Flow-Triggering

- Trigger = the variable that causes the vent to begin the inspiratory phase
- Common triggers
  - 1-
  - 2-
  - 3-
- Effort required to trigger =

Flow-Triggering

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

---

Important to remember!

If patient flow demand $>$ set flow

"flow starvation"

$\uparrow WOB$

---

Modes - Pressure

Pressure ventilation

operator sets pressure

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

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

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

The most significant difference between volume & pressure-based ventilation is how the flow is delivered!
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
① 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 $\uparrow R_{AW}$ take longer to receive $V_T$

② PV Reduces V/Q Mismatch

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

as press gradient $\downarrow$ $\rightarrow$ flow slows $\rightarrow$ laminar flow when gas enters small airways

$\downarrow$ better gas distribution ($\downarrow$ V/Q mismatch)

② PV Optimizes T₁

- By observing flow pattern, T₁ can be optimized

[Graph showing flow over time]
PV Matches Flow with Patient Demand

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

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

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:
  - \(FIO_2\) 1.0
  - PIP \(\geq 50\) cmH\(_2\)O
  - PEEP \(\geq 15\) cmH\(_2\)O
  - RR \(\geq 16\)/min
  - decreasing PaO\(_2\) and \(C_L\)
**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 (↓ risk of barotrauma & CV side-effects)
  - decreases need for PEEP
  - MAP increases
  - can cause auto-PEEP
Monitoring PCIRV

<table>
<thead>
<tr>
<th>VT</th>
<th>SpO₂</th>
<th>CVP</th>
</tr>
</thead>
<tbody>
<tr>
<td>RR</td>
<td>ABG</td>
<td>PAP</td>
</tr>
<tr>
<td>VE</td>
<td>HR</td>
<td>PCWP</td>
</tr>
<tr>
<td>PIP</td>
<td>UO</td>
<td>PVR</td>
</tr>
<tr>
<td>MAP</td>
<td>BP</td>
<td>PpCO₂</td>
</tr>
<tr>
<td>Cl</td>
<td>QT</td>
<td>P(ET)CO₂</td>
</tr>
<tr>
<td>waveforms</td>
<td>PEEP</td>
<td>auto-PEEP</td>
</tr>
</tbody>
</table>

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, T₁, target VT
- Breath give at minimal pressure
- Exhaled VT compared to target VT
- Pressure automatically adjusted to achieve target VT (breath to breath)
- Set Pressure Limit high enough
S1 Advanced Concepts

<table>
<thead>
<tr>
<th>PRVC/APV</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Advantage</strong> - Guaranteed of $V_T$ with the least amount of pressure to deliver that volume</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>VS</th>
</tr>
</thead>
</table>
| - Volume Support (Servo 300)  
- Automatic Pressure Support  
- Works like PRVC/APV  
- Spontaneous breathing mode (no rate set)  
- Set target $V_T$, Pressure Limit |

<table>
<thead>
<tr>
<th>VS</th>
</tr>
</thead>
</table>
| **Advantage** - automatic weaning  
  - as patient assumes more of the work of breathing $\rightarrow$ reduce target volume to 5-7 ml/kg  
  - apnea - vent switches to PRVC  
  - when no apnea, spont $V_T$ 5-7ml/kg,  
    $PS \leq 8$ cmH$_2$O $\rightarrow$ extubate |
Modes - Review

<table>
<thead>
<tr>
<th>Mode</th>
<th>Trigger</th>
<th>Cycled</th>
<th>PEEP</th>
<th>Limited</th>
</tr>
</thead>
<tbody>
<tr>
<td>AC</td>
<td>T, Pt</td>
<td>V, T</td>
<td>yes</td>
<td>P</td>
</tr>
<tr>
<td>PC</td>
<td>T, Pt</td>
<td>T</td>
<td>yes</td>
<td>P</td>
</tr>
<tr>
<td>SIMV ()</td>
<td>T, Pt</td>
<td>V, T</td>
<td>yes</td>
<td>P</td>
</tr>
<tr>
<td>SIMV ()</td>
<td>T, Pt</td>
<td>T</td>
<td>yes</td>
<td>P</td>
</tr>
<tr>
<td>PRVC/APV</td>
<td>T, Pt</td>
<td>T</td>
<td>yes</td>
<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 Pt</td>
<td>yes</td>
<td>P</td>
<td></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
- \( \text{Cause} = \text{expiratory time is too short} \)

\[ WHY? \]
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)

Complications of AutoPEEP

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 =

```plaintext
Graphic Wave Forms
```

---

15
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
- $C_3$ calculation must include autoPEEP

Decrease AutoPEEP Effects

- Increase $T_E$
  - ↑ flows → ↓ $T_i$
  - ↓ $V_T$
  - ↓ RR

Decrease AutoPEEP Effects

- Decrease $R_{AW}$
  - 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