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**UNIT TERMINAL OBJECTIVE**

2-1 At the completion of this unit, the student will be able to establish and/ or maintain a patent airway, oxygenate, and ventilate a patient.

**COGNITIVE OBJECTIVES**

At the completion of this unit, the student will be able to:

2-1.1 Explain the primary objective of airway maintenance. (C-1)
2-1.2 Identify commonly neglected prehospital skills related to airway. (C-1)
2-1.3 Identify the anatomy and functions of the upper airway. (C-1)
2-1.4 Describe the anatomy and functions of the lower airway. (C-1)
2-1.5 Explain the differences between adult and pediatric airway anatomy. (C-1)
2-1.6 Define normal tidal volumes for the adult, child, and infant. (C-1)
2-1.7 Define atelectasis. (C-1)
2-1.8 Define $FiO_2$. (C-1)
2-1.9 Explain the relationship between pulmonary circulation and respiration. (C-3)
2-1.10 List factors which cause decreased oxygen concentrations in the blood. (C-1)
2-1.11 List the factors which increase and decrease carbon dioxide production in the body. (C
2-1.12 Describe the measurement of oxygen in the blood. (C-1)
2-1.13 Describe the measurement of carbon dioxide in the blood. (C-1)
2-1.14 List the concentration of gases which comprise atmospheric air. (C-1)
2-1.15 List the factors which affect respiratory rate and depth. (C-1)
2-1.16 Describe the voluntary and involuntary regulation of respiration. (C-1)
2-1.17 Describe causes of upper airway obstruction. (C-1)
2-1.18 Define normal respiratory rates for adult, child, and infant. (C-1)
2-1.19 Describe causes of respiratory distress. (C-1)
2-1.20 Define and differentiate between hypoxia and hypoxemia. (C-1)
2-1.21 Define pulsus paradoxus. (C-1)
2-1.22 Describe the modified forms of respiration. (C-1)
2-1.23 Define gag reflex. (C-1)
2-1.24 Explain safety considerations of oxygen storage and delivery. (C-1)
2-1.25 Identify types of oxygen cylinders and pressure regulators (including a high-pressure regulator and a therapy regulator). (C-1)
2-1.26 List the steps for delivering oxygen from a cylinder and regulator. (C-1)
2-1.27 Describe the indications, contraindications, advantages, disadvantages, complications, liter flow range, and concentration of delivered oxygen for supplemental oxygen delivery devices. (C-3)
2-1.28 Describe the use, advantages and disadvantages of an oxygen humidifier. (C-1)
2-1.29 Define, identify and describe a tracheostomy, stoma, and tracheostomy tube. (C-1)
2-1.30 Explain the risk of infection to EMS providers associated with ventilation. (C-3)
2-1.31 Describe the indications, contraindications, advantages, disadvantages, complications, and technique for ventilating a patient by: (C-1)
- b. Mouth-to-mouth
- c. Mouth-to-nose
- d. Mouth-to-mask
- e. One person bag-valve-mask
- f. Two person bag-valve-mask
- g. Three person bag-valve-mask
- h. Flow-restricted, oxygen-powered ventilation device

2-1.32 Explain the advantage of the two person method when ventilating with the bag-valve-mask. (C-1)

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2-1.33 Describe indications, contraindications, advantages, disadvantages, complications, and technique for ventilating a patient with an automatic transport ventilator (ATV). (C-1)
2-1.34 Describe the Sellick (cricoid pressure) maneuver. (C-1)
2-1.35 Describe the use of cricoid pressure during intubation. (C-1)
2-1.36 Compare the ventilation techniques used for an adult patient to those used for pediatric patients. (C-3)
2-1.37 Define how to ventilate a patient with a stoma, including mouth-to-stoma and bag-valve-mask-to-stoma ventilation. (C-1)
2-1.38 Define complete airway obstruction. (C-1)
2-1.39 Define and explain the implications of partial airway obstruction with good and poor air exchange. (C-1)
2-1.40 Describe complete airway obstruction maneuvers. (C-1)
2-1.41 Describe laryngoscopy for the removal of a foreign body airway obstruction. (C-1)
2-1.42 Identify types of suction catheters, including hard or rigid catheters and soft catheters. (C-1)
2-1.43 Explain the purpose for suctioning the upper airway. (C-1)
2-1.44 Identify types of suction equipment. (C-1)
2-1.45 Describe the indications for suctioning the upper airway. (C-3)
2-1.46 Identify techniques of suctioning the upper airway. (C-1)
2-1.47 Identify special considerations of suctioning the upper airway. (C-1)
2-1.48 Describe the technique of tracheobronchial suctioning in the intubated patient. (C-3)
2-1.49 Define gastric distention. (C-1)
2-1.50 Describe the indications, contraindications, advantages, disadvantages, complications, equipment and technique for inserting a nasogastric tube and orogastric tube. (C-1)
2-1.51 Describe manual airway maneuvers. (C-1)
2-1.52 Describe the use of an oral and nasal airway. (C-1)
2-1.53 Describe the indications, contraindications, advantages, disadvantages, complications, and technique for inserting an oropharyngeal and nasopharyngeal airway (C-1)
2-1.54 Differentiate endotracheal intubation from other methods of advanced airway management. (C-3)
2-1.55 Describe the indications, contraindications, advantages, disadvantages and complications of endotracheal intubation. (C-1)
2-1.56 Describe the visual landmarks for direct laryngoscopy. (C-1)
2-1.57 Describe the methods of assessment for confirming correct placement of an endotracheal tube. (C-1)
2-1.58 Describe methods for securing an endotracheal tube. (C-1)
2-1.59 Describe the indications, contraindications, advantages, disadvantages, complications, equipment and technique for extubation. (C-1)
2-1.60 Describe methods of endotracheal intubation in the pediatric patient. (C-1)
2-1.61 Describe the indications, contraindications, advantages, disadvantages, complications, equipment, and technique for using a dual lumen airway. (C-3)
2-1.62 Define, identify, and describe a laryngectomy. (C-1)
2-1.63 Describe the special considerations in airway management and ventilation for patients with facial injuries. (C-1)
2-1.64 Describe the special considerations in airway management and ventilation for the pediatric patient. (C-1)

**AFFECTIVE OBJECTIVES**

At the completion of this unit, the intermediate student will be able to:

2-1.65 Defend oxygenation and ventilation. (A-1)
2-1.66 Defend the necessity of establishing and/ or maintaining patency of a patient's airway. (A-1)
2-1.67 Comply with standard precautions to defend against infectious and communicable diseases. (A-1)

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## PSYCHOMOTOR OBJECTIVES

At the completion of this unit, the student will be able to:

2-1.68 Perform body substance isolation (BSI) procedures during basic airway management, advanced airway management, and ventilation. (P-2)
2-1.69 Perform pulse oximetry. (P-2)
2-1.70 Perform end-tidal $CO_2$ detection. (P-2)
2-1.71 Perform oxygen delivery from a cylinder and regulator with an oxygen delivery device. (P-2)
2-1.72 Deliver supplemental oxygen to a breathing patient using the following devices: nasal cannula, simple face mask, partial rebreather mask, non-rebreather mask, and venturi mask. (P-2)
2-1.73 Perform oxygen delivery with an oxygen humidifier. (P-2)
2-1.74 Perform medication administration with an in-line small-volume nebulizer. (P-2)
2-1.75 Demonstrate ventilating a patient by the following techniques: (P-2)
- a. Mouth-to-mask ventilation
- b. One person bag-valve-mask
- c. Two person bag-valve-mask
- d. Three person bag-valve-mask
- e. Flow-restricted, oxygen-powered ventilation device
- f. Automatic transport ventilator
- g. Mouth-to-stoma
- h. Bag-valve-mask-to-stoma ventilation

2-1.76 Perform the Sellick maneuver (cricoid pressure). (P-2)
2-1.77 Ventilate a pediatric patient using the one and two person techniques. (P-2)
2-1.78 Perform complete airway obstruction maneuvers, including: (P-2)
- a. Heimlich maneuver
- b. Finger sweep
- c. Chest thrusts
- d. Removal with Magill forceps

