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This CPG provides evidence–based guidelines for management of acute respiratory distress syndrome (ARDS) in military trauma patients.
**Summary**

- Lung protective strategies should be implemented for patients with ARDS along with minimizing intravenous fluids and blood product transfusions.

- Early consultation with available support staff and activation of Advanced Critical Care Evacuation team (ACCET) evacuation assets should be considered in patients with ARDS.
Key Principles

- Background
- Diagnosis
- Management
- Transport of ARDS Patients
- Special Situations
- PI Monitoring
- References
- Appendices
Background

- ARDS occurs between 26%-33% of combat casualties.
  - Patients with ARDS had significant increased risk of death (12.8% vs 5.9%).
  - 8% of preventable deaths occur due to multi-organ failure which includes ARDS.

Patient with ARDS chest X-ray
Source: Medical Aspects of Chemical Warfare, Borden Institute.
ARDS Definition

- ARDS is defined as follows:
  - New or worsening respiratory systems within a week of a known injury.
  - Bilateral opacities on chest imaging not fully explained by pulmonary edema, effusions/hemothorax, lobar collapse, or pulmonary nodules.
  - Severity determined by degree of hypoxemia with a Positive End Expiratory Pressure (PEEP) or Continuous Positive Airway Pressure (CPAP) of at least 5 cm H2O.

- ARDS Severity Definitions:
  - Mild ARDS: PaO$_2$ to FiO$_2$ ratio (P:F) of > 200 and ≤ 300
  - Moderate ARDS: P:F of > 100 and ≤ 200
  - Severe ARDS: P:F of ≤ 100
ARDS develops as a result of both direct and indirect injury to the lungs.

- **Direct injury examples**: pulmonary contusion, inhalation injury, pneumonia
- **Indirect injury examples**: multiple transfusions, septic shock, severe acute pancreatitis

Cardiac failure or fluid overload must be ruled out when considering ARDS.

Several other diseases may mimic ARDS and may benefit from lung-protective ventilator management, but require further interventions.

- **Examples**: acute eosinophilic pneumonia, acute interstitial pneumonitis, diffuse alveolar hemorrhage
Diagnosis

- Diagnosis is typically made in patients who have respiratory failure which requires intubation and mechanical ventilation.

- Diagnosis is confirmed by the following steps:
  1. Verify the patient is likely to have respiratory failure from either a direct or indirect pulmonary injury or the need for mechanical ventilation support.
  2. Consider diagnoses which can mimic ARDS.
  3. Obtain a good quality anteroposterior upright chest x-ray (CXR) or CT scan if possible and look for diffuse infiltrates.
  4. If unable to exclude cardiogenic pulmonary edema or fluid overload, consider placing a central venous pressure catheter and obtain transthoracic echocardiogram.
Diagnosis confirmed by the following steps *(continued)*:

5. Place patient on volume or pressure-control ventilation based on ARDSNet Card and obtain an arterial blood gas (ABG) 30 minutes later to calculate the patient’s P:F ratio.

When ARDS is confirmed, document grade (mild, moderate, severe) in patient record along with diagnostic criteria used.

Sample of ARDS Mechanical Ventilator Protocol card. *Source: ARDS Network*
Management Goals

- Safely support gas exchange without further injuring the patient lung.
  - Limit barotrauma ($P_{PLAT} \leq 30$ cm H$_2$O or PIP $\leq 35$ cm H$_2$O)
  - Limit Volutrauma ($V_T$ 6-8 mL/kg Predicted body weight (PBW))
  - Limit Atelectrauma (Moderate to high PEEP)

- Goals should include:
  - $SpO_2 \geq 88-95\%$
  - $pH \geq 7.3$ (in TBI patients $PaCO_2$ should be 35- 40 mm Hg)

- Early consultation with intensivist is encouraged for all patients and is available by phone if needed to either Landstuhl Regional Medical Center or San Antonio Military Medical Center.
Ventilation

- Place patient on Lung-Protective Ventilation Settings according to ARDSNet ventilator management card.
  - Two different PEEP tables on card and either is acceptable.
  - Driving pressure (P_{PLAT} – PEEP) should be minimized.
  - During initial management a V_T of 8 mL/kg may be used, but should be reduced to 6 mL/kg within 2-4 hours.
  - If P_{PLAT} remains above 30 cm H_2O, the tidal volume can be further reduced to 4 mL/kg as long as oxygen delivery to peripheral tissues is normal (normal lactate and base deficit).

