Mechanical Ventilation for Patient Transport

Graham Kane B.S., FP-C, CCP-C, P-CC
Eagle County Paramedic Services

Objectives
- Respiratory Failure
- Common Vent Parameters
- Control
- Modes
- Support Modes
- Non-Invasive Positive Pressure Ventilation
- Trouble Shooting
- Strategies
- Cases
- Sedation package

Ventilator Parameters
- Ventilation parameters to be familiar with:
  - $V_t$ - Minute Volume ($V_t \times F$) (4-8L/min)
  - $V_t$ - Tidal Volume - 6-10 ml/Kg (IBW)
  - $F$ - Frequency - 8-20 bpm
  - I:E - Inspiratory to Expiratory Ratio - 1:2 - 1:3
  - $FiO_2$ - Fraction of Inspired Oxygen - 0.21-1.00
  - $pPlat$ - Plateau pressure - < 30 cm H$_2$O
  - $PIP$ - Peak Inspiratory Pressure ~20-30 cm H$_2$O

Respiratory Failure
- 2 Types of Failure:
  - Hypercarbic
    - Failure to remove CO$_2$ from the body
  - Hypoxic
    - Failure to Oxygenate Tissue

Ventilatory Failure
- Failing to remove adequate CO$_2$
  - Dx: Respiratory Acidosis - specifically $pCO_2 > 50$mmHg and not improving
  - Rx: Increase $V_t$ - Increase $T_{i}$ and then $F$

Hypoxic Failure
- Failure to Oxygenate the tissue
  - Dx: ABGs Respiratory Alkalosis, or Metabolic Acidosis
  - Critical Value is a $PO_2 < 60$mmHg
  - Rx: Increasing Mean Airway Pressure
    - PEEP
    - I:E Ratio modification
    - $FiO_2$ Increase
**PEEP**

Positive End Expiratory Pressure
- Retains airway pressure in the lungs at the end of expiration.
- Reduces effective TV
- Treat associated HOTN
- Physiologic is 3-5 cmH₂O, therapeutic is as high as 20 cmH₂O

**I:E Ratio**

Inspiratory to Expiratory Ratio
- Normal I:E is 1:2 - 1:3
- Mean Airway Pressure increases as we equalize the I:E
- 1:1 or inverted
  - Causes CO₂ retention
  - Permissive Hypercapnia
  - Keep pH above 7.2

**FiO₂**

Fraction of Inspired Oxygen
- Raising the FiO₂ is a short term solution
  - Oxydative stress, free radical damage in the lungs
  - Occurs in the space of hours.
- Target is to Keep FiO₂ as low as possible, while maintaining adequate oxygenation.

**The Decision to PPV**

Pros:
- Airway Control
- Real time assessment of respiratory system

Cons:
- Invasive Ventilation is not intrinsic
- Reduction in Cardiac Output
- VAP

**Ventilator Related Lung Injury**

- Lung Injury
  - Volutrauma
  - Barotrauma
  - Reduced Cardiac Output
  - Alveolar Shear injury

**PPV - Breath Mechanics**

- Normal Inspiration - the diaphragm and intercostals used to power negative pressure
  - Overcome resistance to flow created by airways, and lung compliance
  - PIP = airway resistance + lung compliance
  - pPlat = static measure of compliance, no flow
  - Exhalation is passive
**pPlat - Measuring...**
- Expiratory Hold
  - High PIP and High pPlat = lung compliance problem
  - High PIP and Normal pPlat = Airway flow resistance

**PPV - patient workload**
- PPV reduces Oxygen demand
  - Patient still needs to perform some work
    - Muscle atrophy in hours - VIDD
    - Avoid prolonged paralysis
  - Acute vs. Longer term care strategies involve the patient doing a percentage of the work load

**Syncrony**
- The vent and the patient will work together if...
  - Set vent to the patient
  - meet the patient’s demand
  - bucking? - adjust for demand.
  - Ensure adequate sedation and analgesia

