Chapter 79
Approach to Setting PEEP in ARDS Patients in the ICU

79.1 Introduction

Acute respiratory distress syndrome (ARDS) is a severe condition characterized by diffuse alveolar damage, reduced lung compliance, and hypoxemia. Positive end-expiratory pressure (PEEP) is a crucial component of mechanical ventilation in ARDS, aiming to maintain alveolar recruitment, improve oxygenation, and prevent ventilator-induced lung injury. However, setting the appropriate PEEP level requires balancing the benefits of alveolar recruitment against the risks of overdistension and hemodynamic compromise [1, 2] [Ref: Algorithm 79.1].

79.2 Setting PEEP

79.2.1 Ensure the Patient Is Fully Sedated or Paralyzed If Required

- Adequate sedation and/or paralysis reduce patient-ventilator dyssynchrony, allowing controlled delivery of mechanical ventilation. This is especially important when titrating PEEP to prevent erratic pressure changes due to spontaneous breathing efforts.
- Use neuromuscular blocking agents (NMBAs) only if necessary, as excessive paralysis carries risks of critical illness myopathy. Monitor sedation depth using validated scales [3].

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79.2.2 Evaluate Lung Recruitability and Obtain Baseline Values

- Utilize imaging techniques (e.g., CT scans, electrical impedance tomography [EIT]) or bedside evaluations of compliance changes during incremental PEEP trials [4]. This determines the potential for alveolar recruitment. Record the baseline PaO_2/FiO_2, compliance, cardiac output, and mean arterial pressure (MAP).

79.2.3 Assess Patient Stability

- Stable Hemodynamics: Adequate MAP without significant dependence on vasoactive agents.
- Minimal oxygenation requirement adjustments: Stable PaO_2/FiO_2.
- If Unstable: Use lower PEEP to avoid worsening hemodynamics and to minimize barotrauma risks. Reassess after stabilization [5].

79.2.4 Evaluate P/F Ratio (<100 or ≥100)

- P/F < 100:
- Severe ARDS likely benefits from higher PEEP to achieve alveolar recruitment and improve oxygenation.
- Initiate with a PEEP of 24 cm H_2O, then gradually reduce in 2 cm H_2O increments, observing for clinical and physiological improvements (e.g., oxygenation or compliance).
- P/F ≥ 100:
- For moderate ARDS, set low PEEP (6 cm of H_2O) [6].

79.2.5 Monitoring During PEEP Titration

79.2.5.1 Key Parameters

- Oxygenation: Improvements in PaO_2 or PaO_2/FiO_2 suggest effective alveolar recruitment.
- Compliance: Better static compliance indicates optimal lung mechanics with current PEEP.
- Hemodynamics: Monitor for cardiac output reduction or hypotension due to high intrathoracic pressures compressing venous return.
- Overdistension: Watch for plateau pressures >30 cm H_2O, as this indicates risk of barotrauma.

79.2.5.2 Action for Complications

- Reduce PEEP if signs of hemodynamic compromise or overdistension emerge.
- Optimize fluid status and vasoactive support as needed [7, 8].

79.2.6 Reassessment

- Rationale: Changes in patient position, lung pathology, or ventilator settings can alter lung recruitability.
- Frequency: Reassess PEEP settings with any clinical or ventilatory changes to ensure optimal management.
- Tools: Repeat imaging or compliance evaluations to determine the need for adjustment.

79.2.7 Establish Optimal PEEP

- The goal is to identify the PEEP level that provides:
- The best lung compliance.
- Adequate oxygenation with the least FiO_2 requirement.
- Minimal adverse effects, such as overdistension or hemodynamic instability.
- Once identified, maintain this PEEP and continue monitoring patient progress.

Reassess the PEEP setting after every change in ventilator setting or any change in patient positioning in bed.

