Ventilator Management

ATS Virtual Bootcamp 2021

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https://wiki.thoracic.org
The assumption today -

• Safe space to learn
• We’re all learning together
• Your answer may be wrong, but I guarantee you weren’t the only one thinking what you said.
• We all learn better if we interact with each other, so if you don’t volunteer to answer our questions, we might call on you.
  • We’re not mean. We’re not picking on you.
  • Most of the people on this call have no idea who you are . . .
• We want you to participate and learn.
• It’s fine to participate without being called on.
Some Basics

Ren Ashton, MD
Inside every vent, is a . . .

Union monkey,
Who will do whatever you tell him to do, but you have to worry about the rest.
The Equation of Motion

\[ P_{\text{vent}} = P_{\text{elastic}} + P_{\text{resistive}} \]

\[ P_{\text{vent}} = \text{Elastance} \times \text{Volume} + \text{Resistance} \times \text{Flow} \]

• You can tell the monkey to manage either side of the equation, but you have to worry about the other side.
  • If monkey does pressure \( \rightarrow \) control variable is pressure ("pressure control mode")
    • Alarms will tell you when volumes or flows are too low
  • If monkey does volume/flow \( \rightarrow \) control variable is volume ("volume control mode")
    • Alarms will tell you when pressures are too high
The respiratory cycle on a ventilator:

- What signals the start of inspiration?
  (Also called “triggering”)
  - Preset time since last breath
  - Patient-generated pressure drop
  - Patient-generated inward air flow

- What signals the end of inspiration?
  (also called “cycling”)
  - Preset time since triggering
  - Preset volume target reached
  - Preset flow target reached
Breath Types

• Mandatory breaths
  • Breaths are either triggered, cycled or both by machine

• Spontaneous breaths
  • Breaths are both triggered and cycled by patient

• CMV = continuous mandatory breaths
• IMV = intermittent mandatory breaths
• CSV = continuous spontaneous breaths

To look forward to:
Targeting schemes – what makes modes with the same control variable and breath type distinct from each other . . .
Knob-ology

- Find the **input areas**
- Find the **output areas**
- Learn how to highlight a parameter and change the setting
  - Most vents now have touch screens and a system with control knob/accept
- Learn how to display waveforms and which ones are most useful
- Learn how to perform inspiratory and expiratory holds
BREAK OUT SESSION START NOW
CASE 1: ARDS
CASE 1
You receive a blood gas

- pH 7.32
- PaCO2 65 mmHg
- PaO2 50 mmHg

Should we make any changes to the ventilator?
Why does PEEP help improve PaO2?

Atelectasis

Poorly Oxygenated Blood

Oxygenated Blood

O_{2}

Decreased Oxygenation

SHUNT
Another secret about PEEP
Which one should we adjust (PEEP or FiO2)?

<table>
<thead>
<tr>
<th>Lower PEEP/higher FiO2</th>
<th>(\text{FiO}_2)</th>
<th>0.3</th>
<th>0.4</th>
<th>0.4</th>
<th>0.5</th>
<th>0.5</th>
<th>0.6</th>
<th>0.7</th>
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<td>5</td>
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</table>

<table>
<thead>
<tr>
<th>Higher PEEP/lower FiO2</th>
<th>(\text{FiO}_2)</th>
<th>0.3</th>
<th>0.3</th>
<th>0.3</th>
<th>0.3</th>
<th>0.3</th>
<th>0.4</th>
<th>0.4</th>
<th>0.5</th>
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</thead>
<tbody>
<tr>
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<tr>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Higher PEEP/lower FiO2</th>
<th>(\text{FiO}_2)</th>
<th>0.5</th>
<th>0.5-0.8</th>
<th>0.8</th>
<th>0.9</th>
<th>1.0</th>
<th>1.0</th>
</tr>
</thead>
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<td>PEEP</td>
<td>18</td>
<td>20</td>
<td>22</td>
<td>22</td>
<td>22</td>
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</table>
Recap

• Use PEEP and FIO2 to adjust the PaO2
After adjusting the PEEP, what has changed?

Initial Settings

Current Settings
How do we evaluate what is causing the high peak pressures?

\[ P_{\text{vent}} = P_{\text{elastic}} + P_{\text{resistive}} \]

\[ P_{\text{vent}} = (\text{Elastance} \times \text{Volume}) + (\text{Resistance} \times \text{Flow}) \]
Plateau Pressure – No flow; measures lung elastance
Back to the Pressure Volume Curve

Volume

Pressure

Atelectrauma Zone

Safe Zone

Volutrauma Zone
What can we change to lower the plateau pressure?

\[ P_{\text{vent}} = \text{Elastance} \times \text{Volume} + \text{Resistance} \times \text{Flow} \]
<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
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<tbody>
<tr>
<td>$P_{peak}$</td>
<td>32 cmH$_2$O</td>
</tr>
<tr>
<td>$P_{plateau}$</td>
<td>29 cmH$_2$O</td>
</tr>
<tr>
<td>$P_{mean}$</td>
<td>14 cmH$_2$O</td>
</tr>
<tr>
<td>$P_{PEEP}$</td>
<td>10 cmH$_2$O</td>
</tr>
<tr>
<td>RR (B/min)</td>
<td>18 B/min</td>
</tr>
<tr>
<td>$O_2$ (%)</td>
<td>42 %</td>
</tr>
<tr>
<td>$V_{vee}$</td>
<td>0 ml</td>
</tr>
<tr>
<td>$T_i$ (s)</td>
<td>0.91 s</td>
</tr>
<tr>
<td>$I:E$</td>
<td>1:2.3</td>
</tr>
<tr>
<td>$MV_{I}$ (l/min)</td>
<td>7.6 l/min</td>
</tr>
<tr>
<td>$MV_{E}$ (l/min)</td>
<td>7.4 l/min</td>
</tr>
<tr>
<td>VT$_i$ (ml)</td>
<td>394 ml</td>
</tr>
<tr>
<td>VT$_e$ (ml)</td>
<td>385 ml</td>
</tr>
</tbody>
</table>

**Tidal Volume**: 400 ml
With lower Vt, what might happen?
With lower Vt, what might happen?
Recap

• Use PEEP and FIO2 to adjust the PaO$_2$
• Use PEEP and Vt to adjust the plateau pressure
• Use Vt and Rate to adjust the minute ventilation (and pCO$_2$)
The patient’s sedation is liberated...
CASE 2: ASTHMA
Case 2

Pressure

Flow

Volume
What is the problem with the vent waveform?
How do we know what is causing the high peak pressures?

\[ P_{\text{vent}} = P_{\text{elastic}} + P_{\text{resistive}} \]

\[ P_{\text{vent}} = (\text{Elastance} \times \text{Volume}) + (\text{Resistance} \times \text{Flow}) \]
Is there air trapping or simply high resistance?
What is AutoPEEP?
For more on Auto-PEEP...

Best of ATS Video Lecture Series Video
How might we correct AutoPEEP?
Uh Oh... what’s wrong now!
LARGE GROUP
Key Points

• Remember the equation of motion
• Tidal volume and PEEP affect the plateau pressure
• PEEP and FIO2 affect PaO2
• Rate and tidal volume affect PCO2
• Maximize expiratory time to prevent dynamic hyperinflation.
• Look at the waveforms
• Don’t be afraid of the vent. It won’t bite you (despite what they say).
We wish you the best in your fellowship

- Rendell Ashton, MD
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