Chapter 6: Respiratory Emergencies and Airway Management

Lecture

I. Introduction

Time: 3 Minutes

Slides: 1–2

Lecture/Discussion

A. There is no more important or controversial skill associated with prehospital care than airway management.
   1. EMT levels
      a. BLS: Ability to assess and manage airway starting point in airway management
      b. ALS: Standard to fall back on
   2. Assessment of airway and breathing critical first step in ABCs of resuscitation
      a. Guides treatment plan development
   3. Ensuring adequacy of ventilation and oxygenation in critically ill patients are primary treatment goals of CCTP
      a. When respiratory compromise occurs and time is critical, the CCTP must be prepared to perform rapid, accurate respiratory assessment followed by the appropriate intervention

II. Anatomy and Physiology of the Respiratory System

Time: 14 Minutes

Slides: 3–11

Lecture/Discussion

A. Upper Airway Structures
   1. Nose
      a. Cartilaginous, bony structure in midline of face
      b. Warms and humidifies inspired air
      c. Lined with coarse hairs that filter and trap small inspired particles
      d. Source of olfaction via first cranial nerve (olfactory nerve)
      e. Connect to four sinuses:
         i. Frontal
         ii. Ethmoidal
         iii. Sphenoidal
         iv. Maxillary
      f. Opens into nasopharynx

g. Significant source of epistaxis
    i. Complicates airway patency and management

2. Mouth
    a. Primarily designed for phonation and mastication
    b. Begins at lips, ends with oropharynx
    c. Size of oral cavity can affect airway management
        i. Larger is better
    d. Contains tongue (attached to mandible) and teeth
        i. Both can make airway management more difficult due to edema
        ii. Buck teeth may also make airway management more difficult
        iii. Tongue most common cause of airway obstruction in unconscious patient
    e. Salivary glands continuously secrete saliva
        i. Makes topical anesthesia, visualization of airway structures difficult
3. Pharynx
    a. U-shaped tube that begins at base of skull and extends to lower border of cricoid cartilage near esophagus
    b. Composed of three parts:
        i. Nasopharynx
        ii. Oropharynx
        iii. Hypopharynx
    c. Normal resting muscle tone of oropharynx maintains upper airway patency
    d. Ninth cranial nerve (glossopharyngeal) provides sensory innervation to many structures
        i. Posterior tongue
        ii. Valleculae
        iii. Parts of epiglottis
    e. Inferior portion ends with entrance to both trachea and esophagus
4. Larynx
    a. Includes the following structures:
        i. Thyroid cartilage
        ii. Aryepiglottic folds
        iii. Epiglottis
        iv. Vallecula
        v. Arytenoid cartilages
    b. Final structure before entering trachea
    c. Vagus nerve provides strong sensory innervations
        i. This may cause significant increases in heart rate and blood pressure.
    d. Contains cricothyroid membrane

B. Lower airway structures
1. Trachea
    a. Begins at inferior border of cricoid ring, ends at carina
    b. Approximately 9 to 15 mm in diameter; approximately 12 to 15 cm long
    c. Not quite cylindrical
    d. Composed of 16 to 20 C-shaped cartilaginous rings on anterior portion, with fibrous tissue and muscular fibers on posterior portion
        i. Rings maintain luminal patency to allow unimpeded air flow
    e. Larger in adult males than in adult females
2. Lungs
    a. Trachea divides into right and left mainstem bronchi, which lead to right and left lobes of lungs

b. Right lung divided into three lobes
c. Left lung has two lobes
d. Bronchi continue to divide into smaller bronchi
    i. Divide into progressively smaller bronchioles
    ii. After total of 23 divisions into smaller, end at alveolar ducts
    iii. Ducts lead to (about 300 million) alveoli or area where gas exchange occurs
e. Alveolar capillary (AC) membrane where each alveolus contacts pulmonary capillary
f. Alveolus
    i. Made of type I and type II squamous epithelial cells
    ii. Type I cells involved in gas exchange
    iii. Type II cells manufacture surfactant to reduce surface tension within alveolus, preventing collapse and making it easier for the alveoli to expand during inhalation.
    iv. Alveolar macrophage helps defend body by ingesting inhaled particles
g. Lungs' blood supply arises from right ventricle
    i. Pulmonary arteries contain deoxygenated blood high in carbon dioxide
    ii. Vasculature is low-pressure system: approximately 25/10 mm Hg versus systemic pressure of approximately 120/80 mm Hg

C. Pediatric considerations
1. There are several variations in airway anatomy specific to the pediatric patient, including:
    a. Newborns and infants have a proportionally larger head with prominent occiput
        i. May cause flexion of airway and difficulty in visualizing laryngeal structures unless proper positioning is maintained
    b. Infants are obligate nose breathers
        i. Congestion may result in respiratory distress.
    c. Tongue occupies much larger proportion of mouth compared with adults
        i. Possible airway obstruction in unresponsive pediatric patient
        ii. Makes visualization of glottis more difficult when performing laryngoscopy
    d. Glottic opening is more cephalad and anterior
        i. At 45° angle to anterior pharyngeal wall while adult's lies parallel to base of tongue
    e. Epiglottis proportionally larger, floppier, and U-shaped compared with an adult
        i. May necessitate use of straight blade to lift epiglottis to improve visualization during laryngoscopy
    f. Larger adenoidal tissue may result in significant hemorrhaging when traumatized.
    g. Cricothyroid membrane small in children younger than 4 years
        i. May make needle cricothyrotomy difficult, surgical cricothyrotomy impossible
    h. Children have significantly higher oxygen consumption rates when compared with adults.
        i. Approximately double that of adult
        ii. Can result in significant hypoxemia despite adequate preoxygenation
        iii. Do not overuse bag-mask device. Excessive volumes exacerbate gastric distention, causing vomiting and increasing risk of pneumothorax.

