters
Suction Catheters

• Whistle-tip catheter
  – Narrow, flexible tube
  – Used primarily for tracheobronchial suctioning to clear secretions through either an ET tube or nasopharynx
  – Designed with molded ends and side holes to cause minimal trauma to mucosa

Suction Catheters

• Whistle-tip catheter
  – Should be lubricated before insertion
  – Side opening in proximal end is covered with thumb to produce suction
  – Using sterile technique, paramedic advances catheter to desired location
  – Suction is applied intermittently as catheter is withdrawn

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Suction Catheters

- Tonsil-tip (Yankauer) suction catheter
  - Rigid pharyngeal catheter
  - Used to clear secretions, blood clots, other foreign material from mouth and pharynx
  - Carefully inserted into oral cavity under direct visualization
  - Slowly withdrawn while suction is activated

Suction Catheters

- Before any suctioning is begun, all equipment should be checked
- Suction should be set between 80 and 120 mmHg
  - Higher suction needed for tracheobronchial suctioning
  - If possible, patient’s lungs should be oxygenated with 100 percent O₂ for at least 2 minutes before suction is initiated
  - Suction should never be applied for longer than 10 seconds in adult patients, 5 seconds in pediatric patients
  - If more suctioning is needed, patient’s lungs should be reoxygenated first
Suction Devices

• Possible complications from suctioning
  – Sudden hypoxemia that occurs secondary to decreased lung volume during application of suction
  – Severe hypoxemia that may lead to cardiac rhythm disturbances and cardiac arrest
  – Airway stimulation that may increase arterial pressure and cardiac rhythm disturbances
  – Coughing that may result in increased intracranial pressure with reduced blood flow to brain and increased risk of herniation in patients with head injury
  – Soft tissue damage to the respiratory tract

Tracheobronchial Suctioning

• Before tracheobronchial suctioning is performed through an ET tube, patient must be oxygenated with 100 percent oxygen for 5 minutes
• For tracheal suctioning, a Y- or T-piece or a lateral opening should lie between suction tube and source of on-off suction control

Tracheobronchial Suctioning

• Using sterile technique, advance catheter to desired location (about level of carina)
  – Suction is applied intermittently by closing side opening as catheter is withdrawn in rotating motion
  – Patient’s cardiac rhythm should be monitored throughout procedure
    • If dysrhythmias or bradycardia develops, stop suctioning
    • Manually ventilate and oxygenate patient
    • Before suctioning is resumed, ventilate patient with 100 percent O₂ for about 30 seconds
Gastric Distention

- Results from trapping of air in stomach
  - As stomach enlarges, pushes against diaphragm and interferes with lung expansion
  - Abdomen becomes more and more distended (especially in small children)
  - Resistance may be felt to bag mask ventilation

Gastric Distention Management

- Begins by slightly increasing bag mask ventilation inspiratory time
  - Large-volume suction should be readily available
  - If possible, patient should be placed in left lateral recumbent position
  - Manual pressure should be slowly applied to upper stomach or epigastric region
  - Gastric distention that cannot be managed with these techniques may require insertion of gastric tube
What are two harmful effects of gastric distention during artificial ventilation?

Gastric Tubes

- Gastric decompression for gastric distention or vomiting control
  - Can be achieved through nasogastric (NG) or orogastric emptying or decompression of stomach
  - Done with extreme caution in patients who have esophageal trauma or esophageal disease
  - Should not be performed if esophageal obstruction is present
  - NG decompression should not be attempted in patient with facial trauma or esophageal varices (large, swollen veins in the esophagus that are susceptible to hemorrhage)
Nasogastric Compression

• Prepare patient
  – Place head in neutral position
  – Preoxygenate
  – Instill a topical anesthetic, per protocol (check for allergies)
  – Locate larger nostril
• Measure NG tube from patient’s nose to ear and ear to xiphoid for correct insertion length
  – Lubricate tube with viscous lidocaine or water-soluble lubricant per protocol
Nasogastric Compression

• Advance tube gently along nasal floor and into stomach
  – Having patient swallow during insertion may help advance tube into esophagus and prevent tracheal insertion
  – If patient is conscious and starts to cough vigorously, ask patient to speak
  – If patient is unable to do so, tube has likely passed through vocal cords
Nasogastric Compression

• Confirm placement (as per agency protocol)
  – Auscultate epigastric region while injecting 30 to 50 mL of air
  – Note gastric contents in NG tube
  – Ensure no reflux appears around NG tube
• Secure NG tube in place and attach to suction if indicated

Orogastric Compression

• Prepare patient and tube as described above for NG insertion
• Introduce orogastric tube down midline of oropharynx and into stomach
• Confirm placement
  – Secure orogastric tube as described above for NG insertion

Gastric Decompression Complications

• Whatever method is chosen, gastric decompression is uncomfortable for patient
  – May induce nausea and vomiting even when gag reflex is suppressed
  – Gastric tubes interfere with mask seals
  – Interfere with visualization of airway structures during intubation
Gastric Decompression Complications

- Complications
  - Nasal
  - Esophageal or gastric trauma
  - Tracheal placement
  - Gastric tube obstruction

Airway Management Mechanical Adjuncts

- Use of mechanical devices for airway management should never delay manual opening of airway
  - Devices should be used only after efforts have been made to open airway manually

What should you do if you find that it is suddenly more difficult to ventilate a nonintubated patient?
Nasopharyngeal Airway

- Nasal airways
  - Used to maintain open airway passage in unconscious patients or in patients who are responsive but not alert enough to control their own airway
  - Useful as temporary airway maintenance maneuver
  - Used to control airway in patients with seizures or possible cervical spine injury
  - Used before nasotracheal intubation
  - Can serve as guide for insertion of nasogastric tube

What are two or three specific patient conditions that would warrant the use of a nasal airway?

Description

- Nasal airways
  - Soft and pliable
  - Have gentle curve, outer end is flared
  - Available in variety of sizes to accommodate infants and adults
Description

- Nasal airways
  - Range in length from 17 to 20 cm (about 7 to 8 inches) and in size from 12 to 36 French
    - As with most other catheters, French scale system used to indicate internal diameter
    - Each unit of the scale = 1/3 mm
    - 21 French catheter = 7 mm (about 1/3 inch) in diameter
  - To determine correct size, choose airway with tube length = distance from tip of patient's nose to earlobe

Description

- Recommended sizes of nasopharyngeal airways
  - Large adult: 8 to 9 mm (0.3 to 0.35 inch) internal diameter (24 to 27 French)
  - Medium adult: 7 to 8 mm (about 1/3 inch) internal diameter (21 to 24 French)
  - Small adult: 6 to 7 mm (about 1/4 inch) internal diameter (18 to 21 French)
Nasopharyngeal Insertion

• Nasal airway
  – Should be lubricated with water-soluble lubricant
  • Helps to ease airway through nasal cavity
  – Device is placed in nostril with beveled tip (designed to protect nasal structures) directed toward nasal septum
  – Airway is gently passed close to midline, along floor of nostril, following natural curve of nasal passage
  – Airway should not be forced
    • If resistance is encountered, rotating tube slightly may help, or insertion can be attempted through other nostril

• After insertion, nasal airway rests in posterior pharynx behind tongue
  – If patient begins to gag, tube may be stimulating posterior pharynx
  – May be necessary to remove airway or withdraw it 0.5 to 1 cm (1/4 to 1/2 inch) and reinsert it
  – Maintain displacement of mandible with head-tilt chin-lift or jaw-thrust without head-tilt maneuver when using this airway
Nasopharyngeal Advantages

- A nasal airway is well tolerated by conscious and semiconscious patients with intact gag reflex
- Insertion is a quick procedure
- Nasal airway may be used when insertion of oropharyngeal airway is contraindicated or difficult because of oral trauma or soft tissue injury

Nasopharyngeal Complications

- Possible complications
  - Long nasal airways may enter esophagus
  - Airway may precipitate laryngospasm and vomiting in patients with gag reflex
  - Airway may injure nasal mucosa, causing bleeding and possibly airway obstruction
  - Small-diameter airways may become obstructed by mucus, blood, vomitus, and soft tissues of pharynx
  - Nasal airway does not protect lower airway from aspiration
  - Suctioning through nasal airway is difficult

Oropharyngeal Airway

- Oral airways are designed to prevent tongue from obstructing glottis
  - Indicated in unconscious or semiconscious patients who have no gag reflex and who are not intubated
Oropharyngeal Airway

- Oral airway is semicircular device designed to hold tongue away from posterior wall of pharynx
  - Most oropharyngeal airways are made of disposable plastic
- Two types of airways most often used
  - Guedel airway
    - Distinguished by its tubular design
  - Berman airway
    - Distinguished by airway channels along each side of device

