Acute Respiratory Distress Syndrome: Beyond ARDSnet

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No financial or other conflicts of interest to declare.

I have received funding from the NIH to perform clinical research on ARDS.
Overview

• Paradigm Shift
  • Gas exchange vs. mechanics
  • Baby lung & inhomogeneity

• Evidence-based Management
  • Prone positioning
  • PEEP titration
  • Neuromuscular blockade

• The Controversy
  • Pulmonary vasodilators
  • ECMO
  • “Rescue” therapies
Overview

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  • Pulmonary vasodilators
  • ECMO
  • “Rescue” therapies
ARDSnet ARMA Trial

• Multicenter RCT of 861 patients
• Intervention
  • $V_T$ 6 (4-8) mL/kg predicted body weight (PBW)
  • Plateau pressure $\leq$ 30 cmH$_2$O
• Control
  • $V_T$ 12 mL/kg PBW
  • Plateau pressure $\leq$ 50 cmH$_2$O
• Both arms
  • Protocolized PEEP & FiO$_2$ management

ARDSnet ARMA Trial

ARDSnet ARMA Trial

- Worse PaO$_2$ : FiO$_2$ and higher PaCO$_2$ with low $V_T$

<table>
<thead>
<tr>
<th>VARIABLE</th>
<th>DAY 1</th>
<th>DAY 3</th>
<th>DAY 7</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tidal volume (ml/kg of predicted body weight)</td>
<td>6.2±0.9</td>
<td>11.8±0.8</td>
<td>6.5±1.4</td>
</tr>
<tr>
<td>No. of patients</td>
<td>387</td>
<td>405</td>
<td>181</td>
</tr>
<tr>
<td>PaO$_2$:FiO$_2$</td>
<td>158±73</td>
<td>176±76</td>
<td>165±71</td>
</tr>
<tr>
<td>No. of patients</td>
<td>350</td>
<td>369</td>
<td>148</td>
</tr>
<tr>
<td>PaO$_2$ (mm Hg)</td>
<td>76±23</td>
<td>77±19</td>
<td>73±17</td>
</tr>
<tr>
<td>No. of patients</td>
<td>350</td>
<td>369</td>
<td>148</td>
</tr>
<tr>
<td>PaCO$_2$ (mm Hg)</td>
<td>40±10</td>
<td>35±8</td>
<td>44±12</td>
</tr>
<tr>
<td>No. of patients</td>
<td>351</td>
<td>369</td>
<td>147</td>
</tr>
<tr>
<td>Arterial pH</td>
<td>7.38±0.08</td>
<td>7.41±0.07</td>
<td>7.40±0.07</td>
</tr>
<tr>
<td>No. of patients</td>
<td>351</td>
<td>369</td>
<td>148</td>
</tr>
</tbody>
</table>

Lung-Protective Ventilation

• Traditional Approach: Normalize blood gas
  • $\text{PaO}_2$ and $\text{SaO}_2$
  • $\text{PaCO}_2$

• Lung-protective Approach: Optimize mechanics
  • Barotrauma
  • Volutrauma
  • High shear strain
  • Cyclic atelectasis
  • … Biotrauma
Rethinking the ARDS Lung
Rethinking the ARDS Lung
The ARDS “Baby Lung”

Figure from: Moloney. *Br J Anaeth.* 2004;92:261-270.
The ARDS “Baby Lung”

- Edema weight of ventral regions compress dorsal lung

SP = superimposed pressure from more ventral lung

Traditional approaches to mechanical ventilation use tidal volumes of 10 to 15 ml per kilogram of body weight. These volumes are larger than those in normal subjects at rest (range, 7 to 8 ml per kilogram), but they are frequently necessary to achieve normal values for the partial pressure of arterial carbon dioxide and pH. Since atelectasis and edema reduce aerated lung volumes in patients with acute lung injury and the acute respiratory distress syndrome, inspiratory airway pressures are often high, suggesting the presence of excessive distention, or “stretch,” of the aerated lung. In animals, ventilation with the use of...
Is the Baby Lung Normal?