III. Physiology of the Respiratory System

Time: 14 Minutes
Slides: 12–20
Lecture/Discussion

A. Gas exchange occurs as a result of pressure gradient changes across the AC membrane.
   1. Capillary:
      a. Partial pressure of oxygen (PO_2) is 40 mm Hg
      b. Partial pressure of carbon dioxide (PCO_2) is 45 mm Hg
   2. Alveolus:
      a. PCO_2 is 40 mm Hg.
      b. PO_2 is 100 mm Hg.
   3. As the gases diffuse they move from an area of higher concentration to an area of lower concentration, seeking equilibrium.
      a. Blood returning to left side of the heart via pulmonary vein contains:
         i. 100 mm Hg of oxygen
         ii. 40 mm Hg of CO_2
   4. Factors that can affect the diffusion of gases across the membrane are known as ventilation-perfusion mismatch.
      a. Three types include:
         i. Low ventilation-perfusion ratio
         ii. High ventilation-perfusion
         iii. Silent unit
   5. Oxyhemoglobin dissociation curve
      a. Relationship between hemoglobin and partial pressure of oxygen (arterial) (PaO_2)
      b. Many substances can bind to hemoglobin and cause it to be dysfunctional
         i. Carbon monoxide
         ii. Nitrite

B. Mechanics and dynamics of breathing
   1. Involve concepts of elastance, compliance, resistance, and pressure gradients
      a. Elastance: Tendency to collapse
         i. Lung tissue
      b. Compliance: Ease with which thorax and lungs expand
         i. Reduced compliance makes it harder for lungs to expand
         ii. Defined as change in volume per unit of pressure
      c. Resistance: Refers to amount of force needed to move a gas or fluid through a single capillary tube
         i. Poiseuille's law
      d. Pressure gradients: Allow for bulk movement of gas in and out of lung
         i. Thoracic expansion and contraction
         ii. Relies on muscle contraction (diaphragm and external intercostals muscles)
         iii. Accessory muscles also used in times of stress, increasing oxygen use, leading to fatigue, hypercapnia/hypoxemia, respiratory failure
   2. The stimulus and innervation of breathing is a complex process involving the pulmonary, cardiac, and neurologic systems.
      a. Drive to breathe normally comes from the need to eliminate CO_2.
         i. As H^+ increases, pH decreases; the change is transmitted across blood-brain barrier and stimulates respiratory centers in brain stem.

        ii. Chemoreceptors located in aortic arch and carotid arteries as backup
    b. The respiratory centers are located in the brain stem.
        i. Medulla
        ii. Pons
3. The proper functioning of the respiratory system can be explained by the following five factors:
    a. Ventilation: There must be an adequate bulk flow of gas in and out of lung.
    b. Distribution: Gas must be delivered into lung areas that are able to engage in gas exchange.
    c. Diffusion: The AC membrane must be able to engage in gas exchange.
    d. Perfusion: Blood must flow through pulmonary vasculature and contact the alveolus.
    e. Circulation: The heart must be able to pump blood not only to lung, but also distribute blood through systemic circulation.

C. Respiratory volumes and capacities
1. Total lung capacity (TLC): Lungs of a healthy male adult can hold between 5 and 6 L of gas.
    a. Tidal volume: Amount of air inhaled and exhaled during each normal breath
    b. Minute volume: Amount of air breathed in 1 minute
        i. Calculated by multiplying respiratory rate per minute by average tidal volume
        ii. Normal minute ventilation: 5 to 10 L/min
    c. Inspiratory reserve volume (IRV): Amount of air that can be inhaled after a tidal volume is inhaled
    d. Expiratory reserve volume (ERV): Air that can be expelled from lungs after normal exhalation
    e. Inspiratory capacity (IC): Sum of IRV and tidal volume
    f. Vital capacity (VC): Total amount of air that can be exhaled following maximal inspiration (pulmonary reserve)
        i. Normal VC: 60 to 70 mL/kg of ideal body weight
        ii. Dependent on gender, age, height
        iii. Decreases with age (approximately 20 mL/kg per year for those > 20 years)
    g. Residual volume (RV): Volume of air that remains at end of maximal forced exhalation
    h. Functional residual capacity (FRC): RV added to ERV
        i. Allows for gas exchange between breaths
        ii. Where application of positive end-expiratory pressure (PEEP) works by increasing FRC and increasing oxygenation
    i. Anatomic dead space (VD): Space found in upper airway in areas that do not participate in gas exchange
        i. Volume approximately 2 mL /kg

IV. Pathophysiology: Obstructive and Restrictive Disease States

Time: 6 Minutes
Slides: 21–24

Lecture/Discussion

A. Disease states can be categorized in several ways.
   1. Obstructive diseases result in difficulty with moving air out of the lungs and involve an increase in airway resistance.
      a. Examples include:
         i. Asthma
         ii. COPD
         iii. Cystic fibrosis
         iv. Bronchioectasis
   2. Restrictive diseases result in difficulty moving air in to lungs and result in loss of chest or lung compliance, either individually or together
      a. Examples include:
         i. Occupational lung diseases (asbestosis, mesotheolioma)
         ii. Idiopathic pulmonary fibrosis
         iii. Pneumonia
         iv. Atelectasis
         v. Chest wall deformities and injuries
         vi. All neuromuscular diseases that affect breathing (Guillian-Barré syndrome)
   3. Diseases and temporary conditions can alter the ventilation-perfusion ratio.
      a. Ventilation in excess of blood flow creates dead space effect, and gas exchange is impaired, causing:
         i. Tachypnea, pulmonary embolism
      b. Blood flow in excess of ventilation can also impair gas exchange, creating shunt effect.
         i. Pneumonia
         ii. Anatomic shunts include: congenital heart defects, bronchial and thebesian veins
   4. The evaluation of the presence of hypoxia and its treatment is crucial.
      a. Hypoxic hypoxia: Insufficient oxygen in blood affecting tissues
         i. Causes include: hypovolemia, airway obstruction, decreased cardiac output, coronary artery disease
         ii. Low oxygen tension in the alveolus itself, caused by hypoventilation, high altitude suffocation
         iii. Diffusion defects (fibrosis, edema)
         iv. Intrapulmonary shunting (atelectasis, bronchospasm, pneumonia)
         v. Extrapulmonary shunting (congenital heart defect)
      b. Anemic hypoxia (hypemic hypoxia): Reduced or dysfunctional hemoglobin
         i. Interferes with transportation phase of respiration, causing reduction in oxygen-carrying capacity
         ii. Causes include: anemias, hemorrhage, hemoglobin abnormalities, use of certain medications, intake of chemicals (carbon monoxide)
      c. Stagnant hypoxia: Reduced cardiac output resulting in tissue hypoxia due to lack of circulation.
         i. Specific causes include: heart failure, shock, continuous positive-pressure breathing, acceleration (g forces), pulmonary embolism
         ii. Reduction in regional or local blood flow may be caused by: extremes of environmental temperatures, postural changes, tourniquets, hyperventilation, embolism by clots or gas bubbles, cerebral vascular accidents

d. Histotoxic hypoxia: Cells unable to use oxygen due to inactivation or destruction of key enzymes
    i. Cyanide and strychnine poisoning, later stages of carbon monoxide poisoning

