“Funky” New Ventilator Modes

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DISCLOSURE

Dr. MacIntyre participates in Carefusion and Breathe Technology speakers’ bureau, but these do not create a conflict related to the following presentation.
“Funky” New Ventilator Modes

• What is wrong with current modes?
• Strategies to enhance lung protection
• Strategies to enhance synchrony
• Strategies to enhance the discontinuation process
What is wrong with current modes?

- Inadequate lung protection
- Discomfort
- Prolonged discontinuation process
Lung Protective Ventilator Strategies

- **Volutrauma**
- **Zone of Overdistension**
- **Safe Window**
- **Atelectrauma**
- **Zone of Derecruitment and Atelectasis**

**Images:**
- Microscopic view of lung tissue
- Sign that says, "Think of Parking Here"

**Key Terms:**
- **V:** Ventilation
- **P:** Pressure
- **LIP:** Level of Inflation Pressure
- **UIP:** Upper Inflection Point

**Concepts:**
- The diagram illustrates the balance between ventilation (V) and pressure (P) to avoid harm to the lungs.
- The "safe window" represents the ideal range of ventilation and pressure to prevent volutrauma and atelectrauma.
- Derecruitment and atelectasis are represented by red areas, indicating areas where the lung tissue is not being adequately inflated or is collapsed.
Trigger Flow Cycle
Discontinuation Speed Heavily Clinician Dependent
“Funky” New Ventilator Modes

• What is wrong with current modes?
• Strategies to enhance lung protection
• Strategies to enhance synchrony
• Strategies to enhance the discontinuation process
Question

• Mode that I use routinely begin with in ARDS?
  – A. Volume assist control
  – B. Pressure assist control
  – C. SIMV (+/- PS)
  – D. Airway Pressure release ventilation
  – E. High frequency oscillation
Mode that I use routinely begin with in ARDS?

A. Volume assist control
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D. Airway Pressure release ventilation
E. High frequency oscillation
Question

• Mode that I go to first in ARDS when my routine mode is failing
  – A. Volume assist control
  – B. Pressure assist control
  – C. Airway Pressure release ventilation
  – D. High frequency oscillation
  – E. Other (including ECMO)
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New Strategies to Enhance Lung Protection

• Airway Pressure Release Ventilation
• High Frequency Oscillation
APRV: pressure target/spont breaths

More “recruit” time, higher mean P without adding more VT or PEEP

Spont breaths help mixing
Influence of effort

Active
- Unsafe
  30 cm H₂O
  -10 cm H₂O
  30 cm H₂O
  40 cm H₂O

Passive
- Safe
  30 cm H₂O
  5 cm H₂O
  25 cm H₂O
APRV: pressure target/spont breaths

Intrinsic vs Applied PEEP

Intrinsic gives longer I time but distributes to compliant and obstructed units.

Applied PEEP gives shorter I time but more evenly distributed.

? Which is best?
Varpula et al. APRV in ARDS. Acta Anaesth Scand 2004;48:772

• RCT of APRV vs SIMV/PS in 58 ARDS pts.
• Both groups
  – VT 8-10 ml/kg, rate for pH (start at 12)
  – Limit Pplat to < 35 cm H2O
  – PEEP set to PV curve
  – Same FiO2, sedation, weaning rules
• 10 cm H2O PS in SIMV group
APRV vs ARDSNet

64 patients with Trauma ALI/ARDS randomized to APRV vs ARDSNet lung protective strategy

**TABLE 2. Outcome Data (None significant)**

<table>
<thead>
<tr>
<th>Dependent Measure</th>
<th>APRV</th>
<th>LOVT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ventilator days</td>
<td>10.49</td>
<td>8.00</td>
</tr>
<tr>
<td>ICU length of stay (d)</td>
<td>16.47</td>
<td>14.18</td>
</tr>
<tr>
<td>Pneumothorax</td>
<td>0%</td>
<td>3.1%</td>
</tr>
<tr>
<td>VAP per patient</td>
<td>1.00</td>
<td>0.56</td>
</tr>
<tr>
<td>Tracheostomy (%)</td>
<td>61.3</td>
<td>65.6</td>
</tr>
<tr>
<td>Failure of modality (%)</td>
<td>12.9</td>
<td>15.6</td>
</tr>
<tr>
<td>Mortality (%)</td>
<td>6.45</td>
<td>6.25</td>
</tr>
</tbody>
</table>

J Trauma 2010:69:501
APRV – Case Control Study

• Retrospective look at vent utilization survey in 349 ICUs
• Identified 234 patients ventilated with APRV
  – Patients without ARDS less likely to get APRV
  – Strongest predictor of use was being in Germany
• Propensity score used to identify matched patients receiving assist-control
  – No differences in:
    • Mortality
    • VFDs
    • Reintubations
    • LOS