**Ventilator Control Modes**
- **Volume Control**
  - TV remains constant regardless of pressure
- **Pressure Control**
  - Breath to preset pressure despite volume
- ***Time Cycled**
  - Approximation of volume based on Flow x Inspiratory Time

**Control Modes**
- **What starts a breath?**
  - CMV
  - A/C
  - IMV
  - SIMV

**Control Mode Ventilation**
- **CMV**
  - Preset TV/PIP x Preset Frequency
  - 100% Ventilator Controlled
  - Low tolerance, poor synchrony in awake patients
  - Requires large amounts of sedation or paralysis
**Assist Control**

- **A/C**
  - Preset Frequency x Preset TV/PIP
  - Patient takes additional breath as desired
  - Each patient breath is at Preset TV/PIP

**Intermittent Mandatory Ventilation (IMV)**

- Preset Frequency x Preset TV/PIP
- Patient can take additional breaths
- Patient breaths are at their own TV

**Synchronized IMV (SIMV)**

- Preset Frequency x Preset TV/PIP
- Spontaneous breaths as in IMV
  - Vent senses breaths – achieves synchrony by:
    - Gives full machine breath if patient starts breathing near the next machine breath
    - All other breaths are at the patient’s TV

**Support Modes**

**PEEP**

- Positive End Expiratory Pressure
- Elevates MAP
- Retains Volume in the airways
Support Modes

**Pressure Support**
- In SIMV, patient receives additional flow during inspiration on patient initiated breaths.
- Eases breathing through the ET tube, dead space, helps achieve higher TV.
- Range of additional 5-10 cmH₂O

**NiPPV**

**Non Invasive Positive Pressure Techniques**
- CPAP
- BPAP, BiPAP (Name Brand)  BiLevel, VLPAP, etc.
- IPAP + EPAP

Trouble Shooting

**High Pressure Alarms**
- Always an Emergency!
- Until proven otherwise
- DOPE or SCOPE

**SCOPE:**
- Suction
- Connections
- Obstruction
- Pneumothorax
- ETT-Displacement

**Low Pressure Alarms**
- Gas Supply
- Circuit disconnect
- ET-Displacement
- Hypovolemia

**Low Oxygenation**
- Vent Settings outside parameters
- ET Placement
- Suction
- Pneumothorax
- Pulmonary Embolus

Universal Vent Strategy

1. Blood Pressure
2. Acid Base Status
3. Synchrony
4. Titration
Vent Titration
- Oxygen status is controlled by *Mean Airway Pressure*
  - PEEP, I:E, FiO2
- Ventilation is controlled by VE (Minute Volume)
  - Freq. and TV

Ve vs. Va
- Making smart adjustments to Ventilation
  - Dead space is about 1ml/lb IBW
  - Ve = Va + Vd
  - Does 12 at 500 = 24 at 250?
    - Ve = yes, but Va = no

Using the whole lung
- PIP vs. pPlat
  - PIP - compliance + resistance to flow
  - Measure pPlat in some cases.
  - Keep PIP <30-35 cmH2O
  - OK to Increase Tv until pressures begin to rise.

Vent Strategies
- Neuromuscular Injuries / Diseases
  - Total Support
  - Larger TVs
  - Higher flow rates
  - No PEEP

ARDS - Lung protective
- pPlat <30 cmH2O
- Maximize PEEP to achieve SpO2 >88-95%
- PaO2 target 55-80mmHg

Vent Strategies
- COPD
  - Apply PEEP
  - AC / with paralysis / heavy sedation for vent synchrony
  - High flow rates

FiO2 <0.60
- Smaller TV (6-8ml/Kg IBW)
- Recruitment / sigh

Low VE, watch for auto PEEP and give longer E-Time as needed.
Vent Strategies

- CHF / AMI
- Proper sedation and analgesia
- Minimize patient work load (Oxygen Demand)
- NPPV for CHF

