ARDS

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ARDS

- Protein rich pulmonary edema due to vascular injury
- Leads to increased shunt (Qs/Qt) with poor response to oxygen (need to recruit)
- Potential RV failure due to hypoxic pulmonary vasoconstriction
Definition

- **Non cardiogenic** pulmonary edema due to increased permeability
- PAOP < 18 mmHg
- PaO2/FiO2 ratio < 200 mmHg (200-300 is ALI)
- Acute bilateral infiltrates

Crit Care Clin 2011;27:429-437
Problems with definition

- Acute ??
- PA catheter not used that much anymore
- PEEP applied prior to diagnosis
Etiology

ANY condition that creates a systemic inflammatory response may cause ALI-ARDS

Curr Opin Crit Care 2010;16(1):62-68
Direct ARDS (pulmonary)

- Inhalation injury
- Aspiration
- Lung contusion
- Pneumonia

Crit Care Clin 2011;27:439-458
Indirect ARDS (non pulmonary)

- Pancreatitis
- Burns
- Trauma
- SEPSIS
- Massive transfusions (NOT typical TRALI)

Crit Care Clin 2011;27:439-458
Case

23 yo G1P0 26 weeks pregnant. Diagnosis is pyelonephritis. Antibiotics and LR at 125 cc/hour are started. After 3 hours, patient is tachypneic and SpO2 is 78% on room air.
Case
Case

- ABG shows a PaO2 of 53 mmHg while on non-rebreathing mask
- PaO2/FiO2 ratio: 66
- Chest X Ray: bilateral infiltrates

- TTE: Normal left heart

Diagnosis: Non cardiogenic pulmonary edema
Treatment

Ventilatory

- Lung protective mechanical ventilation
- Non invasive mechanical ventilation?
- Recruitment maneuvers
- Prone ventilation
- APRV
- HFOV
- ECMO/ECCO2 removal
Treatment

- Non-ventilatory

  Conservative fluid strategy
  Inhaled NO and PGI2
  Immunonutrition
  Neuromuscular blockers
  Glucocorticoid therapy
Ventilatory treatment

- Inadequate management with positive pressure ventilation may lead to ALI/ARDS by itself
- VILI
  - Volutrauma
  - Barotrauma
  - Atelectotrauma
  - Biotrauma

NEJM 2007;357(11):1113-1120
Figure 2. Conventional Ventilation as Compared with Protective Ventilation.

This example of ventilation of a 70-kg patient with ARDS shows that conventional ventilation at a tidal volume of 12 ml per kilogram of body weight and an end-expiratory pressure of 0 cm of water (Panel A) can lead to alveolar overdistention (at peak inflation) and collapse at the end of exhalation. Protective ventilation at a tidal volume of 6 ml per kilogram (Panel B) limits overinflation and end-expiratory collapse by providing a low tidal volume and an adequate positive end-expiratory pressure. Adapted from Tobin.††

Ventilatory treatment
Lung protective mechanical ventilation

- The **ONLY** intervention that has decreased mortality in ARDS
- TV of 6 ml/kg versus 12 ml/kg
- Plateau pressure < 30 cmH20
- Mortality dropped from 40% to 31%

*NEJM 2000;342:1301-1308*
Lung protective mechanical ventilation
Table 1. Settings for Positive End-Expiratory Pressure (PEEP), According to the Required Fraction of Inspired Oxygen ($FiO_2$).*

<table>
<thead>
<tr>
<th>$FiO_2$</th>
<th>PEEP</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.3</td>
<td>5</td>
</tr>
<tr>
<td>0.4</td>
<td>5–8</td>
</tr>
<tr>
<td>0.5</td>
<td>8–10</td>
</tr>
<tr>
<td>0.6</td>
<td>10</td>
</tr>
<tr>
<td>0.7</td>
<td>10–14</td>
</tr>
<tr>
<td>0.8</td>
<td>14</td>
</tr>
<tr>
<td>0.9</td>
<td>14–18</td>
</tr>
<tr>
<td>1.0</td>
<td>18–24</td>
</tr>
</tbody>
</table>
Lung protective mechanical ventilation

Goal is a PaO2 $\geq 55$ mmHg and SpO2 $\geq 88\%$
Lung protective mechanical ventilation and pregnancy

- Plateau pressure may be as high as 35 cmH2O
- PaCO2 will rise (permissive hypercapnia), potentially leading to fetal acidemia
- Evaluate fetal strip
- Could use TV slightly higher than 6 ml/kg

\[ \text{LBW} = 45.5 + 0.91 \times (\text{cm}-152.4) \]
Lung protective mechanical ventilation

- Minute ventilation: RR x TV
- May increase RR up to 35/minute
- May use NaHCO3 drips if Ph <7.15
- May increase TV by 1 ml/kg if Ph <7.15

NEJM 2000;342:1301-1308
Non Invasive Mechanical Ventilation in ALI-ARDS

- May use but careful

- 1/3 of patients are candidates, in which may avoid intubation in 50% of cases

Crit Care Med 2007;35:288-290
Non ventilatory therapy

- In patients with non cardiogenic pulmonary edema avoid excessive fluid therapy.

