ADVANCED RESPIRATORY

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DISCLOSURE

- None

OBJECTIVES

The following topics will be reviewed for enhanced understanding:

- Pulse oximetry
- Oxygenation and ventilation
- Non-invasive Positive Pressure Ventilation
- Indications for use of heated high flow therapy, and weaning from therapy as appropriate
- Mechanical ventilation
- Different types of artificial airways

Pulse Oximetry Review

- Pulse oximetry is universally used for monitoring a patient's oxygenation.
- It warns the clinician of the presence of hypoxemia or low oxygen levels in blood.
- Oxygen saturation is measured by illuminating the skin and measuring changes in light absorption of oxygenated and deoxygenated blood using two light wavelengths. Pulsatile blood flow is required for measurement.
- Multitude of sensors indicated for use on different body parts. Technology dictates correct sensor for extremity or body part (finger, toes, forehead, nose, etc.)
  - Incorrect sensor for extremity or body part may result in erroneous SpO_2 reading.

Oxygenation and Ventilation

Ventilation and oxygenation are distinctly separate processes that have interdependent physiological processes.

- Ventilation is the exchange of air between the lungs and atmosphere so that oxygen may be exchanged for CO2 in the alveoli.
  - Hypercapnia is an elevated $PaCO_2$ and is almost always caused by inadequate ventilation.
- Oxygenation is the process of delivering oxygen from the alveoli to tissue.
- Venous blood gas (VBG) analysis assesses ventilation and monitors acid-base status.
- Arterial blood gas (ABG) analysis provides specific data regarding the patient's respiratory status.
  - PaCO2 is the partial pressure of carbon dioxide dissolved in the aterial blood.
  - PaO2 is partial pressure of oxygen dissolved in arterial blood.
  - SaO2 is the oxygen saturation of arterial blood.

NON-INVASIVE POSITIVE PRESSURE VENTILATION

Non-invasive Positive Pressure Ventilation

- Non-invasive positive pressure ventilation is a type of mechanical ventilation that does not require an artificial airway. May be referred to as mask ventilation.
- Supports spontaneously breathing patients during critical situations and/or for treatment of chronic conditions.
  - Renal failure, heart failure, COPD, etc.
- Adaptable as patient condition improves or deteriorates.
- May be used to prevent or delay intubation, and support ventilation post-extubation.

Continuous Positive Airway Pressure

- One set pressure the patient exhales against to maintain airway patency.
- May be used to prevent or reverse atelectasis in hospitalized patients.
- Aids oxygenation.

Indications:

- Obstructive Sleep Apnea
- Increased shortness of breath and/or work of breathing
- Low oxygen levels
- Ability to protect airway

Bilevel Positive Airway Pressure

- Two alternating pressures delivered to support ventilation.
  - Inspiratory Positive Airway Pressure (IPAP) which supports ventilation or CO2 elimination.
  - Expiratory Positive Airway Pressure (EPAP) supports airway patency and improved oxygenation.

Indications:

- Elevated CO_2
- Dyspnea
- Accessory muscle use
- Respiratory Rate greater than 28
- pH less than 7.35 or $PaCO_2$ greater than 45 mmHg
- Ability to protect airway

Heated High Flow Nasal Cannula

- Heated and humidified high flow nasal cannula (HHFNC) may be used to reduce the work of breathing in patients with the following indicated diagnosis/condition: asthma, COPD, pneumonia, pulmonary edema, ALI-lung contusions, chest trauma, ARDS, and behavioral intolerance to other O2 delivery systems.
- Heated Humidified oxygen may be delivered by nasal prongs or tracheostomy.

MECHANICAL VENTILATION

Mechanical Ventilation

- Mechanical ventilation is indicated when spontaneous ventilation is inadequate to sustain life, to control ventilation in critically ill patients, and as prophylaxis for impending deterioration of other physiologic functions. Either an artificial airway is required to mechanically ventilate patient.
- Different modes of ventilation:
  - Assist Control Ventilation (A/C)
  - Synchronized Intermittent Mandatory Ventilation (SIMV)
  - Pressure Control Ventilation (PCV)
  - Continuous Positive Airway Pressure (CPAP)

Indications:

- Hypercapnic respiratory failure
- Hypoxic respiratory failure

Goals:

- Relieve respiratory distress
- Decrease work of breathing
- Improve pulmonary gas exchange
- Reverse respiratory muscle fatigue
- Permit lung healing
- Avoid complications

Volume Modes of Ventilation

Assist Control Ventilation

- Assist control ventilation is a ventilator mode in which the same tidal volume during every breath, whether initiated by the ventilator or by the patient.
- Peak pressures are monitored to prevent lung injury due to excessive volume and pressure.

Synchronized Intermittent Mandatory Ventilation (SIMV)

- Synchronized intermittent mandatory ventilation is a mode of ventilation when the ventilator is set to deliver a set number of breaths with a set volume while at the same time allowing spontaneous breaths.
- Pressure support is set to support any spontaneous breaths.
- Peak pressures are monitored to prevent lung injury due to excessive volume and pressure.

Pressure Modes of Ventilation

Pressure Control (PC)

- Pressure Control is a ventilator mode in which the peak inspiratory pressure is set to be delivered with each breath.
- Tidal volumes may vary and should be monitored to ensure adequate ventilation.

Pressure Support or Spontaneous

- Patient determines respiratory rate and tidal volume.
- Pressure support is set to help overcome artificial airway resistance.
- Used most commonly with ventilator weaning.
  - Weaning trials may be short lasting less than an hour or quite long lasting days.