Oropharyngeal Airway

- Available in a variety of sizes
  - Range from infant to adult
  - Based on distance in millimeters from flange to distal tip
  - Proper size determined by placing airway next to face so flange is at level of patient’s central incisors and bite block segment is parallel to patient’s hard palate
  - Should extend from corner of mouth to tip of ear lobe or angle of jaw

Oropharyngeal Airway

- The following sizes are recommended:
  - Large adult: 100 mm (about 4 inches) (Guedel size 5)
  - Medium adult: 90 mm (about 3.5 inches) (Guedel size 4)
  - Small adult: 80 mm (about 3.1 inches) (Guedel size 3)
Oropharyngeal Insertion

• Before insertion, mouth and pharynx should be cleared of all secretions, blood, or vomitus
• In adult or older child, may be inserted upside down or at 90-degree angle
  – Helps avoid catching tongue during insertion
  – As airway passes crest of tongue, rotated into proper position
  – Should be situated against posterior wall of oropharynx
Oropharyngeal Insertion

- Another method of insertion recommended for pediatric patients
  - Tongue blade used to displace tongue inferiorly and anteriorly
  - Airway is then inserted and moved posteriorly toward back of oropharynx, following normal curve of oral cavity
  - Regardless of method of insertion, trauma to face and oral cavity should be avoided
  - Be sure patient’s lips and tongue are not caught between teeth and airway

Why is this method (use of a tongue blade to displace the tongue inferiorly and anteriorly) of oral airway insertion used for infants and young children?
Oropharyngeal Insertion

• Placement confirmation
  – Observable chest wall expansion
  – Good breath sounds on auscultation of lungs during ventilation
  – Even with oral airway in place, patient’s head must be kept in proper position
    • Helps to ensure patent airway

Oropharyngeal Insertion

• Advantages
  – Secures tongue forward and down, away from posterior pharynx
  – Provides easy access for airway suction
  – Serves as bite block to protect an ET tube and airway in event of seizures

Oropharyngeal Complications

• Possible complications
  – Oral airways that are too small may fall back into oral cavity, resulting in blockage of airway
  – Long airways may press epiglottis against entrance of trachea, producing complete airway obstruction
  – Airway may stimulate vomiting and laryngospasm in patient with gag reflex
  – Airway does not protect lower airway from aspiration
  – Improper insertion may push tongue back, causing it to obstruct airway
Advanced Airway Procedures

• Subglottic procedures
  – Endotracheal intubation
  – Digital or blind intubation
  – Nasotracheal intubation
• Supraglottic procedures
  – Laryngeal mask airway (LMA)
  – Esophageal-Tracheal Combitube (ETC)
  – King LT-D airways

Advanced Airway Procedures

• All these procedures require special training
  – Before performing advanced airway procedures, paramedic must either receive authorization from medical direction or must be operating under written protocols
  • Written protocols are developed by medical direction and EMS agency

Advanced Airway Procedures

• Long-term complications may result from these procedures, even when procedures are properly performed
  – Aspiration
  – Tracheal stenosis
  – Transient dysphagia
  – Voice changes
Endotracheal Intubation

• Tracheal intubation is preferred technique for controlling airway in patients who are unable to maintain open airway

• Indications
  – Paramedic unable to ventilate unconscious patient with conventional methods
    • Mouth-to-mask method, bag-mask device
  – Patient cannot protect his or her own airway
    • Coma, respiratory and cardiac arrest
  – Prolonged artificial ventilation needed

Endotracheal Intubation

• Advantages
  – Airway is isolated, which prevents aspiration of material into lower airway
  – Ventilation and oxygenation are easier
  – Suctioning of trachea and bronchi is easier
  – Wasted ventilation and gastric insufflation are prevented during positive-pressure ventilation

Endotracheal Intubation

• Advantages
  – Route is provided for administration of some medications
    • Naloxone
    • Atropine
    • Vasopressin
    • Epinephrine
    • Lidocaine
    • N-A-V-E-L
Endotracheal Intubation

• Common ET tube
  – Flexible tube open at both ends
    • Proximal end has a standard 15 mm (about 0.6 inch) adapter
    • Adapter connects to various O₂ delivery devices for positive-pressure ventilation
    • End of tube inserted into trachea is beveled to aid placement between vocal cords

Endotracheal Intubation

• Common ET tube
  – Adult tube size (5 or larger) has balloon cuff that closes off remainder of tracheal opening
    • Prevents aspiration of fluids around tube
    • Minimizes air leakage during ventilation
    • Attached to small tube, with one-way inflating valve with port designed to fit standard syringe
    • Properly positioned ET tube with cuff inflated allows administration of high concentrations of O₂ at controlled pressures
Endotracheal Tubes

• Specialized variations are available:
  – Armored or anode tubes have inner spiral of flat metal to prevent kinking or compression
  – “Trigger” tubes have thin cord running down anterior wall of tube to which ring is attached proximally
    • Pulling on ring with finger or thumb increases curvature of tube
    • May help maneuver tube anteriorly without using stylet
  – Tubes with medication ports for ET drug administration

Endotracheal Tube Sizes

• Markings on ET tube indicate internal diameter of tube in millimeters
  – Available in graduated sizes from 2.5 to 10 mm
  – Length of tube from distal end is indicated in centimeters at several levels
  – Recommended ET tube sizes are 7-8 mm (about 1/3 inch) internal diameter for men and 7 mm (about 1/4 inch) internal diameter for women
  – Tube sizes are expressed simply as “size 6” or “size 7” without millimeter designation

Endotracheal Tube Sizes

• Infant and pediatric ET tubes
  – Available with and without balloon cuffs
  – Cuffed ET tubes are indicated only for children older than 8 to 10 years
Endotracheal Tube Sizes

- Infant and pediatric ET tubes
  - Children under 8 to 10 years of age have circular narrowing at the level of cricoid cartilages
  - Narrowing serves as functional cuff
  - Minimizes air leakage at cricoid ring
  - Uncuffed ET tubes are recommended for this age group
  - Cuffed tracheal tubes for young children may be appropriate when high ventilatory pressures are indicated
  - May occur with status asthmaticus and acute respiratory distress syndrome (ARDS)

Endotracheal Tube Sizes

- Various methods can be used to determine the correct ET tube size for infants and children
- Estimate of tracheal tube size for children older than 1 year may be made using one of the following equations
  - Uncuffed tube
    \[ \text{Tracheal tube size (mm)} = \frac{\text{Age (yr)}}{4} + 4 \]

Endotracheal Tube Sizes

- Cuffed tube
  \[ \text{Tracheal tube size (mm)} = \frac{\text{Age (yr)}}{4} + 3.5 \]
Endotracheal Equipment

- Laryngoscope
  - Required for visualization of glottis during tracheal intubation
  - Includes handle made of plastic or stainless steel
    - Contains batteries for light source and attaches to plastic or stainless steel blade with bulb placed in distal third
    - Electrical contact between blade and handle is made at connection point called the fitting
    - Indentation of blade is attached to bar of handle
    - When blade is elevated to right angle with laryngoscope handle, blade snaps into place and bulb lights
    - Failure of bulb to light may be result of loose connection between bulb and bulb socket, a damaged bulb, or faulty batteries

- Other necessary equipment
  - 10-mL syringe for cuff inflation
  - Water-soluble lubricant
  - Suction equipment
Endotracheal Equipment

• Two types of blades (available in various sizes) are used with laryngoscope
  — Straight blade
    • Miller blade
    • Wisconsin blade
    • Flagg blade
  — Curved blade
    • Macintosh blade
Ask several paramedics and anesthesiologists which laryngoscope blade they prefer and why.