Int Care Med 2010; 36: 817
New Strategies to Enhance Lung Protection

• Airway Pressure Release Ventilation
• High Frequency Oscillation
HFV – CPAP with a “wiggle”
When $V_t << V_d$, the conventional $V_A = f \times (V_t - V_d)$ makes no sense. An alternate formula is thus necessary:

$$\dot{V}_A = f \times V_T \times \frac{V_T}{V_D} \times K$$

$(K = .01-.20)$
HFV in ALI/ARDS:
2010 Meta-analysis

• Key results from 6 peer reviewed studies:
  – Mortality reduced (RR 0.77, P=0.03), 5/6 trials +
  – Treatment failures (RR 0.67, P=0.04), 5/6 trials +
  – Barotrauma (RR 0.68, P=0.2)

• Physiology:
  – Consistently better PaO2/FiO2

BMJ 2010; 340:2327
OSCAR and OSCILLATE Trials

• 2 large RCTs – OSCAR equivalent, OSCILLATE suggested harm
• Concerns (both):
  – HFO expertise – low – HFO has learning curve
  – Moderate ARDS – already on good lung protective ventilation
• Concerns (OSCILLATE)
  – 75 patients excluded because MD wanted HFO
  – High Paw protocol in setting of high vasopressor use
• My take:
  – Should not expose pts with adequate lung protection on CV to risks of HFO (fluid balance, NMBs)
  – Clinician skill important – especially with high mean P and hemodynamic compromise
  – HFO still a legitimate rescue therapy
HFV in the adult - when to use?

• Earlier rather than later

• Suggested criteria - when “lung protection” cannot be provided with conventional strategies:
  – Pplat (corrected for Ccw) > 30
  – FiO2 > 0.6-0.7

• If it is going to work, should have better P/F in 8-12 hrs – otherwise go to “plan B”
“Funky” New Ventilator Modes

• What is wrong with current modes?
• Strategies to enhance lung protection
• Strategies to enhance synchrony
• Strategies to enhance the discontinuation process
Question

• When my patient appears dys-synchronous with the ventilator, I usually
  – A. Stick with the mode I have and adjust trigger, flow, cycle criteria as best I can
  – B. Switch modes (volume to pressure targeting or pressure to volume targeting)
  – C. Try PAV
  – D. Try NAVA
  – E. Sedate
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Trigger Flow Cycle

New Strategies to Enhance Synchrony

• Combining Pressure and Volume Targeting Features
• Proportional Assist Ventilation
• Neurally Adjusted Ventilatory Assist
Breath characteristics

Gas Delivery

Advantage: Guaranteed VT
Disadvantage: Fixed flow, dys-synchrony

Variable flow, synchrony
Variable VT
Response to producing airway obstruction

Response to removal of Airway obstruction
PRVC-VS: A word of caution

- Reduces inspiratory pressure in setting of increased respiratory drive
  - GOOD if increased drive a sign of recovery
  - BAD if increased drive a result of agitation, pain, or dyspnea
New Strategies to Enhance Synchrony

• Combining Pressure and Volume Targeting Features
• Proportional Assist Ventilation
• Neurally Adjusted Ventilatory Assist
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

Pt = 25% of work. Vent = 75% of work.
Effort is amplified by a factor of 4 with a proportionality ratio of 3:1
Proportional Assist Ventilation (PAV)
PAV – Clinical Application

• Performs as designed - gives comfortable support
  – *Int Care Med 2008 on line*
  – *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 dysynchrony
  – Will still have triggering (incl PEEPi) issues
  – Will require monitors/alarms for low, unstable drive
New Strategies to Enhance Synchrony

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• Proportional Assist Ventilation
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Trigger Flow Cycle

NAVA concept

Nature 1999
Catheter for measuring electrical activity of the diaphragm (EAdi or Edi)
NAVA Improved Synchrony

[Image of a medical monitor showing various parameters such as Ppeak, Pmean, PEEP, RR, O2, Ti/Ttot, MV, VTi, VT, etCO2, Ecl peak, Ecl min, and additional settings including O2 conc., PEEP, and NAVA level.]

- O2 conc.: 28%
- PEEP: 5 cmH2O
- NAVA level: 1.3 cmH2O/µV
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 PAV< will require monitors/alarms for low, unstable drive
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Question

- My ventilator discontinuation approach when a patient is awake and has adequate gas exchange on PEEP \( \leq 8 \) and FiO2 \( \leq 0.4 \) is:
  - A. Do SBTs regardless of other vent settings
  - B. Do SBTs when support has been weaned to low levels (eg PS \( \leq 10-12 \), SIMV rate < 4)
  - C. Skip SBTs and evaluate for extubation when support has been weaned to low levels (eg PS \( \leq 5 \), SIMV rate < 2)
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C. Skip SBTs and evaluate for extubation when support has been weaned to low levels (eg PS $\leq 5$, SIMV rate $< 2$)
New Strategies to Facilitate Discontinuation

• Automatic Pressure Support Reduction
  – Tidal volume target – PRVC/VS
  – Tidal volume + other targets
SmartCare II

Int Care Med 2008;34:1788
So is there a role for automatic PS reductions?

- No evidence that says this facilitates muscle recovery
- Patient tolerance to decreasing PS could signal clinicians to initiate SBTs:
  - Rapidly recovering patient (overdose, post op)
  - Slowly recovering after many failed SBTs (PMV population)
  - Thus could use as a diagnostic rather than a therapeutic tool
Discontinuation Speed Heavily Clinician Dependent
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