V. Patient Assessment

Time: 15 Minutes
Slides: 25–34
Lecture/Discussion

A. Breath sound assessment techniques
    1. Overview
        a. Breath sounds created as air moves through tracheobronchial tree and alveoli
        b. Size of airway determines the type of sound that will be produced
            i. Trachea and bronchi have large diameters, produce higher pitch sounds heard during inspiration, expiration
        c. Tracheal breath sounds (bronchial breath sounds) heard by placing stethoscope diaphragm over trachea or sternum
            i. Assess for duration, pitch, intensity
        d. Vesicular breath sounds are softer, muffled sounds
            i. "Wind blowing through trees"
            ii. Expiratory phase barely audible
        e. Bronchovesicular sounds are a combination of the two
            i. Heard in places where airways and alveoli are found (upper part of sternum, between scapulae)
            ii. Assess for duration or length: Expiration normally at least twice as long as inspiration (I:E ratio is 1:2)
            iii. Assess for pitch: Sound intensity depends on airflow rate, constancy of flow throughout inspiration, patient position, site selected for auscultation
            iv. Assess for intensity: Thickness of chest wall may affect
        f. Adventitious breath sounds usually classified as continuous or discontinuous sounds and include:
            i. Wheezes
            ii. Rhonchi
            iii. Crackles
            iv. Stridor
            v. Pleural friction rub
B. Auscultation
    1. For patients with invasive airway tube, listen over epigastrium and sternal notch, plus six recommended sites on anterior chest wall
        a. Assess for proper device placement and airflow.
        b. Baseline respiratory assessment establishes standard by which subsequent assessments will be compared
    2. Patient
        a. Takes slow, deep breaths through an open mouth and seated in semi-Fowler's or high Fowler's position

b. If patient cannot be elevated, auscultate as many of six recommended sites as possible
c. Place diaphragm of stethoscope on bare skin
d. Consider patient's comfort; rushing may increase anxiety
e. Document results

C. Normal and abnormal respiratory patterns
1. Rate
a. Eupnea: Normal breathing
i. 12 to 20 breaths/min in adult patient
ii. 30 to 50 breaths/min in newborn patient
iii. 12 to 20 breaths/min in adolescent patient
b. Tachypnea may be caused by many factors
i. Fever
ii. Pneumonia
iii. Metabolic acidosis
iv. Hypoxemia
v. Some poisonings and drugs
vi. Lesions of respiratory center in brain
vii. Stress, anxiety, pain
c. Bradypnea may be caused by:
i. Narcotic or sedative drugs
ii. Alcohol
iii. Metabolic disorders
iv. Respiratory system decompensation or fatigue
v. Traumatic and nontraumatic CNS lesions
vi. Mild bradypnea normal in certain stages of sleep
d. Apnea
i. May be episodic or periodic
ii. Periods longer than 15 seconds require immediate intervention
2. Depth
a. Assessment can be achieved by direct observation or by palpation.
b. Hyperpnea: Deeper than normal breath
i. Can lead to low levels of CO_2 (respiratory alkalosis)
c. Hypopnea: Shallow breath
i. Can result in increased CO_2 levels (respiratory acidosis)
3. Pattern
a. Cheyne-Stokes respiration
i. Cyclic pattern of increased respiratory rate and depth with periods of apnea
ii. Following apnea, patient begins breathing with slow, shallow breaths that increase in rate and depth until apnea returns
iii. Caused by increased intracranial pressure, renal failure, meningitis, drug overdose, or hypoxia secondary to congestive heart failure
iv. Otherwise, healthy individuals may exhibit following exposure to altitude changes or with hyperventilation syndrome
v. Acidosis may also trigger
b. Cluster breathing
i. Cluster of irregular respirations of varied depth, followed by period of apnea at irregular intervals
c. Biot's (ataxic) breathing
i. Similar to Cheyne-Stokes but with irregular pattern

ii. Causes may include: meningitis, increased intracranial pressure, CNS dysfunction

d. Kussmaul's respiration
   i. Fast and deep without periods of apnea
   ii. Rate and depth greater than the normal rate expected for patient's age group
   iii. May indicate metabolic acidosis, including diabetic ketoacidosis, or renal failure
   iv. Generally appears in conditions that cause severe academia

e. Apneustic breathing
   i. Indicates lesions in the respiratory center of the brain stem
   ii. Results in severe hypoxemia; if uncorrected, rapid death

f. Central neurogenic hyperventilation
   i. Deep, rapid respirations at rates of 40 to 60 breaths/min
   ii. Caused by midbrain lesion or dysfunction
   iii. Comatose patients with Glasgow Coma Scale scores of less than 8

g. Agonal respirations
   i. Deep, slow, shallow, irregular, "all-or-none" breaths or occasional gasping breaths, accompanied by a slow respiratory rate

h. Pursed lip breathing
   i. Seen in patients with COPD and asthma
   ii. Purse lips on exhalation in attempt to maintain positive end-expiratory pressure (PEEP)
   iii. Ventilator can provide supplemental PEEP

4. The appropriate level of intervention in these breathing abnormalities is directly related to the work of breathing and the ability of the patient to maintain that work.
   a. Do not confuse the work of breathing with shortness of breath.
      i. Shortness of breath: Subjective complaint
      ii. Assessment of the work of breathing: Clinical evaluation

D. Palpation
   1. Described in Chapter 5
      a. Placement of the hands directly on the chest wall to evaluate the status of the lungs, skin, and subcutaneous tissues and chest expansion
   2. Subcutaneous emphysema
      a. Indicated by "snap, crackle, pop" sensation
      b. Benign of itself
      c. Underlying cause may be life threatening
         i. Inquire about recent trauma or invasive procedures
   3. Vocal fremitus
      a. Assessed when performing tactile fremitus
      b. Increase in fremitus (vibration) indicates that underlying lung tissue is more solid and contains less air than normal
         i. May indicate pneumonia or atelectasis
         ii. Secretions, requiring suctioning
      c. Usually not practical in transport setting