Endotracheal Equipment

• Straight blade
  – Tip is applied directly to epiglottis to expose vocal cords
  – Provides more exposure of glottis and less need for a stylet
  – Usually recommended for infant intubation
    • Provides greater displacement of tongue into floor of mouth and better visualization of glottic structures

Endotracheal Equipment

• Curved blade
  – Design intended to be inserted into valleula
  – Placement displaces tongue to left to elevate epiglottis without touching it
  – Reduces chance of dental trauma
  – Provides more room for passage of ET tube
Endotracheal Equipment

• Choice of blade is matter of personal preference and patient’s anatomy
  – Paramedics should acquire expertise in using both blades
  • Some patients can be intubated more easily with one type than other
  • Occasions may arise when only one type of blade is available
  • Versatility with both blades may improve patient’s chances of survival

Endotracheal Equipment

• Malleable stylet
  – May be inserted through ET tube before intubation
  – Conforms to any desired configuration and may facilitate proper placement of ET tube
  – If used, must be recessed 1 to 2 inches from distal end of ET tube to prevent injury to patient
  • Recession maintained by bending proximal end of stylet over proximal rim of adapter so it does not advance through lumen with manipulation of ET tube
  • If allowed to extend beyond distal end of tube, the mucosal surface of the larynx or trachea or vocal cords may be damaged
• Gum elastic bougie or tube introducer can be used to assist with ET tube placement
  – Large flexible device is placed in trachea under direct visualization using laryngoscope
  – Tracheal tube is passed over bougie and into position in trachea
Endotracheal Equipment

- Magill forceps
  - Scissors-style clamp with circular tips
  - Used to help direct tip of ET tube into larynx during intubation and to remove some foreign bodies

Intubation Preparation

- Patient should be ventilated by other standard procedures before intubation
  - Assess adequacy of ventilation by
    • Observing chest rise and fall during ventilation
    • Auscultating for breath sounds
    • Noting patient’s skin color
- Before intubation, patient should be ventilated with 100 percent O₂
Intubation Preparation

• In pulseless patient, goal is not to interrupt chest compressions for more than 10 seconds
  – Interruptions for intubations should be minimized by preparing equipment beforehand
  – Interrupted only for placement of tube
  – Should resume immediately after tube is distal to vocal cords

Intubation Preparation

• In pulseless patient, goal is not to interrupt chest compressions for more than 10 seconds
  – When more than one attempt is required, patient should receive adequate ventilation, oxygenation, and chest compressions before each attempt
  – Patient's lungs should then be well ventilated and oxygenated for 15 to 30 seconds by other means before intubation is attempted again
  – Pulse oximetry and electrocardiogram (ECG) should be monitored continuously during intubation attempts

Intubation Preparation

• Before intubation, all equipment should be examined and tested for defects
  – Check integrity of cuff of ET tube by inflating balloon with 5 to 8 mL of air and checking for leaks in cuff or inlet port
  – Blade of laryngoscope should be snapped into place to examine light bulb
  – Bulb should be secured in its socket and checked for brightness (“light, bright, and tight”)
Anatomical Considerations

• ET tube may be passed into trachea through mouth (orotracheal method) or through nose (nasotracheal method)
  – Orotracheal method is used most often
    • Performed under direct visualization of glottic opening
  – Nasotracheal route basically is “blind” (nonvisualized) technique

Anatomical Considerations

• Anatomical structures are key landmarks during intubation
  – Trachea is in midline of neck and has its superior entry at level of glottic opening
    • With orotracheal intubation, vocal cords should be visualized while tube is passed to ensure entry into trachea
  – Uvula is suspended from midline of soft palate
    • Used as guide for correct placement of laryngoscope

Anatomical Considerations

• Anatomical structures are key landmarks during intubation
  – Epiglottis is attached to base of tongue
    • Should be visualized and elevated to expose glottis and vocal cords
    • Pressure on solid ring of cricoid can block esophagus, reducing risk of regurgitation during intubation attempt
    • May help to better visualize entrance of trachea by pushing it slightly posteriorly
Anatomical Considerations

• Trachea extends to level of 2nd intercostal space anteriorly, at which point it divides into left and right mainstem bronchi
  – Right main bronchus branches off at very slight angle to trachea
  – Left branches at a 45- to 60-degree angle

Orotracheal Intubation

• In preparation, patient who is not trauma victim should be placed in sniffing position
  – Neck is flexed at 5th and 6th cervical vertebrae
  – Head is extended at 1st and 2nd cervical vertebrae
    • Allows three axes of mouth, pharynx, and trachea (oropharyngeolaryngeal axis) to be aligned for direct visualization of larynx
    • When trauma is not a factor, may help to place a few layers of towels under patient’s head to elevate it
Orotracheal Intubation

• Orotracheal tube should be lubricated
• Stethoscope, stylet, and suction equipment (with large-bore catheters) should be readily available
• Patient’s lungs should be ventilated with 100 percent O₂ before intubation

Orotracheal Intubation

• Orotracheal intubation procedure
  – Position yourself at patient’s head
  – Inspect oral cavity for secretions and foreign material
    • Suction mouth and pharynx if needed
Orotracheal Intubation

• Orotracheal intubation procedure
  – Open patient’s mouth with fingers of right hand
    • Retract patient’s lips on teeth or gums to avoid pinching them in blade
    • “Crossed-finger technique” also may be useful in opening patient’s mouth
    • To perform procedure, cross right thumb and index finger to form an X
    • Place thumb on patient’s lower incisors and index finger on patient’s upper incisors; apply crossed-finger pressure to open patient’s mouth

Orotracheal Intubation

• Orotracheal intubation procedure
  – Grasp lower jaw with right hand and draw it forward and upward
    • Remove any dentures
Orotracheal Intubation

- Orotracheal intubation procedure
  - Holding laryngoscope in left hand, insert blade into right side of mouth, displacing tongue to left
    - Move blade toward midline and base of tongue and identify uvula
    - Working gently and avoiding pressure on lips and teeth are essential
Orotracheal Intubation

- Orotracheal intubation procedure
  - When using curved blade, advance tip of blade into vallecula, space between base of tongue and pharyngeal surface of epiglottis
  - When using straight blade, insert tip under epiglottis
    • Glottic opening is exposed by exerting upward traction on handle
    • Never use prying motion with handle and do not use teeth as fulcrum
Orotracheal Intubation

- Orotracheal intubation procedure
  - Advance ET tube through right corner of mouth and, under direct vision, through vocal cords
    - If stylet has been used, it should be removed from tube after tube passes through cords into trachea

- After viewing vocal cords, ensure that the proximal end of cuffed tube has advanced past cords about 1 to 2.5 cm (⅝ to 1 inch)
  - Tip of tube should then be halfway between vocal cords and carina
  - Allows some displacement of tube tip during flexion or extension of patient’s neck without extubation or movement of tip into mainstem bronchus
  - In average adult, distance from teeth to carina is 27 cm (about 11 inches)
Orotracheal Intubation

• Orotracheal intubation procedure
  – After viewing vocal cords, ensure that proximal end of
cuffed tube has advanced past cords about 1 to 2.5 cm (½
to 1 inch)
    • Observe depth markings on ET tube during intubation
    • In average adult, tube is properly positioned when patient’s teeth
      are between 19 and 23 cm marks on tube
    • Places tip of tube 2 to 3 cm (¾ to 1½ inches) above carina
    • Average tube depth in men is 22 cm (about 9 inches) ("teeth and
tube at 22")
    • Average tube depth in women is 21 cm (about 8½ inches)

Orotracheal Intubation

• Orotracheal intubation procedure:
  – Inflate cuff with about 10 mL of air to prevent any
    air leaks around tracheal cuff seal
  – Attach tube to mechanical airway device and
    ventilate patient’s lungs
  – During ventilation, confirm accurate tube
    placement using primary and secondary
    confirmation methods
Primary Confirmation Methods

• Initially confirm proper tube placement by auscultating over epigastrium, midaxillary region, and anterior chest line on right and left sides of chest
  – If stomach gurgling is present or chest expansion is absent, immediately deflate cuff and remove tracheal tube
    • Reattempt intubation after oxygenating patient’s lungs with 100 percent O₂ for 15 to 30 seconds

Primary Confirmation Methods

• Initially confirm proper tube placement by auscultating over epigastrium, midaxillary region, and anterior chest line on right and left sides of chest
  – When appropriate tube placement has been confirmed, reconfirm and note tube mark at front of patient’s teeth
  – Secure tube to patient’s head and face with tape or commercially available device
  – Reevaluate lung sounds to ensure that tube was not inadvertently repositioned
  – Insert oral airway or bite block
    • Prevents patient from biting down and blocking airway

Secondary Confirmation Methods

• Requires use of mechanical devices
  – End-tidal CO₂ detectors
  – Esophageal detectors
  – Pulse oximetry for patients who have a perfusing rhythm
• Tube confirmation should include both clinical and mechanical methods
  – Do not rely on single method
  – Confirm correct placement immediately after intubation and each time patient is moved
Fiberoptic Intubation

• Appropriate for both oral and nasal intubation procedures
  – AirTraQ®
  – C-MAC®
  – Glidescope®
  – McGrath®
  – Shinkani®
  – Storz®

Fiberoptic Intubation

• Using fiberoptic laryngoscope, glottis can be visualized and intubation performed while viewing video monitor
  – Requires special training that is manufacturer specific and authorization from medical direction
  – Any patient who meets criteria for intubation can be intubated using fiberoptic devices
Fiberoptic Intubation

- Involves inserting video laryngoscope into mouth and into pharynx
  - Upon visual confirmation of glottic opening, endotracheal tube is advanced behind or alongside laryngoscope
  - Tube is placed in trachea under direct vision, using video monitor

