

Ventilator Basics – all you need to know in just 2 pages! ;)

Vents can get fairly complicated but all interns and residents rotating through the ICU should be able to understand the basic principles, settings, and modes used in our medical intensive care unit. This is our very basic overview, GL!

Principles:

- **C=V/P** (Compliance=Volume/Pressure) (I remember this bc “CVP”)
 - Very simple formula, but the main principle behind the ventilator
 - Compliance = the ventilator system itself, the airways, the lungs (the patient)
 - Initially, consider compliance to be fixed. However, appreciate that we diurese, optimize sedation and vent settings to improve comfort, and even paralyze a patient in part to improve compliance. These aspects are beyond the scope of this basic discussion.
 - Volume = this could be your DEpendent or INdependent variable, depending on your **mode**
 - Pressure = same as volume (it’s either your dependent or independent variable), because you will always set **either** volume **or** pressure, **not both** (for this basic overview)
- The ventilator does just 2 things: **1 it oxygenates, 2 it ventilates**
 - Oxygenation: depends on MAP (mean airway pressure) and FiO₂
 - MAP can be adjusted by:
 - PEEP (and inspiratory pressure if in pressure control mode)
 - Adjusting the inspiratory time, which changes the proportion of time the vent system is at the higher, inspiratory pressure.
 - Ventilation: depends on tidal volume (Vt) and respiratory rate (RR)
 - Note that, **depending on your mode**, you may set the volume or the volume may depend on pressure → If your volume depends on pressure then the PEEP affects your ventilation as well (will explain below in “mode” section)
 - **Also consider:** Physiologic dead space may effectively decrease tidal volume. While generally accurate, the Vt is only what the machine reports.
- **pH ~ bicarb/CO₂** AKA pH is **proportionate** to the bicarb (measured on the BMP, NOT the ABG!) divided by the CO₂ (measured on the ABG performed at a similar time to the BMP)
 - This principle is to help you adjust your ventilator settings to adjust your pH (**basically, ventilation**)
 - The CO₂ is dependent on the minute ventilation (volume of each breath x RR)
 - Adjust volume or RR (within reasonable limit) to increase or decrease CO₂
 - **Be aware** that increasing RR will decrease the expiratory time, diminishing effective ventilation. This is much more of a concern for patients with COPD.

Modes:

- **Assist Control, Volume Control (AC/VC):** This is the mode we use most commonly here. Assist control means that you get the breaths set for you PLUS you get assisted (with the full settings) on breaths that you initiate yourself. Volume control means that in this mode, your volume is your INdependent variable, therefore making pressure your DEpendent variable. The inspiratory pressure is determined by the compliance of the system to accept that volume (going back to C=V/P!)
 - Settings: **Volume/RR/PEEP/FiO₂** (this is how you’ll report the settings on daily rounds)
 - Volume: At the most basic level we set the Vt at 6-8cc/kg for ideal height, **however** you should set Vt based on clinical scenario. For patients with sepsis we lean towards ARDSnet settings but a patient with DKA will need higher minute ventilation and greater Vt.
 - RR:
 - If the patient was intubated primarily for hypoxemic respiratory failure, then consider setting the rate just below the patient’s actual RR once they’re intubated. Ideally **watch the patient after intubation**, and adjust the RR until they are initiating a few breaths themselves (RT can help you determine this).
 - If the patient had an acidosis, increase their rate to achieve an appropriate minute ventilation that allows them to blow off adequate CO₂.
 - If they’re alkalemic, they should have a depressed respiratory drive, so they may just breathe with the machine until their pH normalizes.
 - PEEP: Set based on ARDSnet. We generally start at a PEEP of 5 and adjust.
 - There’s a high PEEP/low FiO₂ strategy and vice versa. **Print out the ARDSnet protocol and keep it in your white coat pocket to help you out!** (attached)
 - FiO₂: Also use ARDSnet as above. We generally start at 100% but you may start lower if the patient is not intubated for hypoxemia (for example, in DKA or AMS).

