VENTILATORS

PURPOSE

To familiarize and acquaint the transfer Paramedic with the skills and knowledge necessary to adequately maintain a ventilator in the interfacility transfer environment.

OBJECTIVES

COGNITIVE

☑ Identify the indications for ventilatory support
☑ Identify the types of ventilators and be knowledgeable of the ventilator(s) most likely to be utilized
☑ Discuss the various ventilator controls and their corresponding settings
☑ Define the four major types of ventilator delivery modes
☑ Discuss ventilator complications with their associated remedies
☑ Name the major complication associated with barotrauma and describe its treatment

PSYCHOMOTOR

☑ Observe the steps required for attaching a patient to a ventilator
☑ Demonstrate the steps required to attach a patient to a ventilator

AFFECTIVE

☑ Explain the rationale for using a ventilator versus a bag-valve-mask device
☑ Defend the need to reassess the patient throughout transport with a ventilator

INDICATIONS

There are many uses for a mechanical ventilator, whether it is a cardiac arrest situation to ease the workload on the code team, a tired asthmatic patient in need of assistance, or a victim of multiple trauma who has been pharmacologically paralyzed. However, all of these reasons may be broken down into one category, acute respiratory failure.

The objective criteria for respiratory failure are very simple and straight forward, PaO_2 <60 mm Hg on 50 % oxygen and/or $PaCO_2$ >50 mm Hg with a pH less than or equal to 7.25. Many other factors must be taken into consideration before the decision is made to provide mechanical support, such as age, effort of breathing, etc.

There are five categories of pulmonary problems which may progress to the need for mechanical ventilatory support. These are:

- Central nervous system problems which depress the drive to breathe (e.g., cerebrovascular accident).
- Neuromuscular problems which lead to the failure of the peripheral nerves and muscles that aid respirations (e.g., multiple sclerosis).
- Musculoskeletal and pleural dysfunctions (e.g., flail chest)
- Problems with the airways themselves (e.g., asthma)
- Reduction in the ability to exchange gases (e.g., pneumonia)

TYPES OF VENTILATORS

As of this writing, there are three primary types of ventilators currently in use. Each specific type adjusts the flow of air into the patient, based on one of three cycles.

- **Pressure cycled**

Flow is shut off when a preset amount of pressure in the lungs is reached

- **Time cycled**

Flow is shut off when a preset time limit is reached

- **Volume cycled**

Flow is shut off when a preset amount of volume is reached

Normal breathing consists of an average tidal volume (V_T) of 5 ml/kg; most mechanical ventilations occur at a V_T of 10 ml/kg.

VENTILATOR CONTROLS

Not all ventilators will have every one of these controls listed so it is imperative that the transport paramedic be very familiar with the unit they will be operating well before it is needed for use. The typical settings will be discussed in a later section.

- **FiO_2**

Fractional inspired oxygen, listed as a number between 0 and 1. A FiO_2 of .5 means the patient will be receiving 50% oxygen, and FiO_2 of 1.0 means the patient will be receiving 100% oxygen.

- **Respiratory rate**

The rate at which the ventilator is set to provide respirations per minute. Always double check this for accuracy, do not rely solely on the machine settings to be accurate (this goes for all settings).

- **Tidal volume**

The amount of air the patient will receive with each breath. Remember that as one reduces the flow rate the tidal volume will increase thus producing better alveolar ventilation (Penduloft effect).

- **Peak flow**

Velocity of air per unit of time, typically written as liters/min.

- **Pressure limit**

A preset cut off for the machine in order to reduce the incidence of barotrauma.

- **Sensitivity**

The amount of negative pressure generated by the patient as they initiate a breath that is required to trigger the ventilator into allowing a flow of air.

- **Positive end expiratory pressure (PEEP)**

Helps maintain alveolar function by leaving a small amount of residual pressure on the alveoli. Two purposes are met, one, the alveoli are “splinted” open and two, the increased gas pressure forces oxygen across the alveolar membrane.

- **Sigh**

Typically, people increase their tidal volumes unconsciously two to four times per hour. This increased volume of air reduces the chance for any atelectactic areas (collapsed alveoli) to occur in the lungs. Not many ventilators will have this setting since mechanical ventilation is typically performed at two times the normal tidal volume.

VENTILATORY MODES

There are four ventilator modes. There are only two ventilatory modes to consider, assist and control. The other two modes, assist-control and IMV, are merely variations of the first two.

