Mechanical Ventilation in ARDS

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Overview

- In this presentation we are going to:
  - Define ARDS
    - Review the Berlin definition of ARDS
  - Discuss mortality associated with ARDS
  - Look at what causes ARDS
  - Discuss the progression of ARDS
  - Review what we know about lung protection
  - Discuss how patients with ARDS should be treated

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Definition of Acute Respiratory Distress Syndrome (ARDS)

- In 2012, the ARDS Definition Task Force developed new identifying criteria for ARDS and it was dubbed The Berlin Definition.
- Acute Lung injury (ALI) was eliminated and very specific criteria were outlined that further categorized ARDS into mild, moderate and severe categories.

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Definition of ARDS

Table 3. The Berlin Definition of Acute Respiratory Distress Syndrome

	Acute Respiratory Distress Syndrome
Timing	Within 1 week of a known clinical insult or new or 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 (eg, echocardiography) to exclude hydrostatic edema if no risk factor present
Oxygenation[b]	
Mild	200 mm Hg < Pao_2/Fio_2 ≤ 300 mm Hg with PEEP or CPAP ≥5 cm H_2O[c]
Moderate	100 mm Hg < Pao_2/Fio_2 ≤ 200 mm Hg with PEEP ≥5 cm H_2O
Severe	Pao_2/Fio_2 ≤ 100 mm Hg with PEEP ≥5 cm H_2O

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Definition of ARDS

ARDS is categorized by:

- Acute diffuse inflammatory lung injury
- Increased pulmonary vascular permeability
- Increased lung weight
- Loss of aerated lung tissue

Clinical hallmarks of ARDS:

- Hypoxemia.

  Bilateral radiographic opacities
- Increased venous admixture
- Increased physiological dead space
- Decreased lung compliance

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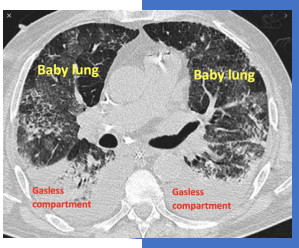
ARDS Has A High Mortality Rate

- ARDS is associated with a hospital mortality of approximately 40%.
  - Mortality increases as comorbidities increase and P:F ratio decreases.
- In the Berlin definition clinical study cohort, ARDS mortality was:
  - Mild (P/F 201–300) 27%
  - Moderate (P/F 101–200) 32%
  - Severe (P/F <101) 45%



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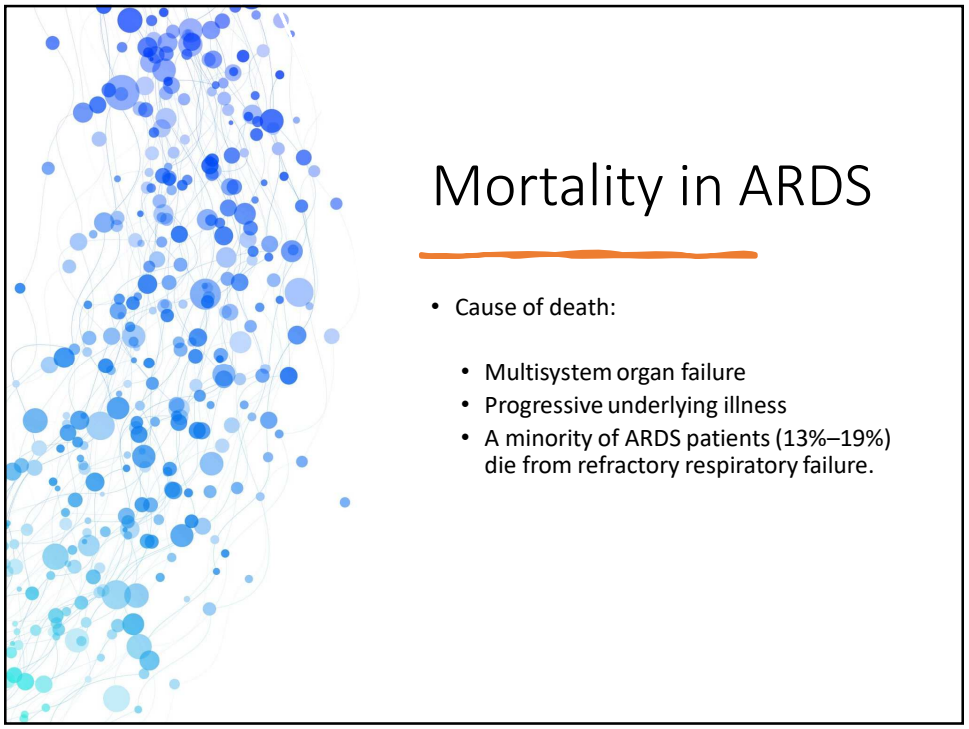

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Direct lung injury	Indirect lung injury
Pneumonia	Severe sepsis
Aspiration of gastric contents	Blood transfusion
Lung contusion	Trauma
Toxic inhalation	Cardiopulmonary bypass
Near-drowning	Pancreatitis

Causes of ARDS

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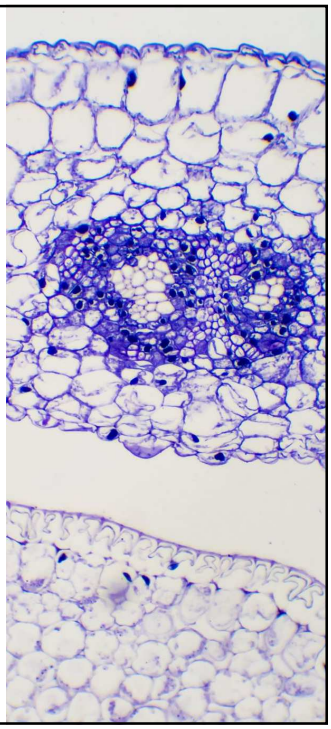
Morphology of ARDS-Acute Phase

- The morphological hallmark of the acute phase is diffuse alveolar damage (i.e., edema, inflammation, hyaline membrane, or hemorrhage).



