

**MWLCEMS SYSTEM**  
**Continuing Education Packet**

**Mechanical Ventilation**

A mechanical ventilator is a machine that generates a controlled flow of gas into a patient’s airways. Oxygen and air are received from cylinders or wall outlets, the gas is pressure reduced and blended according to the prescribed inspired oxygen tension (FIO<sub>2</sub>), accumulated in a receptacle within the machine, and delivered to the patient using one of many available modes of ventilation.

Ventilators are commonly described by which variable terminates the inspiratory phase of the breath. They are either volume controlled, pressure controlled, flow-cycled controlled or time controlled. In volume controlled modes, a desired tidal volume is delivered at a specific flow (peak flow) rate. In pressure controlled modes, flow occurs until a preset peak pressure is met over a specified inspiratory period. Flow-cycled ventilators end inspiration when a predetermined flow rate is achieved. Time cycled ventilator end inspiration after a selected inspiratory time has been achieved. **Volume ventilators are the most common ventilators used.**

**Ventilator Modes**

Refers to how the machine senses or signals the initiation of inspiration. The common ventilator modes that you will use for transporting patients who meet the MWLCEMS criteria are:

<b>Mode</b>	<b>Description</b>	<b>Comments</b>
Control	Preset tidal volume and rate; the ventilator delivers the tidal volume at the rate, and the circuit is closed in between these mandatory breaths	Patient must be apneic or paralyzed or they “fight” the ventilator. Guarantees ventilation with a specific minute ventilation. Allows ventilatory muscle rest.
Assist-Control (AC) – also called assisted mandatory ventilation	Preset tidal volume, minimum rate (control rate), and inspiratory effort required to “trigger” the ventilator to cycle to assist breaths (sensitivity); the ventilator delivers the control breaths of the specified tidal volume and responds by cycling additionally if the patient’s inspiratory effort (negative pressure is adequate.	More comfortable than control mode. Less work of breathing for patient than spontaneous breathing or SIMV. Allows ventilatory muscle rest. Risk for hyperventilation because each assisted breath is delivered at the same tidal volume as mandatory breaths; sedation may be necessary to decrease the number of spontaneously triggered breaths
Synchronized intermittent mandatory ventilation (SIMV)	Preset tidal volume and minimum rate; the ventilatory circuit is open between the mandatory breaths so that the patient may take additional breaths; because the ventilator does not cycle to assist these breaths, the tidal	Allows muscle reconditioning better than control or assist-control. Less potential for hyperventilation because patient-initiated breaths are at the tidal volume determined by the

	<p>volume of these breaths varies. Mandatory breaths are synchronized so that they do not occur during the patient's ventilatory efforts</p>	<p>patient. More work of breathing for patient than assist-control because patient-initiated breaths are not assisted. Less need for sedation than assist-control or control modes Does not decrease cardiac output as much as Assist-Control or Control modes Frequently used for weaning.</p>
CPAP	When used as a mode of ventilation, it describes a mode without additional support.	There is no preset ventilatory rate, and apnea occurs if the patient does not initiate a breath
Pressure support ventilation (PSV)	Preset inspiratory support pressure level; when the patient initiates a breath, this positive pressure flows to assist the patient's spontaneous breaths; tidal volume and rate are patient controlled.	<p>Low level (5 – 10 cm H<sub>2</sub>O) helps to eliminate the increased work of breathing associated with an ET tube; higher levels help to augment the patient's own intrinsic tidal volume. Lessens work of breathing but also allows use of respiratory muscles to lessen muscular atrophy. Lower mean airway pressures than volume ventilation. May be used with SIMV or alone; if used alone, patient must be spontaneously breathing.</p>

### Mechanical Ventilator Parameters

In addition to selecting the mode of ventilation, there are several other parameters depending on your specific transport ventilator that must be set.

- Tidal volume – The tidal volume is the volume of air delivered with each breath. Some of the air in the tidal volume simply fills dead space in the lungs while the remaining air ventilates the alveoli. Tidal volume can be estimated at 5 to 10 ml/kg of ideal body weight; 5 – 7 ml/kg if poor lung compliance (for example from acute lung injury or restrictive or obstructive diseases) is present.
- Rate – The number of breaths delivered per minute. This varies from 8 to 12 per minute. The rate must be matched with the tidal volume to ensure an adequate minute volume.
- Fraction of inspired air (FiO<sub>2</sub>) – Percentage of inhaled oxygen expressed as a decimal. Initially the FiO<sub>2</sub> is set a 1.0 (100%) and titrated downward based on blood gas values. The lowest FiO<sub>2</sub> possible (50% or less) should be used to achieve the desired PaO<sub>2</sub> to avoid oxygen toxicity.
- Sensitivity – The amount of inspired effort required to initiate an assisted breath. Usually set at -1 to -2 cm H<sub>2</sub>O

- I/E ratio – The ratio of inspiration and expiration time. The normal starting I:E ratio is 1:2. If the patient has obstructive airway disease (i.e., COPD), then the ratio should be reduced to 1:4 or 1:5 to avoid air trapping.
- Peak inspiratory pressure – Airway pressure at the peak of inspiration.
- PEEP – Airway pressure at the end of expiration. It is used to increase the functional residual capacity or the amount of air remaining in the lungs at the end of expiration. Increased PEEP helps keep the alveoli open and improves gas exchange. The maximum amount of PEEP allowed during transfer per MWLCEMS System policy is 5 cm

### Alarms

It is the critical care paramedic’s responsibility to ensure all ventilator alarms are on prior to transfer. At no time will any of the alarms be turned off.

