Patient-Ventilator Interactions

Neil MacIntyre MD
Duke University Medical Center
Durham NC, USA

Patient Ventilator Interactions

• Assisted vs controlled mechanical ventilation
• Interactions during conventional assisted mechanical ventilation: properly loading respiratory muscles
  – Trigger, flow delivery, cycling
• Newer approaches to improving interactions

Assisted vs Controlled MV

• Controlled - machine determined rate and VT
  – Patient does no work
  – ? Useful in florid resp failure with fatigued muscles
  – Risk of VIDD, need for excessive NMBs
• Assisted – pt. triggers and interacts with the breath
  – Load depends on effort and applied support
  – ? Useful in recovering respiratory failure
  – Risk of fatigue, dys-synchrony/”fighting”

Ventilatory Muscle Fatigue Recovery

Overload

No load

Overload
Ventilatory Muscle Fatigue Recovery

Normal load
No load
Overload

Assisted vs Controlled MV

- Assisted offers opportunity to avoid NMBs, maintain muscle function, better VQ, cardiac filling
  - Shorter length of mechanical ventilation
  - Less long term myopathy


- BUT survival with 48hrs of NMB in severe ARDS
  - Less “fighting” the ventilator? Lower PTX?
  - BUT control group had: higher “rescue” NMB use than ARDSnet (56% vs 10%) and higher PTX than 3 large RCTs studying PEEP (12% vs 7%)

NEJM 2008; 358:1187

NEJM 2010; 363:1107

Assisted vs Controlled MV

- General consensus is to use assisted modes as soon as clinically possible
- However, assisted modes require patients and ventilators to interact
  - These interactions must be synchronous and comfortable
  - Dys-synchrony and discomfort leads to unnecessary sedation needs and muscle overload

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Poor Interactions Associated with Poor Outcomes

<table>
<thead>
<tr>
<th></th>
<th>Assisted (n=10)</th>
<th>Controlled (n=15)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Percentage of mechanical ventilation (days)</td>
<td>70.20±4.40</td>
<td>29.4±0.40</td>
<td>0.001</td>
</tr>
<tr>
<td>Percentage of mechanical ventilation (weeks)</td>
<td>25.9±0.81</td>
<td>17.8±0.81</td>
<td>0.01</td>
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<tr>
<td>Tracheotomy</td>
<td>20%</td>
<td>5.7±0.3</td>
<td>0.007</td>
</tr>
<tr>
<td>Mortality</td>
<td>10%</td>
<td>7.4±0.4</td>
<td>0.18</td>
</tr>
</tbody>
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Intensive Care Med. 32:1315, 2006

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Patient-ventilator interactions

- During assisted/supported breaths, patients must:
  - trigger the breath
  - synchronize inspiratory effort with the delivered flow
  - synchronize effort termination with machine breath termination
- Dys-synchrony during any of these phases results in high pressure loads on the muscles

Recognizing dys-synchrony

- Clinical signs:
  - excessive breathing effort during the trigger or flow delivery phase
  - inspiratory or expiratory efforts during the cycle phase
- Graphical displays
  - triggering loads in the Paw or Pes tracings
  - airway pressure being “pulled” down
  - airway pressures not at baseline during cycling

Assisted breath triggering

- Pressure trigger - effort produces pressure drop in vent circuit
  - sensitivity determined by set pressure drop
- Flow trigger - effort draws gas out of a continuous flow through the vent circuit
  - sensitivity determined by amount of flow taken by patient

* some vents have both and trigger off the first detected
Extra triggers ("Double triggers")

- Cycle criteria to short – persistent effort triggers breath
- Entrainment during controlled breaths

Double trigger from premature cycling

Double trigger from reverse triggering
Synchrony Issues

- Delayed triggering
- Missed triggering
- Auto triggering
- Reverse triggering
- Flow dys-synchrony
- Double triggering
- Premature cycling
- Delayed cycling

 Patient-ventilator interactions

Solutions for Flow Dys-synchrony

- Increase flow
- Pressure targeting
Synchrony Issues

- Delayed triggering
- Missed triggering
- Auto triggering
- Reverse triggering
- Flow dys-synchrony
- Double triggering
- Premature cycling
- Delayed cycling

Cycling dys-synchrony

Delayed Cycling

Delayed cycling with PS in OAD
Premature cycling

Synchrony - cycling pressure targeted breaths

Set inspiratory time

Adjust flow cycle criteria

Synchrony Issues

- Delayed triggering
- Missed triggering
- Auto triggering
- Reverse triggering
- Flow dys-synchrony
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  - Proportional assist ventilation
  - Neurally adjusted ventilatory support

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Proportional Assist Ventilation (PAV)

- Calculates R and C
- Monitors inspiratory flow demand
  - Calculates work of breathing (ie pressure requirements for desired flow and volume)
- Applies set “proportion” of required pressure
  - Also terminates (cycles) when effort ceases
- Like power steering on an automobile
  - Driver selects distance to turn wheel, system supplies pressure to reduce effort
  - Like automobile driver – patient must be reliable!
Proportional Assist Ventilation (PAV)

**Clinical Application**

- Performs as designed - gives comfortable support
  - Int Care Med 2008 online
  - Thorax 2002:57:79
  - J Appl Physiol 1996;81:429
- No good outcomes trials to date
- Reasonable to use in pts with flow or cycle dys-synchrony
  - Will still have triggering (incl PEEPi) issues
  - Will require monitors/alarms for low, unstable drive

**NAVA concept**

Nature 1999
NAVA – Clinical Application

- Performs as designed
  - *Anesthesiology.* 2010;113:925
  - *Crit Care Med.* 2010;38:518
- No good outcomes trials to date
- Theoretically attractive BUT:
  - Catheters expensive and invasive
  - Needs dedicated control system (also expensive)
  - Like PA< will require monitors/alarms for low, unstable drive

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