79.2.8 Other Methods

1. ARDS.net PEEP FiO_2 table: There are specific PEEP as per the FiO_2 requirement [9]
   Lower PEEP/higher FiO_2 table

FiO_2	0.3	0.4	0.4	0.5	0.5	0.6	0.7	0.7	0.7	0.8	0.9	0.9	0.9	1
PEEP	5	5	8	8	10	10	10	12	14	14	14	16	18	18–24

   Higher PEEP/lower FiO_2

FiO_2	0.3	0.3	0.3	0.3	0.3	0.4	0.4	0.5	0.5	0.5–0.8	0.8	0.9	1	1
PEEP	5	8	10	12	14	14	16	16	18	20	22	22	22	24

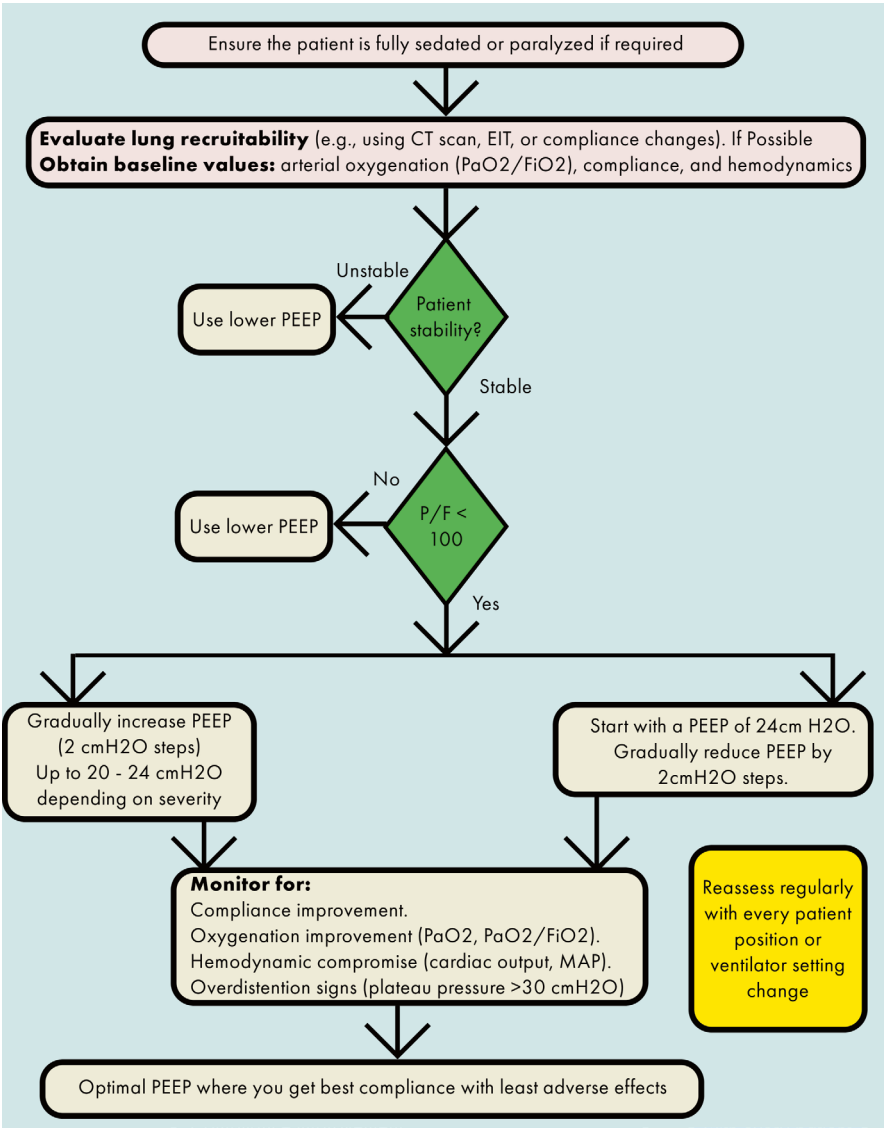
2. Empirical peep: Based on clinical experience and then titrated according to oxygenation and lung mechanics.
3. Recruitment to inflation ratio: PEEP is abruptly reduced by 10 cm of H_2O from 15 to 5. It is calculated as compliance of recruited lung divided by compliance at low PEEP. Recruited volume is the difference of volume during the abrupt fall and the anticipated volume based on compliance at low PEEP.

4. Esophageal manometry: PEEP is adjusted by measuring the esophageal pressure (surrogate of transpulmonary pressure (TPP))—prevents lung collapse and minimizes lung stress. TPP = Plateau pressure—Esophageal pressure ($P_{(plat)} - P_{es}$). Adjust PEEP so that TPP at end-expiration is 0–10. The disadvantages are that it relies on the esophageal balloon position. These readings will not be accurate due to heterogeneity in ARDS patients. P_{es} overestimates pleural pressure in the well-aerated regions of the lung and underestimates it in the dependent regions of the lung.
5. CT scan: PEEP is set depending on the gasless tissue under high and low pressure. Sequential CT scans are done to see the PEEP at which the greatest volume of the lung is recruited.
6. Lung ultrasound: PEEP is set according to reaeration tissue.
7. Electrical impedance tomography (EIT): It offers real-time, bedside imaging of regional lung ventilation, enabling clinicians to assess the distribution of air within the lungs. This tool is particularly useful for titrating PEEP, as it helps identify the optimal level that minimizes both alveolar collapse and overdistension, thereby promoting more uniform and protective ventilation.
8. PEEP should be titrated to the level that results in the smallest difference between arterial and end-tidal CO_2 levels, indicating the point at which physiological dead space is minimized.
9. PEEP slightly above the lower inflection point of the pressure volume curve—not practical to use the hysteresis loop for calculating PEEP.
10. Driving pressure (Dp): It is calculated by subtracting the positive end-expiratory pressure (PEEP) from the plateau pressure (Pplat) (Pplat—PEEP). Target driving pressure below 15 cm of H_2O for improved outcome and mortality.
11. Mechanical power (MP) is a comprehensive measure of the energy transferred from the ventilator to the patient's respiratory system over time. It accounts for the work required to overcome airway resistance during gas movement, the effort needed to inflate the lungs and chest wall, and the energy necessary to counteract the recoil forces associated with end-expiratory pressure, such as PEEP. MP = 0.098 × tidal volume × respiratory rate (Δ Pinsp + PEEP). Higher MP denotes higher work by the ventilator and thus higher chances of ventilator-induced lung injury. The mechanical power is directly proportional to the mortality and outcomes.

79.3 Conclusion

The systematic titration of PEEP in ARDS requires individualized assessment of lung recruitability, oxygenation, and hemodynamics. The algorithm emphasizes starting with stabilization, reassessing lung recruitability, and titrating PEEP based on severity (PaO_2/FiO_2). Continuous monitoring and reassessment are crucial for achieving the optimal balance between oxygenation improvement and adverse effects. This structured approach aligns with evidence-based practices to improve patient outcomes while minimizing ventilator-induced complications.

Algorithm 79.1: Approach to setting PEEP in ARDS patients in the ICU



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