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Complications of Mechanical Ventilation

- Cardiac
  - Decreased cardiac output, dysrhythmias
- Pulmonary
  - Barotrauma
  - Respiratory muscle weakness
  - Atelectasis, airway damage
  - Oxygen toxicity, fibrosis
- Infection (ventilator associated)
- Gastrointestional
  - Stress ulcers
  - Bleeding

ARTIFICIAL AIRWAYS

Oropharyngeal Airways

- Oropharyngeal airways are rigid intraoral devices that conform to the tongue and displace it away from the posterior pharyngeal wall, thereby restoring pharyngeal airway patency.
- Oropharyngeal airways are indicated for unconscious patients in the setting of:
  - Bag-valve-mask ventilation
  - Spontaneously breathing patients with soft tissue obstruction of the upper airway who are deeply obtunded and have no gag reflex
- Absolute contraindications:
  - Consciousness or presence of a gag reflex
- Relative contraindications:
  - Insertion of an oropharyngeal airway may not be feasible in some settings, such as
    - Oral trauma
    - Trismus (restriction of mouth opening including spasm of muscles of mastication). Nasopharyngeal airways may be used instead.
- Complications:
  - Airway obstruction by an improperly sized or improperly inserted oropharyngeal airway
  - Gagging and the potential for vomiting and aspiration

Nasopharyngeal Airways

- Nasopharyngeal airways are flexible tubes with one end flared (hence their synonym: nasal trumpets) and the other end beveled, that are inserted, beveled end first, through the nares into the pharynx.
- Spontaneously breathing patients with soft tissue obstruction of the upper airway
- Nasopharyngeal airways are better tolerated and are preferred rather than oropharyngeal airways for patients who are obtunded with intact gag reflexes.
- Nasopharyngeal airways can be used in some settings where oropharyngeal airways cannot, eg, oral trauma or trismus (restriction of mouth opening including spasm of muscles of mastication).
- Nasopharyngeal airways may also help facilitate bag-valve-mask ventilation.
- Absolute contraindications:
  - Suspected cribriform plate (basilar skull) fracture
  - Passage of the nasopharyngeal airway into the cranial vault through a disrupted cribriform plate has been reported but is rare.
- Relative contraindications:
  - Significant nasal trauma
- Complications:
  - Epistaxis
  - Gagging and the potential for vomiting and aspiration in conscious patients
  - Sinusitis

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Endotracheal Intubation

- An endotracheal tube is inserted directly into the trachea via the mouth or less commonly, the nose.
- Endotracheal tubes may have cuffs to prevent air leakage and minimize the risk of aspiration.
  - Cuffed tubes were traditionally used only in adults and children older than age 8.
  - Uncuffed tubes are often used in infants and younger children. However, cuffed tubes are increasingly being used in this population to limit air leakage or aspiration; cuff may not be inflated unless obvious leakage present.
- An endotracheal tube is the definitive method to secure a compromised airway. Maintains patent airway in patients who cannot protect their own airways and require prolonged mechanical ventilation.
- An endotracheal tube also permits suctioning of the lower respiratory tract.
- May be placed orally or nasally by a trained clinician.

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Endotracheal Intubation

Oral Intubation

Advantages:
- Easily inserted, causes less intubation trauma.
- Permits positive-pressure ventilation and may help to prevent aspiration of stomach contents if cuff is inflated.
- Permits removal of secretions in patients who can`t cough effectively.

Disadvantages:
- May damage teeth or lacerate lips, mouth, pharyngeal mucosa or larynx during insertion.
- Activates the gag reflex in conscious patients, may be bitten or chewed.
- May cause pressure injury (tube and/or securing device).

Nasal Intubation

Advantages:
- Permits improved oral hygiene.
- Permits positive-pressure ventilation and may help to prevent aspiration of stomach contents if cuff is inflated.

Disadvantages:
- Concern for laceration of pharyngeal mucosa or larynx during insertion.
- Smaller tube size used. May kink and/or plug more easily which increases airway resistance.
- Concern for internal pressure necrosis.
- More difficult, time-consuming insertion.
- Increased risk of infection (sinusitis).

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Tracheostomy

- A tracheostomy is a surgically placed airway that is usually done for one of three reasons:
  - To bypass an obstructed upper airway
  - Prolonged mechanical ventilation
  - Inability to manage airway secretions
- All tracheostomies are performed due to a lack of air getting to the lungs. There are many reasons why sufficient air cannot get to the lungs.
- Complications:
  - Bleeding
  - Air trapped around the lungs (pneumothorax)
  - Air trapped in the deeper layers of the chest(pneumomediastinum)
  - Air trapped underneath the skin around the tracheostomy (subcutaneous emphysema)
  - Injury to the nerve that moves the vocal cords
  - Tracheostomy tube occlusion because of blood clots, mucus or pressure of the airway walls.
    - Blockages can be prevented by suctioning, humidifying the air, and selecting the appropriate tracheostomy tube.
  - Accidental removal of the tracheostomy tube (accidental decannulation)
  - Infection in and around the tracheostomy site
  - Airway damage due to increased cuff pressures, scar tissue caused by infection and/or friction.

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Artificial Airway Cuff Pressures

- Artificial airway cuff pressures should be kept within an optimal range that ensures ventilation and minimizes the aspiration risk while maintaining tracheal perfusion.
- A cuff pressure between 20 and 30 cm H_2O is recommended to provide an adequate seal and reduce the risk of complications.
- Usually monitored and adjusted every 8 to 12 hours.
- Cuff pressure varies and may be out of range during the interval between intermittent measurements, increasing the risk for complications.
- Different cuff designs to minimize airway trauma.
- Continuous cuff pressure monitoring devices also available.

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