2-1.79 Perform retrieval of foreign bodies from the upper airway. (P-2)
2-1.80 Demonstrate suctioning the upper airway by selecting a suction device, catheter and technique. (P-2)
2-1.81 Perform tracheobronchial suctioning in the intubated patient by selecting a suction device, catheter and technique. (P-2)
2-1.82 Demonstrate insertion of a nasogastric tube. (P-2)
2-1.83 Demonstrate insertion of an orogastric tube. (P-2)
2-1.84 Perform gastric decompression by selecting a suction device, catheter and technique. (P-2)
2-1.85 Perform manual airway maneuvers, including: (P-2)
- a. Opening the mouth
- b. Head-tilt/ chin-lift maneuver
- c. Jaw-thrust without head-tilt maneuver
- d. Modified jaw-thrust maneuver

2-1.86 Perform manual airway maneuvers for pediatric patients, including: (P-2)
- a. Opening the mouth
- b. Head-tilt/ chin-lift maneuver
- c. Jaw-thrust without head-tilt maneuver
- d. Modified jaw-thrust maneuver

2-1.87 Demonstrate insertion of an oropharyngeal airway. (P-2)
2-1.88 Demonstrate insertion of a nasopharyngeal airway. (P-2)
2-1.89 Intubate the trachea by direct orotracheal intubation. (P-2)
2-1.90 Perform assessment to confirm correct placement of the endotracheal tube. (P-2)

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2-1.91 Adequately secure an endotracheal tube. (P-1)
2-1.92 Perform extubation. (P-2)
2-1.93 Perform endotracheal intubation in the pediatric patient. (P-2)
2-1.94 Insert a dual lumen airway. (P-2)
2-1.95 Perform stoma suctioning. (P-2)
2-1.96 Perform replacement of a tracheostomy tube through a stoma. (P-2)

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**DECLARATIVE**

I. Introduction
- A. The body's need for oxygen
- B. Primary objective of emergency care
  - 1. Ensure optimal ventilation
    - a. Delivery of oxygen
    - b. Elimination of $CO_2$
- C. Brain death occurs within 6 to 10 minutes
- D. Major prehospital causes of preventable death
  - 1. Early detection
  - 2. Early intervention
  - 3. Lay-person BLS education
- E. Most often neglected of prehospital skills
  - 1. Basics taken for granted
  - 2. Poor techniques
    - a. BVM seal
    - b. Improper positioning
    - c. Failure to reassess

II. Anatomy of upper airway
- A. Function of the upper airway
  - 1. Warm
  - 2. Filter
  - 3. Humidify
- B. Pharynx
  - 1. Nasopharynx
    - a. Formed by the union of facial bones
    - b. Orientation of nasal floor is towards the ear not the eye
    - c. Separated by septum
    - d. Lined with
      - (1) Mucous membranes
      - (2) Cilia
    - e. Turbinate
      - (1) Parallel to nasal floor
      - (2) Provide increased surface area for air
        - (a) Filtration
        - (b) Humidifying
        - (c) Warming
    - f. Sinuses
      - (1) Cavities formed by cranial bones
      - (2) Appear to further trap bacteria and act as tributaries for fluid to and from eustachian tubes and tear ducts
        - (a) Commonly become infected
        - (b) Fracture of certain sinus bones may cause cerebro-spinal fluid (CSF) leak
    - g. Tissues extremely delicate and vascular
      - (1) Improper or overly aggressive placement of tubes or airways will cause significant bleeding which may not be controlled by direct pressure

2. Oropharynx
   a. Teeth
      (1) 32 adult
      (2) Requires significant force to dislodge
      (3) May fracture or avulse causing obstruction
   b. Tongue
      (1) Large muscle attached at the mandible and hyoid bones
      (2) Most common airway obstruction
   c. Palate
      (1) Roof of mouth separates oro/ nasopharynx
         (a) Anterior is hard palate
         (b) Posterior (beyond the teeth) is soft palate
   d. Adenoids
      (1) Lymph tissue located in the mouth and nose that filters bacteria
      (2) Frequently infected and swollen
   e. Posterior tongue
   f. Epiglottis
   g. Vallecula
      (1) "Pocket" formed by the base of the tongue and epiglottis
      (2) Important landmark for endotracheal intubation

C. Larynx
1. Attached to hyoid bone
   a. "Horseshoe" shaped bone between the chin and mandibular angle
   b. Supports trachea
   c. Made of cartilage
2. Thyroid cartilage
   a. First tracheal cartilage
   b. "Shield shaped"
      (1) Cartilage anterior
      (2) Smooth muscle posterior
   c. Laryngeal prominence
      (1) "Adam's Apple" anterior prominence of thyroid cartilage
      (2) Glottic opening directly behind
3. Glottic opening
   a. Narrowest part of adult trachea
   b. Patency heavily dependent on muscle tone
   c. Contain vocal bands
      (1) White bands of cartilage
      (2) Produce voice
4. Arytenoid cartilage
   a. "Pyramid like" posterior attachment of vocal bands
   b. Important landmark for endotracheal intubation
5. Pyriform fossae
   a. “Hollow pockets” along the lateral borders of the larynx
6. Cricoid ring
   a. First tracheal ring
   b. Completely cartilaginous
   c. Compression occludes esophagus (Sellick maneuver)
7. Cricothyroid membrane

a. Fibrous membrane between cricoid and thyroid cartilage
b. Site for surgical and alternative airway placement
8. Associated structures
a. Thyroid gland
(1) Located below cricoid cartilage
(2) Lies across trachea and up both sides
b. Carotid arteries
(1) Branches cross and lie closely alongside trachea
c. Jugular veins
(1) Branch across and lie close to trachea

III. Anatomy of lower airway
A. Function of the lower airway
1. Exchange of $O_2$ and $CO_2$
B. Location of the lower airway
1. From fourth cervical vertebrae to xyphoid process
2. From glottic opening to pulmonary capillary membrane
C. Structures of the lower airway
1. Trachea
a. Trachea bifurcates at carina into
(1) Right and left mainstem bronchi
(2) Right mainstem has lesser angle
(a) Foreign bodies, ET tubes commonly displace here
(3) Lined with
(a) Mucous cells
(b) Beta 2 receptors - dilate bronchioles
2. Bronchi
a. Mainstem bronchi enter lungs at hilum
b. Branch into narrowing secondary and tertiary bronchi which branch into bronchioles
3. Bronchioles
a. Branch into alveolar ducts which end at alveolar sacs
4. Alveoli
a. "Balloon like" clusters
b. Site of gas exchange
c. Lined with surfactant
(1) Decreases surface tension of alveoli which facilitates ease of expansion
(2) Alveoli become thinner as they expand which makes diffusion of $O_2$/ $CO_2$ easier
(3) If surfactant is decreased or alveoli are not inflated, alveoli collapse (atelectasis)
5. Lungs
a. Right lung
(1) 3 lobes
b. Left lung
(1) 2 lobes
c. Lobes made of parenchymal tissue
d. Membranous outer lining called pleura
e. Lung capacity

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IV. Differences in pediatric airway
- A. Pharynx
  1. A proportionately smaller jaw causes the tongue to encroach upon the airway
  2. Omega shaped, floppy epiglottis
  3. Absent or very delicate dentition
- B. Trachea
  1. Airway is smaller and narrower at all levels
  2. Larynx lies more superior
  3. Larynx is "funnel shaped" due to narrow, undeveloped cricoid cartilage
  4. Narrowest point is at cricoid ring before 10 years of age
  5. Further narrowing of the airway by tissue swelling of foreign body results in major increase in airway resistance
- C. Chest wall
  1. Ribs and cartilage are softer
  2. Cannot optimally contribute to lung expansion
  3. Infants and children tend to depend more heavily on the diaphragm for breathing

V. Lung/ respiratory volumes
- A. Total lung volume
  1. Adult male, 6 liters
  2. Not all inspired air enters alveoli
  3. Minor diffusion of $O_2$ takes place in alveolar ducts and terminal bronchioles
- B. Tidal volume
  1. Volume of gas inhaled or exhaled during a single respiratory cycle
  2. 5-7cc/ kg (500 cc normally)
- C. Dead space air
  1. Air remaining in air passageways, unavailable for gas exchange (approximately 150 cc)
  2. Anatomic dead space
     - a. Trachea
     - b. Bronchi
  3. Physiologic dead space
     - a. Dead space formed by factors like disease or obstruction
       - (1) COPD
       - (2) Atelectasis
- D. Minute volume
  1. Amount of gas moved in and out of the respiratory tract per minute
  2. Determined by
     - a. Tidal volume - dead space volume times respiratory rate
- E. Functional reserve capacity
  1. After optimal inspiration: optimum amount of air that can be forced from the lungs in a single forced exhalation
- F. Residual volume
  1. Volume of air remaining in lungs at the end of maximal expiration
- G. Alveolar air
  1. Air reaching the alveoli for gas exchange (alveolar volume)
  2. Approximately 350 cc
- H. Inspiratory reserve
  1. Amount of gas that can be inspired in addition to tidal volume
- I. Expiratory reserve

