Advanced Concepts

Flow-Triggering

• Trigger = the variable that causes the vent to begin the inspiratory phase

• Common triggers
  • 1-
  • 2-
  • 3-

• Effort required to trigger =

Goal - Minimal effort required by the patient to trigger inspiration, i.e. make the vent as sensitive to patient effort as possible.
Flow-Triggering

- Flow-triggering is available on the Bennett 7200, Hamilton Galileo, Servo 300, Drager, Bear Cub, etc.

How Does It Work?

Ventilator Differences

*Bennett 7200*

Base Flow: variable 0 - 20 lpm
Flow Sensitivity: variable 1 - 1/2 base flow
Ventilator Differences

Servo 300

Base Flow: preset
Flow Sensitivity:  
- adult: 2 lpm
- pedi: 1 lpm
- neo: .5 lpm

Effects of Flow-Triggering

patient insp effort → fresh gas immediately available to patient → ↓ delay time between insp effort & supply of gas ↓

Modes - Pressure

- Began with IPPB treatment
- Fell out of use for CMV
- Returned with new technology
- PCV, PSV, PRVC, PCIRV
Modes - Pressure

- Remember - volume ventilation:
  - operator sets volume
  - vol delivered until preset vol or time
  - press generated prop. to $C_L, R_{AW}$

- When set $V$, $F \rightarrow$ sets $T_I$, press varies
- When set $V$, $T_I \rightarrow$ sets $F$

Important to remember!

If patient flow demand $> set \ flow$

“flow starvation”

↑ WOB

Modes - Pressure

Pressure ventilation

$\downarrow$

operator sets pressure

$\downarrow$

volume varies with $C_L, R_{AW}$
Modes - Pressure

- If patient “fights” vent, splints pain, $C_L \downarrow$ and/or $R_{AW} \uparrow$

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Modes - Pressure

- Time or flow-cycled
- Pressure-limited
- Set press reached quickly & maintained t/o inspiratory time
- Vent delivers whatever flow is necessary to maintain press & meet patient demand

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Modes - Pressure

The most significant difference between volume & pressure-based ventilation is how the flow is delivered!
Advanced Concepts

PCV vs. PSV

<table>
<thead>
<tr>
<th></th>
<th>PCV</th>
<th>PSV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cycled</td>
<td>T</td>
<td>F</td>
</tr>
<tr>
<td>Limited</td>
<td>P</td>
<td>P</td>
</tr>
<tr>
<td>PEEP</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>Set Rate</td>
<td>yes (AC)</td>
<td>no</td>
</tr>
</tbody>
</table>

Clinical Advantages of PCV

- Little published on optimal flow pattern
- Evidence suggests decelerating flow pattern:
  - improves gas distribution in lungs allowing ventilation with same $V_T$ but lower PIP
  - increases patient comfort when flow responsive to demand
PV Reduces V/Q Mismatch

- Difficult to ventilate if $C_L$, $R_{AW}$ differ from one lung region to another
- Some areas over-ventilated, some under-ventilated
- Airways with ↑ $R_{AW}$ take longer to receive $V_T$

PV Reduces V/Q Mismatch

With PV, gas flow is high early in insp → flow reaches small airways early → allows more time for gas to be distributed according to regional $C_L$ & $R_{AW}$

as press gradient ↓ → flow slows → laminar flow when gas enters small airways

better gas distribution (↓ V/Q mismatch)

PV Optimizes $T_1$

- By observing flow pattern, $T_1$ can be optimized
PV Matches Flow with Patient Demand

With volume ventilation, sometimes difficult to match vent flow to patient demand → patient/vent asynchrony

PV Matches Flow with Patient Demand

• Use of PS helps only on spontaneous breaths
• Increasing flow rate > demand causes turbulent flow → PIP ↑, hit press limit, risk of barotrauma

PV Matches Flow with Patient Demand

Use of pressure ventilation with decelerating flows matches flow rate to patient demand
Remember!

- **PCV** - $V_T$ delivered varies with:
  - $C_L$
  - $R_{AW}$
  - Set pressure
  - $T_i$
  - PEEP level

Remember!

- **PSV** - $V_T$ delivered varies with:
  - $C_L$
  - $R_{AW}$
  - Set pressure
  - Patient effort

Primary Indication for PV

- **ARDS** in patients that volume ventilation with PEEP does not seem to be working:
  - $F_{O_2} ≥ 1.0$
  - PIP ≥ 50 cmH₂O
  - PEEP ≥ 15 cmH₂O
  - RR ≥ 16/min
  - decreasing $PaO_2$ and $C_L$
Advanced Concepts

Initial Settings

- PIP 1/2 - 3/4 previous PIP
- I:E - 1:1 to 1:2

PCIRV

- Primary use - ARDS where $C_L \downarrow \downarrow$
- Lungs empty very quickly so can use short $T_E$
- Patients sedated and paralyzed
- 2:1, 3:1, 4:1, etc.

