Mechanical Ventilation in ARDS

Key Article

Battaglini D, et al. Ten golden rules for individualized mechanical ventilation in acute respiratory distress syndrome. J Crit Care. 2021; online ahead of print.

Background

- More than 3 million people develop ARDS each year
- Accounts for up to 10% of ICU admissions globally
- Many of these patients require mechanical ventilation, which can also result in lung injury
- Several RCTs and other studies have improved the implementation and adjustment of MV in ARDS

Severity

- ARDS is not a disease but rather a syndrome
- Characterized by inflammatory lung injury
    - Parenchymal stiffening/consolidation
    - Alveolar closure
    - Altered vascular permeability
    - Increase in lung water content
    - Severe gas exchange failure
- Berlin Definition
    - Criteria
        - Acute onset of hypoxemia with respiratory symptoms within 1 week of insult
        - Hypoxemia as measured by PaO2/FiO2 ratio
        - Bilateral opacities on imaging not fully explained by pleural effusion, alveolar/lobar collapse, or nodules
        - Absence of cardiac failure or fluid overload
    - Severity
        - Mild: P/F ratio 200-300; predicted mortality of 27%
        - Moderate: P/F ratio 100-200; predicted mortality of 32%
        - Severe: P/F ratio < 100; predicted mortality of 45%

Tidal Volume / Pplat / Driving Pressure

- ARDSNet Study changed the clinical management of ARDS to focus on lung protective ventilation. Vt of 6 ml/kg PBW with a Pplat of < 30 cm H2O.
- Pplat is an important parameter in the pathogenesis of VILI, along with Vt and PEEP.
- Driving pressure has recently been reported to be better at predicting mortality in ARDS patients.
- Driving pressure is Vt/Crs, where Crs is the respiratory system compliance. Driving pressure represents with distending volume in the respiratory system when Vt is delivered by the ventilator. (Driving Pressure = Pplat – PEEP)

- One study suggested a target driving pressure 13-15 cm H2O.
- Whether PEEP should be set to minimize driving pressure remains controversial.
- At present, adjusting ventilator parameters based on reducing driving pressure is not recommended, and Pplat remains the most important parameter for protecting against VILI.

PEEP

- An essential aspect of ARDS management
- Benefits include alveolar recruitment, reduction of intrapulmonary shunt, and improved arterial oxygenation.
- Detrimental effects include increased end-inspiratory lung volume, elevated risks of volutrauma, and VILI
- Current guidelines recommend reserving high PEEP for moderate to severe ARDS
- Per these authors, the threshold for defining high vs. low PEEP is 12 cm H2O, they do not recommend using an average PEEP > 15 cm H2O as this can compromise hemodynamic function and increase the need for fluids.
- There are currently no definitive recommendations on how to set PEEP. Per these authors, the best way to individualize PEEP is to use a low PEEP/PaO2/FiO2 table.
- PEEP should be set at the lowest level to maintain acceptable SpO2 (88-92%) or PaO2 (55-70 mm Hg). PEEP should be set to also protect the right ventricle, because the recruitment of lung units leads to derecruitment of capillaries. At high PEEP, more IVFs are needed to achieve capillary recruitment and improve RV function.

Recruitment Maneuvers

- The total weight of the lungs in increased in ARDS due to interstitial and alveolar edema. As such, atelectasis results in the dependent areas of the lung.
- The collapse of alveoli reduces surface available for gas exchange and promotes injury due to shear stress from cyclic recruitment and derecruitment.
- Recruitment maneuvers (RMs) can decrease intrapulmonary shunt and improve oxygenation.
- However, they can also lead to hemodynamic impairment and overdistension.
- Various RMs have been used – high airway pressure sustained for a limited time, a stepwise increase in PEEP with a fixed driving pressure, etc.
- At present, the evidence is mixed on efficacy of RMs for ARDS.
- As such, they are not currently recommended in the treatment of patients with severe ARDS.

NMBA

- Patients with severe ARDS may benefit from administration of NMBAs.
- NMBAs may reduce patient-ventilator dysynchrony, reduce O2 consumption, increase compliance, and increase FRC. They may also play a role in limiting derecruitment and maintaining PEEP.
- Long term side effect is muscular weakness.
- Current evidence indicates that NMBAs do not reduce 28- or 90-day mortality, ventilator-free days, or duration of MV. They may, however, improve oxygenation and reduce barotrauma.

Prone Positioning

- The ventilation of dependent areas is severely impaired in the supine position in ARDS patients.
- Gravity dependent areas are more extensively perfused, which results in hypoxemia due to V/Q mismatch.

- Marked improvements in oxygenation are seen in patients with ARDS who are prone as more homogeneous V/Q ratio is achieved and shunt is decreased.
- Prone position not only improves oxygenation, but also reduces risk of VILI
- Though there are conflicting studies on the overall benefits of prone positioning, current guidelines recommend cycles of prone positioning lasting at least 16 hours for patients with a P/F ratio < 150
- It is cost effective and relatively easy to implement
- Considered the best technique for opening up the lungs and keeping them open.

Rescue Therapies

- Inhaled Nitric Oxide
    - Used in ARDS patients that do not respond to conventional treatments
    - Originally first reported in 1987 as a vasodilator to treat pulm HTN, it has been recently shown to improve V/Q mismatch.
    - iNO can be considered
    - Adverse effects include methemoglobinemia, reduced platelet aggregation, systemic vasodilation, and renal dysfunction
- ECMO
    - Current ELSO guidelines recommend initiating ECMO in hypoxic respiratory failure for those with:
        - Mortality risk > 50% (P/F ratio < 150 with FiO2 > 90%)
        - Mortality risk > 80% (P/F ratio < 100 with FiO2 > 90%)
        - Retention of PaCO2 despite maximal ventilator settings
        - Severe air leak syndrome
        - On lung transplant list
    - Relative contraindications include > 7 days of maximal MV settings, immunosuppression, CNS hemorrhage, increased age, or terminal malignancy