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1. Amount of gas that can be expired after a passive (relaxed) expiration

J. $FiO_2$
   1. Percentage of oxygen in inspired air (increases with supplemental oxygen)
      a. Commonly documented as a decimal (e.g., $FiO_2$ = .85)

VI. Ventilation
   A. Definition - movement of air into and out of the lungs
   B. Phases
      1. Inspiration
         a. Stimulus to breathe from respiratory center
         b. Impulse transmitted to diaphragm via phrenic nerve
            (1) Diaphragm - "muscle of respiration"
            (2) Separates thoracic from abdominal cavity
         c. Diaphragm contracts - "flattens"
            (1) Causes intrapulmonic pressure to fall slightly below atmospheric pressure
         d. Intercostal muscles contract
         e. Ribs elevate and expand
         f. Air is drawn into lungs like a vacuum
         g. Alveoli Inflate
         h. $O_2$/ $CO_2$ are able to diffuse across membrane
      2. Expiration
         a. Stretch receptors in lungs signal respiratory center via vagus nerve to inhibit inspiration (Hering-Breuer Reflex)
         b. Natural elasticity (recoil) of the lungs passively expires air

VII. Respiration
   A. Definition
      1. Exchange of gases between a living organism and its environment
      2. The major gases of respiration are oxygen and carbon dioxide
   B. Types
      1. External respiration - exchange of gasses between the lungs and the blood cells
      2. Internal respiration - exchange of gases between the blood cells and tissues
   C. The transportation of oxygen and carbon dioxide in the human body
      1. Diffusion - passage of solution from area of higher concentration to lower concentration
         a. $O_2$/ $CO_2$ dissolve in water and pass through alveolar membrane by diffusion
      2. Oxygen content of blood
         a. Dissolved $O_2$ crosses pulmonary capillary membrane and binds to hemoglobin (Hgb) of red blood cell
         b. Oxygen is carried
            (1) Bound to hemoglobin
            (2) Dissolved in plasma
         c. Approximately 97% of total $O_2$ is bound to hemoglobin
         d. $O_2$ saturation
            (1) % of hemoglobin saturated
            (2) Normally greater than 98%
      3. Oxygen in the blood
         a. Bound to hemoglobin
            (1) $SaO_2$

b. Dissolved in plasma
(1) $PaO_2$

4. Carbon dioxide content of the blood
a. $CO_2$ is a byproduct of cellular work (cellular respiration)
b. $CO_2$ is transported in blood as bicarbonate ion
c. About 33% is bound to hemoglobin
d. As $O_2$ crosses into blood, $CO_2$ diffuses into alveoli
e. Carbon dioxide in the blood
(1) $PaCO_2$

5. Diagnostic testing
a. Pulse oximetry
b. Peak expiratory flow testing
c. End-tidal $CO_2$ monitoring
d. Other diagnostic equipment

VIII. Causes of decreased oxygen concentrations in the blood
A. Lower partial pressure of atmospheric $O_2$
B. Lower hemoglobin levels in blood
C. Trauma
1. Less surface area for gas exchange
a. Pneumothorax
b. Hemothorax
c. Combination of pneumothorax and hemothorax
2. Decreased mechanical effort
a. Pain
b. Traumatic suffocation
c. Hypoventilation
D. Medical
1. Physiological barriers
a. Pneumonia
b. Pulmonary edema
c. COPD

IX. Carbon dioxide in blood
A. Increases
1. Hypoventilation
B. Decreases
1. Hyperventilation

X. The measurement of gases
A. Total pressure
1. The combined pressure of all atmospheric gases
2. 100% or 760 torr at sea level
B. Partial pressure
1. The pressure exerted by a specific atmospheric gas
C. Concentration of gases in the atmosphere
1. Nitrogen 597.0 torr (78.62%)
2. Oxygen 159.0 torr (20.84%)
3. $CO_2$ 0.3 torr ( 0.04%)

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4. Water 3.7 torr ( 0.50%)

D. Water vapor pressure

E. Alveolar gas concentration
   1. Nitrogen 569.0 torr (74.9%)
   2. Oxygen 104.0 torr (13.7%)
   3. $CO_2$ 40.0 torr ( 5.2%)
   4. Water 47.0 torr ( 6.2%)

XI. Respiratory rate
   A. Definition - the number of times a person breathes in one minute
   B. Neural control
      1. Primary control from the medulla and pons
      2. Medulla
         a. Primary involuntary respiratory center
         b. Connected to respiratory muscles by vagus nerve
      3. Pons
         a. Apneustic center - secondary control center if medulla fails to initiate respiration
         b. Pneumotaxic center - controls expiration
   C. Chemical stimuli
      1. Receptors for $O_2$/ $CO_2$ balance
         a. Cerebrospinal fluid pH
         b. Carotid bodies (sinus)
         c. Aortic arch
      2. Hypoxic drive - respiratory stimulus dependent on $O_2$ rather than $CO_2$ in the blood
   D. Control of respiration by other factors
      1. Body temperature - respirations increase with fever
      2. Drug and medications - may increase or decrease respirations depending on their physiologic action
      3. Pain - increases respirations
      4. Emotion - increases respirations
      5. Hypoxia - increases respirations
      6. Acidosis - respirations increase as compensatory response to increased $CO_2$ production
      7. Sleep - respirations decrease

XII. Pathophysiology
   A. Obstruction
      1. Tongue
         a. Most common airway obstruction
         b. Snoring respirations
         c. Corrected with positioning
      2. Foreign body
         a. May cause partial or full obstruction
         b. Symptoms include
            (1) Choking
            (2) Gagging
            (3) Stridor
            (4) Dyspnea
            (5) Aphonia (unable to speak)
            (6) Dysphonia (difficulty speaking)

3. Laryngeal spasm and edema
    a. Spasm
        (1) Spasmotic closure of vocal cords
        (2) Most frequently caused by
            (a) Trauma from over aggressive technique during intubation
            (b) Immediately upon extubation especially when patient is semiconscious
    b. Edema
        (1) Glottic opening becomes extremely narrow or totally obstructed
        (2) Most frequently caused by
            (a) Epiglottitis (a bacterial infection of the epiglottis)
            (b) Anaphylaxis (severe allergic reaction)
            (c) Relieved by
        (3) Aggressive ventilation
        (4) Forceful upward pull of the jaw
        (5) Muscle relaxants
4. Fractured larynx
    a. Airway patency dependent upon muscle tone
    b. Fractured laryngeal tissue
        (1) Increases airway resistance by decreasing airway size through
            (a) Decreasing muscle tone
            (b) Laryngeal edema
            (c) Ventilatory effort
5. Aspiration
    a. Significantly increases mortality
        (1) Obstructs airway
        (2) Destroys delicate bronchiolar tissue
        (3) Introduces pathogens
        (4) Decreases ability to ventilate

XIII. Airway evaluation
A. Essential parameters
1. Rate
    a. Normal resting rate in:
        (1) Adult
        (2) Child
        (3) Infant
2. Regularity
    a. Steady pattern
    b. Irregular respiratory patterns are significant until proven otherwise
3. Effort
    a. Breathing at rest should be effortless
    b. Effort changes may be subtle in rate or regularity
    c. Patients often compensate by preferential positioning
        (1) Upright sniffing
        (2) Semi-Fowlers
        (3) Frequently avoid supine
B. Recognition of airway problems
1. Respiratory distress

a. Upper and lower airway obstruction
b. Inadequate ventilation
c. Impairment of the respiratory muscles
d. Impairment of the nervous system

