ARDS MANAGEMENT: A GENERAL APPROACH

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ARDS

1. Diagnostics
   - Definition
   - Common ARDS mimickers
2. Causes
3. Prognosis
4. Principles of Management

ARDS

Acute Respiratory Distress Syndrome is a form of acute respiratory failure characterized by pulmonary inflammation induced by a local or systemic insult.

ARDS is characterized by

- Non-cardiogenic pulmonary edema
- Inflammatory cell migration into the lungs
- Decreased lung compliance

Pathology most commonly associated with ARDS is diffuse alveolar damage

Acute Respiratory Distress Syndrome

The Berlin Definition

	ACUTE RESPIRATORY DISTRESS SYNDROME		
Timing	Within 1 week of a known clinical insult of new/worsening respiratory symptoms		
Chest Imaging [a]	Bilateral opacities – not fully explained by effusions, lobar/lung collapse, or nodules		
Origin of Edema	Respiratory failure not fully explained by cardiac failure or fluid overload; Need objective assessment (e.g., echocardiography) to exclude hydrostatic edema if no risk factor present		
	Mild	Moderate	Severe
Oxygenation [b]	$200 < PaO_2/FiO_2 \leq 300$ with PEEP or CPAP ≥ 5 cmH_2O [c]	$100 < PaO_2/FiO_2 \leq 200$ with PEEP ≥ 5 cmH_2O	$PaO_2/FiO_2 \leq 100$ with PEEP ≥ 5 cmH_2O

[a] Chest x-ray or CT scan

[b] If altitude higher than 1000 m, correction should be made: $PaO_2/FiO_2 \times$ (barometric pressure/760)

[c] This may be delivered non-invasively in the Mild ARDS group

The ARDS Definition Taskforce. JAMA 2012;307:2526-2533.

Cause of ARDS

Pulmonary examples:

Pneumonia
Aspiration
Pulmonary Embolism
Inhalational lung injury

Non-Pulmonary examples:

Pancreatitis
Extra-pulmonary sepsis
Fulminant hepatic failure
Drug overdose
Trauma