Digital (Blind) Intubation

- When used
  - Patient entrapment
  - Airway blocked from view by large amounts of blood or other secretions
  - Equipment fails
  - Certain disaster situations in which victims are widespread and equipment is in short supply

Digital (Blind) Intubation

- Procedure:
  - Position yourself at patient’s left side
    - If spinal injury is suspected, have second paramedic maintain in-line spinal immobilization
  - Ventilate patient with 100 percent O₂ before intubation
  - Use bite stick or other device to hold patient’s mouth open
    - Helps protect rescuer’s fingers
Digital (Blind) Intubation

• Procedure
  – Bend tube and stylet combination into J or hockey stick configuration
  – Insert gloved left middle and index fingers into patient’s mouth
    • Alternating fingers, “walk” down patient’s tongue, pulling tongue and epiglottis away from glottic opening

• Procedure
  – When flap of cartilage covered by mucous membrane is felt with middle finger, epiglottis has been located
    • Maintain contact and advance ET tube with right hand
    • Use index finger of left hand as guide
    • Index finger maintains tube position against middle finger, leading tip of tube into glottic opening
    • May be helpful for second paramedic to perform Sellick maneuver to close off esophagus and help prevent aspiration
Digital (Blind) Intubation

- Procedure
  - Once cuff of ET tube passes tips of paramedic's fingers, inflate cuff, remove stylet, and verify placement in usual manner
  - Secure tube as previously described
  - Correct ET tube placement should be confirmed often
    - At minimum, reconfirm placement each time patient is moved or has sudden change in condition

Intubation Complications

- Possible complications
  - Accidental intubation of esophagus
  - Accidental intubation of bronchus
  - Lacerated lips or tongue (oral)
  - Dental trauma from laryngoscope (oral)
  - Lacerated pharyngeal or tracheal mucosa
  - Tracheal rupture
  - Avulsion of arytenoid cartilage
  - Vocal cord injury
  - Vomiting and aspiration of stomach contents

Intubation Complications

- Possible complications
  - Significant release of epinephrine and norepinephrine, leading to hypertension, tachycardia, or cardiac rhythm disturbances
  - Vagal stimulation (particularly in infants and children), resulting in bradycardia and hypotension
  - Increased intracranial pressure in patients with head injury
  - Rupture of cuff, inflation port malfunction, or severance or kinking of inflation tube may cause cuff malfunction and air leakage
If a prolonged deep breath is held, what other vagal effects might the patient experience?

Nasotracheal Intubation

• Use
  – Patients with spontaneous respirations
  – When laryngoscopy is difficult
  – When motion of cervical spine must be limited
  – Examples of such conditions
    • Medication overdose
    • Asthma or anaphylaxis
    • Chronic obstructive pulmonary disease
    • Stroke
    • Seizure (status epilepticus with constant seizure activity)
    • Altered mental status

Nasotracheal Intubation

• Situations may make it difficult to align oropharyngeolaryngeal axis
  – Rules out successful orotracheal intubation
• Blind procedure
  – High risk of improper tube placement
    • Paramedic cannot visualize the vocal cords
Nasotracheal Intubation

- Conscious patients tolerate nasotracheal tube better than orotracheal tube
  - Often causes less trauma to tracheal mucosa
    - Tube moves less inside trachea with head motion than does orotracheal tube
    - If time allows, prepare patient using vasoconstrictor spray and topical anesthetic
      - May make patient more comfortable
    - Reduce risk of nasal hemorrhage, which may occur secondary to procedure
    - If time allows, placement of soft nasopharyngeal airway before procedure may show which nostril is more passable
      - May compress mucosa, allowing less traumatic placement of ET tube
Nasotracheal Insertion

• Procedure
  – Choose cuffed ET that is 1 mm smaller than optimal for oral intubation
  – Prepare and check all needed equipment (balloon cuff, syringe, suction, stethoscope)
    • Stylets are not used in nasotracheal intubation
    • Stylet reduces flexibility and increases risk of injury during blind insertion
  – Ventilate patient with 100 percent O₂ before intubation

• Procedure
  – Lubricate ET tube with water-soluble or lidocaine jelly
  – Insert tube with flange facing nasal septum
    • Advance tube along nasal floor of nostril that is clearer and more direct
    • If both nostrils appear open, advance through larger nostril first
    • If chosen nostril is impassable, try other nostril before selecting ET tube that is 0.5 mm smaller in diameter

• Procedure
  – Stand beside patient with one hand on tube and thumb and index finger of other hand palpating larynx
    • Curve of tube should follow natural curve of airway
    • Gently advance tube while rotating it medially 15 to 30 degrees until maximal airflow is heard through tube
    • Gently and swiftly advance tube during early inspiration
    • Voluntary tongue extrusion in cooperative patients is helpful, can be wrapped with gauze and pulled forward
    • Flexion of neck (if no spinal instability is suspected) and posterior pressure on thyroid cartilage may help position larynx
Nasotracheal Insertion

• Procedure
  – Externally observe advancement of tube toward carina
    • Misting or condensation on tube should be evident as tube approaches tracheal placement
    • Occurs because patient’s exhaled breath has high concentration of water vapor
    • Water vapor promptly condenses on exposure to cooler room air
    • Tube misting not always reliable indicator of proper tube position

Nasotracheal Insertion

• Procedure
  – On completion of intubation, verify proper tube placement as described before
    • Inflate cuff with about 10 mL of air and secure tube in place
    • Ventilations may then be assisted with supplemental O₂, or patient’s lungs can be ventilated by mechanical means
    – If intubation fails, withdraw tube and redirect it after ventilation and oxygenation of patient
      • It may be possible to recognize tube misplacement by inspecting and palpating neck for bulges

Nasotracheal Complications

• Possible complications
  – Epistaxis (nosebleed)
  – Vagal stimulation
  – Injury to nasal septum or turbinates
  – Retropharyngeal laceration
  – Vocal cord injury
  – Avulsion of arytenoid cartilage
  – Esophageal intubation
  – Intracranial tube placement if patient has basilar skull fracture
Intubation with Spinal Precautions

• Procedure
  – Auscultate for bilateral breath sounds while manual or mechanical ventilations are in progress
    • Provides baseline

Intubation with Spinal Precautions

• Procedure
  – One paramedic should apply manual in-line stabilization from patient’s side
    • Place hands over patient’s ears
    • Little fingers should be under occipital skull
    • Thumbs should be on face over maxillary sinuses
    • Stabilization (without distraction) should be maintained in neutral position throughout the procedure
    • Thin padding under patient’s head may be necessary to maintain neutral, in-line positioning

Intubation with Spinal Precautions

• Procedure
  – In one method of intubation, primary paramedic is positioned at patient’s head
    • Legs straddle patient’s shoulders and arms, and patient’s head is secured between paramedic’s thighs
    • Grip of primary paramedic in this position and of other paramedic (from side) prevents head from moving during intubation
    • In this position, primary paramedic may need to lean back to visualize vocal cords
    • With another method, primary paramedic lies prone at patient’s head, and other paramedic (at patient’s side) maintains in-line position alone
Face-to-Face
Orotracheal Intubation

- May be used when paramedic cannot take position above patient’s head
  - Second paramedic maintains in-line immobilization of patient’s neck and head from behind patient
  - Primary paramedic takes position facing patient
  - Patient’s mouth is opened with left hand
  - Laryngoscope held in right hand, and blade is inserted into patient’s mouth, following normal curve of the tongue

- After visualizing vocal cords from position above patient’s mouth, primary paramedic passes an ET tube between cords with left hand
- Cuff is inflated, and syringe is removed
- Patient then is ventilated with bag mask device
- After proper placement is confirmed, ET tube is secured in place
Extubation
• ET tube is not usually removed in prehospital setting
  – Patient may develop intolerance to tube
  – May not be possible to sedate patient to improve tolerance
  – Medical direction may advise extubation
  – If time allows, patient’s lungs first should be ventilated with 100 percent O₂

Extubation
• To remove ET tube, tilt patient or backboard to one side and proceed as follows
  – Have suction available
    • Oral cavity and area above cuff should be suctioned before ET tube is removed
  – Deflate cuff completely
  – Swiftly withdraw tube on cough or expiration
  – Assess patient’s respiratory status
  – Provide high-concentration O₂; assist ventilations as needed
**Endotracheal Intubation**

- **Advantages**
  - Provides complete airway control
  - Helps prevent aspiration
  - Prevents gastric distention
  - May provide route for administration of some drugs
  - Positive-pressure ventilation can be delivered
  - Tracheal suctioning is possible
  - High concentrations of O₂ and large volumes of ventilation can be delivered