2. Difficulty in rate, regularity, or effort is defined as dyspnea
3. Dyspnea may be result of or result in hypoxia
   a. Hypoxia - lack of oxygen
   b. Hypoxemia - lack of oxygen to tissues
   c. Anoxia - total absence of oxygen
4. Recognition and treatment of dyspnea is crucial to patient survival
   a. Expert assessment and management is essential
      (1) The brain can survive only a few minutes of anoxia
      (2) All therapies fail if airway is inadequate
5. Visual techniques
   a. Position
      (1) Tripod positioning
      (2) Orthopnea
   b. Rise and fall of chest
   c. Gasping
   d. Color of skin
   e. Flaring of nares
   f. Pursed lips
   g. Retraction
      (1) Intercostal
      (2) Suprasternal notch
      (3) Supraclavicular fossa
      (4) Subcostal
6. Auscultation techniques
   a. Air movement at mouth and nose
   b. Bilateral lung fields equal
7. Palpation techniques
   a. Air movement at mouth and nose
   b. Chest wall
      (1) Paradoxical motion
      (2) Retractions
8. Bag-valve-mask
   a. Resistance or changing compliance with bag-valve-mask ventilations
9. Pulsus paradoxus
   a. Systolic blood pressure drops greater than 10mm Hg with inspiration
      (1) Change in pulse quality may be detected
      (2) Seen in COPD, pericardial tamponade
      (3) Possible increase in intrathoracic pressure
10. History
   a. Evolution
      (1) Sudden
      (2) Gradual over time
      (3) Known cause or "trigger"
   b. Duration
      (1) Constant

(2) Recurrent
c. Ease - what makes it better?
d. Exacerbate - what makes it worse?
e. Associate
(1) Other symptoms (productive cough, chest pain, fever, etc.)
f. Interventions
(1) Evaluations/ admissions to hospital
(2) Medications (include compliance)
(3) Ever intubated

11. Modified forms of respiration
a. Protective reflexes
(1) Cough
(a) Forceful, spastic exhalation
(b) Aids in clearing bronchi and bronchioles
(2) Sneeze - clears nasopharynx
(3) Gag reflex - spastic pharyngeal and esophageal reflex from stimulus of the posterior pharynx
b. Sighing
(1) Involuntary deep breath that increases opening of alveoli
(2) Normally sigh about once per minute
c. Hiccough - intermittent spastic closure of glottis

12. Respiratory pattern changes
a. Cheyne-Stokes
(1) Gradually increasing rate and tidal volume followed by gradual decrease
(2) Associated with brain stem insult
b. Kussmall's breathing
(1) Deep, gasping respirations
(2) Common in diabetic coma
c. Biot's respirations
(1) Irregular pattern, rate, and volume with intermittent periods of apnea
(2) Increased intracranial pressure
d. Central neurogenic hyperventilation
(1) Deep rapid respirations similar to Kussmall's
(2) Increased intracranial pressure
e. Agonal
(1) Slow, shallow, irregular respirations
(2) Resulting from brain anoxia

13. Inadequate ventilation
a. Occurs when body cannot compensate for increased $O_2$ demand or maintain $O_2$/ $CO_2$ balance
b. Many causes
(1) Infection
(2) Trauma
(3) Brainstem insult
(4) Noxious or hypoxic atmosphere
(5) Renal failure
c. Multiple symptoms
(1) Altered response
(2) Respiratory rate changes (up or down)

XIV. Supplemental oxygen therapy
- A. Rationale
  - 1. Enriched $O_2$ atmosphere increases oxygen to cells
  - 2. Increasing available $O_2$ increases patient's ability to compensate
  - 3. $O_2$ delivery method must be reassessed to determine adequacy and efficiency
- B. Oxygen source
  - 1. Compressed gas
    - a. Oxygen compressed in gas form in an aluminum or steel tank
    - b. Common sizes and volumes
      - (1) D 400L
      - (2) E 660L
      - (3) M 3450L
    - c. $O_2$ delivery measured in liters/ min (LPM)
    - d. Calculating tank life
      - (1) ((Tank pressure (psi) - 200) * 0.28) ÷ LPM
      - (2) Volume/ LPM = tank life in minutes
  - 2. Liquid oxygen
    - a. $O_2$ cooled to its aqueous state
      - (1) Converts to gaseous state when warmed
    - b. Advantage
      - (1) Much larger volume of gaseous $O_2$ can be stored in aqueous state
    - c. Disadvantages
      - (1) Units generally require upright storage
      - (2) Special requirements for large volume storage and cylinder transfer
- C. Regulators
  - 1. High pressure
    - a. Attached to cylinder stem delivers cylinder gas under high pressure
    - b. Used to transfer cylinder gas from tank to tank
  - 2. Therapy regulators
    - a. Attached to cylinder stem
    - b. 50 psi escape pressure is "stepped down" through regulator mechanism
    - c. Subsequent delivery to patient is adjustable low pressure
- D. Delivery devices
  - 1. Nasal cannula
    - a. Nasally placed $O_2$ catheter for oxygen enrichment
    - b. Optimal delivery: 40% at 6 L/ min
    - c. Indications
      - (1) Low to moderate $O_2$ enrichment
      - (2) Long term $O_2$ maintenance therapy
    - d. Contraindications
      - (1) Poor respiratory effort
      - (2) Severe hypoxia
      - (3) Apnea
      - (4) Mouth breathing
    - e. Advantage
      - (1) Well tolerated
    - f. Disadvantage
      - (1) Does not deliver high volume/ high concentration

2. Simple face mask
   a. Full airway enclosure with open side ports
      (1) Room air is drawn through side ports on inspiration
      (2) Dilutes $O_2$ concentration
   b. Indications
      (1) Delivery of moderate to high $O_2$ concentrations
      (2) Range - 40-60% at 10 L/ min
   c. Advantage
      (1) Higher $O_2$ concentrations
   d. Disadvantage
      (1) Delivery of volumes beyond 10 L/ min does not enhance $O_2$ concentration
   e. Special considerations
      (1) Mask leak around face decreases $O_2$ concentration
3. Partial rebreather
   a. Mask vent ports covered by one-way disc
      (1) Residual expired air mixed in mask and rebreathed
      (2) Room air not entrained with inspiration
   b. Indications
   c. Contraindications
      (1) Apnea
      (2) Poor respiratory effort
   d. Advantages
      (1) Inspired gas not mixed with room air
         (a) Higher $O_2$ concentrations attainable
      (2) Disadvantages
         (a) Delivery of volumes beyond 10 L/ min does not enhance $O_2$ concentration
   e. Special considerations
      (1) Mask leak around face decreases $O_2$ concentration
4. Non-rebreather mask
   a. Mask side ports covered by one-way disc
   b. Reservoir bag attached
   c. Range: 80-95+% at 15 L/ min
   d. Indication
      (1) Delivery of highest $O_2$ concentration
   e. Contraindications
      (1) Apnea
      (2) Poor respiratory effort
   f. Advantages
      (1) Highest $O_2$ concentration
      (2) Delivers high volume/ high $O_2$ enrichment
      (3) Patient inhales enriched $O_2$ from reservoir bag rather than residual air
   g. Disadvantages
5. Venturi mask
   a. Mask with interchangeable adapters
      (1) Adapters have port holes that entrain room air as $O_2$ passes
      (2) Patient receives a highly specific concentration of $O_2$
      (3) Air is entrained by venturi principle

6. Small volume nebulizer
   a. Delivers aerosolized medication
   b. $O_2$ enters an aerosol chamber containing 3-5 ccs of fluid
   c. Pressurized $O_2$ mists fluid

E. Oxygen humidifiers
1. Sterile water reservoir for humidifying $O_2$
2. Good for long term $O_2$ administration
3. Desirable for croup/ epiglottitis/ bronchiolitis

F. Tracheostomy, stoma, and tracheostomy tubes
1. Tracheostomy
   a. Surgical opening into trachea
      (1) Done in operating room under controlled conditions
      (2) A stoma located just superior to the suprasternal notch
2. Stoma
   a. Resultant orifice connecting trachea to outside air
   b. Patient now breathes through this surgical opening
3. Tracheostomy tube
   a. Plastic tube placed within tracheostomy site
   b. 15 mm connector for ventilator acceptance

XV. Ventilation

A. Mouth-to-mouth
1. Most basic form of ventilation
2. Indication
   a. Apnea from any mechanism when other ventilation devices are not available
3. Contraindications
   a. Awake patients
   b. Communicable disease risk limitations
4. Advantages
   a. No special equipment required
   b. Delivers excellent tidal volume
   c. Delivers adequate oxygen
5. Disadvantages
   a. Psychological barriers from
      (1) Sanitary issues
      (2) Communicable disease issues
         (a) Direct blood/ body fluid contact
         (b) Unknown communicable disease risks at time of event
6. Complications
   a. Hyperinflation of patient's lungs
   b. Gastric distension
   c. Blood/ body fluid contact manifestation
   d. Hyperventilation of rescuer

B. Mouth-to-nose
1. Ventilating through nose rather than mouth
2. Indication
   a. Apnea from any mechanism
3. Contraindication
   a. Awake patients