Chest Imaging: ARDS Mimickers

Water

Blood

Eosinophils

Protein

Cancer

Inflammatory cells

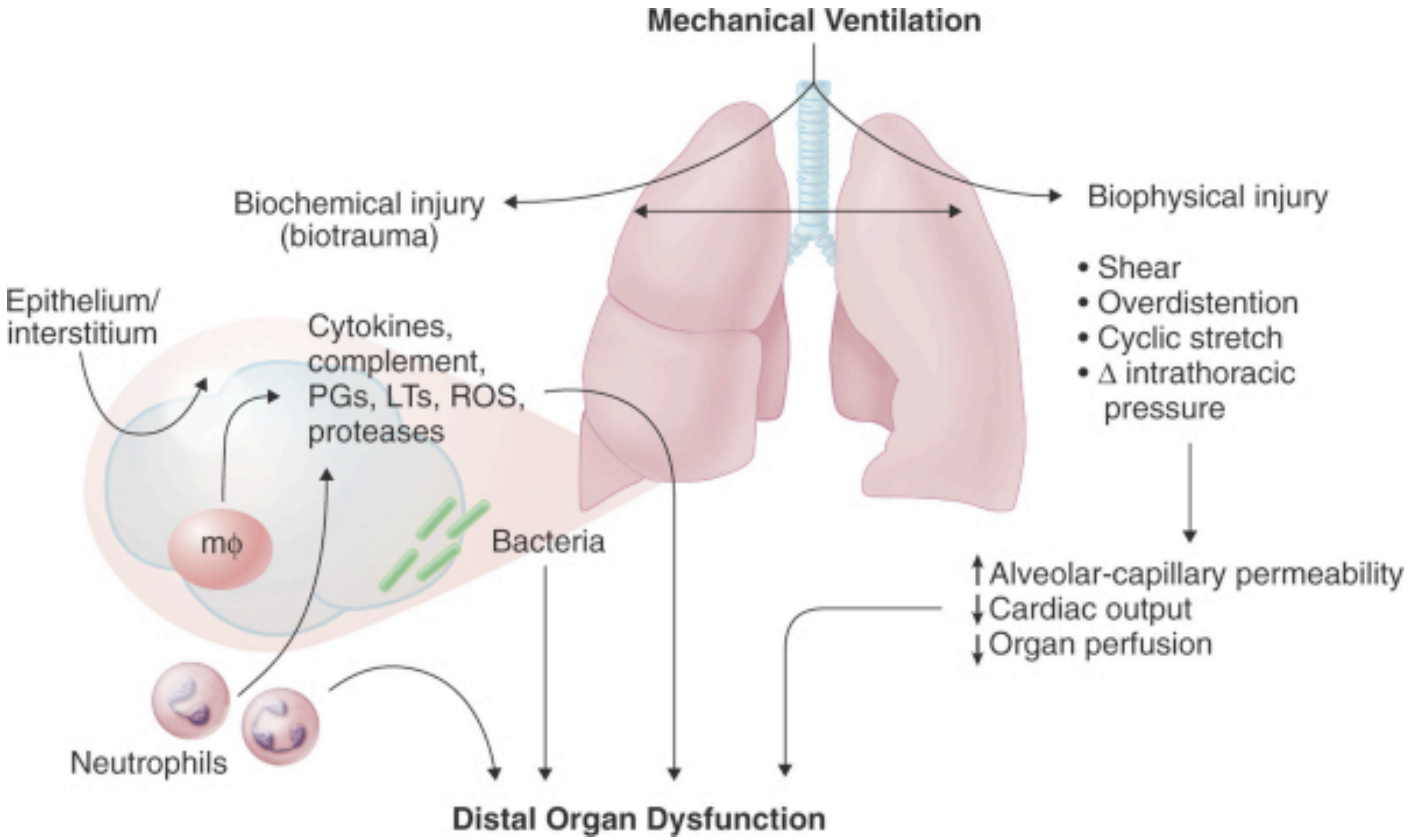
ARDS Prognosis

- Mortality
  - Mild = 25%
  - Moderate = 35%
  - Severe = 45%

- Most deaths are attributable to multi-organ failure
  - Underlying etiology may be sepsis, ventilator induced lung injury, etc

- Only 10-15% die of refractory hypoxia

Ventilator-Induced Lung Injury (VILI)



Slutsky & Tremblay AJRCCM 1998

The method by which we ventilate patients with ARDS is important

Too much pressure and volume on the ARDS lungs may induce VILI:

- Barotrauma
- Volutrauma
- Atelectrauma
- Biotrauma
- Myotrauma

are forms of VILI

Lung Protective Ventilation

The New England Journal of Medicine

VOLUME 342 MAY 4, 2000 NUMBER 18

VENTILATION WITH LOWER TIDAL VOLUMES AS COMPARED WITH TRADITIONAL TIDAL VOLUMES FOR ACUTE LUNG INJURY AND THE ACUTE RESPIRATORY DISTRESS SYNDROME

THE ACUTE RESPIRATORY DISTRESS SYNDROME NETWORK*

VENTILATION WITH LOWER TIDAL VOLUMES AS COMPARED WITH TRADITIONAL TIDAL VOLUMES FOR ACUTE LUNG INJURY AND THE ACUTE RESPIRATORY DISTRESS SYNDROME

