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TITLE: Mechanical Ventilator Use

REVISED: July 01, 2024

I. Introduction:

Mechanical Ventilation is the use of an automated device to deliver positive pressure ventilation to a patient. Proper use of a mechanical ventilator has shown improved oxygenation, ventilation, and patient comfort compared to a BVM. Mechanical ventilation has an increased complexity and risk and should only be used by paramedics familiar with both the general concepts of mechanical ventilation and the specific ventilator in use.

II. Mechanism of Action:

Mechanical Ventilation works by providing increased positive pressure ventilation at the level of the lower airway structures, improving gas exchange in the alveoli.

III. Indications:

Due to the complexities of patient management and the dynamics of each individual call, there are no *absolute* indications for mechanical ventilation. A provider may choose to continue to use a bag-valve-mask (BVM) or other device as the clinical and practical situation dictates.

Mechanical ventilation **should be considered** for patients who have an advanced airway (ETT, SGA, or tracheostomy) *and*:

- Suffer from apnea or agonal respiratory effort during cardiac or respiratory arrest
- Are already on a ventilator.

> **NOTE:** **If not used, provider must document reason(s) for deferring mechanical ventilation in a patient with an advanced airway**

Mechanical ventilation **may be considered** for:

- Are at risk of hyperventilation during cardiac arrest resuscitation
- Non-invasive Face Mask Ventilation
    - Should only be considered when manpower is limited.
    - Oral or nasal adjuncts, as well as proper positioning of the patient are essential.
- Patients who are already in the community (i.e. at home, a nursing facility, or other clinical setting) on a ventilator.
- Administration of non-invasive respiratory support (i.e. CPAP. BiLevel, or similar) (See *appendix 6*) if the mechanical ventilator has that capability.

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IV. Contraindications:

- Suspected Pneumothorax (untreated/developing)
- Pulmonary over pressurization/barotrauma (Blast Injuries, rapid ascent dive injury)
- Patient is outside acceptable parameters and/or capabilities for the ventilator at hand
    - Example: the Zoll Z Vent is not approved for infants < 5 kg (< 11 pounds)
- Provider not trained/credentialed for ACCESS mechanical ventilation.

V. Cautions

- Patients who are being ventilated should be attended by **at least two providers at all times**, one of whom should be an ACCESS Agency Paramedic.
- Use of positive pressure ventilation, including mechanical ventilation, increases the risk of pneumothorax.
- Increased intrathoracic pressure from positive pressure ventilation, PEEP, and overventilation may have severe hemodynamic effects.
- All patients who are being mechanically ventilated should be monitored closely with frequent auscultation, vital signs, SPO2, EKG and waveform ETCO2.
- Proper sedation *AND* analgesia, with or without paralysis, is a key part of ventilator management.
- Paralysis and mechanical sedation in a patient with complex physiological needs, (i.e. metabolic acidosis or asthma) is a last resort, ideally after a trial of BiPAP or CPAP if appropriate.

VI. Procedure:

This procedure is written largely for the Zoll EMV + Ventilator (AKA The Zoll "Z Vent"). It may have to be adjusted for the use of other ventilators based on the manufacturer's guidelines or for expert consultation (medical control, respiratory therapy, etc).

General

- Treat the *patient*
- Ensure minimum patient monitoring. Proper, diligent multifaceted monitoring is crucial for proper ventilator care.
    - ETCO2
    - Plateau Pressure ("P-Plat")
    - EKG
    - SPO2
    - NIBP (every 5 min)
- Asses for indications and contraindications (especially suspected untreated pneumothorax)

- Inspect and prepare the ventilator for use prior to application to the patient.
  - o Attach Oxygen Source
  - o Ensure adequate oxygen supply, battery charge, and location of backup oxygen supply and backup power source.
  - o Select proper ventilator circuit for the patient
    - Zoll: pediatric/adult patient circuits – Vt 200 cc +
    - Zoll: infant/pediatric patient circuits – Vt 50-300 cc
- Select the proper patient mode for the patient. Modes approved for *out-of-hospital* * use include:
  - o AC/V (V)
  - o SIMV (V)
  - o BiLevel/BiPap
  - o CPAP *(See appendix 6).*