- High-pressure alarm: Alerts the paramedic that the ventilator has to use high pressure to deliver the tidal volume. It is usually preset at 10 to 20 cm above the peak airway pressure. Causes include:
  1. Increase airway resistance: secretions; bronchospasm; kink in tubing; displacement of artificial airway; patient coughing during inspiration; patient biting on ET tube; water condensation in tubing
  2. Decreased compliance: pneumothorax (sudden increase); development of pulmonary edema, atelectasis, pneumonia, ARDS (gradual increase).
- Low-pressure alarm – Activated when the tidal volume falls below 50 to 100ml of the set tidal volume. Causes include disconnection in the circuit, cuff leak, leak in circuitry.
- Apnea – Always set when the patient is in CPAP or Pressure Support Mode. It alerts the paramedic that the patient has stopped breathing. Patient should be immediately disconnected and bagged with high flow oxygen. Causes include patient fatigue, overmedication, and decrease in level of consciousness.
- Low FiO2 – Alerts the paramedic that the oxygen source is disconnected or depleted.

### Complications of Mechanical Ventilation

Complication	Cause	Prevention	Clinical Presentation	Treatment
Decreased cardiac output	Increased intrathoracic pressures that decrease venous return to the right heart Increased right ventricular afterload Decreased left ventricular distensibility	Ensure adequate preload before mechanical ventilation Avoid excessive tidal volumes Adjust PEEP carefully	Tachycardia Hypotension Cool, clammy skin Decrease in urine output Change in level of consciousness	Administer fluids to increase preload Administer inotropes as prescribed

Complication	Cause	Prevention	Clinical Presentation	Treatment
Ventilator induced lung injury	Barotrauma : high inflation pressures can cause pneumo-Thorax, pneumo-Mediastinum, or subcutaneous emphysema Volutrauma: high inflation volumes and repeated end-expiratory collapse followed by repeated reopening during inspiration may cause release of inflammatory mediators, injury to the lung ultrastructure and ARDS	Avoid excessive tidal volumes Keep FiO <sub>2</sub> less than 0.6 (60%) Adjust PEEP carefully	Pneumothorax: chest pain, dyspnea, sudden increase in peak inspiratory pressure, decreased breath sounds and chest movement on affected side, tracheal shift, hypotension, jugular venous distention if tension pneumothorax, clinical indications of hypoxia, decreased SpO <sub>2</sub> ARDS: high peak pressures, refractory hypoxemia, pulmonary edema	If pneumothorax suspected, take patient off ventilator and manually ventilate with a manual resuscitation bag notify medical control and divert to closest hospital. If tension pneumothorax suspected, take patient off ventilator and manually ventilate with a manual resuscitation bag, notify medical control for orders to needle decompress and divert to the closest hospital
Aspiration	Stomach contents Tube feedings Oral secretions Gastric distention Impaired gastric emptying Esophageal reflux	Maintain cuff inflation Keep head of bed elevated 30 to 45 degrees Check for gastric retention Stop all gastric feeding during transport	Increased tracheal secretions Fever Rhonchi, wheezes Signs/symptoms of hypoxemia/hypoxia	Suction, If increased respiratory distress or hypoxia disconnect from ventilator and provide manual ventilations, Notify medical control
Infection	Immunosuppression Artificial airways bypass normal upper airway defense mechanisms Ventilatory equipment is a warm moist environment is good for bacterial growth Suctioning procedure	Use good hand-washing techniques Use sterile technique for suctioning Keep head of bed elevated	Tachycardia Tachypnea Fever Crackles, rhonchi or wheezes Hypoxemia Change in color of character of sputum	Supportive

## Patient Transport

Transport of the patient who is receiving ventilation must be planned to ensure patient safety. First you must be familiar with your particular ventilator and its capabilities. A complete assessment must be completed prior to transfer with the transferring nurse to establish the patient's baseline. It is important that you understand why the patient is being ventilated. Ventilator setting should be confirmed by the transferring nurse. Prepare transfer ventilator using patient's pre-transfer ventilator settings. Utilize the respiratory therapist and nurse to adapt your ventilator if you cannot exactly mimic the settings. Call report to Medical Control prior to transferring patient to your cot.