### 70 Kg Male w AMI / Pulmonary Edema
- Intubated, Vent and Labs as noted

<table>
<thead>
<tr>
<th>Vent</th>
<th>ABG</th>
<th>Chem7</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tid 10</td>
<td>pH 7.36</td>
<td>Na 137</td>
</tr>
<tr>
<td>FIO2 0.40</td>
<td>PaO2 56</td>
<td>K 3.5</td>
</tr>
<tr>
<td>PEEP 0</td>
<td>PaCO2 38</td>
<td>Cl 97</td>
</tr>
<tr>
<td>E 1:1.8</td>
<td>SaO2 91</td>
<td>BE -3.2</td>
</tr>
<tr>
<td>PIP 46</td>
<td>BUN 9.3</td>
<td>Cr 0.9</td>
</tr>
<tr>
<td>pPlat 49</td>
<td>Temp 36.9 C</td>
<td>Gluc 89</td>
</tr>
</tbody>
</table>

### 80 Kg Male w CVA / Pulmonary Edema
- Intubated, Vent and Labs as noted

<table>
<thead>
<tr>
<th>Vent</th>
<th>ABG</th>
<th>Chem7</th>
</tr>
</thead>
<tbody>
<tr>
<td>150 x 12</td>
<td>pH 7.10</td>
<td>Na 149</td>
</tr>
<tr>
<td>FIO2 0.40</td>
<td>PaO2 88</td>
<td>K 4.3</td>
</tr>
<tr>
<td>PEEP 0</td>
<td>PaCO2 52</td>
<td>Cl 102</td>
</tr>
<tr>
<td>E 1:2.1</td>
<td>HCO3 23</td>
<td>Cl 11.1</td>
</tr>
<tr>
<td>PIP 46</td>
<td>BUN 9.3</td>
<td>Cr 1.2</td>
</tr>
<tr>
<td>pPlat 32</td>
<td>Temp 36.9 C</td>
<td>Gluc 102</td>
</tr>
</tbody>
</table>

### 75 Kg female w altered LOC / acute respiratory distress
- Intubated, Vent and Labs as noted

<table>
<thead>
<tr>
<th>Vent</th>
<th>ABG</th>
<th>Chem7</th>
</tr>
</thead>
<tbody>
<tr>
<td>80 x 11</td>
<td>pH 7.13</td>
<td>Na 147</td>
</tr>
<tr>
<td>FIO2 0.3</td>
<td>PaO2 56</td>
<td>K 3.2</td>
</tr>
<tr>
<td>PEEP 0</td>
<td>PaCO2 38</td>
<td>Cl 107</td>
</tr>
<tr>
<td>E 1:1.3</td>
<td>SaO2 91</td>
<td>BE -3.2</td>
</tr>
<tr>
<td>PIP 26</td>
<td>BUN 20.1</td>
<td>Cr 1.9</td>
</tr>
<tr>
<td>pPlat 22</td>
<td>Temp 38.8 C</td>
<td>Gluc 189</td>
</tr>
</tbody>
</table>

### 60 Kg female ejected from MVA in a rollover
- Intubated, Vent and Labs as noted

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<thead>
<tr>
<th>Vent</th>
<th>ABG</th>
<th>Chem7</th>
</tr>
</thead>
<tbody>
<tr>
<td>150 x 18</td>
<td>pH 7.51</td>
<td>Na 1.39</td>
</tr>
<tr>
<td>FIO2 1.00</td>
<td>PaO2 95</td>
<td>K 4.2</td>
</tr>
<tr>
<td>PEEP 5</td>
<td>PaCO2 45</td>
<td>Cl 96</td>
</tr>
<tr>
<td>E 1:1.5</td>
<td>HCO3 31</td>
<td>BE -3.2</td>
</tr>
<tr>
<td>PIP 26</td>
<td>BUN 10</td>
<td>Cr 0.8</td>
</tr>
<tr>
<td>pPlat 32</td>
<td>Temp 36.2 C</td>
<td>Gluc 93</td>
</tr>
</tbody>
</table>

### Sedation Package

- RASS score and gauging sedation quality
- Sedatives
- Analgesics
- A1 Sedation Strategy
Hitting the Sweet Spot

- Mistakes of the past lead to delirium
- Profound sedation
- Current Thinking
  - RASS -2 to -4
  - Maybe deeper for techniques that are less natural (i.e. inverse I:E, High PEEP, etc.)