**Lesson 15.6**

**Special Considerations, Pediatric Patients, and Pharmacological Adjuncts**

**Learning Objectives**

- Explain variations in assessment and management of airway and ventilation problems in pediatric patients.
- Given a patient scenario, identify possible alterations in oxygenation and ventilation and appropriate interventions to treat those alterations.
Pediatric Intubations
• In addition to differences in airway and ventilation procedures for pediatric patients, anatomical differences of pediatric airway must be considered
• Differences
  — Infant’s upper airway is relatively small
    • Tongue is disproportionately large
    • Posterior displacement of tongue easily obstructs airway
    • Larger tongue of pediatric patient tends to make laryngoscopy more difficult

Pediatric Intubations
• Differences
  — Epiglottis is shaped like Greek letter omega (ω)
  — Narrower and longer in children than in adults
  — More difficult to control with laryngoscopic blade
  — Lies more anteriorly in relation to base of tongue than in adults
  — Elevated under base of tongue, making visualization more difficult
  — Glottic opening is at 3rd cervical vertebra in premature neonates, 3rd to 4th cervical vertebra in term neonates, and 4th to 5th cervical vertebra in adults

Pediatric Intubations
• Differences
  — During first few months of life, infant’s vocal cords slope from back to front
    • ET tube frequently gets hung up in angle formed by cords
    • Can be minimized by rotating ET tube or by having second paramedic perform Sellick maneuver during intubation
  — Cricoid cartilage is narrowest part of airway in infant and young child
    • As child reaches 8 to 10 years of age, vocal cords become narrowest part
    • Remains the case into adulthood
Pediatric Intubations

• Differences
  – Distance from vocal cords to carina varies and can be correlated with patient’s height
    • Distance is about 4 to 5 cm (2 to 2½ inches) at birth and 6 to 7 cm (3 to 3½ inches) by 6 years of age
    • During placement of ET tube, tube should be advanced until breath sounds are lost unilaterally (usually on left side)
  – Should then be withdrawn slowly until breath sounds return, indicating that tube tip is at carina
  – After return of breath sounds, tube should be withdrawn 2 to 3 cm (¾ to 1½ inches) farther, placing it at safe distance above carina and below cords
  – Tube should then be secured with tape or commercial device

• Differences
  – Children use diaphragm as the major muscle for ventilation
    • Require full diaphragmatic excursion to breathe
    • Gastric distention caused by swallowing air or artificial ventilation can inhibit child’s respiratory efforts
    • Infants are nose breathers until 3 to 5 months of age
Pediatric Intubations

- Differences
  - Deciduous teeth begin to develop at about 6 months
  - Lost between 6 and 8 years
  - May become dislodged during airway procedures such as intubation and oral airway insertion and by child biting on airway
  - During any airway procedure, remember that airway structures of children are very fragile and easily damaged
    - Great care must be taken not to injure these patients

Adjuncts to Aid Confirmation of ET Placement

- Adjuncts to determine correct ET tube placement
  - End-tidal CO₂ detectors
  - Bulb- or syringe-type esophageal detection devices
  - Pulse oximeters
- Tube placement confirmation requires more than one method of assessment

End-Tidal CO₂ Detectors

- Capnography
  - Measurement of CO₂ concentrations in exhaled air
  - Made possible by end-tidal CO₂ detectors
  - Designed to help verify ET tube placement
  - Designed to reveal inadvertent esophageal intubation
  - Provide noninvasive estimate of alveolar ventilation, CO₂ production, and arterial CO₂ content
  - Use as an adjunct to assessment of ET tube placement is strongly encouraged
End-Tidal CO₂ Detectors

• Types
  – Disposable colorimetric devices
  – Electronic capnometry
  – Capnography devices

• Colorimetric devices
  – Contain chemical indicator sensitive to CO₂
  – When detector is attached to ET tube, color of indicator changes with elevated CO₂
  – Elevations would be expected in trachea but not in esophagus

• Colorimetric devices
  – Memory aid for colorimetric devices
    • Yellow: yes, ET tube is correctly placed in trachea
    • Tan: think about it, ET tube may not be in trachea
    • Purple: problem, ET tube is not in trachea
  – Provide limited information and can be used for only short periods
  – Exposure to secretions may render them ineffective
End-Tidal CO₂ Detectors

- Capnometry
  - Electronic device to measure end-tidal CO₂
  - Monitor probe or sampling tubing is connected between ET tube and bag-valve device
  - Display numeric end-tidal CO₂ value, so changes can be measured over time

End-Tidal CO₂ Detectors

- Capnography
  - Method of measuring CO₂ that displays and records both numeric value for end-tidal CO₂ and dynamic wave form
  - Provides visual display of rate, depth, and effectiveness of patient’s ventilation
  - Does not measure oxygenation
End-Tidal CO₂ Detectors

- Capnography
  - Provides indirect measure of perfusion
  - Important during cardiopulmonary resuscitation
  - If end-tidal CO₂ values decline, can indicate that chest compressions are not fast enough or deep enough

- Capnography
  - Waveforms can also provide information about bronchoconstriction
    - When terminal bronchioles are constricted, upslope of capnographic waveform will have “shark-fin” appearance
    - Related to uneven emptying of air from narrowed airways
    - Can monitor capnographic waveform to evaluate effectiveness of bronchodilator treatment

- Can confirm successful tracheal tube placement within seconds of intubation attempt, and subsequent tracheal dislodgement
  - Infrared analyzer measures percentage of CO₂ gas at each phase of respiration
  - Capnometers provide a numerical reading of exhaled CO₂ levels
  - Information may also be displayed in digital waveform using a capnograph with printout capability
End-Tidal CO₂ Detectors

• Can confirm successful tracheal tube placement within seconds of intubation attempt, and subsequent tracheal dislodgement
  – Both colorimetric and electronic devices may be useful as indicators of circulation during some cardiac arrest situations because increase in end-tidal CO₂ concentrations seems to be related to effective perfusion during external chest compression
  – Some capnometers can be used in patients who have not been intubated (i.e., using a device that resembles a nasal cannula)
  – Helpful in determining effectiveness of EMS treatments
Bulb-and-Syringe Detectors

- Esophageal detection devices
  - Operate on principle that esophagus is collapsible tube
  - Vacuum is created when air is removed from esophagus
  - Occurs with bulb device after it is compressed or when air is withdrawn by syringe device if ET tube is in esophagus
  - If ET tube has been correctly placed in trachea, bulb device easily refills with air or syringe device is easily aspirated when plunger is pulled back
  - Esophageal detection devices can also be used to verify correct placement of multilumen airways, provided device is applied before first breath is delivered after intubation

Pulse Oximetry

- Pulse oximeters
  - Help determine how well patient is being oxygenated
  - Measure transmission of red and near-infrared light through arterial beds
  - Hemoglobin absorbs red and infrared light waves differently when it is bound with O₂ (oxyhemoglobin) and when it is not (reduced hemoglobin)
  - Oxyhemoglobin absorbs more infrared than red light
  - Reduced hemoglobin absorbs more red than infrared light
  - Pulse oximetry reveals arterial saturation (SpO₂) by measuring this difference
Pulse Oximetry

• Pulse oximeter
  – Oximeter probe is placed on area of thin tissue, such as a finger, toe, or ear lobe
    • One side of probe sends wavelengths of light through arterial bed
    • Other side detects presence of red or infrared light
    • Using this balance of red and infrared colors, oximeter calculates the O₂ saturation of blood and displays it on monitor screen

Pulse Oximetry

• Percentage of hemoglobin saturated with O₂ is denoted as Sao₂
  – Depends on factors
    • Pco₂
    • pH
    • Temperature
    • Whether hemoglobin is normal or altered
    • Lower range of normal for Spo₂ is 93 to 95 percent
    • Upper range is 99 to 100 percent
    • Once Spo₂ falls below 90 percent (corresponding to a Po₂ of 60 mmHg), further decreases are associated with marked decline in O₂ content
Pulse Oximetry

• Difficulties and inaccuracies may result
  – Consider use only as another tool to assist monitoring oxygenation levels

Pulse Oximetry

• Difficulties and inaccuracies may result
  – Possible false readings
    • Dyshemoglobinemia (hemoglobin saturation with compounds other than O₂)
    • Excessive ambient light (sunlight, fluorescent lights) on oximeter’s sensor probe
    • Patient movement
    • Hypotension
    • Hypothermia/vasoconstriction
    • Patient use of vasoconstrictive drugs
    • Patient use of nail polish
    • Jaundice

Laryngeal Mask Airway

• LMA
  – Advanced airway control device
  – Used when
    • Conventional ET intubation is unsuccessful
    • Access to patient is limited
    • Unstable neck injury may be present
    • Appropriate positioning of the patient for tracheal intubation is impossible
    • Some also allow ET intubation through device
    • Allows easier placement of tube
Laryngeal Mask Airway