4. Advantage
   a. No special equipment required
5. Disadvantages
   a. Direct blood/ body fluid contact
   b. Psychological limitations of rescuer
6. Complications
   a. Hyperinflation of patient's lungs
   b. Gastric distension
   c. Blood/ body fluid manifestation
   d. Hyperventilation of rescuer

C. Mouth-to-mask
1. Adjunct to mouth-to-mouth ventilation
2. Indication
   a. Apnea from any mechanism
3. Contraindication
   a. Awake patients
4. Advantages
   a. Physical barrier between rescuer and patient blood/ body fluids
   b. One-way valve to prevent blood/ body fluid splash to rescuer
   c. May be easier to obtain face seal
5. Disadvantage
   a. Useful only if readily available
6. Complications
   a. Hyperinflation of patient's lungs
   b. Hyperventilation of rescuer
   c. Gastric distention
7. Method for use
   a. Position head by appropriate method
   b. Position and seal mask over mouth and nose
   c. Ventilate as appropriate

D. One person bag-valve-mask
1. Fixed volume self inflating bag can deliver adequate tidal volumes and $O_2$ enrichment
2. Indications
   a. Apnea from any mechanism
   b. Unsatisfactory respiratory effort
3. Contraindication
   a. Awake, intolerant patients
4. Advantages
   a. Excellent blood/ body fluid barrier
   b. Good tidal volumes
   c. Oxygen enrichment
   d. Rescuer can ventilate for extended periods without fatigue
5. Disadvantages
   a. Difficult skill to master
   b. Mask seal may be difficult to obtain and maintain
   c. Tidal volume delivered is dependent on mask seal integrity
6. Complications
   a. Inadequate tidal volume delivery with
      (1) Poor technique

(2) Poor mask seal
(3) Gastric distention

7. Method for use
   a. Position appropriately
   b. Choose proper mask size - seats from bridge of nose to chin
   c. Position, spread/ mold/ seal mask
   d. Hold mask in place
   e. Squeeze bag completely over 1.5 to 2 seconds for adults
   f. Avoid overinflation
   g. Reinflate completely over several seconds
8. Special considerations
   a. Medical
      (1) Observe for
         (a) Gastric distension
         (b) Changes in compliance of bag with ventilation
         (c) Improvement or deterioration of ventilation status ( i.e., color change, responsiveness, air leak around mask)
   b. Trauma
      (1) Very difficult to perform with cervical spine immobilization in place

E. Two person bag-valve-mask ventilation method
1. Most efficient method
2. Indications
   a. Bag-valve-mask ventilation on any patient
      (1) Especially useful for cervical spine-immobilized patients
      (2) Difficulty obtaining or maintaining adequate mask seal
3. Contraindications
   a. Awake, intolerant patients
4. Advantages
   a. Superior mask seal
   b. Superior volume delivery
5. Disadvantages
   a. Requires extra personnel
6. Complications
   a. Hyperinflation of patient's lungs
   b. Gastric distension
7. Method for use
   a. First rescuer maintains mask seal by appropriate method
   b. Second rescuer squeezes bag
8. Special considerations
   a. Observe chest movement
   b. Avoid overinflation
   c. Monitor lung compliance with ventilations

F. Three person bag-valve-mask ventilation
1. Indications
   a. Bag-valve-mask ventilation on any patient
      (1) Especially useful for cervical spine-immobilized patients
      (2) Difficulty obtaining or maintaining adequate mask seal
2. Contraindications
   a. Awake, intolerant patients

3. Advantages
   a. Superior mask seal
   b. Superior volume density
4. Disadvantages
   a. Requires extra personnel
   b. “Crowded” around airway
5. Complications
   a. Hyperinflation of patient’s lungs
   b. Gastric distension
6. Method for use
   a. First rescuer maintains mask seal by appropriate method
   b. Second rescuer holds mask in place
   c. Third rescuer squeezes bag and monitors compliance
7. Special considerations
   a. Avoid overinflation
   b. Monitor lung compliance with ventilations

G. Flow-restricted, oxygen-powered ventilation devices
1. The valve opening pressure at the cardiac sphincter is approx 30 cm $H_2O$
2. These devices operate at or below 30 cm $H_2O$ to prevent gastric distension
3. Indications
   a. Delivery of high volume/ high concentration of $O_2$ (1 L/ sec)
   b. Awake compliant patients
   c. Unconscious patient with caution
4. Contraindications
   a. Noncompliant patients
   b. Poor tidal volume
   c. Small children
5. Advantages
   a. Self administered
   b. Delivers high volume/ high concentration $O_2$
   c. $O_2$ delivered in response to inspiratory effort (no $O_2$ wasting)
   d. $O_2$ volume delivery is regulated by inspiratory effort minimizing overinflation risk
   e. $O_2$ volume delivery is also restricted to less than 30 cm $H_2O$
6. Disadvantages
   a. Cannot monitor lung compliance
   b. Requires $O_2$ source
7. Complications
   a. Gastric distension
   b. Barotrauma
8. Method
   a. Mask is held manually in place
   b. Negative pressure upon inspiration triggers $O_2$ delivery or medic triggers release button
   c. Patient is monitored for adequate tidal volume and oxygenation

H. Automatic transport ventilators
1. Volume/ rate controlled
2. Indications
   a. Extended ventilation of intubated patients
   b. In situations in which a BVM is used

c. Can be used during CPR
3. Contraindications
   a. Awake patients
   b. Obstructed airway
   c. Increased airway resistance
      (1) Pneumothorax (after needle decompression)
      (2) Asthma
      (3) Pulmonary edema
4. Advantages
   a. Frees personnel to perform other tasks
   b. Lightweight
   c. Portable
   d. Durable
   e. Mechanically simple
   f. Adjustable tidal volume
   g. Adjustable rate
   h. Adapts to portable $O_2$ tank
5. Disadvantages
   a. Cannot detect tube displacement
   b. Does not detect increasing airway resistance
   c. Difficult to secure
   d. Dependent on $O_2$ tank pressure

I. Cricoid pressure - Sellick maneuver
1. Pressure on cricoid ring
2. Occludes esophagus
3. Facilitates intubation by moving the larynx posteriorly
4. Helps to prevent passive emesis
5. Can help minimize gastric distension during bag-valve-mask ventilation
6. Indications
   a. Vomiting is imminent or occurring
   b. Patient cannot protect own airway
7. Contraindication
   a. Use with caution in cervical spine injury
8. Advantages
   a. Noninvasive
   b. Protects from aspiration as long as pressure is maintained
9. Disadvantages
   a. May have extreme emesis if pressure is removed
   b. Second rescuer required for bag-valve-mask ventilation
   c. May further compromise injured cervical spine
10. Complications
   a. Laryngeal trauma with excessive force
   b. Esophageal rupture from unrelieved high gastric pressures
   c. Excessive pressure may obstruct the trachea in small children
11. Method
   a. Locate the anterior aspect of the cricoid ring
   b. Apply firm, posterior pressure
   c. Maintain pressure until the airway is secured with an endotracheal tube

J. Artificial ventilation of the pediatric patient

1. Flat nasal bridge makes achieving mask seal more difficult
2. Compressing mask against face to improve mask seal results in obstruction
3. Mask seal best achieved with jaw displacement (two person bag-valve-mask)
4. Bag-valve-mask ventilation
   a. Bag size
      (1) Full-term neonates and infants - minimum of 450 ml tidal volume (pediatric BVM)
      (2) Children up to eight years of age - pediatric BVM preferred but adult-sized BVM (1500 ml) may be utilized
      (3) Children over eight years of age require adult-sized BVM for adequate ventilation
      (4) Proper mask fit
      (5) Length based resuscitation tape
      (6) Bridge of nose to cleft of chin
   b. Proper mask position and seal (EC-clamp)
      (1) Place mask over mouth and nose; avoid compressing the eyes
      (2) Using one hand, place thumb on mask at apex and index finger on mask at chin (C-grip)
      (3) With gently pressure, push down on mask to establish adequate seal
      (4) Maintain airway by lifting bony prominence of chin with remaining fingers forming an “E”; avoid placing pressure on the soft area under chin
      (5) May use one or two rescuer technique
   c. Ventilate according to current standards
   d. Obtain chest rise with each breath
      (1) Begin ventilation and say “squeeze”; provide just enough volume to initiate chest rise; DO NOT OVERVENTILATE
   e. Allow adequate time for exhalation
      (1) Begin releasing the bag and say “release, release”
   f. Continue ventilations using “squeeze, release, release” method
   g. Assess BVM ventilation
      (1) Look for adequate chest rise
      (2) Listen for lung sounds at third intercostal space, midaxillary line
      (3) Assess for improvement in color and/ or heart rate
   h. Apply cricoid pressure to minimize gastric inflation and passive regurgitation
      (1) Locate cricoid ring by palpating the trachea for a prominent horizontal band inferior to the thyroid cartilage and cricothyroid membrane
      (2) Apply gentle downward pressure utilizing one fingertip in infants and the thumb and index finger in children
      (3) Avoid excessive pressure as it may produce tracheal compression and obstruction in infants

