Evaluation of Peak and Plateau Pressure in Acute Respiratory Distress Syndrome

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Introduction

- Epidemiology
  - Annual incidence is 64 per 100,000 person years
- Mortality
  - Estimated to be 40-50%
- Common causes of ARDS
  - Sepsis, aspiration, pneumonia, massive transfusion, severe trauma, intracranial hemorrhage and burns
Definition

- Acute onset of impaired gas exchange with presence of bilateral alveolar or interstitial infiltrates in the absence of congestive heart failure.
Original Definition

- Acute onset
- Bilateral Infiltrates
- No clinical evidence of left heart failure

<table>
<thead>
<tr>
<th>PaO2:FiO2 Ratio</th>
<th>Acute Lung Injury</th>
<th>Acute Respiratory Distress Syndrome</th>
</tr>
</thead>
<tbody>
<tr>
<td>≤ 300</td>
<td></td>
<td>≤200</td>
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</table>
## Berlin Definition 2012

**Table 3. The Berlin Definition of Acute Respiratory Distress Syndrome**

<table>
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<tr>
<th><strong>Timing</strong></th>
<th>Acute Respiratory Distress Syndrome</th>
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<tr>
<td>Within 1 week of a known clinical insult or new or worsening respiratory symptoms</td>
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<tr>
<th><strong>Chest imaging</strong> (^a)</th>
<th>Bilateral opacities—not fully explained by effusions, lobar/lung collapse, or nodules</th>
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<tr>
<th><strong>Origin of edema</strong></th>
<th>Respiratory failure not fully explained by cardiac failure or fluid overload. Need objective assessment (eg, echocardiography) to exclude hydrostatic edema if no risk factor present</th>
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<tr>
<th><strong>Oxygenation</strong> (^b)</th>
<th></th>
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<tbody>
<tr>
<td><strong>Mild</strong></td>
<td>200 mm Hg &lt; PaO(_2)/FiO(_2) ≤ 300 mm Hg with PEEP or CPAP ≥5 cm H(_2)O(^c)</td>
</tr>
<tr>
<td><strong>Moderate</strong></td>
<td>100 mm Hg &lt; PaO(_2)/FiO(_2) ≤ 200 mm Hg with PEEP ≥5 cm H(_2)O</td>
</tr>
<tr>
<td><strong>Severe</strong></td>
<td>PaO(_2)/FiO(_2) ≤ 100 mm Hg with PEEP ≥5 cm H(_2)O</td>
</tr>
</tbody>
</table>

Abbreviations: CPAP, continuus positive airway pressure; FiO\(_2\), fraction of inspired oxygen; PaO\(_2\), partial pressure of arterial oxygen; PEEP, positive end-expiratory pressure.

\(^a\) Chest radiograph or computed tomography scan.

\(^b\) If altitude is higher than 1000 m, the correction factor should be calculated as follows: \([\text{PaO}_2/\text{FiO}_2 \times (\text{barometric pressure}/760)]\).

\(^c\) This may be delivered noninvasively in the mild acute respiratory distress syndrome group.

Et al. JAMA 2012; 307: 2530
Pathophysiology

- Mechanical ventilation can contribute to worsening of lung injury
- Aerated lung volume in ARDS is vastly reduced due to edema and atelectasis
- High tidal volumes against stiff nonaerated lung tissue results in decreased compliance and increased airway pressure
- Excessive volume and pressure lead to over distention and damage to occur
- Mechanisms of injury: release of proinflammatory cytokines, direct physical damage, disruption of alveolar epithelium and capillary epithelium
What works: Evidence based management of ARDS

- Treat the underlying cause
- Low tidal volume ventilation (2)
- Early proning (3)

2. ARDS Network NEJM 2000; 342:1301
3. Guerin et al. NEJM. 2013; 368:2159
Predictors of Mortality

- Driving pressure?

Pressure in ARDS

- Plateau pressure is predictive of lung injury
  - Pressure directly on alveoli
- Guidelines have suggested plateau pressure less than 30
- Limited data
Plateau Pressure

![Diagram showing the concept of Plateau Pressure, Airway Pressure over time with points for Peak Pressure, Plateau Pressure, and Auto-PEEP during Inspiratory Pause and End-Expiratory Airway Occlusion.]( Courtesy ACP Medicine)
Causes of higher plateau pressures

- Decreased compliance
  - ARDS/heart failure
- Auto-peep
- Mucous plugging
- Pneumothorax
- Main stem intubation (R)
- Compartment syndrome
- Obesity*
Objectives

- **Primary**
  - Demonstrate mortality of peak pressures over 30 and less than 30
- **Secondary**
  - Compliance of monitoring plateau pressures in ARDS cases
Study Design and Methods

- Retrospective study of patients carrying an ICD9 code of ARDS
- Measurement of peak pressures and if plateau pressure is documented
- Data from all 4 Catholic Health Sites
Patient Population

- Adult patients with ARDS on ventilator support at Catholic Health System Sites between 2012 and 2014
Inclusion Criteria

- Adult patients with ARDS based on ICD-9 coding from 2012-2014
- Patients on ventilator support with minimum PEEP of 5
- Patients on PRVC or PC during majority of their illness
Exclusion criteria

- Patients with concurrent congestive heart failure (echocardiography needed to exclude)
- Patients on only nasal cannula, NIPPV, or DNI, comfort care
Methodology

- List of patients with diagnosis of ARDS using ICD-9 accessed
- Exclude diagnosis of concurrent CHF by review of echocardiography or clinical exam
- Ventilator logs will be reviewed for peak airway pressure and plateau pressure at various time courses
At baseline, 62.5% of patients with a PIP $\geq$31 were deceased vs. 16.7% of patients with a PIP <31.
- Chi-squared = 5.882, P=0.015
At 72 hours, 70% of patients with a PIP ≥31 are deceased vs. 27.8% of patients with a PIP <31. chi-squared = 4.680, p = 0.031.
Plateau Pressure

- Only checked on 4 of 29 cases

Plateau Pressure evaluated

Yes  No

0.00%  80.00%  100.00%
Discussion

- Higher peak airway pressures *associated* with higher mortality
- Plateau pressures rarely evaluated
Future Study

- Underdiagnosis
  - Add PiO2:FiO2 to EMR?
- Need to monitor peak airway pressures
- Specifically check a plateau!
  - ? Mandatory plateau q6 hours on ventilator log
References

- Radiopaedia.org, ACP medicine
- Et al. JAMA 2012; 307: 2530
- Ware et al. NEJM 2000; 342: 1334