• Available in several sizes (ranging from size 1 for neonates to size 5 for adults)
  – Consists of proximal tube with standard adapters for connecting ventilatory devices
  – Tube is connected to distal mask inflated by means of pilot tube and balloon

LMA Insertion

• Inserted through mouth into pharynx
  – Advanced until resistance is felt as distal portion of tube locates in hypopharynx
  – When device has been properly inserted, black line marked on LMA rests midline against patient’s upper lip
  – Inflating cuff seals larynx and leaves distal opening of tube just above glottis, providing clear and secure airway
LMA Insertion

• Inserted through mouth into pharynx
  – After pilot cuff has been inflated, proper placement is confirmed by
    • Observing equal rise and fall of chest
    • Ensuring bilateral breath sounds
    • End-tidal CO₂ detectors
    • Pulse oximetry monitoring (in a patient who has a perfusing rhythm)

LMA Insertion

• Use requires special training and authorization from medical direction
  – May be hard to maintain during patient movement
  – Difficult to use during patient transport
LMA Equipment

- Necessary equipment
  - Water-soluble lubricant
  - Syringes
  - Bag-valve device
  - O₂ source and connecting tubing
  - Suction equipment
  - Stethoscope
  - Confirmation device(s)

Laryngeal Mask Airway

- Advantages
  - Less skilled training or maintenance is required than for ET intubation
  - Laryngoscopy and visualization of vocal cords are not required
  - Minimal spinal movement is required for insertion
  - ET intubation can be achieved through some LMAs

Laryngeal Mask Airway

- Disadvantages
  - Patient must be unresponsive and have no gag reflex
  - Not all patients can be adequately ventilated with LMA
  - Airway must be removed when patient becomes responsive or agitated
  - Airway should be replaced with ET tube as soon as possible
Laryngeal Mask Airway

- Contraindications
  - Presence of gag reflex
  - Caustic ingestion
  - Esophageal trauma or disease

Esophageal-Tracheal Combitude

- Allows for either esophageal or tracheal insertion
  - Plastic tube with twin lumens that are separated by partition wall
    - One tube resembles ET tube and has open distal end
    - Other tube blocked by obturator at distal end
    - Both tubes use low-pressure balloons that provide seal for either trachea or esophagus, depending on placement

Esophageal-Tracheal Combitude

- Allows for either esophageal or tracheal insertion
  - Plastic tube with twin lumens that are separated by partition wall
    - Holes on one side of tube between balloons allow for ventilation through tube #1
    - When inflated, large pharyngeal balloon fills space between base of tongue and soft palate, anchoring tube in position
    - Usually finds its way into esophagus because of stiffness and curve of tube and shape and structure of pharynx
Esophageal-Tracheal Combitude

• Another option for airway control when endotracheal intubation is indicated but is unsuccessful or unavailable
  – Provides superior ventilation compared with face masks in cardiac arrest
  – Reduces but does not eliminate risk of aspiration
  – Some EMS agencies prefer Combitude over ET intubation because of ease and quickness of inserting the device

Combitude Insertion

• Inserted by gently guiding device into esophagus or trachea
  – Tube should be inserted into midline and to depth so that printed ring is at level of teeth
    • Achieved without hyperextension or flexion of patient’s head
    • Done without visualization of glottic opening
  – Pharyngeal and distal balloons are then inflated
    • Isolates oropharynx above upper balloon
    • Isolates esophagus (or trachea) below lower balloon

• Ventilation is at first provided through esophageal lumen
  • Due to significant chance of esophageal placement with blind insertion
  • In this position, air passes into pharynx and beyond glottis into trachea
  • Placement is confirmed by primary and secondary confirmation methods
Combitude Insertion

- If breath sounds and chest movement are absent with ventilation through the esophageal lumen (tube #1), ventilation should be performed through the tracheal lumen (tube #2) without changing position of airway
  - Air passes through this lumen directly into trachea
  - Placement is confirmed in the usual manner

Your patient is in full arrest, so your ETCO₂ detector is inconclusive and you can’t get the oxygen saturation monitor to work. You are not sure if you hear breath sounds clearly. What should you do?
Combitude Equipment

- Necessary equipment
  - Water-soluble lubricant
  - Syringes
  - Bag mask device
  - O₂ source and connecting tubing
  - Suction equipment
  - Stethoscope

Combitude

- Advantages
  - Airways cannot be improperly placed
  - Less skill training or skill maintenance is needed than for ET intubation
  - Minimal spinal movement is required for insertion
  - Suctioning is easily done

Combitude

- Disadvantages
  - Patient must be unresponsive and without gag reflex
  - Airway must be removed when patient becomes responsive or agitated
  - Proper identification of tube's location may be difficult, leading to ventilation through wrong lumen
  - Trachea cannot be suctioned when tube is in esophagus
  - Airway should be replaced with ET tube as soon as possible
Combitude

- Contraindications
  - Patient height less than 5 feet or age less than 14 years
  - Caustic ingestion
  - Esophageal trauma or disease
  - Presence of gag reflex

King LT-D Airway

- Disposable supraglottic device
  - Designed for positive-pressure ventilation
  - Use with patients breathing spontaneously
  - Alternative to mask ventilation and tracheal intubation
  - Contains single tube placed only into esophagus
    - Tube’s large size and short length virtually prohibit placement into trachea
    - Tube is curved and has proximal and distal cuff

- Large balloon is inflated in oropharynx
  - At same time, smaller cuff is inflated in esophagus by the same port that inflates large cuff

- Ventilations are delivered by attaching bag-mask device to proximal end of tube
  - With each ventilation, air escapes through holes in tube between cuffs
  - Some provide for passage of suction catheters for gastric decompression
  - Available in multiple sizes, based on patient’s height
King LT-D Airway

- Indications
  - Tracheal intubation cannot be established in two attempts AND when patient is unable to adequately maintain his or her airway
  - Has altered mental status (GCS of 8 or less)
  - Respiratory compromise

King LT-D Airway

- Contraindications
  - Less than 4 feet tall
  - Intact gag reflex
  - Ingested caustic substances
  - Known esophageal disease
King LT-D Airway

- Cuff should be tested for integrity and then deflated prior to insertion
  - Lubricant applied to back side of airway, being careful not to clog holes in tube
  - Head should be placed in neutral position, with spinal precautions if indicated
  - Prior to insertion, preoxygenate lungs with 100 percent O₂
  - Mouth should be opened, using head-tilt or chin-lift maneuver
King LT-D Airway

- Cuff should be tested for integrity and then deflated prior to insertion
  - Tube is gently advanced behind base of patient’s tongue while rotating tube back to midline
  - Tube’s blue orientation line should face patient’s chin
  - Tube is then gently advanced until base of connector is aligned with patient’s teeth or gums
  - Airway is then inflated with appropriate sized volume of air

- Device is connected to adaptor on tube and ventilations are provided
  - While providing ventilations, gently withdraw tube until ventilation compliance becomes easy and free-flowing
  - Cuff inflation may be adjusted if necessary to maintain seal of airway at peak ventilatory pressure employed
King LT-D Airway

- Device is connected to adaptor on tube and ventilations are provided
  - Confirm correct placement by listening for breath sounds, observing chest rise and fall, presence of ETCO₂, and a stable or rising SpO₂
  - Confirm equal and bilateral breath sounds
  - Secure device and consider placing bite block
  - Recheck position after each patient movement, on transfer of care to another provider, following ascent/descent of greater than 1000 feet

Pharmacological Adjuncts to Airway Management

- Sedation sometimes used to
  - Reduce anxiety
  - Induce amnesia
  - Decrease the gag reflex
- Indications for sedation
  - Combative patients
  - Patients who require aggressive airway management but who are too alert to tolerate intubation
  - Agitated trauma patients

Pharmacological Adjuncts to Airway Management

- Drug classes used
  - Tranquilizers
  - Barbiturates
  - Benzodiazepines
  - Narcotics
Paralytic Agents in Intubation

• Although controversial, paralysis may be used for emergency intubation
  – Involves use of neuromuscular blocking drugs
    • Indicated for combative patients who need to be intubated
    • Patient suffering head injury may be agitated and combative

Paralytic Agents in Intubation

• Not used in
  – Patients who will be difficult to ventilate
    • Patients with facial hair
  – Patients who will be difficult to intubate
    • Patients with short necks, obstructions

How will you determine whether a patient needs more sedation after a paralytic agent has been administered?
Pharmacology

• Neuromuscular blockers produce skeletal muscle paralysis
  – Bind to nicotinic receptor for acetylcholine (ACh) at neuromuscular junction
  – Junction is point of contact between nerve ending and muscle
    • When nerve impulses pass through junction, ACh and other chemicals are released
    • Causes muscle to contract

Pharmacology

• Neuromuscular blockers produce skeletal muscle paralysis
  – Types
    • Depolarizing agents
    • Nondepolarizing agents
  – Should not be administered to patients until sufficient sedation has been achieved

Pharmacology

• Depolarizing agents
  – Invade neuromuscular junction and bind to receptors for ACh
  – Produce depolarization of muscular membrane
  – Often lead to fasciculations (uncontrollable muscle twitching)
  – May lead to some muscular contractions
Pharmacology

- Nondepolarizing agents
  - Bind to receptors for ACh
  - Block uptake of ACh at neuromuscular junction without initiating depolarization of muscle membrane

Pharmacology

- Neuromuscular blocking agents produce complete paralysis
  - Ventilatory support must be provided
  - Ventilation and oxygenation must be closely monitored to ensure adequacy
  - If patient is conscious, paramedic should explain effects of medication before administering it

Pharmacology

- Administration of atropine should be strongly considered, particularly in children, before neuromuscular blocking agent is administered
- Lidocaine given prior to administration of neuromuscular blocking agent may blunt any increase in intracranial pressure associated with intubation
Pharmacology

- Diazepam, etomidate, midazolam, or another sedative approved by medical direction should be used in any conscious patient to whom blocking agent is administered; neuromuscular blocking agents do not inhibit pain or seizure activity.

