

SAGES BASICS OF MECHANICAL VENTILATION FOR NON-CRITICAL CARE MDS

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Background:

Although the data is still very early and treatment of COVID-19 respiratory failure is still evolving, the current information suggests that the majority of critically ill COVID-19 patients are suffering only from severe hypoxia and only require management of hypoxemia using Positive End Expiration Pressure (PEEP), FiO₂, and possibly prone positioning. Other underlying chronic illnesses must be treated accordingly, but again the effect of COVID-19 appears to be mostly hypoxemia. Fluid resuscitation should be minimized to maintain euvolemia and avoid hypervolemia. This primer can help provide some just in time learning for non-critical care physicians who may be called to help manage ventilators.

Working with patients with confirmed or suspected COVID-19:

When the patients are coughing or on supplemental oxygen the respiratory droplets can spread. Personal Protective Equipment (PPE) is essential for provider protection, following current CDC guidelines ([link](#)). Gowns and gloves for contact isolation and face protection will work when intubation is necessary. Care must be taken when intubating to protect the providers and the patients from harm. If the diagnosis is in question, or there is no testing available, a CT of the chest may help with the diagnosis. With COVID-19, the hypoxemia is profound, and the lung lesions are peripheral and ground glass in appearance.

Indications for mechanical ventilation:

Use of mechanical ventilation is indicated for when patients cannot maintain a patent airway (after trauma, severe altered mental status, intoxicants), have

acute respiratory failure (resulting from sepsis or conditions like pancreatitis), have compromised lung function (from conditions like pneumonia or cystic fibrosis), and have difficulty breathing (weakness from frailty, pain from fracture ribs).

Settings for mechanical ventilation:

In general, the clinician can determine the following parameters for mechanical ventilation:

1. Respiratory rate: normal 10-16
2. Tidal Volume: amount of volume with each mechanical breath (mL per breath)
3. Oxygen concentration: 20-100%
4. Positive End Expiration Pressure (PEEP): amount of pressure at the end of the expiration that helps keep alveoli open for O₂/CO₂ exchange (typically 5-20mmHg) Most patients should have at least a PEEP of 5 to start. Obese or larger patients may need more PEEP.
5. Pressure Support ventilation: a mode of ventilation that adjusts the amount of pressure used to keep the large airways open (typically 5-15mmHg), which helps to decrease the work of breathing
6. Continuous mechanical ventilation (CMV): a full breath is given each time the patient initiates a breath

Definitions

1. **Assist Control:** For every breath initiated by the patient, a total machine volume/pressure will be delivered to the patient. If the patient does not trigger a breath on their own, the ventilator will deliver a breath at a preset rate
 1. Volume controlled: a mechanical breath is delivered at a preset volume
 2. Pressure controlled: a mechanical breath is delivered until a preset pressure is reached
2. **Pressure Support Ventilation:** here the patient may not need full ventilator assistance but is not yet strong enough to maintain adequate oxygenation and ventilation for themselves or they are still unable to maintain their airway.

Improving oxygenation:

Positive End Expiration Pressure (PEEP) can be raised to improve oxygen exchange, typically 5-20 mm Hg. PEEP is used to increase functional capacity, or the volume of gas retained in the lungs at the end of exhalation.

FiO₂: increases the amount of oxygen delivered with each mechanical breath. The goal of oxygen therapy is to maintain a saturation of 93-96% in patients without underlying chronic pulmonary disease, and at 88-92% in patients with chronic respiratory failure and/or severe COPD.

Inspiratory to Expiratory ratio: (I: E) normally this ratio is 1:3 meaning it takes longer to expire than it does to inspire. By decreasing the ratio to 1:2 or 1:1, this allows more time to inspire in oxygen, but it will cause the CO₂ to rise. This technique can also cause *breath stacking* and lead to a pneumothorax.

Permissive hypercapnia comes from allowing lower minute ventilation (which is the respiratory rate x tidal volume) in patients with significant decreased lung compliance, as in ARDS. The higher respiratory rate or tidal volume can injure the alveoli, which would compromise oxygenation. As long as the pH can be maintained above 7.2, the increased CO₂ is allowed in order to preserve lung function and maintain oxygenation. When using this technique in patients with COPD, the patient may also experience breath stacking with *auto PEEP*, meaning their end-expiratory pressure will be high or their peak pressures may be high indicating a risk for more barotrauma. If this occurs, discuss the case with the respiratory therapist who can help reduce the pressure in the lungs.

Improving ventilation:

Respiratory Rate: the rate is used to control the CO₂ content in the serum. For patients with hypercapnia (PaCO₂ > 40), an increase in rate, >20 breaths per minute, can improve this to help treat acidemia.

Tidal Volume: the volume of an inspired breath from ventilator can improve the PaCO₂ such that the larger the volume, the lower the PaCO₂. Normally the volume is set by either:

1. **Volume control:** the ventilator gives a set amount of volume. The recommended tidal volume is 4-8 mL/kg, so a 70kg patient (ideal body weight) would have volumes of 280 – 560 mL per breath. Respiratory rates should be set at higher than normal, 18-25 breaths per minute. Peak

pressures should be maintained at less than 30cm H₂O, and plateau pressures at less than 15 cm H₂O. This means that the patients should be ventilated at faster rates and lower tidal volumes to prevent barotrauma.

2. **Pressure control:** the ventilator gives volume up until a certain pressure. The pressure should be set to give a volume of 4-8cc/kg. In general, pressures above 30cmH₂O result in barotrauma that damages the alveoli, which consequently worsens CO₂ and O₂ exchange. This will typically occur in patients with decreased lung compliance as with ARDS. Using the pressure-controlled technique allows the clinician to deliver an appropriate volume without increasing the pressure.

Other considerations:

Providers should work closely with respiratory therapists to make sure each patient is getting the support they need from the ventilator and that the ventilator is not causing any morbidity.

Proper placement of an endotracheal tube is confirmed by end-tidal CO₂ which should be about 35-45 mmHg and a CXR with the tip of the endotracheal tube approximately 2cm above the carina.

Patients on mechanical ventilation will likely require sedation and perhaps paralysis to improve oxygenation and ventilation.

There are several parameters used for extubation including the Rapid-Shallow Breathing Index and the PaO₂/FiO₂ ratio. In general, a PaO₂/FiO₂ ratio of 300 or greater, and a RSBI of < 80 indicate that the patient is ready to wean from mechanical ventilation. Patients should not be considered for extubation if they require an FiO₂ of more than 40% or a PEEP > 5 to maintain oxygenation.

Links:

[REBELEM: Simplifying Mechanical Ventilation – Part I: Types of Breaths](#)

[AAST: Mechanical Ventilation in the Intensive Care Unit](#)

[Annals of Thoracic Medicine: Rapid shallow breathing index](#)

VIDEO: Behind the Knife Podcast: Ventilators – Simplified By Dr. Patrick Georgoff

NIH NHLBI ARDS Clinical Network: Mechanical Ventilation Protocol Summary

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