E. Assessment in preparation for transport
   1. Prior to transport, review:
      a. Patient care report, noting any medications, disease processes, or trauma that might compromise ventilation
      b. Patient care record noting lab studies
      c. Patient's vital signs

        i. Note last arterial blood gas (ABG) measurement and if data is valid
    2. Note size and type of artificial airway and confirm proper placement before transport.
    3. Note ventilator settings and patient response.
    4. Communicate any concerns about placement of tracheal tubes, nasogastric (NG) tubes, or central lines.
    5. Remember altitude-induced pressure changes can occur during travel by helicopter or fixed-wing aircraft.
        a. Boyle's law
    6. When assessing the respiratory system, begin with the basics:
        a. Assess the ABCs.
        b. Determine the stability of the airway.
        c. Observe the rate, rhythm, depth, and character of respiration.
        d. Inspect the chest, looking for symmetric rise and fall with each respiratory cycle; note:
            i. Any accessory muscle use
            ii. Presence of any central lines or Hickman catheters
            iii. Nitroglycerin or other medication patches
            iv. In-dwelling devices
        e. Note any wounds, abrasion, or bruising.
            i. Note presence and location of bony crepitus or subcutaneous emphysema.
        f. Examine any dressings on the chest and determine if they are dry and intact.
        g. Observe any drainage being collected and note its color and consistency.
        h. Auscultate the chest noting the presence or absence, quality, and type of breath sounds heard.
        i. If patient requires oxygen, assess that the oxygen delivery device and the delivered fraction of inspired oxygen meets patient's needs and adequately maintains desired oxygen saturation as measured by pulse oximetry.
    7. Assess cardiac functions:
        a. Blood pressure
        b. Pulse rate
        c. Capillary refill time
        d. Skin color
        e. Temperature
    8. Assess mental status
        a. Hypoxia directly affects

VI. ABG Monitoring

Time: 2 Minutes
Slide: 35
Lecture/Discussion

A. Measuring ABG level is the gold standard for assessing functioning of the respiratory system.
    1. Involves obtaining blood from a superficial artery with heparinized syringe, then analyzing it for:
        a. pH, $PaCO_2$, PaO_2, HCO_3
        b. Base excess: evaluates

   c. SpO_2
2. Evaluates
   a. Acid/base status
   b. Effectiveness of ventilation
   c. See Chapter 8 for more information.
3. Most CCTPs will rely on noninvasive methods of assessing ventilation and oxygenation
   a. Pulse oximetry
   b. Capnography
   c. Capnometry

VII. Respiratory and Ventilation Abnormalities

Time: 2 Minutes

Slide: 36

Lecture/Discussion

A. Respiratory insufficiency
   1. Inability of respiratory system to keep up with metabolic demands of body
      a. May be from ventilation or oxygenation
      b. Treatment depends on the cause
   2. Respiratory depression
      a. Low respiratory rate (less than 12 breaths/min in adults) for prolonged period of time or hypoventilation
      b. Increasing ventilation will resolve
      c. Oxygen therapy indicated in patients who cannot maintain normal oxygen saturation
B. Respiratory failure
   1. Respiratory system fails to meet body's metabolic needs
      a. Patient may be anxious, confused, or obtunded.
      b. If not reversed, leads to respiratory or cardiopulmonary arrest
   2. Two basic types:
      a. Oxygenation failure
         i. Tachypnea
      b. Ventilatory failure

VIII. Basic Airway Management

Time: 11 Minutes

Slides: 37–43

Lecture/Discussion

A. Positioning
   1. Sitting upright in "sniffing" position most comfortable for patient
      a. Patients with spinal precautions or diminished level of consciousness may need assistance.
      b. Diminished level of consciousness may cause:

i. Tongue to contact posterior pharyngeal wall or soft palate, results in airway obstruction
ii. Less control over secretions (aspiration)
iii. Placing unconscious patients (nontrauma) who are breathing in recovery position helps minimize airway obstruction and aspiration.

2. Manual airway maneuvers for resuscitation that requires supine positioning and include:
   a. Head tilt–chin lift
   b. Tongue-jaw lift
   c. Jaw thrust

B. Airway adjuncts
1. Both the OPA and the NPA are used along with manual airway maneuvers to provide a patent airway.
   a. Neither used independently in unconscious patient
   b. Oropharyngeal airway (OPA)
      i. Require patient gag reflex to not be present
      ii. Size by measuring from the central incisors to the angle of the jaw
      iii. Device does not does not replace need for manual methods, but supplements them
   c. Nasopharyngeal airway (NPA)
      i. Better tolerated than the OPA in semi-conscious patients
      ii. Size from tip of the nose to the tragus of ear
      iii. To prevent laceration of nose mucosa, do not force
      iv. Contraindicated with head trauma with evidence of basilar skull fracture or facial fracture

C. Suction
1. The ability of the prehospital provider to clear debris (vomit, blood) from a patient's airway; may be lifesaving.
   a. Use large-bore suction apparatus
      i. Fixed or portable
      ii. Also turn patient on side for large volumes of debris or vomit
   b. Use flexible or soft-type suction catheters for suctioning nasopharynx, oropharynx, and lower airways in patients with an artificial airway
      i. Not designed to remove large particulate matter
      ii. May cause hypoxia and hemodynamic instability so preoxygenate and limit attempts to 10 seconds or less
2. Critical care setting will use will use suctioning while ET tube in place; indications for this suctioning in this scenario include:
   a. Dyspnea
   b. Obstruction
   c. Excessive secretions
3. Complications are as follows:
   a. Hypoxemia
   b. Cardiac arrhythmias
   c. Mechanical trauma
   d. Infection
   e. Increased intracranial pressure
   f. Inability to remove material due to a mucous plug or dried crusting
4. Review Skill Drill 6-1: Suctioning a Patient with an Endotracheal Tube in Place

D. Oxygen administration
1. Mostly administered in hospital

2. As a general rule, all ALS patients should receive some form of supplemental oxygen based on provider assessment, regardless of documented SpO_2.
    a. Should not be withheld based on normal reading as it does not harm and may improve regional or global tissue hypoxia
        i. Patient can have SpO_2 greater than 95% and still be hypoxic at cellular level
3. Devices include:
    a. Nasal cannula
    b. Nonrebreathing mask
    c. Choose based on physical assessment