- Yes: Regional mechanics

<table>
<thead>
<tr>
<th></th>
<th>Patients with ARF (n = 20)</th>
<th>Normal Subjects Anesthetized and Paralyzed (n = 11)</th>
<th>Normal Subjects Awake (CT Scan) (n = 8)</th>
</tr>
</thead>
<tbody>
<tr>
<td>PEEP</td>
<td>5 cm H(_2)O</td>
<td>0 cm H(_2)O</td>
<td>0 cm H(_2)O</td>
</tr>
<tr>
<td>Compliance/lung gas volume*</td>
<td>21.7 ± 6.8</td>
<td>23.9 ± 5.6</td>
<td>Not available</td>
</tr>
<tr>
<td>Compliance/normally aerated tissue†</td>
<td>8.75 ± 3.9</td>
<td>Not available</td>
<td>7.2 to 8.60†</td>
</tr>
</tbody>
</table>

Is the Baby Lung Normal?

- No: Inflammation

\[ K_{IS} = \text{FDG uptake rate per fractional volume of tissue} \]

Is the Baby Lung Real?

- Dorsal recruitment, ventral de-recruitment
  - Supine

Is the Baby Lung Real?

- Dorsal recruitment, ventral de-recruitment
  - Supine
  - Prone

## Baby Lung: Implications for Lung Injury

- **Well-aerated regions**
  - Risk of overdistension (volutrauma/barotrauma)

- **Poorly aerated regions**
  - Risk of cyclic atelectasis

- **Collapsed regions**
  - Decrease lung volume available for ventilation

- **Inhomogeneity (border zones)**
  - High shear forces

*Best evidence: Therapies targeting optimal mechanics*
Overview

• Paradigm Shift
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• Evidence-based Management
  • Prone positioning
  • PEEP titration
  • Neuromuscular blockade

• The Controversy
  • Pulmonary vasodilators
  • ECMO
  • “Rescue” therapies
Prone Positioning
PROSEVA Trial

• Multicenter RCT of 466 patients
  • ARDS severity: PaO₂:FiO₂ < 150 with FiO₂ ≥ 60%
  • Key exclusions: ICP > 30 mmHg, MAP < 65 mmHg

• Intervention
  • Prone position at least 16h daily
  • Stop criterion: PaO₂:FiO₂ ≥ 150, PEEP ≤ 10, FiO₂ ≤ 60% for at least 4h in supine position

• Control: Supine position only

• Both arms
  • Vₜ 6 mL/kg PBW
  • Protocolized PEEP & FiO₂ management

PROSEVA Trial

## Table 3: Primary and Secondary Outcomes According to Study Group.

<table>
<thead>
<tr>
<th>Outcome</th>
<th>Supine Group (N = 229)</th>
<th>Prone Group (N = 237)</th>
<th>Hazard Ratio or Odds Ratio with the Prone Position (95% CI)</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mortality — no. (%) [95% CI]</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>At day 28</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Not adjusted</td>
<td>75 (32.8 [26.4–38.6])</td>
<td>38 (16.0 [11.3–20.7])</td>
<td>0.39 (0.25–0.63)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Adjusted for SOFA score†</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>At day 90</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Not adjusted</td>
<td>94 (41.0 [34.6–47.4])</td>
<td>56 (23.6 [18.2–29.0])</td>
<td>0.44 (0.29–0.67)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Adjusted for SOFA score†</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Successful extubation at day 90 — no./total no. (%) [95% CI]</td>
<td>145/223 (65.0 [58.7–71.3])</td>
<td>186/231 (80.5 [75.4–85.6])</td>
<td>0.45 (0.29–0.70)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Ventilation-free days</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>At day 28</td>
<td>10±10</td>
<td>14±9</td>
<td></td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>At day 90</td>
<td>43±38</td>
<td>57±34</td>
<td></td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>
Prone Positioning: Rationale

- Improved lung homogeneity & recruitment

Supine

Prone

X-axis: Non-dependent Zones ➔ Dependent Zones

Gattinoni. AJRCCM. 2013;188:1286-1293.
Prone Positioning: Rationale

• Proposed mechanisms of benefit
  • Pleural pressure gradient uniformity
  • Unload weight of heart & abdomen
  • Changes in chest & lung shape, chest wall compliance

• Consequences
  • More uniform stress & strain distribution
  • Recruitment of dependent zones
  • Prevent overdistension of non-dependent zones
  • Improved V/Q matching
  • Enhanced drainage of tracheobronchial secretions

What About the Negative Proning Trials?

