Mechanical Ventilation-Adult-Interfacility

POLICY:

- This policy is primarily intended to address ventilator use during inter-facility transports. See Mechanical ventilation-911 for additional information on initial settings for pre-hospital mechanical ventilation
- Adequate patient sedation and end-tidal CO_2 monitoring needs to be proactively provided and continually monitored.
- Consider paralytics where appropriate.
- These procedures provide starting ventilatory guidelines for various conditions. However, patient's conditions are variable and so these procedures need to be adjusted to meet the patient's clinical needs. If in doubt about appropriate ventilator settings, contact medical control.
- Unless contraindicated, mechanically ventilated patients should be maintained semi-recumbent, with the head of the bed raised to 45° to prevent the development of ventilator-associated pneumonia.
- Efforts should be taken to minimize use of bag-valve ventilation of the patient and maximize mechanical ventilation to provide consistent tidal volumes and respiratory rates.
- Clamping of endotracheal tube during transitions between ventilators is strongly encouraged with patients who have PEEP >5mmHg to maintain alveolar recruitment and to minimize the loss of that recruitment.
- A new ventilator circuit shall be used with each new patient with calibrations already performed prior to assuming of care.
- Consideration of current oxygen supply in transport vehicle should be calculated based upon mission requirements (see attachment).

COMPLICATIONS:

- Hemodynamic compromise from reduced venous return
- Bronchospasm
- Accidental extubation
- Bronchial intubation
- ET tube cuff leak/air leak
- Endotracheal tube obstruction- from sputum, kinking, biting
- Auto-PEEP
- Barotrauma - lung injury from alveolar over distention, alveolar hypoperfusion, and repetitive shear stress across alveolar walls, which leads to an inflammatory response. ~~Initially thought to be due to barotrauma, but now thought to be from volutrauma (excess volume of air delivered to lungs that cannot accept that much volume)~~
- Pneumothorax
- Ventilator associated pneumonia
- Ventilator malfunction
    - NOTE: If at any time acute respiratory deterioration occurs and obvious cause not immediately determined (tube disconnected, tube kinked, etc), disconnect the patient from the ventilator and initiate manual ventilation with ~~a self-inflating resuscitation bag hooked up to~~ 100% oxygen. Then perform a rapid physical exam and assess the ventilator circuit and settings. Consider assessing the patency of the airway by passing a suction catheter through the airway.

SCOPE: PARAMEDIC / CRITICAL CARE PARAMEDIC / RN PROVIDER

NOTE: If the patient is being mechanically ventilated prior to transfer, use pre-transport ventilator settings initially and then adjust as needed to optimally ventilate and oxygenate the patient.

General Initial Ventilator Settings

- Modes: SIMV[i]**;** Assist Control (AC); or Adaptive Support Ventilation (ASV)
- Tidal Volume (Vt): 6 - 8 ml/kg (if no lung injury) of ideal body weight.
- Rate[ii]: 10 - 12 breaths/min to attain desired minute ventilation, modify to keep $ETCO_2$ 35-45 mm Hg[iii]
- Minute Ventilation (VE): 6-8 L/min
- FiO_2: 1.0 and titrate down to keep Pulse Ox > 90%. Goal $FiO_2 \leq 0.6$
- PEEP[iv]: 0-5 cm H_20 titrate to keep Pulse Ox > 90%
- Peak Flow: 60 L/min
- Peak Pressure goal < 35 cm H_20

COPD Ventilator Settings

- Modes: SIMV; Assist Control (AC); or Adaptive Support Ventilation (ASV)
- Tidal Volume (Vt): 8 ml/kg (if no lung injury) of ideal body weight.
- Rate: 8-12/min to attain desired minute ventilation, modify to keep $ETCO_2 \geq$ 35-45 mm Hg
- Minute Ventilation (VE): 8-10 L/min
- FiO_2: 1.0 and titrate down to keep Pulse Ox > 90%. Goal $FiO_2 \leq 0.6$
- PEEP: 0 cm H_20 titrate to keep Pulse Ox > 90% and $FiO_2 \leq 0.6$. PEEP rarely indicated in COPD. Monitor for intrinsic PEEP (auto PEEP).
- Peak Flow: ≥ 60 L/min
- Plateau Pressure[v] goal < 30 cm H_20

Asthma Ventilator Settings

- Continuous neuromuscular blockade usually indicated
- Modes: SIMV; Assist Control (AC); or Adaptive Support Ventilation (ASV)
- Tidal Volume (Vt): 8-10 ml/kg (no lung injury) of ideal body weight.
- Rate: 10-12 breaths/min adjusted down to first allow adequate expiratory time and Pulse Ox > 90%, and then attain desired minute ventilation
- Anticipate permissive hypercapnia, ETCO2 < 90 mmHg as long as pH > 7.25[vi]
- Minute Ventilation (VE): 8 L/min
- FiO_2: 1.0 and titrate down to keep adequate expiratory time and Pulse Ox > 90%.
- PEEP: 0 cm H_20 titrate to keep Pulse Ox > 90%. Monitor for intrinsic PEEP
- Peak Flow: up to 100-120 L/min to decrease inspiratory time, allowing for more expiratory time
- Plateau Pressure goal < 35 cm H_20
- Peak Pressure < 90-100 cm H_20 (Plateau pressure is most important)