THE ACUTE RESPIRATORY DISTRESS SYNDROME NETWORK*

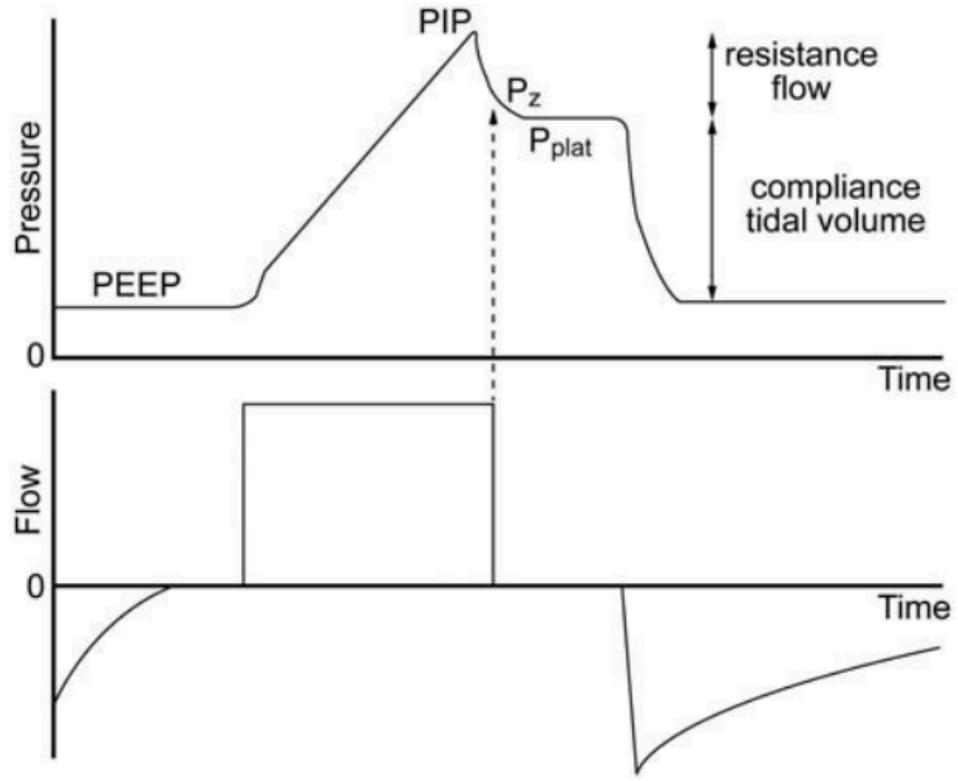
Parameter	High Stretch (Control)	Low Stretch (Intervention)
Tidal Volume (VT)	11.8 mL/kg	6.2 mL/kg
Plateau Pressure	32-34	25
Respiratory Rate	18	29
Minute Ventilation	13	13
PEEP	8	9
Mortality	40%	31%

Ventilating patients using **pressure limited** (plateau pressure <30 cm H2O) and **volume limited** (tidal volume of ≦ 6 cc/kg [4-8 cc/kg]of ideal body weight) ventilation is associated with improved mortality. Mild permissive hypercapnia is well tolerated

ARDS Management 1

- Confirm PaO_2/FiO_2 <300 on PEEP ≧ 5cm H_2O
- Lung Protective Ventilation:
  - Aim for V_T ≦ 6cc/kg using a volume control mode OR pressure control mode
- Permissive Hypercapnia is OK – aim to maintain about >7.25. If not, then consider mechanisms to help with CO_2 clearance:
  - Increase minute volume – RR or tidal volume to 8 cc/kg or
  - Increased PEEP *may* improve compliance via recruiting more lung zones.
- Plateau pressure <30 cm H_2O; patient needs to be sedated and paralyzed for this value to be reliable.

What is the plateau pressure?



The plateau pressure (Pplat) is the pressure transmitted to the alveoli and small airways when there is no longer airflow in the circuit

Measure Pplat via an inspiratory hold maneuver at the **end of inspiration on the ventilator**

What about the peak pressure?

- Peak pressure includes resistance from the large airways and ventilator tubing
- Not a clear picture of what is going on at the alveolar level

Image from: Respir Care 2014;59(11):1773–1794.

ARDS Management 2

Sedate: Sedation may be needed to achieve:

- Lung protective ventilation of 6 cc/kg
- Transition to a controlled mode of ventilation from a spontaneous mode for:
  - **More effective ventilation**: in the setting of respiratory acidosis with a pH <7.25, may need to sedate to transition to a controlled mode to take over ventilation (ie RR x tidal volume) to enhance CO_2 clearance (to aim for a ph >7.25)
  - **More effective oxygenation**: PaO_2/FiO_2 ratio is dropping, sedating may decrease excessive oxygen utilization by respiratory muscles and enhance ventilator synchrony

Neuromuscular blocking agents (NMBA): Consider paralyze in the setting of moderate to severe ARDS in the setting of:

- Ongoing need for deep sedation to achieve the above parameters
- Persistent ventilator dyssynchrony despite deep sedation
- Persistently high plateau pressures
- PaO_2/FiO_2 <100
- Needing to perform recruitment maneuvers
- If considering prone positioning

Rationale for NMBA

Promote ventilator synchrony to minimize ventilator-induced lung injury (VILI)

Decrease oxygen consumption of respiratory muscles and other muscles in order to decrease ventilatory demand

A landmark RCT in 2010 (ACURASYS) demonstrated a mortality benefit with 48 hours of continuous NMBA in the setting of moderate-severe ARDS.