E. Supplemental oxygen delivery
1. When gas flow is inadequate, positive-pressure ventilation is required; oxygen delivery may take many forms, including:
    a. Mouth-to-mouth ventilation
    b. Barrier device/resuscitation mask
    c. Bag-mask ventilation

IX. Advanced Airway Management

Time: 108 Minutes
Slides: 44–95
Lecture/Discussion

A. Definitive airway management is considered to be the placement of an endotrachial (ET) tube or tracheostomy tube within the trachea.
1. Patients primarily require intubation for two reasons:
    a. Failure to maintain a patent airway
    b. Failure to adequately oxygenate or ventilate
2. Some indications for ET intubation include:
    a. Diminished level of consciousness with loss of airway control
        i. Absent or diminished gag reflex
        ii. Glasgow Coma Scale score of 8 or less
        iii. Potential for aspiration (secretions, blood, vomitus)
    b. Respiratory failure (hypoxemia, hypercarbia)
    c. Cardiac arrest, after adequate CPR or bag-mask ventilations have been provided

B. Predicting the difficult airway
1. History is one factor.
    a. Anatomic findings suggestive of a difficult airway may include:
        i. Congenital abnormalities
        ii. Recent surgery
        iii. Trauma
        iv. Infection
        v. Neoplastic disease
2. LEMON mnemonic guides assessment of difficult airway:
    a. L = Look externally; following conditions may make intubation difficult:
        i. Short, thick necks
        ii. Morbid obesity
        iii. Overbite or “buck” teeth
    b. E = Evaluate 3-3-2

i. Mouth opens at least three finger-widths
ii. Mandible of at least 3 finger-widths
iii. Distance from hyoid bone to thyroid notch at least two fingers wide

c. M = Mallampati
i. Review Mallampati classification

d. O = Obstruction
i. Examples: foreign body, obesity, hematoma, masses

e. N = Neck mobility
i. Trauma patients and elderly may have problems with "sniffing position."

C. Intubation

1. Equipment for noninvasive advanced airway management includes:
a. Gloves, mask, and goggles
b. ET tubes of various sizes
i. Usual size range of 2.0 to 9.0
ii. Most adults accept a size 7.0 to 8.0
c. Appropriately sized stylet (adult or pediatric)
d. Appropriately sized laryngoscope handle and blades (Miller or Macintosh)
e. Suctioning equipment
f. 10-mL syringe
g. Water-soluble lubricant
h. Commercial tube holding device
i. Age- and size-appropriate bag-mask device with reservoir
j. Supplemental oxygen
k. Stethoscope
l. $ETCO_2$ detector esophageal detection device (EDD), or similar device
m. Magill forceps
n. Topical anesthetic spray (for nasal intubation)
o. Rescue airway device (Combitube, King LT, laryngeal mask airway)
p. 20-mL syringe
q. 40-mL syringe
r. Appropriately sized laryngoscope handles and blades:
i. Straight blades: sizes 00-0-1-2-3-4 (Miller, Wisconsin)
ii. Curved blades: sizes 1-2-3-4 (Macintosh)
iii. Much depends on comfort and experience of CCTP

2. Laryngoscopy
a. Cormack-Lehane grading system grades the view of the glottis opening
i. Grade 1: Entire glottic opening visible
ii. Grade 2: Arytenoid cartilages or posterior portion of glottic opening visible
iii. Grade 3: Epiglottis only visible
iv. Grade 4: Tongue and/or soft palate only visible
b. Limit attempts to 30 seconds or less.
c. Use Cricoid pressure (Sellick maneuver) to minimize passive regurgitation.
d. If you are attempting intubation and not visualizing what you need, stop, ventilate, and try something different.
i. Reposition the head, if possible, to elevate the ear to the level of the sternal notch.
ii. If spinal precautions are present, remove the front of the collar while maintaining manual spinal precautions to allow for increased mandibular displacement.
iii. Consider performing the BURP maneuver.

iv. Consider using a gum elastic bougie or intubating stylet.

D. Orotracheal intubation
   1. Indications for orotracheal intubation include the following:
      a. Airway control as a result of coma, respiratory arrest, and/or cardiac arrest
      b. Ventilatory support prior to impending respiratory failure
      c. Prolonged artificial ventilatory support is required
      d. Patients without a gag reflex
      e. Medication administration
         i. Examples: lidocaine, atropine, epinephrine, naloxone
      f. Impending airway compromise
         i. Examples: burns, trauma
   2. Relative contraindications for orotracheal intubation include:
      a. Inability to open the mouth because of trauma, dislocation, or pathologic condition
      b. Epiglottitis
      c. Inability to see the glottic opening
      d. Copious secretions, vomit, or blood in the airway
   3. Review Skill Drill 6-2: Performing Orotracheal Intubation
   4. Flight Considerations
      a. When performing in pressurized air medical environment, consider filling cuff with water to occupy equivalent volume of 10 mL of air
         i. Decreases risk of tracheal injury due to overexpansion of balloon with increased altitudes

E. Nasotracheal intubation
   1. Once standard; with advent of rapid sequence intubation (RSI), now used infrequently on spontaneously breathing patients:
      a. In prehospital environment where RSI not permitted
      b. Have potential for difficult airway
   2. Disadvantages
      a. High failure rate
      b. Takes longer to perform than direct laryngoscopy
      c. Prolonged attempts may result in significant hypoxemia and glottic edema secondary to trauma
      d. May cause significant bleeding and vomiting
   3. Contraindications include:
      a. Combativeness
      b. Facial trauma with suspected basilar skull fracture
      c. Coagulopathy
      d. Upper airway infection
   4. Indications for nasotracheal intubation include:
      a. Patients who are awake and breathing but are in danger of respiratory failure
      b. Patients with a gag reflex
      c. Patients who are breathing but cannot open their mouth
   5. Additional contraindications to nasotracheal intubation include:
      a. Apneic or near-apneic patients
      b. Inability to pass the tube through the nostril
      c. Blood clotting or anticoagulation therapy
      d. Severe nasal, facial, or basilar skull fractures
   6. Review Skill Drill 6-3: Performing Nasotracheal Intubation