- High Tidal Volume Studies (> 8 mL/kg PBW)

<table>
<thead>
<tr>
<th>Study name</th>
<th>Statistics for each study</th>
<th>Risk ratio and 95% CI</th>
</tr>
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<tbody>
<tr>
<td>Gattinoni, 2001</td>
<td>1.106 0.900 1.360 0.337</td>
<td></td>
</tr>
<tr>
<td>Guerin, 2004</td>
<td>1.020 0.862 1.207 0.819</td>
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<tr>
<td>Mancuso, 2006</td>
<td>0.786 0.551 1.120 0.183</td>
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<tr>
<td>Taccone, 2009 (mod)</td>
<td>0.852 0.575 1.262 0.424</td>
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<tr>
<td>Taccone, 2009</td>
<td>0.996 0.876 1.132 0.949</td>
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</tr>
</tbody>
</table>

Favors Prone  Favors Supine

What About the Negative Proning Trials?

• Low Tidal Volume Studies (≤ 8 mL/kg PBW)

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</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Risk ratio</td>
<td>Lower limit</td>
</tr>
<tr>
<td>Gattinoni, 2001</td>
<td>1.106</td>
<td>0.900</td>
</tr>
<tr>
<td>Guerin, 2004</td>
<td>1.020</td>
<td>0.862</td>
</tr>
<tr>
<td>Mancebo, 2006</td>
<td>0.786</td>
<td>0.551</td>
</tr>
<tr>
<td>Taccone, 2009 (mod)</td>
<td>0.852</td>
<td>0.575</td>
</tr>
<tr>
<td></td>
<td>0.996</td>
<td>0.876</td>
</tr>
<tr>
<td>Voggenreiter, 2005</td>
<td>0.304</td>
<td>0.035</td>
</tr>
<tr>
<td>Fernandez, 2008</td>
<td>0.724</td>
<td>0.362</td>
</tr>
<tr>
<td>Taccone, 2009 (sev)</td>
<td>0.814</td>
<td>0.588</td>
</tr>
<tr>
<td>Guerin, 2013</td>
<td>0.534</td>
<td>0.394</td>
</tr>
<tr>
<td></td>
<td>0.655</td>
<td>0.499</td>
</tr>
</tbody>
</table>

Favors Prone | Favors Supine

Lessons Learned: When Proning Works

- **Patients**
  - Moderate-severe ARDS (PaO$_2$:FiO$_2$ < 150)

- **Timing**
  - Begin within first 36 hours of intubation for ARDS
  - Prone at least 16h/day

- **Co-interventions**
  - Low tidal volumes
  - Neuromuscular blockade

- **Equipment**
  - None!

How to Prone: 5 Simple Steps

- Step 1: Prepare
- Step 2: Lateral move
- Step 3: Side-lying position
- Step 4: Complete proning
- Step 5: Post-pronning management

Excellent instructional video:


PEEP Titration
PEEP Titration

- Probable benefit to “high PEEP” if $\text{PaO}_2:\text{FiO}_2 \leq 200$

Briel. JAMA. 2010;303:865-873.
High PEEP: Rationale

- Proposed mechanisms of lung injury prevention
  - Improved lung homogeneity
    - More uniform stress & strain distribution
  - Recruitment of atelectatic lung
    - Increase “baby lung” available for tidal ventilation
    - Prevent cyclic atelectasis
- Mechanisms similar to those with proning

High PEEP: Rationale

- Offsetting the chest wall contribution (e.g. obesity)
  - Transpulmonary pressure (Ptp) = P_{alveolar} − P_{pleural}

- Also highlights key limitation of plateau pressure

PEEP Titration Protocol?

- Limitation of evidence
  - No single trial has convincingly demonstrated mortality benefit with high PEEP… thus best strategy unknown
  - No harm shown in trials either…

- Many options
  - PEEP-FiO₂ Table (ALVEOLI, LOVS Trials)
    - Most common approach in recent clinical trials
  - Mechanics-based approaches
    - Esophageal pressure, compliance, P-V curve

- Suggestion:
  - Adopt strategy with which your ICU will be most comfortable
PEEP Titration Protocol?

