“Mechanical Ventilation”

An Intern’s Guide to Ventilators

Kevin P Simpson, MD
What's Happening

Your Settings

“Silence” Buttons

“Pause” Buttons
Initial Ventilator Settings

- **Mode Options**
  - Assist Control ("AC/VC")
    - RR & TV
  - Pressure Control ("AC/PC")
    - RR, PIP & I-Time
  - MUCH Less Commonly:
    - PS
    - SIMV + PS

- Always set PEEP & FIO2

- **The Usual First Choice**
  - For Refractory Hypoxemia and/or Comfort
  - NOT initial choice since goal is "REST"
Assist Control / Volume Control
(aka Continuous Mandatory Ventilation)

You set:
1. Respiratory Rate and
2. Tidal Volume.

If the patient wants additional breaths, the patient simply starts to breathe which drops the airway pressure which “triggers” the ventilator to deliver the set TV.
AC/VC Summary

- Patient does ONLY the work necessary to “trigger” the vent.
  - Typically quite minimal (2 cm H₂O or 3 L/min flow)
- TV is always the “set” TV.
- Overall, a very good mode for resting the patient.
Assist Control / Pressure Control

You set:

1. RR
2. Peak Inspiratory Pressure (PIP)
3. Inspiratory Time
   - **NOT** a Tidal Volume -

With each inspiration, the ventilator
(a) delivers a Pressure and
(b) maintains that pressure for the duration of the set Inspiratory Time.
AC/PC

- Not a typical initial setting:
  - Beneficial for refractory hypoxemia.
  - MAY increase gas exchange.
  - Limits Peak Pressure
  - Sometimes (unpredictably) more comfortable

- Prolonged Inspiratory Time results in Reduced Expiratory Time
  - Potential for auto-PEEP

- Titrate PIP and Inspiratory Time to target Tidal Volume and Patient Comfort
  - Requires some experience and daily adjustment
Pressure Support Ventilation

You set:
1. ONLY a “PIP” – Peak Inspiratory Pressure
   - **NOT** a RR a or Tidal Volume -

Whenever the patient starts to breathe, the drop in airway pressure “triggers” the ventilator to deliver a Pressure (rather than a Volume).
Pressure Support Ventilation

- TV depends upon the combination of the amount of pressure applied AND patient lung mechanics AND patient effort

- Patient does a VARIABLE amount of work of breathing:
  - If you supply an “adequate*” peak inspiratory pressure, patient work is limited to simply that required to trigger.
  - Overall, CAN achieve rest if administer enough pressure.

- NO back up rate:
  - Not appropriate if fluctuating level of mental status.

- Limits Peak Pressures

* “adequate” generally implies a pressure that results in an “adequate TV” with minimal patient work of breathing
Typical Initial Settings

- Mode: Desire “Rest”
  - Usually Assist Control/Volume Control
Typical Initial Settings

- Mode: AC/VC
- RR: 12
- Tidal Volume:
  - 6 cc/kg if typical med-surg patients
  - (Previously more typically 7-10cc/kg)
  - 4-6 cc/kg if ARDS
  - ? Which weight
Typical Initial Settings

- **Mode:** AC/VC
- **RR:** 12
- **Tidal Volume:** 500 cc
- **PEEP:**
  - Typically start with 5 cm H$_2$O
  - Some advocate starting with Zero PEEP
  - Increase if needed to reach non-toxic F$_1$O$_2$
  - How much PEEP?
Typical Initial Settings

- **Mode:** AC/VC
- **RR:** 12
- **Tidal Volume:** 500 cc
- **PEEP:** 5 cm H$_2$O
- **F$_{1O_{2}}$:**
  - 100% to start but...avoid O$_2$ Toxicity
  - Titrate by pulse oximeter (> 92%)
Typical Initial Settings

- Mode: AC/VC
- RR: 12
- Tidal Volume: 500 cc
- PEEP: 5 cm H$_2$O
- F$_{1O2}$: 100%

Goal is to “REST” the patient
Talk with your nurse!

- Sedation/Pain Control:
  - Not all require sedation
  - PRN titrated to sedation score = 0
    - +4: Combative
    - +3: Very agitated
    - +2: Agitated
    - +1: Restless
    - 0: Alert/calm
    - -1: Drowsy
    - -2: Light sedation
    - -3: Moderate
    - -4: Deep
    - -5: Unarousable
  - Benzo’s may delay extubation

- Anticipate:
  - ? Shock
  - ? Adequate IV Access

- Dobhoff
  - CNU consult for TF’s

- KUB

- CXR
  - immediate and ? daily

- Restraints

- Change meds to suspension or IV

- Titrate FIO2 to maintain SpO₂ > 92%

- ABG
  - ? Ongoing frequency
  - ? Art line

- ? Bronchodilators

- NOTIFY FAMILY

Don’t forget to enter the vent settings!
Daily Assessment
and sounding like a doctor...

Presentation Style:
- Hx:
  - Since yesterday...
  - Overnight...
  - Presently...
- Vitals
  - State if on pressors
- Focused Exam

Ventilator Settings:
- Mode/Rate/Volume...
- PEEP/FIO₂
- (PS)

On these settings...
- Total RR _____
- Peak/Plateau __ /__
- Raw _____
- Compliance _____

ABG:
- pH/pCO₂.../pO₂/Sat
What are Peak and Plateau Pressures?

