Mechanical Ventilation for COVID-19

Setting the Ventilator

Introduction

There are three settings common to every conventional mode of ventilation:

1. FiO_2 - the amount of oxygen delivered to the patient
2. PEEP - pressure maintained in the respiratory system at the end of exhalation
    a. Maintaining PEEP keeps an open lung and prevents atelectasis
3. Trigger sensitivity - criteria used to see if the patient is making an effort (flow-triggered and pressure-triggered)

The three most common modes of ventilation include volume assist control, pressure assist control, and pressure support. Assist control modes (pressure or volume) are typically used in the acute phase of mechanical ventilation, or when the patient has no or very minimal drive to breath. Pressure support is used when patients have an intact respiratory drive.

Common Ventilator Modes

	Volume	Flow	Pressure	Cycle
Volume Assist Control	Controlled	Controlled	Determined by respiratory system	Volume or Time
Pressure Assist Control	Determined by Respiratory System	Variable	Controlled	Time
Pressure Support	Determined by respiratory system and patient demand	Variable	Controlled	% of Peak

Volume Assist Control (AC-VC) requires a frequency of respirations per minute. Patients can trigger additional breaths greater than the devised respirations per minute. If the trigger criteria is not being met, the machine will trigger all of the breaths. When patients are starting to interact with the ventilator, a spontaneous mode such as pressure support should be considered.

The tidal volume should be 6-8 mL/kg of ideal body weight. **The weight should be predicted weight, NOT actual weight,** as actual weight will overestimate the tidal volume.

To calculate predicted weight we relied on the work of emDocs, and the group recommends using the equation 50 + 2.3 x (height [in] - 60) for men and 45 + 2.3 x (height [in] - 60) for women.

Current practice based on several trials suggests that the patient should be ventilated with "lower" tidal volumes of 6–8 mL/kg. Flow is the speed at which the tidal volume is delivered (50-60L/min will minimize discomfort when patients start making an effort). PEEP should always be set at a minimum of 5 cm H_2O, to reduce atelectasis.

The inspiratory flow is commonly set between 50 and 60 L/min and a minimum I:E ratio of 1:1.5 to 1:2 (affected by respiratory rate as well). Common inspiratory times are 0.75–1 s. In certain circumstances, such as in airway obstruction with asthma, allowing more time for exhalation is beneficial. In these cases, one can increase the inspiratory flow or decrease the I:E ratio, to 1:3 or 1:4.

The inspiratory pause helps distinguish between resistive pressure and elastic pressure (compliance of the respiratory system). The inspiratory pause allows the ventilator to

display the plateau pressure, which is helpful for monitoring the patient's respiratory system mechanics (resistance and compliance). It also prolongs the inspiratory time to the common time of 0.75-1 s.

Pressure Assist Control (AC-PC) similarly requires a frequency of respirations per minute. The inspiratory time is the length of time the pressure is maintained while the rise time is the time the ventilator will take to reach the set pressure. The default setting for rise time is generally acceptable at 0.1 sec. As resistance or elastance of the respiratory system changes, a result will be changes in tidal volume and minute ventilation. **Consequently, it is very important to monitor the tidal volume and keep it in the proper range in AC-PC.** The I:E ratio is the simplest parameter to monitor if there is enough time to exhale. It must be maintained at 1:2 or higher to ensure there is enough time to exhale. If the patient starts spontaneously breathing, this will affect I:E and it is worth considering transition to spontaneous breathing. Similar to volume assist control, the inspiratory flow is commonly set at 60L/min and tidal volume should be 6-8 mL/kg.

Pressure Support (PS) is distinguished from AC-PC because breaths are cycled off by a % of peak flow, as opposed to time. It is important to adjust the default settings for the % of peak flow to initiate the cycling off of each breath, as it depends highly on the resistance and elastance of the lungs.

Levels to monitor:

- Volume Assist Control
    - Elevated peak pressure and/or plateau pressure will result from abnormal resistance and elastance due to ARDS, COPD, asthma, intra-abdominal hypertension, etc.
- Pressure Assist Control
    - Significant changes to tidal volume and minute ventilation will result from abnormal resistance and elastance due to ARDS, COPD, asthma, intra-abdominal hypertension, etc.

PEEP can be increased to improve oxygenation. However, it should not be so much to overdistend the lungs. The risk of potential injury increases when plateau pressure is greater than 27 cm H_2O.

pH should be kept between 7.35 and 7.45. To increase pH, increase minute ventilation. To decrease pH, decrease minute ventilation. However, minute ventilation should not be increased to the point that $PaCO_2$ < 30 mmHg. Cerebral perfusion may be impacted with levels that low. In management of ARDS, permissive hypercapnia is often considered to minimze injury to the lung and a pH 7.25 is considered the lower acceptable limit.