K. Ventilation of stoma patients
   1. Mouth-to-stoma
      a. Locate stoma site and expose
      b. Pocket mask to stoma preferred
         (1) Seal around stoma site, check for adequate ventilation
         (2) Seal mouth and nose if air leak evident
   2. Bag-valve-mask to stoma
      a. Locate stoma site and expose

b. Seal around stoma site, check for adequate ventilation
c. Seal around mouth and nose if air leak evident

XVI. Airway obstructions
A. Causes
1. Tongue
2. Foreign body
3. Laryngeal spasm
4. Laryngeal edema
5. Trauma
B. Classifications/ assessment
1. Complete obstruction
2. Partial obstruction
a. With good air exchange
b. With poor air exchange
C. Management
1. Heimlich maneuver
2. Finger sweep
3. Chest thrusts
4. Suctioning
5. Direct laryngoscopy for the removal of foreign body in airway obstruction
a. If unable to ventilate and BLS methods fail
(1) Patient is unconscious
(a) Insert laryngoscope blade into patient's mouth
(b) If foreign body is visualized
i) Carefully and deliberately remove foreign body with Magill forceps
6. Intubation

XVII. Suctioning
A. Suction devices
1. Hand-powered suction devices
a. Advantages
(1) Lightweight
(2) Portable
(3) Mechanically simple
(4) Inexpensive
b. Disadvantages
(1) Limited volume
(2) Manually powered
(3) Fluid contact components not disposable
2. Oxygen-powered portable suction devices
a. Advantages
(1) Lightweight
(2) Small in size
b. Disadvantages
(1) Limited suctioning power
(2) Uses a lot of oxygen for limited suctioning power
3. Battery-operated portable suction devices

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a. Advantages
(1) Lightweight
(2) Portable
(3) Excellent suction power
(4) May "field" troubleshoot most problems
b. Disadvantages
(1) More complicated mechanics
(2) May lose battery integrity over time
(3) Some fluid contact components not disposable
4. Mounted vacuum-powered suction devices
a. Advantages
(1) Extremely strong vacuum
(2) Adjustable vacuum power
(3) Fluid contact components disposable
b. Disadvantages
(1) Non-portable
(2) Cannot "field service" or substitute power source
B. Suctioning catheters
1. Hard or rigid catheters
a. "Yankauer" or "tonsil tip"
b. Suction large volumes of fluid rapidly
c. Standard size
d. Various sizes
2. Soft catheters
a. Can be placed in oropharynx, nasopharynx, or down endotracheal tube
b. Various sizes
c. Smaller inside diameter than hard tip catheters
d. Suction tubing without catheter (facilitates suctioning of large debris)
C. Suctioning the upper airway
1. Prevention of aspiration critical
a. Mortality increases significantly if aspiration occurs
b. Preoxygenate if possible
c. Hyperoxygenate after suctioning
2. Description
a. Soft tip catheters must be prelubricated
b. Place catheter
c. Suction during extraction of catheter
d. Suction to clear the airway
e. Reevaluate patency of the airway
f. Ventilate and oxygenate
D. Tracheobronchial suctioning
1. Use sterile technique, if possible
2. Preoxygenation essential
3. Description
a. Pre-lubricate soft tip catheter
b. Hyperoxygenate
(1) May be necessary to inject 3 to 5 cc's of sterile water down endotracheal tube to loosen secretions
c. Gently insert catheter until resistance is felt

d. Suction upon extraction of catheter
e. Do not exceed 15 seconds
f. Ventilate and oxygenate

E. Gastric distention
1. Air becomes trapped in the stomach
2. Very common when ventilating non-intubated patients
3. Stomach diameter increases
4. Pushes against diaphragm
5. Interferes with lung expansion
6. Abdomen becomes increasingly distended
7. Resistance to bag-valve-mask ventilation
8. Management
a. Non-invasive
(1) May be reduced by increasing bag-valve-mask ventilation time
(a) Adults - 1.5 to 2 seconds
(b) Pediatrics - 1 to 1.5 seconds
(2) Prepare for large volume suction
(3) Position patient left lateral
(4) Slowly apply pressure to epigastric region
(5) Suction as necessary
b. Gastric tubes
(1) Tube placed in the stomach for gastric decompression and/ or emesis control
(2) Nasogastric decompression
(a) Indications
i) Threat of aspiration
ii) Need for lavage
(b) Contraindications
i) Extreme caution in esophageal disease or esophageal trauma
ii) Facial trauma (caution)
iii) Esophageal obstruction
(c) Advantages
i) Tolerated by awake patients
ii) Does not interfere with intubation
iii) Mitigates recurrent gastric distension
iv) Mitigates nausea
v) Patient can still talk
(d) Disadvantages
i) Uncomfortable for patient
ii) May cause patient to vomit during placement even if gag is suppressed
iii) Interferes with BVM seal
(e) Complications
i) Nasal, esophageal or gastric trauma from poor technique
ii) Endotracheal placement
iii) Supragastric placement
iv) Tube obstruction

(f) Method
- i) Prepare patient
  - a) Head neutral
  - b) Oxygenate
  - c) Suppress gag with topical anesthetic or IV lidocaine
  - d) Anesthetize and dilate nares
- ii) Lubricate tube
- iii) Advance gently along nasal floor
  - a) Encourage patient to swallow or drink to facilitate passage
- iv) Advance into stomach
- v) Confirm placement
  - a) Auscultate while injecting 30-50 cc's of air
  - b) Note gastric contents through tube
  - c) No reflux around tube
- vi) Secure in place

(3) Orogastric decompression
- (a) Indications
  - i) Same parameters as NG
  - ii) Generally preferred for unconscious patients
- (b) Contraindication
  - i) Same parameters as NG
- (c) Advantages
  - i) May use larger tubes
  - ii) May lavage more aggressively
  - iii) Safe to pass in facial fracture
  - iv) Avoids nasopharynx
- (d) Disadvantage
  - i) May interfere with visualization during intubation
- (e) Complications
  - i) Same as NG
  - ii) Patient may bite tube
- (f) Method
  - i) Neutral or flexed head position
  - ii) Introduce tube down midline
  - iii) Procedure same as NG

XVIII. Airway management
- A. Manual maneuvers
  - 1. Head-tilt/ chin-lift maneuver
    - a. Technique
      - (1) Tilt head back
      - (2) Lift chin forward
      - (3) Open mouth
    - b. Indications
      - (1) Unresponsive patients who
        - (a) Do not have mechanism for c-spine injury
        - (b) Unable to protect their own airway

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c. Contraindications
   (1) Awake patients
   (2) Possible c-spine injury
d. Advantages
   (1) No equipment required
   (2) Simple
   (3) Safe
   (4) Non-invasive
e. Disadvantages
   (1) Head tilt hazardous to c-spine injured patients
   (2) Does not protect from aspiration

2. Jaw-thrust without head-tilt maneuver
   a. Technique
      (1) Head is maintained neutral
      (2) Jaw is displaced forward
      (3) Lift by grasping under chin and behind teeth
      (4) Mouth opened
   b. Indications
      (1) Patients who are
         (a) Unresponsive
         (b) Unable to protect their own airway
         (c) May have c-spine injury
   c. Contraindications
      (1) Responsive patients
      (2) Resistance to opening mouth
   d. Advantages
      (1) May be used in c-spine injury
      (2) May be performed with cervical collar in place
      (3) Does not require special equipment
   e. Disadvantages
      (1) Cannot maintain if patient becomes responsive or combative
      (2) Difficult to maintain for extended period
      (3) Very difficult to use in conjunction with bag-valve-mask ventilation
      (4) Thumb must remain in patient's mouth in order to maintain displacement
      (5) Separate rescuer required to perform bag-valve-mask ventilation
      (6) Does not protect against aspiration

