Lung Protective Ventilatory Strategies

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Consultant Carefusion
Lung Protective Ventilator Strategies

- What are we protecting the lung from?
- What are “conventional” strategies to provide protection?
- What are new strategies to provide protection?
Preventing Overdistention and Collapse Injury

“Lung Protective” Ventilation

- Add PEEP
- Limit VT
- Limit Distending Pressure
- Pressure
- Volume
PEEP = 5 mbar

Pinsp = 40 mbar
Overdistention

Graph showing the relationship between transpulmonary pressure and lung injury outcomes.

- Rupture (PIE, pneumothorax)
- Tissue Injury (inflammation, edema)
- None

Y-axis: Transpulmonary Pressure
X-axis: Volutrauma
Overdistention

![Graph showing relationship between Transpulmonary Pressure and Volutrauma]

- **None**
- **Tissue Injury** (inflammation, edema)
- **Rupture** (PIE, pneumothorax)

Transpulmonary Pressure vs. Volutrauma
NIH ARDS Network trial
NEJM 2000;342:1301

Pplat =
mid 20s
low 30s
Controversies in VILI - Overdistention

- Is it “maximal” stretch or “tidal” stretch (or both) that causes VILI?
  - If “maximal”, goal is to keep $P_{plat} < 30$ with any VT
    - $P_{plat} < 30$ is “safe”
  - If “tidal”, goal is to reduce VT and $P_{plat}$ to minimums
Stretch injury - Is it max stretch or tidal stretch?

Mortality

(Pplat < 30 in both)  (Pplat > 30 in both)
Peak P 35 29 32
Crs .37 .46 .52
AP III 77 69 69
Post op 38 61 66

Peri-operative VILI?

- Normal lungs - small VT reduces post-op respiratory complications:
  - Chest 2011;139:530-7
  - J Cardiothor and Vasc Anesth. 2010; 24:681-90
  - Anesthesiol. 2006; 105:14-8
  - J Cardiothor Vasc Anesth. 2000;14:514-8

- Donor lungs for transplant – small VT doubles viability
  - JAMA 2010;304:2620
Controversies in VILI - Overdistention

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Preventing Overdistention and Collapse Injury

“Lung Protective” Ventilation

**Pressure**

- Add PEEP

**Volume**

- Limit VT

- Limit Distending Pressure
Preventing Overdistention and Collapse Injury

“Lung Protective” Ventilation

- Add PEEP
- Limit VT
- Limit Distending Pressure
- Pressure
- Volume
One more point: VILI is more than a lung injury

- Cytokines released into circulation cause other organ failures
- Lung barrier function to bacteria broken

**ALI/ARDS patients do NOT die from respiratory failure – they die of multi-organ failure and sepsis**

- ARDS Net mortality benefit accompanied by lower cytokine levels and fewer organ failures
Lung Protective Ventilator Strategies

- What are we protecting the lung from?
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Lung Protective Ventilator Strategies

- Zone of derecruitment and atelectasis
- "Safe" window
- Zone of overdistension
- LIP
- UIP
- Atelectrauma
- Volutrauma

V

DON'T EVEN
THINK
OF PARKING
HERE
NIH ARDS Network trial
NEJM 2000;342:1301

Pplat =
mid 20s
low 30s
Balancing need for support vs distending pressures

Crs also better in the HIGH Vt group
Balancing need for support vs pH and PCO2

ARDSnet rules allowed pH values as low as 7.15
Improving synchrony (and still following ARDS Net)

- Can increase to 8 ml/kg
- Flow rate and insp pause adjustments
- Optimize triggering
- Can use pressure targeting adjusted to ARDS Net tidal volume
  - pressure slope
  - I time adjustments
  - PRVC or VS tidal volumes
Lung Protective Ventilator Strategies

- safe window
- zone of derecruitment and atelectasis
- volutrauma
- zone of overdistension
- "safe" window
- atelectrauma
- UIP
- LIP

DON'T EVEN THINK OF PARKING HERE
Recruit Alveoli (actually prevent de-recruitment)
Approaches to Setting PEEP/FiO2

- **Visual**
  - CT, EIT, Ultrasound

- **Mechanical**
  - PV curves, “Best” compliance, Pes, Stress Index

- **Gas exchange**
  - PEEP/FiO2 Tables
    - Goal is “adequate”, not “maximal” PaO2
PEEP-FiO2 Tables

Balancing “adequate” PO2 against FiO2 and overdistention

Targets: PO2 55-80, Pplat < 30-35
### Three RCTs: High vs Low PEEP Tables:

**ARDS Net (n=585), Canadian (n=983) European (n=767)**


<table>
<thead>
<tr>
<th></th>
<th>Low PEEP</th>
<th>High PEEP</th>
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<td><strong>PaO2/FiO2</strong></td>
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<td>222</td>
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<td>187</td>
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<tr>
<td>European</td>
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*GOOD*
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*GOOD*

*BAD*
Lung Protective Ventilator Strategies

- What are we protecting the lung from?
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- What are new strategies to provide protection?
APRV: pressure target/spont breaths

Two ways to think about it:

1. “Comfortable” PCIRV

2. Basically CPAP - periodic release (upside down SIMV)
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>
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<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>
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<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>
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<tr>
<td>Failure of modality (%)</td>
<td>12.9</td>
<td>15.6</td>
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<tr>
<td>Mortality (%)</td>
<td>6.45</td>
<td>6.25</td>
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J Trauma 2010:69:501
HFV – CPAP with a “wiggle”
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)
- VFDs not consistently reported – no obvious difference

Physiology:

- Consistently better PaO2/FiO2 but comparable OI

BMJ 2010; 340:2327
OSCAR and OSCILLATE Trials

- 2 large RCTs – OSCAR equivalent, OSCILLATE suggested harm
- Concerns (both):
  - HFO expertise – low
- Concerns (OSCILLATE)
  - 47% mortality highest recorded for HFO despite highest P/F
    - 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
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 > 0.5-0.6
Extracorporeal Life Support (ECLS) to Reduce Ventilator Support and thus VILI

- ELSO database: 1145 adults through 2006
  - 40% ARDS, 52% cardiac
  - Overall survival to discharge 52% (predicted mortality of >80%)
  - Major complications are bleeding (usually requires heparin), stroke, ischemic bowel, PE
    - Much improved over systems in the 1970s

*Sem Resp Crit Care Med 2006; 27: 416*
Conventional Ventilation vs ECLS in Severe Acute Respiratory Distress Syndrome

- 180 patients with severe “potentially reversible” ARDS in UK
- Randomized to “usual care” or sent to one center for ECLS
  - Not all received ECLS – died en route, “too healthy”
- ITT survival:
  - 63% ECLS vs 46% usual care
  - P = 0.03

Lancet. 2009; 374(9698):1351-63
Health Technology Assessment. 2010;14(35):1-46
New approaches *NOT* for routine use in respiratory failure

- **Negative data**
  - Nitric oxide - ? Better PO2, no survival benefit

- **Controversial - studies underway/pending**
  - Prone positioning
  - Surfactant
  - Paralytics

- **No data**
  - Feedback control - ASV untested in resp failure
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