- ARDSnet PEEP-FiO₂ Table
  - Most widely used in clinical trials & practice

<table>
<thead>
<tr>
<th>FiO₂</th>
<th>0.3</th>
<th>0.3</th>
<th>0.4</th>
<th>0.4</th>
<th>0.5</th>
<th>0.5</th>
<th>0.5–0.8</th>
<th>0.8</th>
<th>0.9</th>
<th>1.0</th>
</tr>
</thead>
<tbody>
<tr>
<td>PEEP</td>
<td>12</td>
<td>14</td>
<td>14</td>
<td>16</td>
<td>16</td>
<td>18</td>
<td>20</td>
<td>22</td>
<td>22</td>
<td>22–24</td>
</tr>
</tbody>
</table>

- Safety demonstrated in multiple trials
Neuromuscular Blockade
ACURASYS Trial

• Multicenter RCT of 466 patients
  • ARDS severity: PaO₂:FiO₂ < 150

• Intervention
  • Cisatracurium 15mg IV bolus, then 37.5 mg/h gtt x 48h

• Control:
  • Placebo infusion x 48h

• Both arms
  • Vₜ 6 mL/kg PBW
  • Protocolized PEEP & FiO₂ management
  • Heavy sedation (Ramsay score 6, RASS -5)
ACURASYS Trial

### Table 3. Secondary Outcomes, According to Study Group.*

<table>
<thead>
<tr>
<th>Outcome</th>
<th>Cisatracurium (N=177)</th>
<th>Placebo (N=162)</th>
<th>Relative Risk with Cisatracurium (95% CI)</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Death — no. (% [95% CI])</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>At 28 days</td>
<td>42 (23.7 [18.1–30.5])</td>
<td>54 (33.3 [26.5–40.9])</td>
<td>0.71 (0.51–1.00)</td>
<td>0.05</td>
</tr>
<tr>
<td>In the ICU</td>
<td>52 (29.4 [23.2–36.5])</td>
<td>63 (38.9 [31.7–46.6])</td>
<td>0.76 (0.56–1.02)</td>
<td>0.06</td>
</tr>
<tr>
<td>In the hospital</td>
<td>57 (32.2 [25.8–39.4])</td>
<td>67 (41.4 [34.1–49.1])</td>
<td>0.78 (0.59–1.03)</td>
<td>0.08</td>
</tr>
<tr>
<td>No. of ventilator-free days†</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>From day 1 to day 28</td>
<td>10.6±9.7</td>
<td>8.5±9.4</td>
<td></td>
<td>0.04</td>
</tr>
<tr>
<td>From day 1 to day 90</td>
<td>53.1±35.8</td>
<td>44.6±37.5</td>
<td></td>
<td>0.03</td>
</tr>
<tr>
<td>No. of days without organ failure, from day 1 to day 28</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No cardiovascular failure</td>
<td>18.3±9.4</td>
<td>16.6±10.4</td>
<td></td>
<td>0.12</td>
</tr>
<tr>
<td>No coagulation abnormalities</td>
<td>22.6±8.9</td>
<td>20.5±9.9</td>
<td></td>
<td>0.05</td>
</tr>
<tr>
<td>No hepatic failure</td>
<td>21.3±9.6</td>
<td>19.1±10.6</td>
<td></td>
<td>0.05</td>
</tr>
<tr>
<td>No renal failure</td>
<td>20.5±10.1</td>
<td>18.1±11.6</td>
<td></td>
<td>0.05</td>
</tr>
<tr>
<td>None of the four</td>
<td>15.8±9.9</td>
<td>12.2±11.1</td>
<td></td>
<td>0.01</td>
</tr>
<tr>
<td>No. of days outside the ICU</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>From day 1 to day 28</td>
<td>6.9±8.2</td>
<td>5.7±7.8</td>
<td></td>
<td>0.16</td>
</tr>
<tr>
<td>From day 1 to day 90</td>
<td>47.7±33.5</td>
<td>39.5±35.6</td>
<td></td>
<td>0.03</td>
</tr>
</tbody>
</table>
ACURASYS Trial