3. Modified jaw-thrust maneuver
   a. Technique
      (1) Head maintained neutral
      (2) Jaw is displaced forward at mandibular angle
   b. Indications
      (1) Unresponsive
      (2) Cervical spine injury
      (3) Unable to protect own airway
      (4) Resistance to opening mouth
   c. Contraindication
      (1) Awake patients
   d. Advantages
      (1) Non-invasive

(2) Requires no special equipment
(3) May be used with cervical collar in place
e. Disadvantages
(1) Difficult to maintain
(2) Requires second rescuer for bag-valve-mask ventilation
(3) Does not protect against aspiration

B. Nasal airway
1. Soft rubber with beveled tip
a. Distal tip rests in hypopharynx
b. For adults, length measured from nostril to earlobe
c. Diameter roughly equal to patient's little finger
2. Indications
a. Unconscious patients
b. Altered response patients with suppressed gag reflex
3. Contraindications
a. Patient intolerance
b. Caution in presence of facial fracture or skull fracture
4. Advantages
a. Can be suctioned through
b. Provides patent airway
c. Can be tolerated by awake patients
d. Can be safely placed "blindly"
e. Does not require mouth to be open
5. Disadvantages
a. Poor technique may result in severe bleeding
(1) Resulting epistaxis may be extremely difficult to control
b. Does not protect from aspiration
6. Placement
a. Determine correct length and diameter
b. Lubricate nasal airway
c. With bevel towards septum, insert gently along the nasal floor parallel to the mouth
d. Do not force
e. Measurement from corner of the mouth to the jaw angle rather than tip of the ear
f. Too long airway causes airway obstruction

C. Oral airway
1. Hard plastic airway designed to prevent the tongue from obstructing glottis
2. Indications
a. Unconscious patients
b. Absent gag reflex
3. Contraindication
a. Conscious patients
4. Advantages
a. Non-invasive
b. Easily placed
c. Prevents blockage of glottis by tongue
5. Disadvantages
a. Does not prevent aspiration
b. Unexpected gag may produce vomiting

6. Complications
   a. Unexpected gag may produce vomiting
   b. Pharyngeal or dental trauma with poor technique
7. Placement
   a. Open mouth
   b. Remove visible obstructions
   c. Place with distal tip toward glottis using tongue depressor as adjunct
   d. Alternate method - place airway with distal tip toward palate and rotate into place
8. Pediatrics
   a. Place with tongue depressor
   b. Place with tip toward tongue, not palate

D. Endotracheal tube
1. Tube passed into the trachea in order to provide externally-controlled breathing through a BVM or ventilator
   a. Sizes
      (1) 2.5-9.0 mm inside diameter (id)
      (2) Length 12-32 cm
   b. Types
      (1) Cuffed 5.0-9.0
         (a) Proximal end 15 mm adapter
         (b) Proximal end inflation port with pilot balloon
         (c) Cm markings along length
         (d) Distal end beveled tip
         (e) Distal end balloon cuff
      (2) Uncuffed 2.5-4.5
         (a) Proximal end 15 mm adapter
         (b) Distal end bevel tip
         (c) Distal end depth markings
         (d) No balloon cuff or pilot balloon
2. Indications
   a. Present or impending respiratory failure
   b. Apnea
   c. Failure to protect own airway
3. Contraindications
4. Advantages
   a. Provides a secure airway
   b. Protects against aspiration
   c. Route for medication
5. Disadvantages
   a. Special equipment needed
   b. Bypasses physiologic function of upper airway
      (1) Warming
      (2) Filtering
      (3) Humidifying
6. Complications
   a. Bleeding
   b. Laryngeal swelling
   c. Laryngospasm

d. Vocal cord damage
e. Mucosal necrosis
f. Barotrauma

7. Orotracheal intubation by direct laryngoscopy
   a. Directly visualizing the passage of an ET tube into the trachea
   b. Indications
      (1) Apnea
      (2) Hypoxia
      (3) Poor respiratory effort
      (4) Suppression or absence of gag reflex
   c. Contraindications
      (1) Caution in unsuppressed gag reflex
   d. Advantages
      (1) Direct visualization of anatomy and tube placement
      (2) Ideal method for confirming placement
      (3) May be performed in breathing and apneic patients
   e. Disadvantages
      (1) Requires special equipment
   f. Complications
      (1) Dental trauma
      (2) Laryngeal trauma
      (3) Misplacement
         (a) Right mainstem
         (b) Esophageal
   g. Equipment
      (1) Laryngoscope
         (a) Device used to visualize glottis during endotracheal intubation
         (b) Battery pack/ handle with interchangeable blades
         (c) Blade types
            i) Straight (Miller) lifts epiglottis
            ii) Curved (Macintosh) lifts epiglottis by fitting into vallecula
      (2) 10 cc syringe to inflate/ deflate balloon cuff
      (3) Water soluble lubricant to lubricate endotracheal tube, promote ease of passage, and decrease trauma
      (4) Stylet - semi-rigid wire for molding and maintaining tube shape
      (5) Securing device
         (a) Tape
         (b) Commercially available endotracheal tube holder
      (6) Suction
      (7) Body substance precautions
         (a) Gloves
         (b) Mask
         (c) Eyewear or face shield
   h. Method
      (1) Position used when the potential for c-spine injury does not exist
         (a) Sniffing position
            i) Optimal hyperextension of head with elevation of occiput
            ii) Brings the axis of the mouth, the pharynx, and the

trachea into alignment
(2) When potential for c-spine injury exists head is held firmly in neutral position during intubation
(3) Ensure optimal oxygenation and ventilation with 100% $O_2$
(4) Ensure all equipment is prepared
(a) Lubricated tube with stylet in place
i) Best position is "hockey stick"
ii) Bend directly behind balloon cuff
(b) Working laryngoscope
i) Blade locks securely in place
ii) Light is bright and steady (unpleasant to look at)
(c) Test cuff by inflating and then deflating
(5) Ideally, hyperoxygenate patient for 30 seconds to 1 minute
(6) Insert laryngoscope blade
(a) Gently insert to hypopharynx
(b) Lift tongue and jaw with firm, steady pressure
i) Avoid fulcrum against teeth
(7) Identify vocal cords
(8) Gently pass ET tube until observe passage of balloon cuff past cords
(9) Remove stylet
(10) Inflate balloon cuff
(11) Ventilate patient
(12) Confirm placement with multiple methods
(13) Reconfirm placement with major patient movement or head movement

8. Confirming placement
a. Methods
(1) Direct re-visualization
(a) Re-visualize glottis
(b) Note tube depth
i) Average tube depth in males is 22 cm at the teeth
ii) Average tube depth in women is 21 cm at the teeth
(2) Note condensation in the tube
(3) Auscultation
(a) Epigastric area
i) Air entry into stomach indicates esophageal placement
(b) Bilateral bases
i) Equal volume and expansion
(c) Apices
i) Equal volume
(d) Unequal or absent breath sounds indicate
i) Esophageal placement
ii) Right mainstem placement
iii) Pneumothorax
iv) Bronchial obstruction
(4) Palpation of balloon cuff at sternal notch by compressing pilot balloon
(5) Pulse oximetry
(6) Expired $CO_2$
(a) Measures presence of $CO_2$ in expired air

i) Colormetric
ii) Digital
iii) Digital/ waveform

(7) Bag-valve-mask ventilation compliance
(a) Increased resistance to BVM compliance may indicate
i) Gastric distension
ii) Esophageal placement
iii) Tension pneumothorax

b. Evidence of a misplaced tube regardless when it was last checked must be reconfirmed
c. Confirmation must be performed
(1) By multiple methods
(2) Immediately after tube placement
(3) After any major move
(4) After manipulation of neck (manipulation of neck may displace tube up to 5 cm)

9. Corrective measures
a. Esophageal placement
(1) Ready to vigorously suction as needed
(2) Likelihood of emesis is increased especially if gastric distension is present
(3) Ideally, preoxygenate prior to reintubation
(4) Misplaced tube may be removed after proper tracheal placement is confirmed or it may be removed beforehand provided diligent and vigorous airway suctioning is ready
b. Right mainstem placement
(1) Loosen or remove securing device
(2) Deflate balloon cuff
(3) While ventilation continues, SLOWLY retract tube while simultaneously listening for breath sounds over left chest
(4) STOP as soon as breath sounds are heard in left chest
(5) Note tube depth
(6) Reinflate balloon cuff
(7) Secure tube

