ACUTE RESPIRATORY DISTRESS SYNDROME (ARDS)
ACUTE LUNG INJURY (ALI)

**Definitions**
Acute lung injury is defined as a syndrome of acute lung inflammation with increased vascular permeability, characterized by the following:
1. Bilateral diffuse pulmonary infiltrates on chest radiograph
2. $200 \text{ mmHg} < \text{PaO}_2 / \text{FiO}_2 < 300 \text{ mmHg}$, irrespective of the level of PEEP
3. No clinical evidence of elevated left atrial pressure or pulmonary capillary wedge pressure $<18 \text{ mmHg}$

Acute respiratory distress syndrome is defined as a syndrome of acute lung inflammation with increased vascular permeability, characterized by the following:
1. Bilateral diffuse pulmonary infiltrate on chest radiograph
2. $\text{PaO}_2 / \text{FiO}_2 < 200 \text{ mmHg}$, irrespective of the level of PEEP
3. No clinical evidence of elevated left atrial pressure or pulmonary capillary wedge pressure $<18 \text{ mmHg}$

ARDS and ALI represent the same disease spectrum but differ in severity

**Causes of ARDS/ALI:**

**Direct Pulmonary injury**
- Pneumonia
- Aspiration of gastric contents
- Pulmonary contusion
- Fat emboli
- Near-drowning
- Inhalation of toxic gases
- Reperfusion pulmonary oedema following dissolution of pulmonary emboli

**Extrapulmonary injury**
- Sepsis
- Severe trauma
- Massive transfusion of blood
- Cardiopulmonary bypass
- Drug overdose
- Acute pancreatitis

**Pathophysiology**
- Inflammation of alveoli with diffuse alveolar injury
- Release of pro-inflammatory cytokines
- Recruitment of neutrophils to lung to release reactive oxygen species and protease
- Loss of barrier to alveolar oedema
• Influx of protein rich fluid into alveoli
• Ventilation-perfusion mismatch, physiological shunting, ↑ dead space and impaired lung compliance
• Patchy heterogeneous collapsed and flooding of alveoli

Clinical features: dyspnea, cyanosis, cough

Laboratory findings: non-specific
Hypoxaemia
Elevated alveolar-arterial oxygen gradient

Complications:
• Barotrauma: pneumothorax, pneumomediastinum, interstitial emphysema
• Nosocomial pneumonia
• Biotrauma: Multi-organ failure resulting from injurious local and systemic inflammatory response to ventilator associated lung injury (VALI)

Management
1) Search and treatment of disorders precipitating ARDS/ALI eg pneumonia
2) Respiratory support – Strategy of mechanical ventilation – low tidal volume, appropriate PEEP and permissive hypercapnia
   ● Low tidal volume to reduce “volutrauma”, barotrauma
   ● PEEP to reduce cyclic recruitment/derecruitment (“atelectrauma”) of lung units and redistribute lung water
   ● Permissive hypercapnia – frequent consequence of ventilation with low tidal volumes
   ● In ARDS net trial, patients with increased intracranial pressure were excluded

NIH ARDS Network Lower Tidal Volume Ventilation for ALI/ARDS Protocol
Summary

<table>
<thead>
<tr>
<th>Variables</th>
<th>Protocol</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ventilator mode</td>
<td>Volume assist-control</td>
</tr>
<tr>
<td>Tidal volume</td>
<td>≤6 mL/kg predicted body weight †</td>
</tr>
<tr>
<td>Plateau pressure</td>
<td>≤30 cm H₂O</td>
</tr>
<tr>
<td>Ventilation set rate/pH goal</td>
<td>6–35/min, adjusted to achieve arterial pH ≥7.30 if possible</td>
</tr>
</tbody>
</table>
Inspiratory flow, I:E
Adjust flow to achieve I:E of 1:1–1:3

Oxygenation goal
55 ≤ PaO₂ ≤ mm Hg or 88 ≤ SpO₂ ≤ 95%

FIO₂/PEEP (mm Hg)
combinations†
0.3/5, 0.4/5, 0.4/8, 0.5/8, 0.5/10, 0.6/10, 0.7/10,
0.7/12, 0.7/14, 0.8/14, 0.9/14, 0.9/16, 0.9/18, 1.0/18,
1.0/22, 1.0/24

Weaning
Attempts to wean by pressure support required when FIO₂/PEEP ≤ 40/8

* SpO₂ = oxyhemoglobin saturation by pulse oximetry.

†Predicted body weight for male subjects = 50 + (2.3 x [height in inches - 60])
or 50 + (0.91 x [height in centimeters - 152.4]); predicted body weight for female subjects = 4.5 + (2.3 x [height in inches - 60]) or 4.5 + (0.91 x [height in centimeters - 152.4]).

‡Further increases in PEEP to 34 cm H₂O allowed but not required

- May use pressure controlled ventilation mode (PCV), pressure-regulated volume control (PRVC) or SIMV
- Frequently needs intravenous sedation or even muscle relaxant
- Oxygen toxicity may cause absorption atelectasis and exacerbate lung injury. FIO₂ < 0.6 is usually considered safe

2b) Prone positioning

- May improve oxygenation in many patients (>60%) with ARDS allowing reduction in PEEP and FIO₂
- However, trials have not demonstrated improvement in mortality
- Risks: dislodgement of endotracheal tubes and intravascular catheters, pressure sores, injury to eyes, compromised general nursing care
- No consensus on when it should be used and the duration of prone positioning. One paper suggests the use of prone ventilation if the requirement of FIO₂ ≥ 0.6, PEEP ≥ 10 cm water to maintain SpO₂ ≥ 90%

2c) Recruitment manoeuvres

- Oxygenation of patients with ARDS can be improved by applying a sustained continuous airway pressure by recruiting collapsed alveoli
- No consensus which is the best recruitment manoeuvres
- For example 40 cm water for 40 seconds
- Can be used for patients who have lung derecruitment due to temporary disconnection from ventilators (eg during suctioning of ET tube)
To assess PEEP responsiveness

3) Maintain intravascular volume at the lowest level that is compatible with adequate systemic perfusion to decrease pulmonary oedema, which can occur at lower pulmonary capillary pressure

References