During transfer a manual resuscitator (bag-mask device) must be available at all times. Continue to monitor ventilator performance and patient response during the transport utilizing the cardiac monitor, pulse oximetry and end tidal CO<sub>2</sub> wave for monitor. **If acute respiratory deterioration occurs and an obvious cause is not immediately determined (i.e. tube disconnected, tube kinked, etc) disconnect the patient from the ventilator and initiate manual ventilation with a self-inflating resuscitation bag connected to 100% oxygen. Perform a complete physical assessment, including patency of the airway and assess ventilator circuit and settings. Divert to the closest hospital and notify medical control.**

Upon arrival at accepting facility verify and document airway patency, respiratory assessment and parameters with the receiving nurse.

**MWLCEMS SYSTEM**  
**Mechanical Ventilation**  
**Post Test**

Name: \_\_\_\_\_

Date: \_\_\_\_\_

1 – 7 Match the ventilator parameter with its definition

Parameter	Definition
Tidal volume	A. The ratio of inspiration and expiration time
Rate	B. Percentage of inhaled oxygen expressed as a decimal
FiO2	C. The volume of air delivered with each breath
Sensitivity	D. Airway pressure at the peak of inspiration
I:E Ratio	E. The amount of inspired effort required to initiate an assisted breath
PEEP	F. The number of breaths delivered per minute
Peak Inspiratory Pressure	G. Airway pressure at the end of expiration

8 – 12 Match the ventilator mode with its definition

Mode	Definition
Control	A. Ventilator delivers a set number of mandatory breaths at a specific tidal volume. Additional breaths are spontaneous breaths at the patient's own rate and tidal volume.
Assist-Control (AC)	B. Preset inspiratory support pressure level; when the patient initiates a breath, this positive pressure flows to assist the patient's spontaneous breaths; tidal volume and rate are patient controlled.
SIMV	C. No breaths are initiated by the ventilator. All breaths are spontaneous.
CPAP	D. Ventilator delivers a specific set respiratory rate and volume, controlled by the ventilator. The patient is not allowed any other breaths.
Pressure Support	E. Ventilator is set to deliver a specific number of breaths at a specific tidal volume. Any spontaneous breaths are delivered at the preset tidal volume.

13. You are transferring a 64 yr old patient who has a tracheostomy and is on a ventilator. The patient develops respiratory distress and becomes cyanotic. Their pulse oximeter and HR are dropping. Patient is extremely anxious. Your first action would be

- A. Increase the FiO2 on the ventilator
- B. Call for permission to needle decompress the chest
- C. Disconnect the patient from the ventilator and begin bagging the patient with 100% O2
- D. Check your oxygen supply to the ventilator

14. You are transferring a patient on your transfer vent and the high pressure alarm goes off. List 4 possible causes of this alarm.

- A. \_\_\_\_\_
- B. \_\_\_\_\_
- C. \_\_\_\_\_
- D. \_\_\_\_\_

15. A possible causes of a low pressure alarm is

- A. Depleted oxygen supply
- B. Kink in the tube
- C. Disconnect in the circuit
- D. No spontaneous respirations

16. Your patient suddenly develops dyspnea and becomes cyanotic. You see no obvious cause so you disconnect the patient from the ventilator. You assess your patient and find absent breath sounds on the right, jugular vein distention, decreased chest movement on the right side and the patient is hypotensive. The correct order of care would be

- A. Needle decompress the right side of the chest, contact medical control
- B. Disconnect the ventilator from the patient, bag the patient with 100% O<sub>2</sub>, notify medical control for permission to needle decompress the chest
- C. Disconnect the ventilator, bag patient with 100% O<sub>2</sub>, needle decompress, notify medical control
- D. Notify medical control to obtain order to needle decompress, needle decompress, if no improvement disconnect from ventilator and bag patient with 100% O<sub>2</sub>

17. Patients on a ventilator should be transferred with their head elevated 30 to 45 degrees.

- A. True
- B. False

18. You must use sterile technique when suctioning a patient's trach or ET tube that is on a ventilator.

- A. True
- B. False

19. Patients on a ventilator need to be monitored for decreased cardiac output.

- A. True
- B. False

20. The maximum amount of PEEP approved for a Tier II Critical Care Transport according to the MWLCEMS System policy is \_\_\_\_\_.

**If you are NOT a member of the McHenry Western Lake County EMS System, Please include your address on each optional quiz turned into our office. Our mailing address is: Northwestern Medicine – McHenry Hospital EMS, 4201 Medical Center Drive, McHenry, Illinois 60050. We will forward to your home address verification of your continuing education hours.**

**If you ARE a member of our EMS System, your credit will be added to your Image Trend record. Please refer to Image Trend to see your current list of continuing education credits. Any questions regarding this can be addressed to Cindy Tabert at 224-654-0160. Please fax your quiz to Cindy Tabert at 224-654-0165.**