- Safety: No difference in muscle strength or ICU-acquired weakness

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<thead>
<tr>
<th>Outcome</th>
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<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>MRC score — median (IQR)§</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>At day 28</td>
<td>55 (46–60)</td>
<td>55 (39–60)</td>
<td>1.07 (0.80–1.45)</td>
<td>0.49</td>
</tr>
<tr>
<td>At ICU discharge</td>
<td>55 (43–60)</td>
<td>55 (44–60)</td>
<td>0.92 (0.71–1.19)</td>
<td>0.94</td>
</tr>
<tr>
<td>Patients without ICU-acquired paresis¶</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>By day 28 — no./total no. (% [95% CI])</td>
<td>68/96 (70.8 [61.1–79.0])</td>
<td>52/77 (67.5 [56.5–77.0])</td>
<td>0.64</td>
<td></td>
</tr>
<tr>
<td>By ICU discharge — no./total no. (% [95% CI])</td>
<td>72/112 (64.3 [55.1–72.6])</td>
<td>61/89 (68.5 [58.3–77.3])</td>
<td>0.51</td>
<td></td>
</tr>
</tbody>
</table>

- Critics question whether tests used adequately sensitive

Potential Mechanisms for Paralysis

- Minimize biotrauma
- Minimize atelectrauma & improve homogeneity
- Minimize barotrauma/volutrauma
Potential Mechanisms for Paralysis

- Minimize biotrauma
Potential Mechanisms for Paralysis

- Minimize biotrauma
  - Direct anti-inflammatory effect(?)
  - Secondary effect of preventing ventilator-induced lung injury
- Minimize atelectrauma & improve homogeneity
  - Inhibit active expiration
    - Allows PEEP to translate into sustained recruitment
- Minimize barotrauma/volutrauma
  - Inhibit active inspiration
Paralysis to Minimize Barotrauma

- With paralysis, less:
  - Barotrauma
  - Pneumothorax

---

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<td>57 (32.2 [25.8–39.4])</td>
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<td>0.78 (0.59–1.03)</td>
<td>0.08</td>
</tr>
<tr>
<td>Barotrauma — no. (% [95% CI])‡</td>
<td>9 (5.1 [2.7–9.4])</td>
<td>19 (11.7 [7.6–17.6])</td>
<td>0.43 (0.20–0.93)</td>
<td>0.03</td>
</tr>
<tr>
<td>Pneumothorax — no. (% [95% CI])</td>
<td>7 (4.0 [2.0–8.0])</td>
<td>19 (11.7 [7.6–17.6])</td>
<td>0.34 (0.15–0.78)</td>
<td>0.01</td>
</tr>
</tbody>
</table>

Paralysis Prevents Lung Injury?

- No difference between study arms in…
  - Ventilator mode: volume assist-control
  - Protocolized tidal volume: 6-8 mL/kg PBW
  - Actual set tidal volume: 6.5 ± 1.0 mL/kg PBW
  - Plateau pressure: 25 ± 5 cmH₂O
  - PEEP titration protocol: ALVEOLI low-PEEP

- Biological plausibility of barotrauma prevention?
Breath Stacking Dyssynchrony

- *Breath stacking*: Consecutive inspiratory cycles with incomplete exhalation between them

Breath Stacking Dyssynchrony

- *Breath stacking*: Consecutive inspiratory cycles with incomplete exhalation between them

- Single-center study of 20 ARDS patients
  - Volume assist-control
  - $V_T$ set by clinician: 5.9 mL/kg PBW
  - $V_T$ stacked breaths: 10.1 mL/kg PBW
  - Stacked breath rate: 2.3 ± 3.5 breaths/min (~10% of all breaths)

Breath Stacking Dyssynchrony

• Volume delivered by ventilator exceeds set $V_T$

• “… But that’s why we use volume-targeted ventilation”

• Misconception of volume assist-control mode
  • *False claim:* Clinician sets $V_T$
  • *Fact:* Clinician sets inspiratory cycle volume
  • *Implication:* Patient determines # of inspiratory cycles per breath/effort
    Patient determines “true” tidal volume!
More to Come on Paralysis…

- NHLBI PETAL Network
  - Prevention & Early Treatment of Acute Lung Injury
- ROSE Trial
  (Re-evaluation Of Systemic Early Neuromuscular Blockade)
  - Multicenter RCT at ~50 US hospitals
  - Intervention: Cisatracurium per ACURASYS
  - Control: Usual care, emphasizing light sedation
- Ancillary Study
  - Measure breath stacking dyssynchrony in both arms
  - Hope to provide insights into individualized therapy
Overview

