Episode 25: Advanced Ventilator Modes With Dr. Scott Stephens

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

In this episode I am joined once again by Dr. Scott Stephens as we review advanced ventilator modes, prone positioning, and ventilation of patients on VV ECMO.

The fantastic review article I mentioned is: Mireles-Cabodevila E. Et al. Alternative Modes of mechanical ventilation: A review for the hospitalist. Cleveland Clinic Journal of Medicine. 2009(75);7:417-430.

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Pressure Control Volume Guarantee

- Aka. pressure regulated volume control (PRVC), auto flow, adaptive pressure ventilation, volume control plus, volume targeted pressure control
- Used as adaptive pressure control mode to achieve set tidal volume
- **Settings required:** maximum pressure, tidal volume target (not guaranteed), PEEP, FiO_2, respiratory rate
    - Machine adjusts pressure to deliver intended tidal volume
- **Advantage:** avoids high inspiratory airway peak pressures → used when peak pressure alarm keeps on going off
- **Disadvantage:** in patient with very non-complaint lungs, may not achieve tidal volume desired with maximum pressure → possibility of hypoventilating patient

Volume Support

- Machine raise pressure to whatever it needs to ensure patient gets set tidal volume (TV)
- Way to mandate some degree of minute ventilation → give reliable TV on spontaneous mode
- **Uses:**
    - As alternative for patients who can breathe spontaneously, but uncomfortable on pressure support
    - Patients have spontaneous drive to breath, but huge pressure support requirement or dynamic pressure support required
    - Monitor pressure required to achieve TV and eventually switch to pressure support
- **Settings required**: PEEP, FiO_2, TV target → NO RESP RATE, set peak pressure alarm but no limit
    - No respiratory rate setting → if patient doesn't make effort, patient won't get a breath
- **Disadvantage:** patient with high drive to breath (eg. metabolic acidosis), machine won't give much help but patient could tire out

Proportional Assist Ventilation (PAV)

- Match support given by ventilator with patient's respiratory effort → improves synchrony and comfort on ventilator
- **Settings required**: proportional assist number which is % of support of work of breathing, type of tube, size of tube (plays into resistance calculations), tidal volume limit, pressure limit
- **Advantages:** calculates real-time lung compliance and resistance

Adaptive Support Ventilation (ASV)

- Weaning mode
- Machine will display # and size of spontaneous breaths, minute ventilation and other data → if patient meeting extubation requirements, bar display will be white
- Machine calculates respiratory rate and tidal volume
- **Settings required**: minute ventilation, maximum % of how much ventilator contributes to minute ventilation, height, weight, gender, PEEP, FiO_2
- **Advantage:** few studies have shown faster weaning time from ventilator in post-op cardiac patients

- **Disadvantage:** machine might think ↑ RR with ↓ TV is sufficient, but patient may be dyspneic

Neurally Adjusted Ventilatory Assist (NAVA)

- Use NG or OG tube with electrodes to crux of diaphragm to detect diaphragmatic electrical activity when diaphragm contracts
- ↓ lag time between initiation of breath by patient to when machine delivers support
- **Uses:**
  - Patient with chronic neuromuscular weakness
  - Patient with bad COPD who will need long term wean from ventilatory
- **Advantage:** could improve ventilatory synchrony
- **Disadvantage:** needs intact respiratory drive and diaphragm to work, OG/NG tube needs to be positioned correctly → may need frequent repositioning

Airway Pressure Release Ventilation (APRV)

- Aka. bilevel ventilation; combines bilevel pressure support ventilation with inverse ratio ventilation
- Sustained at high pressure, and intermittently drops pressure
- Exhalation occurs at periodic decompressions
- Machine has valves allowing spontaneous breathing throughout cycle
- Inspiratory: Expiratory ratio at ~4:1
- Uses:
  - Most common use in ARDS → ↑ time in high pressure recruits and utilizes lung volume
    - Injurious factors in ARDS: pressure which over distends lung, sheer stress from cycling of high to low pressure, atelectrauma
    - APRV attempts to keep all alveoli open to ↓ sheer stress
- **Settings required**: P_{High} (starting at 25 to 35 cmH_2O) , P_{Low} (normally 0 cmH_2O), T_{High} (starting at 4sec) , T_{Low} (starting at 1sec)
  - If patient becomes hypoxemic → increase airway pressure
  - If patient becomes hypercarbic → increase number of decompressions, not time spent at low pressure
- No data to show it is a proven mode of mechanical ventilation

Patient Example

- Patient with severe ARDS, tried volume control, on high PEEP, 100% FiO_2 → still hypoxemic
- Management:
  - Low tidal volume ventilation
  - Neuromuscular blockade with vecuronium
    - Threshold of PaO_2: FiO_2 ratio < 150 for thinking about neuromuscular blockade = Alveolar-arterial gradient 450 to 500 mmHg
    - Bolus dosing better than infusion if possible
  - Prone positioning → reposition patient frequently to prevent skin breakdown
    - Used if don't get better within 6hrs of neuromuscular blockade
    - Data suggest longer duration of prone positioning associated with better outcomes
    - Prone positioning is helpful in ARDS because:

- Homogenizes distribution of ventilation → no over distention of specific sections
- Improves right ventricular function

▪ Shown to have improved mortality for patients with ARDS

Ventilation To Put Patients on ECMO for Respiratory Support

- Indications:
  - Refractory hypoxemia despite optimum ventilatory management (ie. low tidal volume, titrating PEEP, neuromuscular blockade, prone position)
  - ↑ alveoli pressure (↑ plateau pressures)
  - Refractory hypercarbia with pH < 7.1 and inability to raise tidal volume or respiratory rate for concerns of injuring lungs
- Reasons to not consider ECMO:
  - If patient is not recoverable
  - End stage lung disease (eg. cystic fibrosis, pulmonary fibrosis) and not a transplant candidate
- Ventilation strategy:
  - Pressure control or volume control with tidal volume < 4cc/kg to have cyclic ventilation
  - Inspiratory pressure 10 cmH_2O
  - PEEP 10 to 15 cmH_2O to maintain some degree of recruitment
  - Respiratory rate 4 to 10 breaths per minute
  - Drop FiO_2 to as low as possible, but do it slowly to avoid absorptive atelectasis

References

Mireles-Cabodevila E. Et al. Alternative Modes of mechanical ventilation: A review for the hospitalist. Cleveland Clinic Journal of Medicine. 2009(75);7:417-430.