Rapid Sequence Intubation

- Involves administration of potent sedative and neuromuscular blocking agent at same time to achieve optimal intubation conditions in less than 1 minute.
- Blocking agent most often used is succinylcholine.
- In addition to providing optimal intubation conditions, also minimizes risk of aspiration of gastric contents.

Rapid Sequence Intubation

- Indications
  - Emergency intubation is warranted
  - Patient has “full” stomach
  - Intubation is predicted to be successful
  - If intubation fails, ventilation is predicted to be successful.
Rapid Sequence Intubation

• Contraindications
  – Patients in cardiac arrest
  – Deeply comatose patients when immediate intubation is required
  – Concern that intubation or mask ventilation would be unsuccessful
  – Significant facial or laryngeal edema, trauma, or distortion
  – Spontaneously breathing patient who requires upper airway muscle tone and positioning

Rapid Sequence Intubation

• Organized approach to endotracheal intubation
  – Specific steps and actions that lead to rapid sedation and paralysis without positive-pressure ventilation once procedure begins
  – Purpose is to achieve optimal and rapid tracheal intubation in patients who are at risk for aspiration
  – Intended to take patient from a conscious, breathing state to a state of unconsciousness
  – Accomplished with complete neuromuscular paralysis
  – Intubation is performed without interposed mechanical ventilation

Rapid Sequence Intubation

• Six steps of RSI (the six “Ps”):
  – Preparation
  – Preoxygenation
  – Pretreatment
  – Paralysis (with sedation)
  – Placement of tube
  – Postintubation management
RSI Technique

• Preparation
  – Assess patient for difficulty of intubation (e.g., using Mallampati score)
  – Prepare all drugs and equipment
  – Ensure one or more patent IV lines
  – Explain procedure to patient

RSI Technique

• Preoxygenation
  – Done simultaneously with preparation
  – Preoxygenate patient with 100 percent O₂ for 5 minutes
    • Essential step of “no-bagging” approach of RSI
  – Consider use of pulse oximeter

RSI Technique

• Pretreatment
  – Done 3 minutes before intubation
  – Consider lidocaine to protect against rise in intracranial pressure and to prevent laryngospasm
  – Consider beta blockers or opioids to reduce sympathoadrenal response to intubation
RSI Technique

• Paralysis (with sedation)
  – Administer sedative (per protocol) to produce unconsciousness
    • Should be immediately followed by rapid push of neuromuscular blocker
  – Apply cricoid pressure as patient loses consciousness to prevent vomiting
    • Once neuromuscular blockade is established, active vomiting cannot occur

RSI Technique

• Paralysis (with sedation)
  – Do not initiate ventilations unless patient’s O₂ saturation falls below 90 percent
  – Within 45 seconds of administration of succinylcholine, patient will be relaxed enough for intubation

RSI Technique

• Placement
  – Perform orotracheal intubation and confirm placement
• Postintubation management
  – Secure tube in place
  – Begin mechanical ventilation
  – Monitor patient continuously
• If RSI is unsuccessful and patient cannot be intubated, patient’s airway should be managed by other means
Translaryngeal Cannula Ventilation

• Also known as percutaneous transtracheal ventilation and needle cricothyrotomy
• Valuable in initial stabilization of patient whose airway cannot be managed by usual manual measures
• Valuable in patients who cannot be intubated by oral or nasal means, or who have complete airway obstruction

Translaryngeal Cannula Ventilation

• Temporary procedure
• Provides oxygenation when airway is obstructed as result of edema of glottis, fracture of larynx, or severe oropharyngeal hemorrhage
• Requires special training and authorization from medical direction

Translaryngeal Cannula Ventilation

• Provides high-volume, high-pressure oxygenation of lungs
  – Occurs through cannulation of trachea below glottis
  – Delivers large volume of O₂ through small port at high pressure to lungs
  – O₂ delivery (50 psi) is much greater than can be achieved with other methods
Translaryngeal Cannula Ventilation

- Necessary equipment
  - 12- or 14-gauge over-the-needle catheter with a 5- or 10-mL syringe
  - Alcohol or povidone-iodine swabs
  - Adhesive tape or appropriate ties
  - Pressure-regulating valve and pressure gauge attached to high-pressure (30 to 60 psi) O₂ supply
    - Most O₂ tanks and regulators can provide 50 psi at 15 L/min or when opened to flush

Translaryngeal Cannula Ventilation

- Necessary equipment
  - High-pressure tubing connecting high-pressure regulating valve to hand-operated release valve (5-foot tubing recommended)
  - Release valve connected by tubing to catheter
    - May be provided via Y- or T-connector, through three-way stopcock directly attached to high-pressure tubing, or by cutting hole in O₂ line to provide “whistle-stop” effect

Translaryngeal Cannula Ventilation Technique

- Steps
  - Make sure patient is supine
    - Make sure cricothyroid membrane has been identified
    - If spinal injury is suspected, in-line stabilization may be provided as for nasal and tracheal intubation
  - Stabilize larynx using thumb and middle finger of one hand
    - With other hand, palpate small depression below thyroid cartilage (“Adam’s apple”)
    - Slide index finger down to locate cricothyroid membrane
Translaryngeal Cannula Ventilation Technique

- Insert needle of syringe downward through midline of membrane at 45- to 60-degree angle toward patient’s carina
  - Apply negative pressure to syringe during insertion
  - Entrance of air into syringe indicates needle is in trachea

- Advance catheter over needle toward carina and remove needle and syringe
  - Care must be taken not to kink catheter when removing needle and syringe
- Hold hub of catheter to prevent accidental dislodgement while providing ventilation
  - Remove end of the O₂ tubing from hub of cannula and connect it to O₂ regulator
  - Provide for release valve as described before
Translaryngeal Cannula Ventilation Technique

- When release valve is closed, O₂ under pressure is introduced into trachea
  - Pressure is adjusted to level that allows adequate lung expansion
  - Observe patient's chest closely
  - Release valve must be opened to allow for exhalation

Translaryngeal Cannula Ventilation Technique

- When release valve is closed, O₂ under pressure is introduced into trachea
  - Correct ratio of inflation to deflation varies
    - Depends on whether upper airway obstruction is present
    - For open upper airway, an inspiratory to expiratory ratio of 1 to 4 seconds is adequate
    - Ratios of about 1 to 8 seconds are needed to prevent barotrauma (injuries caused by excessive pressures) when upper airway is obstructed
Translaryngeal Cannula Ventilation

• Advantages
  – Least invasive of surgical procedures
  – Can be initiated quickly
  – When performed by trained paramedic, is simple, inexpensive, and effective
  – Minimal spinal movement is needed for insertion

• Disadvantages
  – Invasive procedure
  – Constant monitoring required
  – Jet ventilation required
  – Airway not protected
  – Procedure does not allow for efficient elimination of CO₂
  – Patient’s lungs may be adequately ventilated for only 30 to 45 minutes

• Complications
  – High pressure during ventilation and air entrapment may cause pneumothorax
  – Hemorrhage may occur at insertion site
    • Thyroid and esophagus also may be perforated if needle is advanced too far
  – Direct suctioning of secretions is impossible
  – Subcutaneous emphysema may occur
Translaryngeal Cannula Removal

• Temporary emergency procedure
  – Provides time for use of other airway management techniques
  – Removal should follow only after successful orotracheal or nasotracheal intubation or after cricothyrotomy or tracheostomy has been performed
  – Removal involves withdrawing catheter and dressing wound

