**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 the 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 measure of the lung’s ability to expand, essentially
    - 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, thus, appreciate that your pt’s compliance may worsen or improve during their clinical course.
  + 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 (Vte) and respiratory rate (RR)
    - Note that, **depending on your mode,** you may set the volume or the volume may depend on pressure 🡪 note that in a pressure mode, your volume may change w/ your compliance.
    - **Also consider:** Physiologic dead space may effectively decrease tidal volume. While generally accurate, the Vte is only what the machine reports.
* **pH ~ bicarb/CO2** AKA pH is **proportionate** to the bicarb divided by the CO2
  + 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 can get you into trouble w/ pts w/ obstructive lung disease, particularly in status asthmaticus, where you may have to paradoxically DECREASE the RR to improve ventilation – remember, you can only get CO2 out by exhaling – and you’ve gotta give your pts the time to exhale!

**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 based on the ARDSnet protocol, **however** you should set Vt based on clinical scenario. Ie, for patients with severe acidemia, a higher MV may be needed requiring increase in RR and occasionally tidal volume (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 is acidemic, you may need to increase the RR to achieve an appropriate minute ventilation that allows them to blow off adequate CO2 (but be wary of the e-time in pts w/ obstructive lung disease, as mentioned above).
      * 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!**
    - 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).
* **>AC/VC continued…**
  + - * 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!!!
  + 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: This will generally appear at the top left of the screen (on PB 840 vents)
    - 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
      * Our goal is usually to **keep this pressure under 30-35**
      * 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” or pleural process, or a a chest wall or abdominal issue is going on (**remember C=V/P**, high pressure means low compliance)
* **Assist Control, Pressure Control (PC):** In this mode, you set the pressure (INdependent variable) making volume your DEpendent variable. The **“delta” pressure** (called “pressure control”/PC 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 RT/resident/fellow/attending before setting this on your own.
  + Settings: **PC/PEEP/RR/FiO2**
    - PC: Pressure control, AKA the “delta pressure” (pressure above the PEEP that the pt will receive during inspiration). 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** before you leave the bedside**.**
    - PEEP: Positive end expiratory pressure, same as in VC! Set according to ARDSnet again.
      * Remember, PC/PEEP (ie 20/8) is how you’ll present these settings on rounds
      * BUT **you MUST know the corresponding volumes** your patient is getting with these pressures as well as the minute ventilation as mentioned above!
    - RR: Same as above. But in PC, the RT will set an i-time (inspiratory time) which mandates how long the pt receives the PC. PC is a time-cycled mode, meaning once that i-time is up, the breath is over, and the exhalation valve opens. Whatever Vt the pt gets w/ that PC during that i-time, is the Vte.
    - FiO2: Same as above.
  + Things to check: Vte, MV, actual RR, NOT pressures (they’re set). Because pressure is your DEpendent variable now, **your peak pressure should approximately equal your PC + your PEEP** (ie a pt set on 20/8 will have peak pressures of 28), so long as there isn’t significant auto-PEEP (a discussion for another day).
    - 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. Thus, all PSV breaths are spontaneous w/ pressure to support the breath, but not “control it”, ie no mandated Vt or i-time. It is generally thought that PS provides a small amount of pressure during inspiration to help the patient overcome the resistance of the ET tube and is often used during weaning because it reduces the work of breathing. This may vary depending on ET tube size and machine.
  + Settings: **PS/PEEP/FiO2, no RR bc this is a spontaneous mode**
    - PS similar to PC, is the delta pressure (the amount of additional pressure above the PEEP that your patient will get with each spontaneous breath)
    - PEEP in this mode is almost always 5-8 (if you’re looking to extubate your patient, they should not be requiring more than a minimal PEEP of 5 anyway, except for some cardiac or obese pts)
    - FiO2 should be minimal or you shouldn’t be trying to extubate your patient, generally
  + The RTs are usually in charge of weaning and will use PSV during their daily SBTs (spontaneous breathing trials) so long as the patient has passed their AM SAT (spontaneous awakening trial) and has met requirements for an SBT, for more on this topic please see your ICU’s SAT/SBT protocol.

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! ☺