F. Digital intubation
   1. One of the first techniques developed to facilitate the placement of an ET tube

2. Advantages include:
    a. No additional equipment is needed except ET tube
    b. Useful in confined space incidents
3. Limitations include:
    a. Safety of provider
        i. Requires patient to be profoundly unconscious without airway reflexes
        ii. Bite block
4. Indications for digital intubation include:
    a. Deeply unconscious patients who are apneic and without a gag reflex
    b. When other techniques have failed, the patient is obese, or the patient has a short neck
    c. A laryngoscope is not available or the patient is in a confined space
    d. Oral secretions are obscuring the view, and the head cannot be moved due to trauma, or immobilization equipment is complicating other techniques
    e. Massive trauma has made identification of intubation landmarks impossible
5. Contraindications to digital intubation include:
    a. Patients with a gag reflex
    b. Inability to open mouth due to:
        i. Trauma
        ii. Dislocation
        iii. Fracture
        iv. Pathologic condition
6. Review Skill Drill 6-4: Performing Digital Intubation

G. Retrograde intubation
1. Utilized when intubation is unsuccessful by standard means.
2. Indications for retrograde intubation include:
    a. Dyspnea
    b. Obstruction
    c. Secretions
    d. Failure to intubate the trachea by other less invasive methods
3. Contraindications to retrograde intubation include:
    a. Lack of familiarity with procedure
    b. Laryngeal trauma
    c. Unrecognizable or distorted landmarks
    d. Coagulopathy (relative)
    e. Severe hypoxia
        i. Due to inability to ventilate during procedure and time to perform procedure
4. Complications of retrograde intubation include:
    a. Hypoxemia
    b. Cardiac arrhythmias
    c. Mechanical trauma
    d. Infection
    e. Increased intracranial pressure
5. Assessment findings and transport complications with retrograde intubation are the same as with standard ET intubation.
6. Review Skill Drill 6-5: Performing Retrograde Intubation

H. Face-to-face intubation
1. Intubation may be performed with the provider's face at the same level as the patient's face when other positions are not possible.
    a. Example: motor vehicle collision with tight space

   b. "Tomahawk" method
2. Procedure the same as orotracheal intubation except for the following:
   a. The patient's head cannot be placed in sniffing position
      i. Manually stabilized by second provider during entire procedure
   b. Hold laryngoscope (Macintosh blade) in right hand with blade facing downwards like hatchet while holding ET tube in left hand
      i. Insert laryngoscope blade into right side of patient's mouth
      ii. Sweep tongue to patient's left
      iii. Visualize cords
   c. Once laryngoscope blade has been placed, provider who is intubating may slightly adjust patient's head for better visualization by pulling mandible forward while pressing down

I. Transillumination
1. Light source placed within the trachea is able to be visualized through the thin tissue that covers the trachea
   a. Requires specific piece of equipment.
   b. May not be possible on morbidly obese patients with short necks

J. Complications of intubation
1. Misplaced ET tube requires the following:
   a. If breath sounds are not heard bilaterally but are heard over the epigastrium, deflate cuff and extubate.
      i. Suction the airway and repeat the steps for oral intubation.
   b. If breath sounds are heard on the right side only, deflate cuff and retract ET tube until you can auscultate breath sounds bilaterally.
      i. Reinflate cuff
      ii. Resecure tube
      iii. Auscultate breath sounds again
2. Failed intubation
   a. Less than 2.5% of attempted intubations result in failure
      i. Rate may be higher in prehospital environment
   b. Perform simple BLS airway maneuvers with an OPA and/or NPA and bag-mask device.
   c. Consider using a laryngeal mask airway (LMA) or another blind insertion airway device.

K. The LMA
1. Advocated for use as a rescue airway in the setting of failed intubation in both the emergency and EMS environments
2. Advantages include:
   a. Ease of insertion because it does not require laryngoscopy
   b. Provides superior oxygenation and ventilation compared with bag-mask ventilation
3. Disadvantages include:
   a. Risk of aspiration
   b. Difficulty with obtaining adequate seal, allowing loss of tidal volume and gastric insufflations
4. Indications for LMA use include:
   a. Deep coma, cardiac arrest, and/or respiratory arrest
   b. When ET intubation is not possible or available
5. Contraindications to LMA use include:
   a. Patients with gag reflex
   b. Facial and/or esophageal trauma

   c. Suspected foreign body airway obstruction
6. Review Skill Drill 6-6: LMA Insertion

L. Esophageal tracheal Combitube
1. Indications for Combitube use are:
   a. When ET intubation is not possible, not available, or not successful
   b. As a rescue airway in failed intubation, especially in the setting of failed RSI
      i. Remember, the patient must be kept sedated and paralyzed once proper placement has been verified.
   c. Deep coma, cardiac arrest, and/or respiratory arrest
   d. To reduce the risk of gastric distention
2. Contraindications for the use of the Combitube include:
   a. Patients with a gag reflex
   b. Upper airway obstruction or suspected foreign body airway obstruction
   c. Facial and/or esophageal trauma
   d. Known esophageal disease
   e. Possibly caustic ingestions
   f. Children younger than 16 years
   g. Anyone shorter than 4'
3. Review Skill Drill 6-7: Insertion of the Combitube
4. Other types of supraglottic airways
   a. King LT airway
   b. Cuffed oropharyngeal airway

M. Surgical airways
1. Patient who cannot be intubated or ventilated may require placement of surgical airway
2. Requires adequate understanding of anatomy of the anterior part of neck
   a. Thyroid cartilage (Adam's apple) most prominent
      i. More easily palpable in males than in females
   b. Cricoid cartilage
      i. Directly inferior to thyroid cartilage
   c. Cricothyroid membrane lies between these two structures.
      i. Important landmark to identify
3. Equipment
   a. ET tube or tracheostomy tube (various sizes)
   b. Scalpel
   c. Curved hemostats
   d. Suction equipment
   e. 14-gauge or larger over-the-needle catheter
   f. ¼" tape
   g. 10-mL syringe
   h. Three-way stop cock
   i. Two pieces of standard oxygen tubing, 4' to 5' each
   j. Y-connector
   k. Oxygen cylinder (coupled with a 50-psi step-down regulator and a needle flow meter)
   l. Povidone-iodine swabs
   m. Body surface isolation, including sterile gloves
   n. Sterile fenestrated drape (hole in center)
   o. 4" x 4" gauze pads
   p. Bag-mask device
   q. Guide wire (70 cm)
   r. Cotton tie or commercial trach holder