"Inspiratory Pause" Button
Airways Resistance and Compliance
But you said there would be no math....

**Raw:**
- \[
\frac{P_{pk} - P_{plat}}{\text{Flow Rate}}
\]
  - Flow Rate is in L/sec and is typically ~1 L/s (displays 60 L/min)

**Static Compliance:**
- \[
\frac{TV (cc)}{P_{plat} - PEEP}
\]

- Normal < 10 (cm H2O/L per sec)
- > 10 is elevated
  - Upper airway
  - Lower airway

- Normal > 60 (mL/cm H2O)
- Stiff! < 20
  - Chest Wall
  - Parenchymal Lung
Peak and Plateau Pressures: Pattern Recognition

**Increased $R_{aw}$**
- ↑ $P_{pk}$ with normal $P_{plat}$
  - ETT trouble
  - Pass suction catheter
  - Bronchospasm
- Give Bronchodilators

**Decreased Compliance**
- ↑ $P_{pk}$ AND ↑ $P_{plat}$
  - CWD
  - Effusions/Ascites/PTx
  - Stiff Lungs
- ARDS, IPF
- Check a CXR
Prima non nocere...
Peak and Plateau Pressures

Avoid:
- $P_{\text{plateau}} > 32 \text{ cm H}_2\text{O}$

How?
- Smaller TV
- Lower PEEP
- Reduced Flow Rate?
  - But can result in auto-PEEP
Flow Rates

„Normal” ~ 1 L/sec or 60 L/min

„Abnormal” Flow Rates

- May be uncomfortable and increase WOB
- May induce tachypnea, double-triggering, auto-PEEP, ALARMS!

- May be adjusted directly or indirectly

  By changing the **flow profile**

*also not vent 101*
Choose Your Poison Pressure:
Peak or auto-PEEP
Flow Rates
.....not vent 101

☐ May adjust (верху/вниз) if:
- Elevated $P_{\text{peak}}$
- Patient discomfort
- Unexplained tachypnea
- Auto-PEEP

☐ Increasing Flow Rate:
- Reduces auto-PEEP but increases peak pressures

☐ Decreasing Flow Rate:
- Reduces peak pressures but increases auto-PEEP
If negative pressure generation continues at the conclusion of breath delivery, will result in “double triggering”.
Auto-PEEP

.....not vent 101
Measuring Auto-PEEP

- Apply an “expiratory hold”

- Assess pressure rise
Trouble Shooting

1. Increased Peak Pressures:
   - Look at the patient
     - Distress, biting the ETT?
   - Pass suction catheter through ETT
     - Biting the ETT, crusted ETT?
   - Check Peak/Plateau Pressures
     - Primarily increased Raw ..... Bronchodilators
     - Primarily decreased compliance....check CXR
   - Consider Lower TV, Lower Flow Rate, Sedation
Trouble Shooting

2. ETT Position:
   - What’s correct:
     - Below the larynx
     - At least 2 cm above the carina
   - How do you know?
     - “corner of the mouth”
       - Average 22 cm in women, and 23 cm in men
     - CXR position
       - ? Variation with head position
Trouble Shooting

3. Desaturation
   - 100% FIO2, Suction/Bag Patient

4. Cuff Leak (Exhaled TV < Inhaled TV)
   - Inflate Balloon, Replace ETT

5. Self-Extubation
   - URGENT assessment, “Dr. Respiratory”

6. Shock
   - Pneumothorax, Auto-PEEP

7. Patient Ventilator Dyssynchrony
   - Adjust mode/volume/flow

8. Trach Trouble
   - ENT (Don’t replace yourself if a fresh trach)
“Weaning”

1. Daily Assessment
Daily Assessment:
Carpe Diem

1. Cause is Resolved
2. Not on Pressors
3. Not requiring more than 40% FIO2 and PEEP of 5 cm H20
4. Adequate Neurologic Function
5. No impending doom....
**“Weaning”**

1. **Daily Assessment**

2. **Weaning Parameters**
   - RSBI
     - \(\text{RR/TV}_L < 100\) predicts *success*
   - NIF (or MIP)
     - Less negative than \(-20\) cm H2O predicts *failure*
“Weaning”

1. Daily Assessment
2. Weaning Parameters
   - RSBI
   - NIF
3. T-Piece Trial
   - Pressure Support possibly equivalent
   - SIMV delays extubation
# Weaning Trials

**Table 2. The Length of Time from the Initiation of Weaning to Successful Extubation in the Four Groups.**

<table>
<thead>
<tr>
<th>Weaning Technique</th>
<th>Median</th>
<th>First Quartile</th>
<th>Third Quartile</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intermittent mandatory ventilation</td>
<td>5</td>
<td>3</td>
<td>11</td>
</tr>
<tr>
<td>Pressure-support ventilation</td>
<td>4</td>
<td>2</td>
<td>12</td>
</tr>
<tr>
<td>Intermittent trials of spontaneous breathing</td>
<td>3</td>
<td>2</td>
<td>6</td>
</tr>
<tr>
<td>Once-daily trial of spontaneous breathing</td>
<td>3</td>
<td>1</td>
<td>6</td>
</tr>
</tbody>
</table>

Tobin et al, NEJM 1995;332:345-350
“Weaning”

1. Daily Assessment
2. Weaning Parameters
   - RSBI
   - NIF
3. T-Piece Trial
4. Trial of Extubation