Avoiding Delirium
- 2.5-3.2x the mortality rate
- Other persistent cognitive impairments

All Sedatives can provoke HOTN in the setting of shock.

Opiates and Benzos
- Fentanyl with Versed is common
- Bolus dose vs. Infusion
- Dosing should be regimented to keep dosing as low as possible.
- Caution with large bolus doses of Benzos if the patient is at risk for HOTN

Propofol / Diphivan
- Lecithin based sedative hypnotic
- Avoid with Soy or egg allergies
- Use strict aseptic technique.
- Only use for 4 hours in the original container, or 2 hours as drawn up

Propofol
- Propofol produces a dose dependent sedative/hypnotic effect.
- Also is cardio suppressive and produces a dose dependent hypotension in susceptible patients
- Dosing is 2-100 mcg/Kg/Min

Richmond Agitation Sedation Scale (RASS)!

<table>
<thead>
<tr>
<th>Score</th>
<th>Term</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>-4</td>
<td>Comatose</td>
<td>Deathly combative, violent, immediate danger to staff</td>
</tr>
<tr>
<td>-3</td>
<td>Very agitated</td>
<td>Falls or moves without obvious aggression</td>
</tr>
<tr>
<td>-2</td>
<td>Agitated</td>
<td>Frequent non-purposeful movement, nights ventilator</td>
</tr>
<tr>
<td>-1</td>
<td>Restless</td>
<td>Anxious but movements not aggressive, vigorous</td>
</tr>
<tr>
<td>0</td>
<td>Alert &amp; calm</td>
<td>Not fully alert, has maintained awakening: eyes opening/eye contact to voice (10 seconds)</td>
</tr>
<tr>
<td>-1</td>
<td>Drowsy</td>
<td>Briefly awakens eyes opening/eye contact to voice (+10 seconds)</td>
</tr>
<tr>
<td>-2</td>
<td>Light sedation</td>
<td>Movement or eye opening to voice (but no eye contact)</td>
</tr>
<tr>
<td>-3</td>
<td>Moderate sedation</td>
<td>Movement or eye opening to voice (not eye contact)</td>
</tr>
<tr>
<td>-4</td>
<td>Deep sedation</td>
<td>No response to voice, but movement or eye opening to physical stimulation</td>
</tr>
<tr>
<td>-5</td>
<td>Unresponsive</td>
<td>No response to voice or physical stimulation</td>
</tr>
</tbody>
</table>

Use Caution and reduced dosing as needed.
Propofol Trivia

- Propofol Infusion Syndrome
  - Huge doses (>5mg/Kg/Hr) for periods longer than 48 hours
  - Results in a syndrome characterized by severe metabolic acidosis, hyperkalemia, lipemia, rhabdomyolysis, hepatomegaly, cardiac and renal failure.

Dexmedetomidine

- A2 agonist
- Causes Sedation with arousability
- Should be combined with some analgesia
- Dosing is 0.2-0.7 mcg/Kg/Hr
- Can Cause AV and SA nodal blocks, bradycardia, HOTN
- Side effects are most common with initial dosing

Sedation strategies

- A1 Sedation Analgesia
  - Avoiding delirium
  - Analgesia is given in doses high enough to make being intubated (almost) comfortable / tolerable
  - Sedation is then added to a level that allows the patient to achieve the preferred RASS score
  - This minimizes the amount of sedative and lowers the risk of delirium.

Questions or Comments?