N. Needle cricothyrotomy
   1. Indications for needle cricothyrotomy include:
      a. Intubation is not feasible
      b. Intubation does not relieve obstruction
      c. Field procedure is to establish a temporary airway
   2. Contraindications to needle cricothyrotomy include:
      a. Patients with severe airway obstruction below the site of the catheter insertion
   3. Complications of needle cricothyrotomy are:
      a. Hemorrhage
      b. Subcutaneous emphysema
      c. Infection
      d. Misplacement of cannula
      e. Accidental removal
      f. Subglottic stenosis
      g. Mediastinal emphysema
      h. Tracheal and esophageal laceration
      i. Barotrauma
   4. Review Skill Drill 6-8: Performing Needle Cricothyrotomy

O. Surgical cricothyrotomy
   1. Indications for surgical cricothyrotomy include:
      a. Intubation is not feasible
      b. Intubation does not relieve obstruction
      c. Field procedure to establish a temporary airway
   2. Contraindications to surgical cricothyrotomy are:
      a. Inability to identify anatomic landmarks, usually secondary to trauma
      b. Pediatric patients younger than 8 years
   3. Complications to surgical cricothyrotomy include:
      a. Hemorrhage
      b. Infection
      c. Misplacement of cannula/tube
      d. Accidental removal
      e. Subglottic stenosis
      f. Mediastinal emphysema
      g. Tracheal and esophageal laceration
   4. Several types of surgical cricothyrotomies include:
      a. Open cricothyrotomy
      b. Modified cricothyrotomy
         i. Seldinger technique
         ii. Nu-Trake kit
         iii. Pertrach kit
   5. Review Skill Drill 6-9: Performing Surgical Cricothyrotomy

P. Rapid sequence intubation (RSI)
   1. Procedure of choice in the emergency department and trauma bay
      a. Use in the prehospital setting relatively new
         i. Now used by both air medical and ground providers
      b. Indications
         i. Include many of same indications for ET intubation
         ii. Exception of patient in cardiac arrest who should not require administration of medications to facilitate intubation
      c. Sedatives and paralytics remove patient's ability to protect his or her airway and breathe

2. The normal contraindications and complications for standard intubation apply for RSI.
    a. Most important contraindication: Fear of inability to intubate
    b. Most devastating complication: Not being able to ventilate
    c. Requires careful patient selection
3. Capnography should be available, considered mandatory, and used throughout all phases of transportation of the patient.
4. Equipment for performing RSI includes:
    a. Gloves, gowns, mask, goggles
    b. Neuromuscular blocking agents
    c. Sedative agents
    d. Cardiac agents
    e. Syringes
    f. Needles
    g. Intubation equipment
    h. Suction
    i. Oxygen
5. RSI is a series of steps to facilitate ET intubation.
    a. First step is preparation
    b. Second step is preoxygenation
6. Medications
    a. Fall under two broad categories:
        i. Sedative or induction agents to induce unconsciousness
        ii. Neuromuscular blocking agents to induce paralysis
    b. Combination is essential, results in greater success
7. Review Skill Drill 6-10: Performing Rapid Sequence Intubation

X. Pharmacologic Agents Used in RSI

Time: 5 Minutes
Slides: 96–98
Lecture/Discussion

A. Sedative/induction agents
    1. The induction agent chosen must be appropriate for the individual patient.
        a. Ultra-short acting barbiturates sodium thiopental and methohexital
        b. Benzodiazepines midazolam, lorazepam, and diazepam
            i. Slightly longer onset of action
            ii. Significantly longer duration of action
            iii. Less attractive as induction agents
        c. Ketamine
        d. Propofol
        e. Lidocaine and atropine
            i. Pediatric patients
B. Neuromuscular blocking agents
    1. Depolarizing agents act by rapidly depolarizing the neuromuscular end plate, causing resistance to further stimulation.
        a. Succinylcholine
    2. Nondepolarizing agents block the binding of acetylcholine to its receptors in the neuromuscular end plate.

a. Examples: vecuronium, pancuronium, rocuronium, cisatracurium
b. Primarily used in three ways as a part of the RSI sequence:
    i. Pretreatment agents to prevent fasciculations encountered with succinylcholine
    ii. Primary paralytic in event of contraindications to succinylcholine (hyperkalemia)
    iii. Most commonly used to maintain postintubation paralysis

XI. Tracheostomy Management

Time: 2 Minutes

Slides: 99

Lecture/Discussion

A. Patients receiving interfacility transport may already have a tracheostomy in place.
    1. Various reasons include:
        a. Facial trauma
        b. Significant tracheal trauma
        c. Head injury
        d. Failure to wean/long-term ventilator support
            i. Most common
    2. Contraindications to a tracheostomy include:
        a. Coagulopathy
        b. Neck tumor
        c. Infection
        d. Relative contraindications; alternative is death.
    3. Complications of a tracheostomy include:
        a. Accidental removal
            i. "Fresh" or nonmature tracheostomy
        b. Infection
        c. Hemorrhage
        d. Aspiration
        e. Mediastinal emphysema
        f. Tracheoesophageal fistula
        g. Tracheal stenosis
        h. Tracheomalacia
        i. Tracheoarterial fistula
            i. Frequently from "low-lying" tracheostomy that erodes into innominate artery
    4. Not generally performed in the field
        a. Not in the skill set of the prehospital provider
        b. Takes longer
        c. Requires special equipment