- One good tip, **PaO₂ should be about 5x the set FiO₂ if the patient has NO lung problems**. Therefore, if your FiO₂ is 20% (room air) your PaO₂ should be 100. If your FiO₂ is 100%, your PaO₂ should be 500. Thus, if your patient is set on an FiO₂ of 100% and their PaO₂ is 100 - this is not good!!!

>AC/VC continued...

- Things to check: MV, actual RR, peak and plateau pressures
 - MV: You'll need to report your patients' average minute ventilation over the night each AM on rounds
 - It's important to know if your patient's pH has changed despite their MV being unchanged → step 1, check the BMP to see if the changing pH is due to a metabolic cause; step 2, if this is not the case, look out for new dead space that may have been created by a PE or other lung pathology, **be thoughtful!**
 - RR: Always check your patient's ACTUAL RR, not just the SET RR!!!
 - Peak pressure: In VC mode, peak pressure is always shown on the main screen of the vent (our goal is usually to **keep this under 30-35**)
 - Plateau pressure: To check this, you'll need to perform an **inspiratory hold**
 - During inspiratory hold, all valves remain closed after the full breath has been given, pressure measured at this time represents the pressure across the alveoli
 - A difference in peak and plateau pressure indicates something is wrong with the system itself, tube, or large airways of the patient
 - When both the peak and plateau pressures are elevated, this indicates a more "parenchymal" process is going on (**remember C=V/P**, high pressure means low compliance) or sometimes it just happens when the patient is obese
- **Assist Control, Pressure Control (PC)**: In this mode, you set the pressure (INdependent variable) making volume your DEpendent variable. The "**delta**" **pressure** (difference in IPAP-EPAP determines your volume) – and of course as always, compliance matters! C=V/P!!! This mode is more complicated at first, you probably need to ask for help from your resident/fellow/attending before setting this on your own.
 - Settings: **IPAP/EPAP/RR/FiO₂**
 - IPAP: Inspiratory positive airway pressure. Set this to maintain the same goal volume as above, 6-8cc/kg. You'll have to adjust the settings for a bit and **watch the patient's response**.
 - EPAP: Expiratory positive airway pressure – this is PEEP! Set according to ARDSnet again.
 - Remember, IPAP/EPAP (ie 20/8) is how you'll present these settings on rounds
 - **BUT you MUST present the corresponding volumes** your patient is getting with these pressures as well as the minute ventilations as mentioned above!
 - RR: Same as above.
 - FiO₂: Same as above.
 - Things to check: MV, actual RR, NOT pressures (they're set) > Because pressure is your DEpendent variable now, **your peak pressure and plateau pressure will be equal, and they will equal your IPAP + your EPAP** (ie a patient set on 20/8 will have peak pressures of 28).
 - MV: Same as above.
 - RR: Same as above.
- **Pressure Support (PSV)**: Our usual weaning mode. Unlike the 2 assist control modes mentioned above, pressure support depends on the patient initiating breaths. PSV provides a small amount of pressure during inspiration to help the patient draw in a spontaneous breath. Pressure support makes it easier for the patient to overcome the resistance of the ET tube and is often used during weaning because it reduces the work of breathing.
 - Settings: They'll look the same as pressure control (**IPAP/PEEP/RR/FiO₂**)
 - IPAP will be the actual pressure support here (usually ~10 and wean down to 5)
 - PEEP in this mode is almost always 5 (if you're looking to extubate your patient, they should not be requiring more than a minimal PEEP of 5 anyway!)
 - RR is just a back up rate in this setting so is usually set ~8-10
 - FiO₂ should be minimal or you shouldn't be trying to extubate your patient!
 - The RTs are usually in charge of weaning and will use PSV during their daily SBTs so long as the patient has passed their AM SAT and has met requirements for an SBT, for more on this topic please see the separate SAT/SBT notes.

By no means is this a comprehensive discussion of pulmonary physiology and ventilator modes/settings BUT we hope that now you feel a little less afraid to present your vent settings each morning and we encourage you to learn from every vented patient you have and to suggest setting changes when you feel they are indicated. Good luck and have fun! ☺