NOTE: *Never use the CPAP and BiLevel (BiPAP) mode on a patient who is NOT spontaneously breathing and/or may stop spontaneous breathing. CPAP and BL are intended for ventilatory support, **NOT** ventilation.*

**** Interfacility transports with mechanical ventilation already applied:** Discuss with the patient's provider (MD/DO or PA/NP) or Respiratory Therapist at the sending facility regarding current ventilator settings. Modifications from the prescribed ventilator settings may be made based on changes in patient condition and response to ongoing mechanical ventilation. Consult OLMC as needed.*

NOTE: *ACCESS Providers may use Volume-supported modes AC(v) and SIMV (v); as well as CPAP /BiLevel (BiPAP) modes.* **If the patient is requires another mode (i.e. Pressure Control) or specialty settings (i.e: Inverse I:E ratios) for transfer, then additional expertise (i.e. RT, etc) is required during transport.**

- Adjust and double-check settings visually.

Setting	Adult (15+) Range/Default	Pediatric (<14) Range/Default
Pt already on mechanical ventilation		
Default	Matching previous vent settings, titrating as allowed or instructed by expert consultation (See Above)	
Oxygen Concentration (FiO2 or %): *Titrate to SPO2 94%-99% when appropriate.*		
Default	FiO2: 1.0 (100%) -> Titrated to FiO2 0.5 (50%) if tolerated while targeting SpO2 94-99%. FiO2 21% -100% Permissible.	
Peak inspiratory pressure (PIP) ALARM Limit: highest pressure recorded during the inspiratory phase of mandatory breaths.		
STOP This is not adjustable in Volume Control Modes. See the comments above about expert consultation. Additional expertise (i.e. RT, etc) is required during transport.		
Default	35	35
Cardiac Arrest	100	**100**

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Setting	Adult (15+) Range/Default	Pediatric (<14) Range/Default
PEEP (Found in PIP Menu)		
Default	*Start at 5 cm H20 (range 2-10 cm H20)*	
Cardiac Arrest (During CPR)	*Do not exceed 5 cm H2O*	
CPAP: CPAP MODE is set in the start menu or in the mode menu. CPAP level is adjusted in the PIP Menu under PEEP.		
Default **MAX 10 cmH2O**	*Start at 5 cm H20 (range 2-10 cm H20)*	
BiPap/BiLevel: (**BL is set in the CPAP mode sub menu).** *Inspiratory positive airway pressure (IPAP) and Expiratory positive airway pressure (EPAP). IPAP is typically 5-10 cmH2O over EPAP*		
Default *IPAP:* **MAX 20 cmH2O** *EPAP:* **MAX 10 cmH2O**	*IPAP: Start at 9 (9-20 cmH2O)* *EPAP: Start at 5 (3-10 cmH2O)* *Note: Many patients do better with a short trial of CPAP first then transitioning to BiPAP*	
Obstructive *(Asthma, COPD, etc)* *IPAP:* **MAX 20 cmH2O** *EPAP:* **MAX 10 cmH2O**	*IPAP: start at 15 (10-20 cmH2O)* *EPAP: Start at 5 (5-10 cmH2O)* *Note: Many patients do better with a short trial of CPAP first then transitioning to BiPAP*	
Tidal Volume (Vt): *Vt should be based on Ideal/Predicted Body weight chart in older children and adults. See Based on I/PBW chart*		
NOTE: Vt < 200 cc requires use of the INFANT/PED ventilation Circuit only. Not indicated for infants <5 kg		
Default	*4-8 ml/kg I/PBW(6ml/kg default)*	
Obstructive (Asthma, COPD, etc)	*4-8 ml/kg I/PBW (8 ml/kg default)*	
Metabolic Acidosis	*4-10 ml/kg I/PBW (8 ml/kg default)*	