PCIRV

- Results -
  - oxygenation improves
  - gas exchange improves
  - PIP decreases (\downarrow risk of barotrauma & CV side-effects)
  - decreases need for PEEP
  - MAP increases
  - can cause auto-PEEP
Monitoring PCIRV

- $V_T$
- SpO$_2$
- CVP
- RR
- ABG
- PAP
- $V_E$
- HR
- PCWP
- PIP
- UO
- PVR
- MAP
- BP
- $P_{a-ti}CO_2$
- $C_L$
- QT
- $P_{a-ti}CO_2$
- waveforms
- PEEP
- auto-PEEP

PRVC/APV

- Pressure Regulated Volume
  Control/Adaptive Pressure Ventilation
- PC with control over volume
- Assist-control
- Available on Servo 300
  (PRVC)/Hamilton Galileo (APV)

PRVC/APV

- Set RR, $T_i$, target $V_T$
- Breath give at minimal pressure
- Exhaled $V_T$ compared to target $V_T$
- Pressure automatically adjusted to
  achieve target $V_T$ (breath to breath)
- Set Pressure Limit high enough
PRVC/APV

*Advantage* -
Guarantee of $V_T$ with the least amount of pressure to deliver that volume

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VS

- Volume Support (Servo 300)
- Automatic Pressure Support
- Works like PRVC/APV
- Spontaneous breathing mode (no rate set)
- Set target $V_T$, Pressure Limit

---

VS

- *Advantage* - automatic weaning
  - as patient assumes more of the work of breathing → reduce target volume to 5-7 ml/kg
  - apnea - vent switches to PRVC
  - when no apnea, spont $V_T$ 5-7 ml/kg, PS $\leq$ 8 cmH$_2$O → extubate

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Advanced Concepts

Modes - Review

<table>
<thead>
<tr>
<th>Mode</th>
<th>Trigger</th>
<th>Cycled</th>
<th>PEEP</th>
<th>Limited</th>
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</thead>
<tbody>
<tr>
<td>AC</td>
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<td>F</td>
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<tr>
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<td>V, T</td>
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<td>F</td>
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<tr>
<td>SIMV (p)</td>
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<td>yes</td>
<td>P</td>
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<td>PRVC/APT</td>
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<td>P</td>
</tr>
<tr>
<td>PS</td>
<td>Pt</td>
<td>F</td>
<td>yes</td>
<td>P</td>
</tr>
<tr>
<td>CPAP</td>
<td>Pt</td>
<td>Pt</td>
<td>yes</td>
<td>P</td>
</tr>
</tbody>
</table>

AutoPEEP

- Intrinsic PEEP
- Unintended PEEP
- Inadvertent PEEP
- Occult PEEP

AutoPEEP

- PEEP that develops when a new breath is delivered before expiration has ended
- Air-trapping, breath-stacking
- Cause = expiratory time is too short

WHY?
AutoPEEP

- Why is $T_e$ too short?
  - COPD
  - $V_e > 10$ lpm
  - small ETT
  - $C_l \uparrow$
  - RR \uparrow
  - insp flow rate slow
  - large $V_T$

Complications of AutoPEEP

1. *Increased WOB due to air-trapping* (impairs respiratory muscle function)

2. *Decreased venous return* ↓

3. *Barotrauma*
Complications of AutoPEEP

- Auto-PEEP can artificially look like LVF.
- But if give positive inotropic agents, diuretics → condition will get worse

Detecting Auto-PEEP

- Auto-PEEP can’t be seen on pressure manometer
- If monitoring digital $V_{TE}$ - transient reduction in volume, then lung volume stabilizes

Detecting AutoPEEP

- Best way =
  
  Graphic Wave Forms

  ![Graphic Wave Forms](image-url)
Other - AutoPEEP

- Patient may not be able to trigger vent (neg. pressure trigger)
  - must 1st pull off autoPEEP, the pull sensitivity → Pt/Vent asynchrony; ↑ WOB
- C₅ calculation must include autoPEEP

Decrease AutoPEEP Effects

- Increase Tₑ
  - ↑ flows → ↓ Tᵢ
  - ↓ Vₑ
  - ↓ RR

Decrease AutoPEEP Effects

- Decrease R₅₈
  - secretion removal
  - bronchodilators
  - ↑ ETT size
Decrease AutoPEEP Effects

- Permissive hypercapnia
- Add PEEP (85% of autoPEEP)

Benefits of AutoPEEP

- AutoPEEP can improve oxygenation when using PCIRV