Acute Respiratory Failure and Acute Respiratory Distress Syndrome

Maneesh Bhargava

Case: History (First 24 hours)

- 64 YOM with history of hypertension
- Witnessed out of hospital cardiac arrest (V fib)
  - prolonged time for ROSC
- Intubated during resuscitation
- ST elevation
  - LHC: 3 Vessels CAD but TIMI 3 flow in all vessels.
  - LVEF 40%
- Hypothermia protocol initiated
- Difficult to ventilate
- Bronchoscopy demonstrated aspirated material in the airway (? pieces of chicken)
First 24 hours

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>HR</td>
<td>143</td>
</tr>
<tr>
<td>BP</td>
<td>110/18</td>
</tr>
<tr>
<td>Lactic Acid</td>
<td>2.8</td>
</tr>
</tbody>
</table>

- Needs multiple vasopressors
  - Vasopressin, Dobutamine, Norepinephrine
- ABG on 100% FiO₂
  - pH: 7.17
  - PCO₂: 64
  - PO₂: 61
- N-Terminal Pro BNP: 639

Imaging

CXR at admission

CXR 4 hours later
Normal Lung Structure

Alveolar Structure
Respiratory Failure

**Hypoxemic** (Oxygenation failure)  
\[ \text{PaO}_2 \leq 60 \text{ mm Hg on 60\% Oxygen} \]

**Hypocapnic** (Ventilatory failure)  
\[ \text{PaCO}_2 \geq 60 \text{ mm Hg and pH < 7.35} \]

Insufficient \textit{Oxygen} transferred into the blood

Insufficient \textit{CO}_2 removal from the blood

Hypocapnic respiratory failure

Acute (minutes to hours)  
Chronic (days or longer)

Causes of Respiratory Failure

**Hypoxemic Respiratory Failure**
V/Q mismatch- shunt physiology

**Hypocapnic respiratory failure**
Alveolar hypoventilation /dead space
ARDS: History

- Vietnam lung
- Da Nang Lung
- Shock lung
  Hum Pathol 1974; 5:121-1
- Post traumatic lung
  J Trauma 8:63–983, 1968
- Congestive Atelectasis
- Respirator Lung
  Minn Med 1967, 50:1693-1705

- Acute Respiratory Distress in Adults
  ‘The clinical pattern .... includes severe dyspnea, tachypnea, cyanosis that is refractory to oxygen therapy, loss of lung compliance, and a diffuse alveolar infiltrate seen on chest X-Ray’


- Adult Respiratory Distress Syndrome
What is ARDS

- **Inflammatory lung injury**
  - Increased vascular permeability
  - Increased extravascular lung water

- **Clinical hallmarks**
  - Hypoxemia
  - Decreased lung compliance.

- **Histology**
  - Diffuse alveolar damage

The ARDS Definition Task Force. JAMA. 2012;307(23):2526-2533

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Pathogenesis

Pathogenesis

Chest imaging (CXR or CT)
- Bilateral opacities (not explained by effusions, lung collapse or nodules)

Origin of edema
- Respiratory failure not fully explained by cardiac failure or fluid overload.
- Need objective assessment (Eg. Echo) to exclude hydrostatic edema

Berlin Definition of ARDS

Timing
Within 1 week of known clinical insult

JAMA. 2012;307(23):2526-2533
**Berlin Definition of ARDS**

<table>
<thead>
<tr>
<th>Severity of ARDS</th>
<th>PaO₂:FiO₂</th>
<th>PEEP or CPAP ≥ 5 cm H₂O</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mild*</td>
<td>200-300 mm Hg,</td>
<td></td>
</tr>
<tr>
<td>Oxygenation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Moderate</td>
<td>100-200 mm Hg,</td>
<td></td>
</tr>
<tr>
<td>Severe</td>
<td>≤ 100 mm Hg,</td>
<td></td>
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* Term ALI removed

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**Etiology**

**Direct Injury**
- Pneumonia
- Gastric aspiration
- Lung contusion
- Fat emboli
- Near Drowning
- Inhalation injury
- Reperfusion injury
  - Lung transplant
  - Pulmonary embolectomy

**Indirect Injury**
- Sepsis
- Severe trauma with shock & multi-transfusions
- Cardiopulmonary bypass
- Drug overdose
- Acute pancreatitis
- Blood transfusion

*JAMA. 2012;307(23):2526-2533*
Case

Clinical Findings
- Onset: Acute
  - (aspiration of gastric contents)
- B/L opacities
- $\text{PaO}_2: \text{FiO}_2 = 61$
- ? About left heart
  - BNP low
  - LVEF resonable

Epidemiology of ARDS

<p>| | |</p>
<table>
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<tbody>
<tr>
<td>Annual incidence</td>
<td>190,600</td>
</tr>
<tr>
<td>Annual mortality</td>
<td>74,500</td>
</tr>
<tr>
<td>Mortality</td>
<td>38.5%</td>
</tr>
</tbody>
</table>

- Hospital days: 3.5 million
- ICU days: 2.1 million

Long term care
- Long term limitations
  - Decreased endurance
  - Psychological issues

