Episode 23: Basic Ventilator Review with Dr. Scott Stephens

On this episode: Dr. Jed Wolpaw and Dr. Scott Stephens

In this episode I welcome Dr. Scott Stephens, Pulmonary Critical Care Physician at Johns Hopkins to the show. Dr. Stephens and I discuss basic ventilator settings, how to appropriately ventilate patients with hypoxemic vs. hypercarbic respiratory failure and how to think about weaning patients off of the ventilator.

Table of Contents

Hyperlinks to section of notes.

Historical mechanical ventilation

- Basic positive pressure ventilation began in the OR
- Non-operative ventilation began in ICU setting at Johns Hopkins Bayview
- Primitive – no ability to synchronize. Set rate, tidal volume and quite uncomfortable for the conscious

Modern mechanical ventilation

- **Volume / Pressure Control** (VC/PC)
    - Patient may trigger but machine gives set volume or pressure
- **Intermittent-Mandatory Ventilation** (IMV)
    - Patient can breathe through mandatory breaths thanks to valves
- **Synchronized IMV** (SIMV)
    - Looks for patient effort within set window.
    - If trigger detected, give full breath. Trigger of breath = ↓ pressure or ↑ flow
    - If none detected, give breath anyway
    - Institution dependent. Most commonly seen in Surgical ICU
- **Assist Control** (AC):
    - Volume Control
        - Most commonly in Medical/Cardiac ICU
        - If not spontaneously breathing, this is identical to SIMV
        - AC assists all breaths vs SIMV assists only programmed breaths
        - Thought that this mode is more restful for patients
        - Concern for rapid breathers on AC to stack volume
    - Pressure Control
        - Set inspiratory pressure
        - More complex because also considers resistance and time component
        - If proximal airway resistance is high, eg mucus plug or bronchospasm, will hit pressure threshold earlier
        - Common populations: postop lung transplant, ECMO, interstitial lung disease, pediatric ICU
- **Pressure Support Ventilation** (PSV)
    - Most common
    - Set inspiratory pressure, PEEP, FiO2
    - Advantage of comfort for patient to dictate own breathing pattern
    - “5/5”
        - 5 cmH2o inspiratory pressure, PEEP 5 cmH2O
        - total inspiratory pressure = 10 cmH2O
- **Synchronized IMV** (SIMV)
    - Pressure support above set RR
- Primary settings
    - Tidal Volume
    - Respiratory Rate
    - FiO2
    - PEEP

How to decide on ventilator settings?

- Depends on indication for intubation
- Rule of thumb:

    - Volume control, TV set to 400 or 500 based on body size
    - RR 10-16, PEEP 5, FiO2 60
- How do I know this is correct?
    - FiO2 → follow pulse ox > 92%
    - Adequacy of ventilation based on ABG 20-30 min after intubation
- ETCO2 not common in ICU given lots of V/q mismatch that it becomes unreliable
    - In OR, expect PCO2 5-7mmHg above ETCO2
- VBG for adequacy of ventilation (not for oxygenation or pH) ~5-7mmHg higher than ABG
- If PCO2 high and acidemic?
    - ↑ minute ventilation by ↑ RR rather than TV to avoid too much lung stretch
- If PCO2 low and alkalemic?
    - ↓ RR or TV
- Modify FiO2 based on O2 sats
    - Experimental mouse on >FiO2 100 lived 3-5 days → target normoxia

Just intubated patient in hypoxemic respiratory failure

- 1) Is this person developing or at risk of developing ARDS?
    - Pay attention to TV, make it on lower end 6ml/kg of predicted body weight (based on height and gender)
- 2) Is FiO2 alone sufficient to correct hypoxemia?
    - Lots of atelectasis or consolidation, use PEEP to re-recruit and decrease pulm shunt
    - PEEP works best if evenly consolidated
- Just intubated, still hypoxic, not on 100% O2. What do you do first? PEEP or FiO2?
    - Depends on bilaterality of infiltrate.
- What PEEP is too high?
    - > 16-18
    - Keep in mind BP because ↓ venous return. Make sure they are PEEP responders, eg not just transmitting pressure to functional area, otherwise may worsen physiologic deadspace
- What if pt has asymmetric atelectasis? Role of recruitment?
    - Best if symmetric
    - Recruitment strategy: increase PEEP to 30-40 cmH2o for 30-40 sec then go back down, then repeat – 30-40% will cause pneumothorax, hypotension, or worsen gas exchange. Limited use
- Severe respiratory failure?
    - Low threshold for neuromuscular blockade
        - 1) easier to synchronize with ventilator
        - 2) homogenize distribution of ventilation → less likely to overinflate areas of lung
        - 3) ↓ oxygen consumption
    - Prone - mortality benefit of both of these

Just intubated patient with hypercarbic respiratory failure

- Maintain adequate minute ventilation without making situation worse
- Easy with no respiratory drive. Harder with asthma/COPD or other obstructive lung diseases because ↑ inspiratory pressure and time for lung to empty → harder to expel CO2
- Make sure enough time to exhale by limiting tidal volume (less gas to inhale) or decreasing respiratory rate (more time between breaths to exhale, eg I:E ratio – 1:2 common)
    - This is an advanced setting, but can also adjust with inspiratory flow rate which gives I:E

- We tolerate hypercarbia well. Trouble is when trying to correct too quickly and not enough time to exhale → dynamic hyperinflation or intrinsic PEEP → pleural pressure builds up to a point that diminishes venous return → cardiac arrest
    - Lazarus effect where autoresuscitation from taking a breath after failed CPR
- Tolerate pH 7.2 range with lots of bronchodilators
- If worried about obstructive lung disease and BP going down, disconnect circuit so that dynamic hyperinflation will get better immediately, then readjust settings
- Resist urge to correct too quickly in chronic CO2 retainers

Ventilation weaning

- Many approaches, none are better. Just stick with a system
- Every day, if on controlled mode, trial spontaneous mode ~5 pressure support/ PEEP. If patient looking great in 30 minutes and can follow command, take tube out
- If SIMV, turn respiratory rate down to 4-5 and wait to see if over breathing. If yes, then put on pressure support, see how this goes
- What's "great" or ready?
    - MICU: how patient looks qualitatively (not hypertensive, looks comfortable, not struggling)
    - SICU: pulmonary function like FVC, RR, TV, min inspiratory pressure, but not any better than qualitative – one study showed that best prediction was what bedside nurse thought
- T-piece trial
    - Disconnect and place T piece over tube
    - Advantage: gives no support, especially good for someone you worry about respiratory strength, or worried about provoking flash pulm edema (and don't want to take risk of taking tube out)