- Sepsis has 2 different phases, initially needs massive fluid resuscitation. Later may restrict fluid therapy!
Non ventilatory therapy

- The recent FACTT trial compared liberal vs conservative fluid management in patients NOT in shock with ALI/ARDS.

- Patients on conservative fluid arm had less ventilator days, less ICU days, and a tendency to decreased 60-day mortality.

### Table 2—Simplified Algorithm for Conservative Management of Fluids in Patients With ALI, Based on Protocol Used in the FACTT*

<table>
<thead>
<tr>
<th>CVP, mm Hg (Recommended)</th>
<th>PAOP, mm Hg (Optional)</th>
<th>MAP ≥ 60 mm Hg and Not Receiving Vasopressors for ≥ 12 h</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Average Urine Output &lt; 0.5 mL/kg/h</td>
</tr>
<tr>
<td>&gt; 8</td>
<td>&gt; 12</td>
<td>Furosemide†; reassess in 1 h</td>
</tr>
<tr>
<td>4–8</td>
<td>8–12</td>
<td>Fluid bolus as fast as possible†; reassess in 1 h</td>
</tr>
<tr>
<td>&lt; 4</td>
<td>&lt; 8</td>
<td>Fluid bolus as fast as possible†; reassess in 1 h</td>
</tr>
</tbody>
</table>

*CVP = central venous pressure; PAOP = pulmonary artery occlusion pressure; MAP = mean arterial pressure. Reprinted with the courtesy of the NHLBI Acute Respiratory Distress Syndrome Network. Patients must have had a MAP of > 60 mm Hg without requiring vasopressors for at least 12 h before this protocol is initiated.

†Furosemide dosing: begin with a 20-mg bolus, 3 mg/h infusion, or last known effective dose. Double each subsequent dose until the goal is achieved (oliguria reversal or intravascular pressure target), with a maximal dose of 160-mg bolus or 24 mg/h. Do not exceed 620 mg/d. If the patient has heart failure, treatment with dobutamine may be considered. Diuretic therapy should be withheld for patients with renal failure, which is defined as dialysis dependence, oliguria with a serum creatinine level of > 2 mg/dL, or oliguria with a serum creatinine level of < 2 mg/dL but with urinary indices indicative of acute renal failure.

‡Fluid bolus: 15 mL/kg crystalloid (round to nearest 250 mL) or 1 unit of packed RBCs or 25 g of albumin.
Non ventilatory therapy

Methylprednisolone Infusion in Early Severe ARDS*

Results of a Randomized Controlled Trial

G. Umberto Meduri, MD, FCCP; Emmel Golden, MD; Amado X. Freire, MD, MPH, FCCP; Edwin Taylor, MD; Muhammad Zaman, MD; Stephanie J. Carson, RN; Mary Gibson, RN; and Reba Umberger, RN, MS
Steroids for ARDS

- Low dose methylprednisolone in early ARDS lead to less ventilator days, less ICU mortality and faster shock reversal
- Immunomodulation
- No increase in infections or hyperglycemia
- DON’T do if onset ≥ 2 weeks

CHEST 2007; 131(4): 954-963
Crit Care Med 2012
Methyl prednisolone drip

1 mg/kg per day for 14 days
0.5 mg/kg per day for 1 week
0.25 mg/kg/day for 4 days
0.125 mg/kg per day for 3 days
Non ventilatory therapy

- Muscle paralysis with cisatracurium for 48 hours

- Early enteral nutrition (controversial role of anti-oxidants and Omega 3 FAs)

**NEJM 2010;363(12):1107-1116**
Cardiogenic pulmonary edema

- TTE
- Swan Ganz Catheter
- Non invasive CO monitors
Cardiogenic pulmonary edema

- Limit fluids and sodium
- Morphine 2-4 mg IV q 1-2 hours
- Furosemide (bolus or infusion: no difference)
- Not inferior to ultrafiltration

NEJM 2012;367:2296-2304
NEJM 2011;364:797-805
Cardiogenic pulmonary edema

- Nitroglycerin infusion
  10-200 mcg/min, increase q 5 minutes

- Inotropes
  Dobutamine  2.5-20 mcg/kg/min
  Milrinone   0.25-0.75 mcg/kg/min
Decrease afterload!

- Systolic dysfunction
  - Nicardipine
  - Clevidipine
  - Nitroprusside

- Diastolic dysfunction
  - Calcium channel blockers
  - Beta blockers
Cardiogenic pulmonary edema

- Mechanical ventilation
  - Non Invasive (CPAP, BiPAP)
  - Invasive
    - IABP, LVAD
THANK YOU