Rubenfeld. NEJM; 353: 1685-93 Oct 2005
Clinical Manifestations

- Admission for at risk conditions
- Severe hypoxemia refractory to oxygen therapy
  - Decreased lung compliance
- Multiorgan dysfunction is usually present
- Recovery usually starts by week two
- Progressive respiratory failure in some patients

Treatment

- Supportive care
- Mechanical Ventilation
- Refractory Hypoxemia
- Fluid management strategy
Case - Day 3

- More episodes of V fib arrest
- Lactic acid peak 12.0
- Ventilator Settings
  Mode: Assist Control
  Tidal Volume: 600
  RR: 24
  PEEP: 12
  FiO₂: 1.00
- Plateau pressure: 24
- ABG: 7.28/44/58

Mechanical Ventilation

- Goals
  - Maintain oxygenation with FiO₂ < 60%
  - Buy time for lung to heal
  - Prevent Ventilator Induced Lung Injury (VILI)
- Ventilator issues
  - What type of ventilator?
  - What mode of ventilation?
  - What is the optimal tidal volume?
  - What is optimal PEEP?
1. Lung Protective Ventilation

- Randomization to 2 ventilator strategies
  - Conventional ventilation
    - 12 ml/kg (Plateau pressure 45-50 cm of H₂O)
  - Low tidal volume
    - 6ml/kg (Plateau pressure 25-30 cm of H₂O)

- Primary endpoint
  - Death before discharge
  - Breathing without assistance

- Results
  - Tidal volume: 6.2 vs. 11.8 ml/kg PBW
  - Lower mortality: 31% vs. 40%


2. Early Neuromuscular Blockade

- Early severe ARDS with PF ratio < 150
- Mechanical ventilation with 6 - 8 ml/kg
- Cisatracurium
  - 15 mg bolus
  - 37.5 mg/hour for 48 hours
- Pneumothorax more in placebo

3. Prone ventilation

- Severe ARDS with PF ratio < 150
- Strict exclusion criterion
  - ~ 1,400 patients screened
  - 474 randomized
- Prone ventilation group
  - 17 ± 3 hours per day
  - 4 ± 4 days per patient


Treatment of Refractory Hypoxia

- Inhaled pulmonary vasodilators
  - Prostacyclin
  - Nitric oxide
- Recruitment maneuvers
  - More effective in indirect lung injury
  - Unproven safety
  - Best strategy unknown
- Extracorporeal oxygen support

JAMA, 2009; 302, No: 1838
ECMO for ARDS: CESAR Trial

Lancet. 2009 Oct 17; 374(9698):1330

Is there an optimal fluid strategy in ARDS
Fluid strategy in ARDS

- Inclusion
  - All patients who met ALI/ARDS
- Target CVP
  - Liberal: 10-14 mm Hg
  - Conservative: < 4 mm Hg
- Results
  - Dialysis need: Same
  - ICU free days: Higher in fluid conservative group

Other supportive measures

- Daily interruption of sedation
- Ventilator bundle
  - HOB > 30 degrees
- Stress hyperglycemia management
- Stress ulcer prophylaxis
- DVT prophylaxis
- Prevention of nosocomial infections
### Specific therapy for ARDS

<table>
<thead>
<tr>
<th>No Benefit</th>
<th>Probably No Benefit</th>
<th>Possible &amp;/or ? Subgroup Benefit</th>
<th>Proven Benefit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Early PEEP</td>
<td>N-Acetyl cysteine</td>
<td>Fluid restriction; diuresis</td>
<td>Lower Vt + P limit (ARDSNet)</td>
</tr>
<tr>
<td>Anti-LPS Abs</td>
<td>Increased SOT</td>
<td>HR Surfactant apoprotein</td>
<td>NM Blockade</td>
</tr>
<tr>
<td>PGE1</td>
<td>Liquid Ventilation - Perflubron</td>
<td>Liposomal PGE1</td>
<td>Prone Ventilation</td>
</tr>
<tr>
<td>Exosurf</td>
<td>Ketoconazole</td>
<td>Antioxidant vitamins</td>
<td>ECMO</td>
</tr>
<tr>
<td>Early steroids</td>
<td>High PEEP</td>
<td>Albumin infusion</td>
<td></td>
</tr>
<tr>
<td>NSAIDs</td>
<td>Late steroids</td>
<td></td>
<td></td>
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<tr>
<td>High frequency Oscillation</td>
<td>Beta-agonists</td>
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<tr>
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<td>Swan Ganz use</td>
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### Case-Outcome

- Lung protective ventilation
- Needed 19 infusion pumps at point of time for care in the ICU
- Prone ventilation
- Gas exchange improved and taken off the ventilator
- Discharged after ~3 weeks of ICU/hospital stay
• Molecular phenotyping in ARDS
  Identify targeted therapy
• Early recognition of ARDS
• Prevention of ARDS

Nutrition in ARDS

**ASPEN and SCCM Guidelines**

• EN in critically ill patients
  • Initiate if unable to maintain volitional intake (Grade C)
  • Should be started early (within 24-48 hours) (Grade C)
• EN is preferred over TPN (Grade B)
• Withhold EN till full resuscitation in setting of compromised hemodynamics (Grade E)
• Bowel sound not required to initiate EN (Grade E)
• Either gastric or post pyloric tube is acceptable (Grade E)