Setting	Adult (15+) Range/Default	Pediatric (<14) Range/Default
BPM : (Respiratory Rate or f) Breaths per minute		
Default	*Adults: 12 (range 10 -20) Titrated for effect*	**STOP: Not indicated for infants <5 kg/< 1 year old** *1-2 y/o: 30 (25-45/min)* *3-6 y/o: 25 (20-30/min)* *7-12y/o: 20 (16-25/min)* *13-14 y/o: 16 (range 10 -20)*
Cardiac Arrest	*8 -> Titrated for effect (6-10/min)*	**STOP: Not indicated for infants <5 kg/< 1 year old** *1-2 y/o: 30 (25-45/min)* *3-6 y/o: 25 (20-30/min)* *7-12 y/o: 20 (16-25/min)* *13-14 y/o: 16 (range 10 -20)*
Metabolic Acidosis	*Titrated for effect and required minute volume* **(See Minute volume recommendations)**	
Rise Time: *(Found in BPM sub Menu) The speed at which inspiratory pressure increases to the set target pressure is known as the rise time on BiLevel (BiPAPs) . Adjustments in rise time can improve patient comfort/tolerability with BiPAP. 1 is the shortest and 10 is the longest. Lower rise time = Faster Inspiration.*		
STOP **This is not adjustable in Volume Control Modes, only in CPAP and BiLevel.** **See comments above about expert consultation for use in other modes.** **Additional expertise (i.e. RT, etc) is required during transport**		
NOTE: The transition into CPAP or BL from invasive modes automatically sets the rise time to 3 which may be too fast for infants and small children. Adjust to 5 to start and titrate		
Default	*5 (Range 1-10)*	
CPAP/BiLevel	*5 (Range 1-10)*	
Cycle Time- BiLevel (BiPAP Only): *(Found in BPM sub-Menu) When the ventilator switches from inspiration to exhalation. If the patient has asynchrony with BiLevel causing distress, may adjust to 40%*		
Default	*Defaults to 25% (25-40%)* *Adjust to 40% for asynchrony or discomfort*	
Minute Volume (Ve or Vmin): *Vt x f = Ve Normal calculated Ve: 100 ml/kg/min* *Minute Volume is found under the BPM menu on the Zoll Z Vent. It is adjusted by adjusting BPM and Tidal volume.*		
Default	*100 ml/kg/min (Range 100-200 ml/kg/min)*	
Metabolic Acidosis	*Targeted to re-create the immediate pre-intubation minute ventilation. Start at 150 ml/kg/min (Range 100-200 ml/kg/min)*	

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Setting	Adult (15+) Range/Default	Pediatric (<14) Range/Default
Inspiration: Exhalation Ratio (I:E): *The ratio of the time of inspiratory and expiratory phases.*		
Default - Lung Protective	*1:2 -1:6 (1:3.0 default) Titrated to prevent air trapping.*	
Obstructive (Asthma, COPD, etc)	*1:2– 1:6 (1:4 default) Titrated to prevent air trapping.*	
Inverse I:E Ratios	*STOP See comments above about expert consultation. Additional expertise (i.e. RT, etc) is required during transport.*	
MODE:		
Default	*AC/V (V), SIMV (V), CPAP, BiLevel (BiPap) as indicated*	
Pressure Control and other modes of ventilation	*STOP See the comments above about expert consultation. Additional expertise (i.e. RT, etc) is required during transport.*	
Trigger: *The inspiratory threshold/sensitivity for the patient to "trigger" a spontaneous breath by the ventilator.*		
Default	*-0.5 to -6.0 (-2.0 Default)*	
CPR, Rough roads, etc	*-6.0 Requires heavy sedation and paralysis*	