• Paradigm Shift
  • Gas exchange vs. mechanics
  • Baby lung & inhomogeneity

• Evidence-based Management
  • Prone positioning
  • PEEP titration
  • Neuromuscular blockade

• The Controversy
  • Pulmonary vasodilators
  • ECMO
  • “Rescue” therapies
Pulmonary Vasodilators & ECMO

• **Pulmonary vasodilators**
  • No clinical study has demonstrated definitively survival benefit
    • Prior randomized trials of iNO did not use low $V_T$
    • *My Opinion* **I have no data testing this opinion**
      • Population likely to benefit (if any) is ARDS with cor pulmonale and RV failure on high-dose vasopressors

• **ECMO: CESAR Trial**
  • Randomized to ECMO Center transfer vs. no transfer
  • Mortality benefit with transfer to ECMO center
    • 25% randomized to hospital transfer did not receive ECMO
    • Low $V_T$ 23% less common in control arm
  • *My Opinion*: Target ECMO population unknown. May be useful, but evidence not yet there. Not standard of care in US.

ARDS Rescue Therapies

• None!
  • No therapy newly initiated late in ARDS course (after 2-3d) has ever been shown to have clinical benefit

• Implications
  • Proning, high PEEP, and/or neuromuscular blockade must be initiated early in ARDS course

• Suggestion
  • Think of ARDS like sepsis
    • Lung protection must be initiated early (within first 24-48h) to afford survival benefit
    • If this “critical window” is missed, ideal management unknown
Conclusions
Conclusions

• Paradigm shift in approach to mechanical ventilation
  • Maintain blood gas compatible with life
    • Need not be normalized (worse PaO₂:FiO₂ with low Vₜ)
  • Do so using strategies that also prevent ventilator-induced lung injury
    • Improve lung homogeneity & increase baby lung size
    • Prevent occult overdistension

• Proven survival benefit if PaO₂:FiO₂ ≤ 150 from:
  • Prone positioning
  • High PEEP (some controversy)
  • Neuromuscular blockade
Conclusions

• Practical approach if $\text{PaO}_2::\text{FiO}_2 \leq 150-200$
  • 1) Increase PEEP using standardized protocol
    • *Especially for obese patients*
    • Downside: less compelling evidence than paralysis or proning
  • 2) Neuromuscular blockade x 48 hours
  • 3) Prone position
    • Stronger evidence than high PEEP if willing to commit & train your ICU
Thank You

Questions?

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Extra Slides (Not Presented)

How to Prone in 5 Simple Steps
Extra Slides: Steps in Proning

- Step 1: Prepare
- Step 2: Lateral move
- Step 3: Side-lying position
- Step 4: Complete proning
- Step 5: Post-proning management


Extra Slides: Steps in Proning

• Step 1: Prepare
  • 3-4 staff required, including one to manage head
  • Confirm adequate sedation and hemodynamic status
  • Equipment check
    • Ensure IV lines are long enough and secure
    • Move ventilator as close to patient as possible
    • Secure endotracheal and gastric tubes
    • New electrodes to place on back
  • Patient safety
    • Protect skin at forehead, knees, iliac crest, and thorax
    • Close eyelids to protect eyes
  • Confirm direction of move

Extra Slides: Steps in Proning

• Step 1: Prepare
• Step 2: Lateral move
  • Move patient laterally using bed sheet
  • Recommend moving toward side of central line
  • Place patient’s opposite hand under backside
  • Prepare new bed sheet, tuck under patient

Extra Slides: Steps in Proning

• Step 1: Prepare
• Step 2: Lateral move
• Step 3: Side-lying position
  • Rotate patient 90° to side-lying position
  • Remove electrodes from chest and attach to back

Extra Slides: Steps in Proning

- Step 1: Prepare
- Step 2: Lateral move
- Step 3: Side-lying position
- Step 4: Complete proning
  - Remove old bed sheet
  - Pull new bed sheet to position in center of bed
  - Turn head laterally
Extra Slides: Steps in Proning

- Step 1: Prepare
- Step 2: Lateral move
- Step 3: Side-lying position
- Step 4: Complete proning
- Step 5: Post-proning management
  - Rotate head every 2 hours
  - Avoid ear kinking
  - Ensure eyelids closed