- Other modes of ventilation besides volume-assist-control can be used but only at the discretion of an intensivist experienced in ARDS management.
Rescue Oxygenation Therapies

- Limited options in austere environments.

- Low-level recruitment maneuvers performed by holding 40 cm H\textsubscript{2}O for 40 seconds can be done, but should be prepared to manage hemodynamic instability from decreased venous return.

- Inhaled Nitric Oxide (iNO) or Prostacyclin not typically available in theater.

- Advanced ventilator modes such as inverse ratio ventilation or pressure release ventilation should be utilized under supervision of experienced intensivist.
ECLS & ECMO

- **Extracorporeal Life Support (ECLS)**
  - Should be considered early in patients that are failing attempts at lung-protective ventilation.
  - Consider if gas exchange and perfusion goals are not met after 12 hours of lung-protective ventilation and the patient has been paralyzed and proned.
  - Indications for initiating Extracorporeal Membrane Oxygenation (ECMO) for respiratory failure include:
    - P:F ratio < 100 or plateau pressure > 30 cm H₂O despite optimal ventilatory management.
    - Respiratory acidosis with pCO₂>70 and a pH<7.25 despite optimal ventilator management.
    - Initiation of ARDS rescue therapies (PEEP>15, prone, iNO, paralysis).
    - Respiratory failure associated with significant barotrauma.
ECLS & ECMO

- ECMO consultation is available 24 hours a day through U.S. Army Institute of Surgical Research.

  - Early notification and consultation is paramount given time to generate transport capability.

Patient placed on ECMO at Role 3 being prepared for transport

Source: Out Of The Crucible: How The US Military Transformed Combat Casualty Care In Iraq And Afghanistan, Borden Institute
Neuromuscular Management

- Neuromuscular Blockade
  - A 48-hour course of neuromuscular blockade may facilitate use of lung protective strategy and eliminate problems such as ventilator dyssynchrony.
  - Survival benefit if used within 48 hours of ARDS.
  - Cisatricurium is the preferred neuromuscular blockade.

- Prone Positioning
  - Done if disease primarily in lower lobes (based on CXR or CT findings).
  - Initial trial of 2-6 hours with continuation if gas exchange improves.
Fluids & Transfusions

■ Fluid Management
  - Minimize volume infusion as soon as possible.
  - Aggressive diuresis recommended if patient can tolerate it.
  - Continuous Renal Replacement Therapy (CRRT) can be used to eliminate intravascular volume.
  - Albumin infusions combined with diuresis should be considered if the patient has hypoproteinemia.

■ Blood Product Transfusions
  - There is risk of initiating or exacerbating respiratory failure with each unit – especially plasma (7% per unit).
  - Always balance the risk and benefit of blood products.
Corticosteroid Administration
- No benefit in the initial treatment of ARDS.
- Only consider beginning administration in patients with ARDS between day 7 and 13 of onset.

Nutrition and Venous Thromboembolism Prophylaxis
- Enteral feeding preferred with nasojejunal feeding tubes ideally over nasogastric feeding tubes.
- Stress ulcer and chemical venous thromboembolism should be considered in all patients.