- **Assist**

The patient initiates a breath and the ventilator is triggered to allow the airflow. The patient must have a drive to breathe.

- **Control**

The ventilator controls the patient and will not allow any "extra" breaths of air. Typically, the patient will be unconscious or under the influence of a paralytic.

- **Assist-control**

The base respiratory rate is set, however if the patient wishes to take any additional breaths he/she may. Hyperventilation may occur with this setting due to the fact that the V_T remains the same whether it was a controlled breath (ventilator) or a patient initiated breath.

- **Intermittent mandatory ventilation (IMV)**

This setting basically works the same as assist control with one major difference. Any spontaneous breaths that are initiated by the patient will have no ventilatory support, that is to say the V_T will be entirely dependent on the patient.

TYPICAL VENTILATOR SETTINGS

There are no "typical" settings for every patient. Just as treatment modalities differ from patient to patient, so it is with ventilators. The following are guidelines that may be used for the "average" patient.

- **FiO_2**
  1.0 (100%)
- **Tidal volume**
  10-15 ml/kg
- **Respiratory rate**
  10-15 breaths per minute
- **Inspiratory flow**
  40-60 liters per second
- **Sensitivity**
  -2 cm H_2O
- **Sigh rate**
  1-2 times per minute with V_T=20 ml/kg
- **PEEP**
  0-5 cm H_20

VENTILATOR PRECAUTIONS

- In patients who exhibit an inadequate circulatory volume the use of PEEP will decrease the cardiac output and subsequently decrease the amount of oxygenation to the cells. This is due to the increase in intrathoracic pressures decreasing the amount of blood flow back to the heart.
- There are two primary roles of the upper airway, warming and humidifying the incoming air. Since an ET tube effectively bypasses the upper airway, one needs to take these considerations into account. A separate heater may not be feasible for ambulance transports; however, humidification of the oxygen is mandatory.
- Suctioning will need to be performed if rhonchi are auscultated or secretions are heard during respiration.
  - ✓ Suction pressure should not exceed 100-120 mm Hg.
  - ✓ Suction no longer than 10 seconds while monitoring the EKG for any dysrhythmias.

VENTILATOR COMPLICATIONS

AIRWAY COMPLICATIONS

- Aspiration may occur before, during, and/or after intubation.
- Most ventilator patients should have their hands restrained.
- Pseudomonas pneumonia frequently develops due to contaminated equipment.

ENDOTRACHEAL TUBE PROBLEMS

- Arterial circulation is occluded by ET cuff pressures that exceed 30 mm Hg. The resulting tracheal stenosis and malacia may be prevented by decreasing the cuff pressures of the ET tube. An easy way to minimize this problem is to auscultate at the neck for the sound of rushing air while inflating the ET tube cuff. Do not inflate the tube past the point where the sound of rushing air disappears.
- Always be alert for the signs of an occluded, whether partial or complete, ET tube (decreasing SaO_2, poor skin color, etc.).
- Be alert for a displaced ET tube particularly after moving the patient.

MECHANICAL PROBLEMS

Ventilators today are extremely reliable and dependable; however, they are machines and as such are capable of breaking down (usually at the worst possible times). Ventilator problems are potentially the most serious. The major problem is simply inadequate V_T.

Inadequate V_T caused by:

- Leaks in the ventilator circuit or the ET cuff
- Disconnected tubing or ventilator
- Obstruction of airflow
  - ✓ Kinked tubing
  - ✓ Retained secretions
  - ✓ Severe bronchospasms
  - ✓ Coughing spasms
  - ✓ Biting on the ET tube

BAROTRAUMA

Unlike normal passive ventilation, ventilators force air into the lungs which results in greatly increased pressures. This increase in pressure may rupture weakened alveoli or preexisting blebs (blebs are "blisters" on the surface of the lung, typically emphysemic patients).

If alveoli or blebs are caused to rupture the patient may develop a tension pneumothorax. One of the most reliable signs of a tension pneumothorax is progressive hypotension and bradycardia which ultimately leads to a refractory cardiac arrest. Additionally, the paramedic listening for breath sounds should notice a reduction in breath sounds on the affected side. Therefore, the chest should be auscultated at least once every fifteen minutes during transport. The only intervention available to the EMT-paramedic is to remove the patient from the ventilator and provide small, rapid breaths with a bag-valve device, until decompression may be performed at a hospital.