- **Ensure proper functioning by inspecting settings and cycling a few breaths with the "test lung" PRIOR to attaching the ventilator to the patient.**
- Pre-oxygenate the patient as needed.
- Transition the patient from manual ventilation to the ventilator.
- Assess breath sounds and reconfirm airway placement.
- Adjust ventilator settings as clinically indicated.
    - Only change one parameter at a time and reassess before another adjustment.
    - The ventilator rate should adjusted to maintain a pulse oximetry of 94-99 (or as high as possible up to 99%) while maintaining an ETCO2 of 35-45.
- If any worsening of the patient's condition, decrease in oxygen saturation, or any question regarding the function of the respirator, remove the respirator and resume bag-valve mask ventilations until the situation is resolved.
- Document time, complications, and patient response on the patient care report (PCR).
- An in-line nebulizer may be run simultaneously with the ventilator, CPAP or BiLevel/BiPAP.
- Treatment should be given continuously throughout transport to ED.

VII. Documentation:

- It is required that patients on a transport ventilator should be monitored continuously through EKG, waveform capnography and pulse oximetry as well as frequent physical assessment.

Documentation on the patient care record should include:

Ventilator (ESO Field)

- Mode (AC/Volume, SIMV/VC, CPAP*, BiLevel/BiPAP)
- Ventilation Rate (BPM)
- PEEP/CPAP
- BiLevel/BiPap (iPAP and ePAP)
- Tidal Volume (Vt)
- Peak Inspiratory Pressure (PIP)
- Oxygen Concentration (FiO2)
- I:E Ratio

  * If using FLOW SAFE II CPAP or similar use CPAP field instead.

ETI Verification (ESO Field)

- Tube Depth (CM) at intubation
- Method of confirmation

Other Documentation

- Vital Sign q5 minutes, including ETCO2 and SPO2
- Tolerance of Ventilation
- Any adverse reactions
- Justification for sedation, paralysis, etc. Be specific.

VIII. Special Notes

The following are special considerations and notes when using a mechanical ventilator.

- **Different Ventilators:** The provider must be familiar with the ventilator at hand. If in doubt, the provider should secure expertise from other personnel or facility staff prior to taking responsibility for the patient.
- **Tidal Volume**: Tidal volume should be based on ideal body weight. To do this we use the NIH estimate for predicted body weight (PBW) by gender. The morbidly obese do not have substantially larger lungs compared to patients of more normal mass.
- **Nebulizers and Ventilators:** An in-line nebulizer may be run simultaneously with the non-invasive support (CPAP and BiLevel) and mechanical ventilation. **Monitor airway pressures closely**.
- **CPAP and BiLevel:** Many patients tolerate a trial of CPAP first *before* transitioning to BiLevel, rather than progressing immediately to BiLevel.
- **Alarms:** Persistent alarms, particularly **pressure alarms** should never be discounted.

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- **Sedation and Paralysis:** Proper paralysis and sedation is essential to good ventilator management, balanced against the patient's hemodynamic status. See Appendix 2: Indicators of poor sedation or paralysis include:

  o Tachycardia
  o ETCO2 for the "Curare Cleft" and other signs of spontaneous breathing
  o Tears, grimacing, coughing, or other motor movements.

- **DOPERS:** The first step of troubleshooting a ventilator is to place the patient back on the BVM and conduct a modified *DOPES* check. Therefore, all ventilated patients should have a complete BVM (with mask) at bedside at all times.

  D - Displacement of tube: Attach end-tidal CO2 to verify and check depth (cm at lip)

  O - Obstruction of tube/circuit: Use a suction catheter to remove mucus plug, or make sure the patient not biting down, Insure that in line suction catheter is not partially blocking the ETT tube.

  P – Pneumothorax: Auscultate, assess, visualize chest wall, and perform needle decompression if needed.

  E - Equipment failure: Connect to BVM to buy time to evaluate your patient and the ventilator

  R – Rigidity/Resistance to Ventilation – Evaluate sedation and paralysis.

  S - Stacked breaths - Auto-PEEP especially in COPD/Asthma: Disconnect from the ventilator and allow open circuit exhalation. Increase I:E ratio (1:4 or 1:6), Decrease Respiratory rate or Tidal volume (or both) if tolerated. Consider bronchodilators and/or ETT suctioning.