Impact of Positive End Expiratory Pressure (PEEP) on Heterogeneity of Lung Mechanics and Ventilation Distribution During Acute Respiratory Distress Syndrome (ARDS)

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Regional alveolar flooding and collapse

Heterogeneity of flooding and collapse has an impact on overall *DYNAMIC* lung function

**Selecting PEEP**

**CURRENT PRACTICE:** based on *STATIC* measures

**NEW APPROACH:** based on *DYNAMIC* lung function
The static pressure volume relationship may not provide distinctive guidance in setting mechanical ventilation.

Can the assessment of dynamic lung function be used to guide PEEP setting during ARDS?
**GOALS**

- Use CT scans to assess regional and global static mechanics
- Assess dynamic lung mechanics as a function of PEEP
- Determine if dynamic lung mechanics would be sufficient to guide PEEP setting
Experimental Design

- 5 sheep (ARDS induced via saline-lavage)

- Ventilated for 15m with 100% oxygen at PEEP levels ranging from 7.5 to 20 cmH₂O in steps of 2.5 cmH₂O

- At each PEEP level, we acquired:
  - disease distribution via CT scans
  - dynamic lung mechanics and ventilation pressures
  - blood gases
Regional Lung Mechanics

**Diffuse**

**Localized**

Normalized Volume

Pressure (cmH₂O)

Normalized Volume

Pressure (cmH₂O)

Total Volume (ml)

Pressure (cmH₂O)

Pressure (cmH₂O)

Regional Lung Mechanics

Total Volume

Pressure (cmH₂O)

Volume (ml)

<table>
<thead>
<tr>
<th>Pressure (cmH₂O)</th>
<th>Top</th>
<th>Middle</th>
<th>Bottom</th>
</tr>
</thead>
<tbody>
<tr>
<td>7.5</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>10.0</td>
<td>0.2</td>
<td>0.4</td>
<td>0.6</td>
</tr>
<tr>
<td>12.5</td>
<td>0.4</td>
<td>0.6</td>
<td>0.8</td>
</tr>
<tr>
<td>15.0</td>
<td>0.6</td>
<td>0.8</td>
<td>1.0</td>
</tr>
<tr>
<td>17.5</td>
<td>0.8</td>
<td>1.0</td>
<td></td>
</tr>
<tr>
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<td>1.0</td>
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Pressure (cmH₂O)

Volume (ml)

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<td>50</td>
<td>60</td>
<td>70</td>
<td>80</td>
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**Regional Lung Mechanics**

Regional Lung Mechanics

Total Volume

Pressure (cmH₂O)

Volume (ml)

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CT Analysis of Aeration

Boundary of Lung

Non-Aerated Lung
Normally-Aerated
Over-Aerated
PEEP Dependence of Lung Recruitment

Boundary of Lung

Normally Aerated Lung

Dependent  Non-Dependent
Boundary of Lung

Over Aerated Lung

PEEP Dependence of Lung Overdistension
Tradeoff Between Recruitment and Overdistension

Normally Aerated *

Over Aerated *

* p<0.05 – Variable depends on PEEP level
# p<0.05 – Level different from lowest PEEP

- Requires many CT scans and rapid analysis
- Tracking dynamic lung mechanics may be alternative strategy
PEEP Dependence of Dynamic Lung Mechanics

Dynamic Elastance
- sensitive to derecruitment relative to overdistension

Frequency Dependence of Resistance
- sensitive to heterogeneity

PEEP=7.5
PEEP=12.5
PEEP=15
PEEP=20
**PEEP Dependence of Dynamic Lung Mechanics**

**Frequency Dependence of Resistance**  
(cmH$_2$O/L/s)

**Dynamic Elastance**  
(cmH$_2$O/L)

* p<0.05 – Variable depends on PEEP level  
# p<0.05 – Level different from lowest PEEP
**PEEP Dependence of Clinical Outcome Variables**

**Oxygenation**

<table>
<thead>
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<th>PEEP (cmH₂O)</th>
<th>Oxygenation (mmHg)</th>
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<tbody>
<tr>
<td>7.5</td>
<td>![Graph]</td>
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* p<0.05 – Variable depends on PEEP level

**Peak to Peak Ventilation Pressures**

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# p<0.05 – Level different from lowest PEEP
Conclusions

• Functional impact of ARDS distribution may not be evident in static measures of lung function.

• Dynamic mechanical function is sensitive to heterogeneity and is consistent with CT scans.

• Using dynamic mechanics to set PEEP may be a more effective and practical approach to balancing the relation between normally aerated and overdistended lung.
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