However, a more recent RCT published in 2019 (ROSE) did not show a mortality advantage. Differences in results may be attributable to the differences in the control arm design with the latter having a higher PEEP strategy and no mandated sedation protocol.

N Eng J Med 2010; 363:1107-1116 (Acurasys 2010)
N Engl J Med 2019; 380:1997-2008 (ROSE 2019)

ARDS Management 3

If progressively **worsening hypoxia,** cause may be due to worsening ARDS, however, consider alternative superimposed causes where relevant:

Pneumothorax

Hydrostatic pulmonary edema

Mucous plug

In the setting of worsening hypoxia due to ARDS, consider prone positioning if PaO_2/FiO_2 <100 (some consider prone positioning at a threshold of 150).

https://www.youtube.com/watch?v=E_6jT9R7WJs

Additional adjunctive therapies such as PEEP titration, inhaled nitric oxide, recruitment maneuvers and ECLS will be discussed in a separate talk.

Rationale for Prone Positioning

Proposed mechanisms for prone positioning include:

- Induces homogeneous compliance across the chest wall
  - Anterior chest wall
  - Weight of mediastinum
  - Improved displacement of abdomen contents
- Better recruitment of posterior/dependent lung zone
- May lead to an alteration of blood flow and better ventilation/perfusion matching
- Improved drainage affect on respiratory secretions

Evidence for Prone Positioning

The PROSEVA trial (2013) evaluated ventilation in the supine position compared to ventilation in the prone position

Study Inclusion Criteria: **PaO_2/FiO_2 <150, FiO2 60%, PEEP 5 cm H_2O**

- After eligibility determined, 12-24 hour of stabilization before enrollment
- Time spent in prone position/day goal: at least 16 hrs
- Threshold to stop daily proning sessions:
  - $PaO_2/FiO_2 \geqq 150$, $FiO_2 \geqq 60\%$, PEEP $\leqq 10$ (met 4 hours after supine)

Findings

- Median 4 sessions/patient; Mean duration spent prone/day 17 hours
- Adjusted 28-day mortality; **HR 0.42** (95% CI 0.26-0.66)
- Adjusted 90-day mortality; **HR 0.48** (95% CI 0.32-0.72)

Guerin C et al, N Eng J Med 2013; 368:2159-2168 (Proseva 2013)

AMERICAN THORACIC SOCIETY DOCUMENTS

An Official American Thoracic Society/European Society of Intensive Care Medicine/Society of Critical Care Medicine Clinical Practice Guideline: Mechanical Ventilation in Adult Patients with Acute Respiratory Distress Syndrome

Eddy Fan, Lorenzo Del Sorbo, Ewan C. Goligher, Carol L. Hodgson, Laveena Munshi, Allan J. Walkey, Neill K. J. Adhikari, Marcelo B. P. Amato, Richard Branson, Roy G. Brower, Niall D. Ferguson, Ognjen Gajic, Luciano Gattinoni, Dean Hess, Jordi Mancebo, Maureen O. Meade, Daniel F. McAuley, Antonio Pesenti, V. Marco Ranieri, Gordon D. Rubenfeld, Eileen Rubin, Maureen Seckel, Arthur S. Slutsky, Daniel Talmor, B. Taylor Thompson, Hannah Wunsch, Elizabeth Uleryk, Jan Brozek, and Laurent J. Brochard; on behalf of the American Thoracic Society, European Society of Intensive Care Medicine, and Society of Critical Care Medicine

This official clinical practice guideline of the American Thoracic Society (ATS), European Society of Intensive Care Medicine (ESICM), and Society of Critical Care Medicine (SCCM) was approved by the ATS, ESICM, and SCCM, March 2017

Recommendation:

Prone positioning for more than 12 hours/day in severe ARDS (moderate confidence in effect estimates)

Key Points

ARDS diagnosis = acute onset, bilateral infiltrates, hypoxemia, non-cardiac etiology

Lung protective ventilation is key: Low tidal volumes (6mL/kg or less), keep plateau pressure less than 30cmH_20, permissive hypercapnia

If challenges with achieving lung protective ventilation, or worsening hypoxia/hypercapnia, first consider increasing sedation and paralysis

**separate talk on PEEP, recruitment maneuvers, ECLS and inhaled pulmonary vasodilators

Prone patients with severe ARDS (PaO_2/FiO_2 ratio < 100)

May consider earlier (PaO_2/FiO_2 ratio < 150)