10. Securing the tube
a. As critical as the intubation itself
b. Multiple methods and products available
c. Adjuncts include
(1) Securing to maxilla rather than mandible
(2) Tincture of benzoin to facilitate tape adhesion

11. Field extubation
a. Generally, the only reason to field extubate is the patient is unreasonably intolerant of the tube
b. Awake patients are at high risk of laryngospasm immediately following extubation
c. There may be a problem re-inducting and re-intubating a laryngospastic patient
d. Indications
(1) Able to protect and maintain airway
(2) Risks for need to reintubate significantly reduced

(3) Must not be sedated
e. Contraindication
(1) Any risk of recurrence of respiratory failure
f. Complications
(1) Highest risk of recurrence of laryngospasm is immediately post extubation
(2) Respiratory distress or failure may return necessitating re-intubation
g. Method
(1) Ensure oxygenation
(2) Intubation equipment and suction immediately available
(3) Confirm patient responsiveness
(4) Suction oropharynx
(5) Deflate cuff
(6) Remove upon cough or expiration
h. Special considerations
(1) Need for field extubation is extremely rare
(2) Intolerance of ET tube evidenced by gag reflex should be addressed by increasing sedation rather than removing tube

12. Pediatric endotracheal intubation
a. Laryngoscope and size appropriate blades
(1) Straight blades are preferred
(2) General guidelines
(a) Premature infant - 0 straight
(b) Full-term infant to one year of age - 1 straight
(c) Two years of age to adolescent - 2 straight
(d) Adolescent and above - 3 straight or curved
b. Appropriate size endotracheal tube
(1) Formula = (16 + age in years) ÷ 4
(2) Anatomical clues
(3) General guidelines
(a) Premature infant - 2.5 to 3.0 uncuffed
(b) Full-term infant - 3.0 to 3.5 uncuffed
(c) Infant to one year of age - 3.5 to 4.0 uncuffed
(d) Toddler - 4.0 to 5.0 uncuffed
(e) Preschool - 5.0 to 5.5 uncuffed
(f) School age - 5.5 to 6.5 uncuffed
(g) Adolescent - 7.0 to 8.0 cuffed
(4) Depth of insertion
(a) 2-3 cm below the vocal cords
i) Uncuffed - place the black glottic marker of the tube at the level of the vocal cords
ii) Cuffed - insert until the cuff is just below the vocal cords
(b) Formula = (3 x inside diameter - 1)
(c) General guidelines
i) Premature infant - 8 cm
ii) Full-term infant - 8 to 9.5 cm
iii) Infant to one year of age - 9.5 to 11 cm
iv) Toddler - 11 to 12.5 cm
v) Preschool - 12.5 to 14 cm

vi) School age - 14 to 20 cm
vii) Adolescent - 20 to 23 cm
(5) Appropriate sized endotracheal tube stylet
c. Endotracheal tube securing device
(1) Tape
(2) Commercial device
d. Technique
(1) Separate parent/ guardian and patient
(2) Manually open airway
(3) Insert appropriate airway adjunct if needed
(4) Ventilate patient with 100% oxygen via age appropriate sized bag
(5) Place the patient's head in the sniffing position
(6) Pre-oxygenate the patient with 100% oxygen a minimum of 30 seconds
(7) Prepare all equipment
(a) Lubricate endotracheal tube with sterile water/ saline or water-soluble gel
(b) Lubricate stylet if utilized
(8) Insert the laryngoscope to the right side of the mouth and sweep the tongue to the left side
(9) Lift tongue with firm, steady pressure
(a) Avoid fulcrum against teeth or gums
(10) Use the tip of the blade to lift epiglottis
(11) Identify the vocal cords
(12) Introduce the endotracheal tube to the right side of the mouth
(13) Pass the tube through the vocal cords to about 2-3 cm below the vocal cords
(14) Confirm proper tube placement
(a) Observe for symmetrical chest expansion
(b) Auscultate for equal breath sounds over each lateral chest wall high in the axillae
(c) Absence of breath sounds over the abdomen
(d) Improved heart rate and color
(e) If available, end-tidal carbon dioxide detector
(15) Secure tube noting placement of distance marker at teeth/ gums
(16) Reconfirm tube placement

E. Multi-lumen airways
1. Pharyngo-tracheal lumen airway (PTL)
a. An endotracheal tube encased in a large pharyngeal tube
b. Designed to be passed blindly
c. Dual ventilation ports provide means to ventilate regardless of whether the ET tube is placed in the esophagus or the trachea
d. Indication
(1) Alternative airway control when conventional intubation procedures are not available or successful
e. Advantages
(1) Can ventilate with tracheal or esophageal placement
(2) No facemask to seal
(3) No special equipment
(4) Does not require sniffing position

f. Disadvantages
   (1) Cannot be used in awake patients
   (2) Adults only
   (3) Pharyngeal balloon mitigates but does not eliminate aspiration risk
   (4) Can only be passed orally
   (5) Extremely difficult to intubate around
g. Method
   (1) Head neutral
   (2) Pre-intubation precautions
   (3) Insert at the midline using jaw-lift
   (4) Ventilate through pharyngeal tube (green) first
      (a) Chest rise indicates ET tube is in esophagus
         i) Inflate pharyngeal balloon and ventilate
      (b) No chest rise indicates ET tube in trachea
         i) Inflate ET tube balloon cuff
         ii) Ventilate through ET tube
h. Complications
   (1) Pharyngeal or esophageal trauma from poor technique
   (2) Unrecognized displacement of ET tube into esophagus
   (3) Displacement of pharyngeal balloon
i. Special considerations
   (1) Good assessment skills are essential to properly confirm placement
   (2) Mis-identification of placement has been reported
   (3) Reinforce multiple confirmation of placement techniques

2. Combitube
   a. Pharyngeal and endotracheal tube molded into a single unit
   b. Indication
      (1) Alternative airway control when conventional intubation measures are unsuccessful or unavailable
   c. Contraindications
      (1) Children too small for the tube
      (2) Esophageal trauma or disease
      (3) Caustic ingestion
   d. Advantages
      (1) Rapid insertion
      (2) No special equipment
      (3) Does not require sniffing position
   e. Disadvantages
      (1) Impossible to suction trachea when tube is in esophagus
      (2) Adults only
      (3) Unconscious only
      (4) Very difficult to intubate around
   f. Method
      (1) Head - neutral position
      (2) Pre-intubation precautions
      (3) Insert with jaw-lift at midline
      (4) Inflate pharyngeal cuff with 100 cc's of air
      (5) Inflate distal cuff with 10-15 cc's of air
      (6) Ventilate through longest tube first (pharyngeal)

(a) Chest rise indicates esophageal placement of distal tip
(b) No chest rise indicates tracheal placement, switch ports and ventilate

g. Special considerations
(1) Good assessment skills are essential to confirm proper placement
(2) Mis-identification of placement has been reported
(3) Reinforce multiple confirmation techniques

XIX. Special patient considerations
A. Patients with laryngectomies (stomas)
1. Mucous plug
a. Laryngectomees possess less efficient cough
b. Mucous commonly obstructs tubes
c. Tube may be removed/ cleaned and replaced
2. Stenosis
a. Stoma spontaneously narrows
(1) Potentially life-threatening
(2) Soft tissue swelling decreases stoma diameter
b. Trach tube is difficult or impossible to replace
c. ET tube must be placed before total obstruction
3. Suctioning
a. Must be done with extreme caution if laryngeal edema is suspected
b. Procedure
(1) Preoxygenate
(2) Inject 3 cc sterile saline down trachea
(3) Instruct patient to exhale
(4) Insert suction catheter until resistance detected
(5) Instruct patient to cough or exhale
(6) Suction during withdrawal
4. Tube replacement
a. Lubricate appropriately sized tracheostomy tube or ET tube (5.0 or greater)
b. Instruct patient to exhale
c. Gently insert tube about 1-2 cm beyond balloon cuff
d. Inflate balloon cuff
e. Confirm comfort, patency and proper placement
f. Ensure false lumen was not created
B. Dental appliances
1. Dentures, partials, etc.
2. Best removed prior to intubation
C. Airway management considerations for patients with facial injuries
1. Facial injuries lend to a high suspicion of cervical spine injury
a. In-line stabilization
(1) Trauma technique endotracheal intubation
2. Foreign body/ blood in oropharynx
a. Suction airway
3. Inability to ventilate/ intubate orally
a. Requires surgical intervention

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