Cricothyrotomy

• Surgical procedure
  – Allows rapid entrance to airway through cricothyroid membrane
  – Can be performed quickly
  – Much faster and easier than tracheostomy
  – Does not require manipulation of the cervical spine

Cricothyrotomy

• Can provide ventilation and oxygenation for patients in whom airway control is not possible by other means
  – Should not be performed on patients who can be orally or nasally intubated
  – Few situations require this surgical procedure
Cricothyrotomy

- Indications
  - Severe facial or nasal injuries that preclude oral or nasal intubation
  - Massive midfacial trauma
  - Possible spinal trauma preventing adequate ventilation
  - Anaphylaxis
  - Chemical inhalation injuries
  - Requires special training and authorization from medical direction

Cricothyrotomy Equipment

- Commercially prepared kits available through a number of manufacturers
  - If such a kit is not available, the following equipment is required
    - Scalpel blade
    - Size 6 (preferred) or size 7 ET tube or tracheostomy tube
    - Antiseptic solution
    - O₂ source
    - Suction device
    - Bag-valve device
Cricothyrotomy Technique

- In patients suspected of spinal injury, in-line stabilization should be maintained throughout the procedure
- If possible, neck should be cleaned with alcohol or another antiseptic solution

Cricothyrotomy Technique

- Steps
  - Locate anatomical landmarks of neck
    - Identify cricothyroid membrane
  - Make 2-cm (¾-inch) horizontal incision with scalpel at level of cricothyroid membrane
    - Some physicians may recommend a vertical skin incision instead of a horizontal one

Cricothyrotomy Technique

- Steps
  - Open incision in cricothyroid membrane by inserting scalpel handle
    - Rotate 90 degrees
    - Allows placement of size 6 or size 7 ET tube or tracheostomy tube, which will not damage larynx
    - Cuff should be inflated and tube securely tied
  - Provide ventilation by bag-mask device with highest available \(O_2\) concentration
  - Determine adequacy of ventilation
    - Can be done through bilateral auscultation and observation of rise and fall of chest
What conditions could make the anatomic landmarks for translaryngeal cannulation or cricothyrotomy difficult to locate?

Cricothyrotomy

- Possible complications
  - Prolonged procedure time
  - Hemorrhage
  - Aspiration
  - Possible misplacement
  - False passage
  - Perforation of esophagus
  - Injury to vocal cords and carotid and jugular vessels lateral to incision (patient must be immobilized)
  - Subcutaneous emphysema
Cricothyrotomy

• Contraindications
  – Inability to identify anatomical landmarks
  – Underlying anatomical abnormality (e.g., tumor, subglottic stenosis)
  – Tracheal transection
  – Acute laryngeal disease caused by trauma or infection
  – Small child under 10 years of age
    • Inserting 12- to 14-gauge catheter over needle may be safer than cricothyrotomy

Cricothyrotomy Removal

• In prehospital setting, no attempt should be made to remove endotracheal tubes used during emergency cricothyrotomy

Summary

• The upper airway opens at the nose and mouth and extends to glottic opening
• Structures of the lower airway include the trachea, right and left bronchus, bronchi, bronchioles and the functional units of the lungs, the alveoli
• Base of the lungs rests on the diaphragm
  – Right lung has three lobes and the left has two
Summary

• The primary muscles of ventilation are the diaphragm and the intercostal muscles
• The phrenic nerve enervates the diaphragm
• Respiration is the exchange of O₂ and CO₂ between an organism and environment
  – Pulmonary ventilation involves movement of gas into and out of the lungs

Summary

• External respiration is the transfer of gases between inspired air and pulmonary capillaries
  – Internal respiration is the transfer of gases between blood and tissue cells
• During inspiration, size of the thoracic cavity increases
  – Creates negative pressure inside the chest as compared to atmospheric pressure so air rushes into the lungs

Summary

• During exhalation, the chest muscles relax passively and air is forced out of the lungs
• Work of breathing increases if surfactant is lost, airway resistance increases or pulmonary compliance decreases
• Normal adult respiratory rate is 12 to 24 per minute
Summary

• No gas exchange occurs in anatomic dead space
  – Physiologic dead space includes the anatomic dead space plus any nonfunctioning alveoli
• The tidal volume is the amount of gas inhaled or exhaled with each normal breath
• Respiratory rate x Tidal volume = Minute volume

Summary

• Atmospheric gas contains approximately 79 percent nitrogen, 21 percent O₂ and less than 1 percent CO₂
• As pulmonary capillaries pass alveoli, CO₂ diffuses into alveoli and O₂ diffuses into pulmonary capillaries

Summary

• O₂ is carried in the blood on hemoglobin
  – Small amount is also dissolved in plasma
  – Amount of O₂ dissolved in the blood influences the extent to which O₂ binds with hemoglobin
  – Normal partial pressure of arterial blood O₂ (Pₐ) is 80 to 100 mmHg
  – Venous PO₂ in lungs is only 40 mmHg so O₂ diffuses easily from alveoli into pulmonary capillaries
Summary

• Respiratory centers are normally controlled by pH of body fluids, which are related to CO₂ levels
  – O₂ plays role in regulation of breathing in abnormal situations
• Body temperature, medications, pain, emotion, and sleep also influence breathing

Summary

• Modified forms of respiration are protective and include coughing, sneezing, and sighing
• Older adults experience alterations in ventilation and respiration that lead to a gradual decline in PO₂

Summary

• Respiratory compromise and hypoxia can be caused by
  – interruption of nervous control, structural damage to the thorax, bronchoconstriction, disruption of airway patency, O₂ deprivation, environmental factors, changes in alveolar–capillary gas exchange, ventilation deficiencies, decreases in lung compliance, ventilation–perfusion mismatch, disrupted O₂ transport, disrupted circulation, or cellular disruptions
Summary

• Upper airway obstruction can rapidly cause death if not corrected
• Aspiration is inhalation of food, fluid, or foreign bodies into the lungs
  – Can cause airway obstruction and chemical damage with collapse of alveoli

Summary

• Assess rate, regularity, and rhythm of breathing
  – Note patient's position, color, and heart rate
  – Thorough patient history should be obtained

Summary

• Respiratory distress may be caused by upper or lower airway obstruction, inadequate ventilation, impairment of the respiratory muscles, ventilation–perfusion mismatching, diffusion abnormalities, or impairment of the nervous system
• Supplemental O₂ is administered to increase O₂ content in pulmonary capillaries and to help patient compensate
Summary

• $O_2$ is administered by a variety of devices that regulate concentration of $O_2$ delivered to patient

• Patient ventilation is provided by several methods
  – Include rescue breathing (mouth to mouth, mouth to nose, mouth to stoma), mouth-to-mask breathing, bag-mask devices, and automatic transport ventilators

Summary

• Airway management should progress from the least to most invasive methods
  – Airway management begins with manual maneuvers

Summary

• Oropharyngeal or tracheal suction is used to remove liquids and foreign objects from airway

• Gastric distention can impair ventilation and it increases risk of aspiration
  – Orogastric or nasogastric tubes are inserted to reduce gastric distention
Summary

• After manual airway maneuvers are performed, mechanical adjuncts can be used to maintain airway
  – Nasopharyngeal airways are used to maintain airway in patients with a gag reflex
  – Oropharyngeal airway is inserted in patients with no gag reflex

Summary

• Advanced airways include those that intubate trachea and peritracheal airways such as laryngeal mask airway, King LT-D Airway, and esophageal-tracheal Combitude airway

Summary

• ET intubation permits direct ventilation of the trachea, protection against aspiration, and a route to administer some medications
  – ET tube may be inserted orally or nasally (in breathing patients)
  – Adjuncts to assist with intubation include the stylet, tube introducer (bougie), or Magill forceps
Summary

• It is essential to confirm proper placement of the ET tube
  – Measures include auscultation of breath sounds, absence of gastric sounds, use of an esophageal detector device, and measurement of end-tidal CO₂ and O₂ saturation

• Laryngeal mask airway is inserted blindly into the hypopharynx in unresponsive patients with no gag reflex

Summary

• An esophageal-tracheal Combitude is a twin-lumen airway placed blindly in unconscious patients with no gag reflex
  – In most cases, the distal lumen is positioned in the esophagus and inflation of balloons in the hypopharynx permits ventilation through tube number 1
  – In rare cases, when the distal lumen is positioned in the trachea, the patient is ventilated through tube number 2

Summary

• Sedation is sometimes used in airway management and ventilation to reduce anxiety, induce amnesia, and decrease the gag reflex

• In some systems, neuromuscular blocking agents are used with sedation to permit ET intubation
Summary

• When an airway cannot be introduced through the nose or mouth and the patient cannot be ventilated, translaryngeal cannula ventilation or cricothyrotomy may be performed to access airway by creating an opening in the cricothyroid membrane in the neck.

Questions?