Interstitial Lung Disease[vii] Ventilator Settings

- Modes: SIMV; Assist Control (AC); or Adaptive Support Ventilation (ASV)
- Tidal Volume (Vt): 6-8 ml/kg (if no lung injury) of ideal body weight.
- Rate: 12-16 breaths/min to attain desired minute ventilation, modify to keep $ETCO_2$ 35-45 mm Hg
- Minute Ventilation (VE): 8-10 L/min
- FiO_2: 1.0 and titrate down to keep Pulse Ox > 90%. Goal $FiO_2 \leq 0.6$
- PEEP[viii]: 5 cm H_20 titrate to keep Pulse Ox > 90% and $FiO_2 \leq 0.6$.
- Peak Flow: ≥ 60 L/min
- Plateau Pressure goal < 35 cm H_20

ARDS/Lung Injury Ventilator Settings

- Modes: Assist Control (AC) or Inverse Ratio Ventilation (IRV)[ix]
- Tidal Volume (Vt): 6-8 ml/kg of ideal body weight.
- Rate: 20-25 breaths/min to attain desired minute ventilation, modify to keep $ETCO_2 \geq$ 35-45 mm Hg
- Minute Ventilation (VE): > 10 L/min
- FiO_2: 1.0 and titrate down to keep Pulse Ox > 90%. Goal $FiO_2 \leq 0.6$
- PEEP: Minimum 7.5; max 15 cm H_2O to keep Pulse Ox > 90% and $FiO_2 \leq 0.6$. Adjust PEEP to minimum mean airway pressure for
- Pulse Ox > 90%
- Peak Flow: 60 L/min
- Peak Pressure < 45 cm H_20
- Plateau Pressure goal ≤ 30 cm H_20

NON-INVASIVE MECHANICAL VENTILATION (Bi-PAP)

- **Objective:** To establish guidelines for the selection of patients appropriate to receive non-invasive positive pressure ventilation (NPPV) and define procedures for the administration of NPPV with current issued ventilators. **Note:** Fine tune adjustments of ventilator settings may be required based upon which brand of ventilator used and/or comfort level of patient.
- **Indications:** Adult patients with respiratory compromise of sufficient severity who warrant ventilatory support but in whom it is desirable to avoid intubation.
- **Contraindications:** Apnea, recent surgery or trauma to the face, upper airway or upper GI tract, Fixed upper airway obstruction, absent or insufficient ability to protect airway, life threatening hypoxemia, hemodynamic instability, impaired consciousness, confusion / agitation, vomiting, bowel obstruction, copious respiratory secretions, high risk for aspiration.
- **Equipment Needed**: Current issued ventilator, patient appropriate ventilator tubing, patient and device appropriate mask with system for securing it to the patients face.

Procedure:

I. Prepare ventilator and tubing as usual.
II. Tape holes in mask (if applicable) to minimize air leaks.
III. Put ventilator into non-invasive mode
IV. Settings for NPPV
   A. Inspiratory Pressure is represented as the pressure control value. Start at 10 cmH_2O and titrate upward to correct ventilation problems (ie. High PCO_2). To avoid gastric insufflation, the inspiratory pressure should not exceed 20 cmH_2O. **Note: Some ventilators do not compensate for PEEP. If for example you need an inspiratory pressure of 20, you need to set an inspiratory pressure of 20.**
   B. Expiratory pressure is represented as PEEP. Start at 5 cmH_2O and titrate upward to correct problems with hypoxemia. Expiratory pressure should not exceed 10 cmH_2O.
   C. Maintain a 5 – 8 point difference between inspiratory and expiratory pressures.
   D. Set inspiratory time to 0.8 – 1.0 second.
   E. Set breath rate to 0[x].
   F. Adjust FIO2 to maintain SPO2 ≥ 92%.
V. All patients receiving NPPV should have an AMBU bag and mask of appropriate size accompany them throughout the transfer process.
VI. Monitor SPO2 continuously.

Footnotes

[i] SIMV- Synchronized Intermittent Mandatory Ventilation

[ii] Ventilatory rate and tidal volume make up minute ventilation (VE).

[iii] Unless increased ICP with signs of brain herniation- then mild hyperventilation with goal $ETCO_2$ 30-35 mmHg

[iv] PEEP (Positive End Expiratory Pressure) increases intrathoracic pressure which decreases venous return. If patient develops hypotension not easily responsive to fluid therapy, reduce or turn off PEEP. PEEP with high airway pressures increases the risk of pneumothorax. If possible, reduce PEEP to keep peak airway pressures < 35 cm H_20, as long as maintaining Pulse Ox ≥ 88-92%.

[v] Plateau Pressure is measured by giving an inspiratory pause at the end of inspiratory phase and measuring the pressure then. This most accurately reflects the pressure in the alveoli.

[vi] If pH unknown, $ETCO_2 \leq 50$ mmHg will be well tolerated.

[vii] Pulmonary Fibrosis, Asbestosis, Sarcoidosis, Lung disease from Rheumatoid Arthritis

[viii] Monitor for intrinsic PEEP (auto PEEP).

[ix] Inspiratory time > expiratory time

[x] In the event of apnea, the ventilator with alarm and initiate a back-up ventilatory rate of 12 breaths/min. Particularly at lower pressure settings, this will probably not generate a sufficient tidal volume to support the patient. Remember apnea is a contraindication of NPPV. If this occurs, the patient will need to be intubated and ventilated.