**Lung Recruitment and PEEP Titration for ARDS using PCV Mode of Ventilation**

**Acute Respiratory Distress Syndrome (ARDS)**

A syndrome of acute and persistent lung inflammation with increased vascular permeability. It is characterized by three clinical features:

- Widespread, bilateral radiographic infiltrates.
- PaO2/FiO2 less than or equal to 200 mm Hg, regardless of the level of PEEP.
- No clinical evidence for an elevated left atrial pressure. If measured, the pulmonary capillary wedge pressure is 18 mmHg or less.

**ARDS**

กลุ่มอาการ ARDS เป็นกลุ่มอาการที่เกิดจากการอักเสบทางรูปแบบของปลอดแห้งให้ alveolar capillary membrane ซึ่งประกอบด้วย alveolar epithelial cells และ endothelial cells ได้รับอีสระมาและเกิดการรั่วซึมของสารเคม์ไปสู่อังกฤษจากหลอดเลือดเข้าไปสะสมในเชื้อ interstitium และ alveolar air spaces จนเกิดภาวะ pulmonary edema ขึ้นในที่สุด
Pathogenesis

- Exudative phase
  - Macro: Heavy, rigid, dark
  - Micro: Edema, hyaline membrane, neutrophils, epithelial and endothelial cells damage

- Proliferative phase
  - Macro: Heavy, grey
  - Micro: Edema, barrier disruption, Type II cells proliferation, myofibroblast infiltration

- Fibrotic phase
  - Macro: Cobblestoned
  - Micro: Fibrosis, matrix organization
Ventilating the Patient with ARDS in 2009 and beyond

• Adopt "Lung-protective ventilation strategy".
• Adhere to the ‘open up the lung and keep the lung open’ concept which is the state of the art in ventilation at the present day in adults and pediatrics.*


Lung-Protective Ventilation Strategy in ARDS
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• Maintenance of adequate gas exchange
• Avoidance of ventilator-associated lung injury (VALI)

Maintenance of adequate gas exchange

• Targeted goals of CO2
  – 7.30 ≤ Arterial pH ≤ 7.45
  – End-inspiratory alveolar (Plateau) pressure < 30 cm H2O
• Targeted ranges for oxygenation
  – 55 mm Hg ≤ PaO2 ≤ 80 mm Hg
  – 88% ≤ SpO2 ≥ 95%

Avoidance of ventilator-associated lung injury

• High lung volume injury
  – Small tidal volume: 6 ml/kg predicted BW*
  – Plateau pressure < 30 cm H2O
• Low lung volume injury
  – Optimal PEEP
  – Recruitment maneuver (RM)

Lung Recruitment: The Open Lung Concept

Lung Recruitment: The open lung concept

- It involves the application of methods to open and recruit the lung immediately at the start of artificial ventilation and whenever atelectasis occurs.

- Opening up all recruitable alveoli by applying high inflation pressures (Critical opening pressure to ‘open up the lung’)

- Once the lung is thought to be recruited, keeping the lung open using optimal PEEP (Critical Closing pressure)
How to Open Up the Lung in ARDS (Lung recruitment)

- Manual ventilation by bagging
- Lengthening the end-inspiratory pause during volume-controlled ventilation using a square wave
- Prone positioning
- Recruitment maneuvers

Recruitment Maneuvers (RMs)

- High CPAP technique
  - CPAP 35-40 cm H2O for 30 sec (NIH ARDS Network)
  - CPAP 40 cm H2O for 40 sec (Grasso et al)
- Intermittent sigh
  - Intermittent sigh (3/min) at plateau pressure of 45 cm H2O
- Stepwise increase in PEEP with a fixed pressure control
  - Okamoto et al

Recruitment Maneuvers (RMs)

- Pressure-controlled ventilation with fixed PEEP at 20 cm H2O and increased driving pressures at 20, 25 and 30 cm H2O for two minutes each
Opening up all recruitable alveoli by applying critical opening pressure = 50 cm H$_2$O

Once the lung is thought to be recruited, the decremental PEEP titration was performed in a stepwise fashion to identify the open lung PEEP (OL-PEEP) above critical closing pressure

How to keep the lung open (PEEP Titration)

- Stepwise incremental PEEP titration
  - PEEP titration while monitoring compliance - looking for maximal compliance
- Stepwise decremental PEEP titration**
  - PEEP reduction after initial high PEEP (20-25 cm H$_2$O) - looking for critical closing pressure that associated with reduction in compliance (alveolar collapse)
Stepwise Incremental vs. Decremental PEEP titration

- A decremental PEEP trial after full lung recruitment allows for PEEP titration along the deflation limb of the pressure/volume curve while observing changes in both oxygenation and respiratory mechanics.

How to keep the lung open (PEEP Titration)

- Stepwise PEEP according to oxygenation
  - Titrate PEEP to achieve target oxygenation (55 mm Hg ≤ PaO₂ ≥ 80 mm Hg or 88% ≤ SpO₂ ≥ 95%) then reduce FiO₂
  - Using target scale of FiO₂/PEEP from NIH ARDS Network study 2000

How to keep the lung open (PEEP Titration)

- Setting PEEP at 2 cm H₂O above lower inflection point in static pressure volume curve.