XII. Mechanical Ventilation

Time: 18 Minutes

Slides: 100–110

Lecture/Discussion

A. Refers to the application of a device that provides patients varying degrees of ventilatory support.
   1. Devices range from simple to complex, depending on the needs of the patient and the capabilities of the machine.
      a. Not all ventilators have same range of characteristics, capabilities, or features
   2. Several common characteristics of all ventilators:
      a. Power source
         i. External source required
      b. Cycling
         i. Which variable terminates inspiratory phase of a breath
      c. Breath delivery
         i. Use either positive of negative pressure
      d. Parameters
         i. Mode, tidal volume, respiratory rate, flow, FIO_2, PEEP selected by clinician
      e. Ventilator circuit
         i. External
      f. Alarms
         i. Vary in type
         ii. Set for individual patient
         iii. Never disabled
   3. Indications for mechanical ventilation:
      a. Apnea
      b. Managing work of breathing
      c. Improving distribution of inhaled gases
      d. Ventilatory and respiratory failure
   4. Negative effects on several body systems:
      a. Positive-pressure ventilation increases intrathoracic pressure
         i. Barotrauma (pneumothorax)
      b. An increase in intrathoracic pressure can result in reduced venous return to the right side of the heart
         i. May result in poor cardiac output, hypotension
      c. Increased intrathoracic pressure may reduce blood flow to the liver and kidneys.
      d. Body may be fooled into thinking it is volume depleted.
         i. Hormonal changes: Increased vasopressin and aldosterone activity, decreased levels of atrial natriuretic hormone

B. Negative-pressure ventilators
   1. Iron lung of the 1950s
   2. Replaced by cuirass (“turtle shell”) and poncho type
      a. Not found in acute care
      b. Typically in rehabilitation, long-term care facilities, the home

C. Positive-pressure ventilators
   1. More prevalent than negative-pressure ventilators
   2. Potential hazards include:
      a. Pneumothorax
      b. Subcutaneous emphysema
      c. Decreased cardiac output
   3. Commonly described by which variable terminates the inspiratory phase of the breath:
      a. Pressure ventilators

   b. Volume ventilators
      i. Deliver a preset volume using varying pressures
      ii. Monitor the peak airway pressure.
   c. Flow-cycled ventilators
   d. Time-cycled ventilators
4. All ventilators rely on an external circuit that connects the ventilator to the patient.
   a. Exhaled gas vented into environment
   b. Closed system must exist between ventilator and patient

D. Invasive versus noninvasive ventilation
1. Invasive ventilation refers to placement of an artificial airway, chiefly the ET tube
2. By definition, noninvasive ventilation is any form of mechanical ventilation without an artificial airway.
   a. CPAP
   b. Bilevel positive airway pressure (BiPAP)

E. Ventilator modes and parameters
1. Modes describe what types of breaths are delivered to the patient.
   a. Mandatory or machine breath
   b. Spontaneous breath
2. Parameters refer to the other settings that may be adjusted and should be monitored continuously by the clinician.
   a. Some ventilators have many audio/visual alarms
   b. CCTP must understand prior to transport.

F. PEEP
1. Not a true mode
2. Occurs at the end of a mandatory machine breath
3. Detrimental effects of PEEP include:
   a. Decreased venous return
   b. Resultant decrease in cardiac output
   c. Increased ICP
   d. Decreased renal and portal blood flow
   e. Increased risk of barotraumas
4. Contraindicated in patients with:
   a. Untreated pneumothorax
   b. Bronchopleural fistula
5. During transport, maintain PEEP levels even when using a manual resuscitator (bag-mask device).
   a. Attach external PEEP valve to bag

G. Nitric oxide (NO, nitrogen monoxide)
1. Seeing increased use during critical care transports
   a. Only FDA–approved use is for treatment of refractory hypoxemic respiratory failure in term and near term newborns.
   b. Research is ongoing.
   c. Many institutions have standing agreements to allow compassionate use of NO in adults with refractory hypoxemia from a wide range of clinical syndromes.
   d. Patented and available from a single manufacturer that charges for gas usage and controls:
      i. Administration devices
      ii. Gas supply
      iii. Disposables used to deliver the gas to ventilator circuits
   e. Parameters for titration of NO need to be defined prior to initiating therapy.

f. Abrupt discontinuation of NO has been associated with a rebound phenomenon with significant desaturations and hemodynamic instability.
    i. Calculate gas volumes and battery lifespan.
    ii. Ensure that needed equipment will be available to continue administration throughout a transport.
g. NO gas readily reacts with other gases, including oxygen and water vapor found in ventilator circuit tubing.
h. Methemoglobinemia is another potential complication of NO therapy caused by oxidation of hemoglobin to methemoglobin, a dyshemoglobin that cannot carry oxygen.
i. NO can be a valuable adjunct for critical care transport:
    i. Of extremely hypoxic patients
    ii. To optimize conventional therapies
    iii. To continue care started prior to transfer
    iv. As a bridge to more advanced therapies (ECMO or high-frequency jet ventilation)

H. Ventilator management
1. Indications for using a portable ventilator include:
    a. Impending or actual respiratory failure
    b. Inadequate respiratory drive or apnea
    c. Inadequate gas exchange
    d. Decrease work of breathing and oxygen cost
2. Complications of using a portable ventilator include:
    a. Mechanical failure
    b. Patient anxiety
    c. Improper settings
    d. Increased intrapulmonary pressure
    e. Cardiovascular compromise
    f. Gastrointestinal disturbances
    g. Infection
    h. Impaired clearance and drying of secretions
3. Review Skill Drill 6-11: Using a Portable Ventilator
4. During transport of the critically ill patient receiving mechanical ventilation, only necessary adjustments to the ventilator should be made.
    a. Maintaining adequate oxygenation and minute ventilation
    b. Follow guidelines that should be used by CCTP who is intubating and establishing the patient on the ventilator.
5. It is the responsibility of the transport team to ensure that ventilator function and the patient's ventilatory status are maintained during the transport by:
    a. Maintaining a stable and patent airway
    b. Verifying and documenting the ventilator settings before, during, and after arrival
    c. Ensuring proper power supply and oxygen during the transport.
    d. Assessing and documenting breath sounds before, during (if possible), and after transport
    e. Continuously monitoring pulse oximetry (SpO_2) and $ETCO_2$
    f. Having a manual resuscitator (bag-mask device) available if there is any doubt about the functioning of the ventilator
6. Flight considerations
    a. Use electronic-controlled ventilators for air transport
        i. Pneumatic-controlled ventilators are not accurate in flight
    b. Watch for signs/symptoms of pneumothorax.

I. Troubleshooting
   1. A manual resuscitator must accompany every patient on a ventilator.
   2. More common alarms are:
      a. Low battery/power source
      b. Low-pressure alarm
      c. High-pressure alarm
   3. Review Skill Drill 6-12: Troubleshooting a Ventilator Low-Pressure Alarm