Sedation Management and Physical Therapy
- Patients should undergo daily awakening trials and mobilization as early as possible, even while intubated.
ARDS Treatment Algorithm

Possible ARDS
- Acute onset in at-risk patient?
- Diffuse infiltrates
- \( \text{PaO}_2 : \text{FiO}_2 \leq 300 \text{ mmHg} \)

Exam, Bronchoscopy +/- TTE+/− CVP
- CHF/pulmonary edema?
- Multi-lobar pneumonia?
- Acute eosinophilic pneumonitis
- Acute interstitial pneumonitis
- BOOP?
- Diffuse alveolar hemorrhage?

P:F 201-300
- Mild ARDS

P:F 101-200
- Moderate ARDS

P:F \leq 100
- Severe ARDS

General Management
- Minimize IVF/diurese
- Convert IV meds to enteral
- Minimize unnecessary transfusion
- Ensure optimize nutrition
- PPI/H2 blocker
- DVT prophylaxis
- Early mobilization

Ventilator Management
- Measure patient height
- Calculate Predicted Body Weight (PBW)
- Adjust TV to 6-8 mL/kg PBW and dial down to 6 mL/kg
- Use the PEEP/FiO\(_2\) table targeting \( \text{SpO}_2 \geq 88\% \)

Progressive hypoxemia?
- Diurese aggressively
- Increase PEEP to 14 and FiO\(_2\) to 0.7
- ACCET consult/activation

Severe respiratory acidosis (pH<7.15)?
- Increase RR to 35 (watch for auto PEEP)
- THAM or Bicarb gtt
- Consider CRRT
- ACCET consult/activation

Ventilator dyssynchrony?
- Increase air flow rate (>100 mL/min
- Consider chemical paralysis (cisatricurium preferred)

No ARDS
Limitations are imposed by transportation ventilators. Providers should expect PaO₂ will decrease.

Transportation out of theater is routinely done by the Critical Care Air Transport Team (CCATT).

ACCET are available for patients with severe ARDS with or without ECLS.
Transport

- Indications for ACCET transport Include:
  - P:F < 100
  - Inhalation Injury
  - FiO$_2$ > 0.7 or pH < 7.25 on lung-protective ventilation
  - PEEP > 15 cm H$_2$O w/ P$_{PLAT}$ > 30 H$_2$O
  - Severe brain injury with PaCO$_2$ > 40 mm Hg on a transport ventilator
  - Cardiogenic shock refractory to maximal medical therapy
  - Anatomic derangement (i.e. pneumonectomy)
  - Use of advanced ventilator modes such as air pressure release ventilation
  - Acute pulmonary embolism with cardiac arrest or with persistent hypoxemia
  - Multi-system organ failure

- Transport by ACCET initiated by local chief of Trauma or ICU Director by contacting U.S. Transportation Command.
Pediatric trauma patients are at risk of ARDS.

Diagnosis of ARDS uses Oxygenation Index (OI) rather than P:F ratio to grade severity of ARDS.

OI calculated by \[\frac{100 \times \text{Mean Airway Pressure (MAP)}}{\text{P:F}}\]

- Mild ARDS: OI of 4 to < 8
- Moderate ARDS: OI of 8 to <16
- Severe ARDS: OI ≥16
Intent (Expected Outcomes)
- Presence of triggers for ACCET consultation.
- Use of chemical paralysis and prone positioning in a Role 2 or 3 facility.
- Use of ECLS in a Role 2, 3, or 4 facility.

Performance/Adherence Measures
- ACCET consulted appropriately.
- Paralysis utilized appropriately at Role 2 or 3 facilities.
- Prone position utilized appropriately at Role 2 or 3 facilities.

Data Source
- Patient Record
- Department of Defense Trauma Registry (DoDTR)
References

References


References


References


CPG Appendices

- Appendix A: Diagnosis and Management of ARDS
- Appendix B: ARDSNET Ventilator Management for Patients with ARDS
- Appendix C: Prone Positioning in Patients with ARDS
- Appendix D: Additional Information Regarding Off-label Uses in CPGs