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Progression of ARDS

Exudative phase

- acute inflammatory stage
- release of pro-inflammatory cytokines,
- influx of neutrophils
- impaired endothelial cell barrier function.

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Respiratory failure due to:

- accumulation of protein-rich fluid in distal airspaces
- decreased surfactant production by type II epithelial cells.

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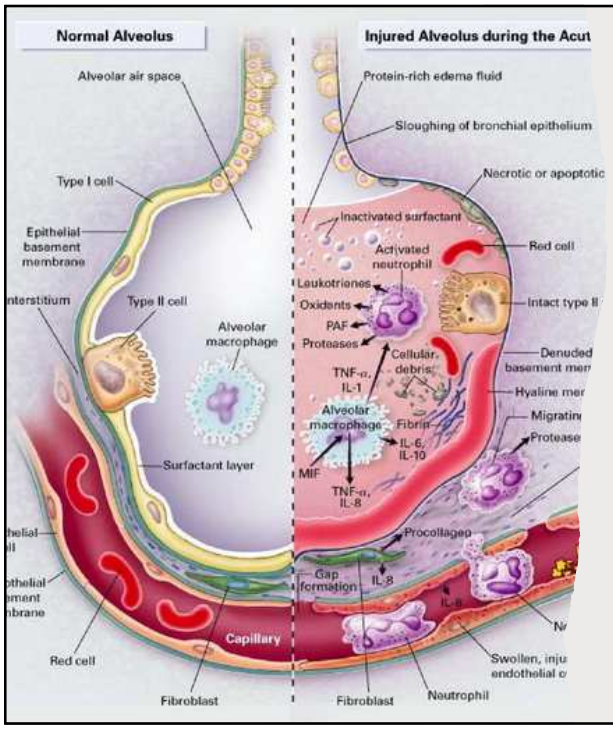

Alveoli in the Exudative Phase of ARDS

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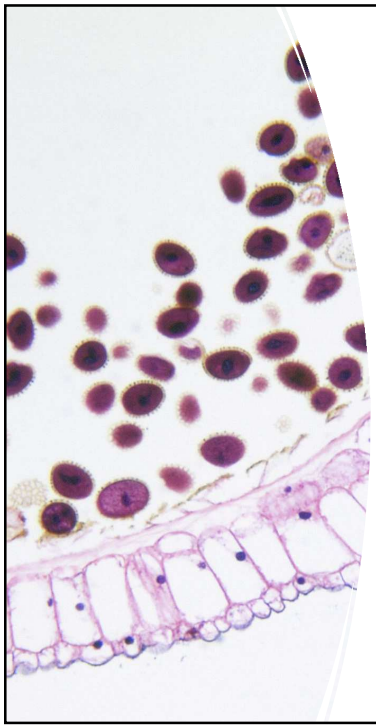

Fibro-proliferative Phase of ARDS

- Proliferative phase:
  - Develops 2–7 days after initiation of lung injury.
  - Proliferation of type 2 pneumocytes
  - Early fibrotic changes
  - Thickening of the alveolar capillaries
- Fibrotic stage:
  - Increased collagen deposition
  - Prolonged period of ventilation–perfusion mismatching
  - Diminished compliance of the lung.

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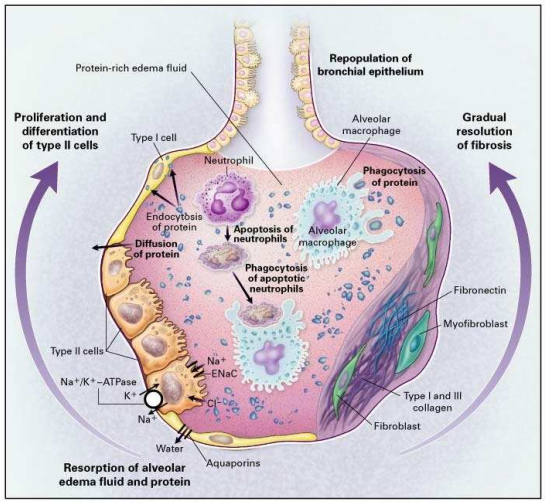
Alveoli in the Fibro-Proliferative Phase of ARDS



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Phases of ARDS progression

- It is clinically important to understand that there is a defined progression leading up to the fibrotic stage.
- Understanding why a patient gets worse, despite treating and supporting them appropriately, is an important part of managing these cases in the long term. The underlying nature of the disease is such that it can progress to fibrosis, despite our best efforts.
- As we progress with treatment efforts, oxygenation status may improve despite a poor lung compliance.

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ARDSNet Study (2000)

- Showed that lower tidal volumes (Vt) and plateau pressures (Pplat) were associated with better outcomes and a decreased mortality rate when compared to traditional parameters.
- Largest reduction in mortality to date.

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ARDSNet Study (2000)

Patients were randomized into groups receiving tidal volumes of 12cc/kg or 6cc/kg of IBW.

The low tidal volume group (6cc/kg) showed a significant reduction (31% vs. 40%), in the primary endpoints.

It was also associated with reduction in 28 day breathing without assistance, ventilator-free days, and non-pulmonary organ failures.

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Why We Still Need To talk About This…

- Rate of Low Tidal Volume Ventilation Use Remains Low in Patients with Acute Respiratory Distress Syndrome Despite Improvement Efforts at a Single Center- JCC 2018
  - Showed that only 27% of patients (out of 214) received appropriate LTVV

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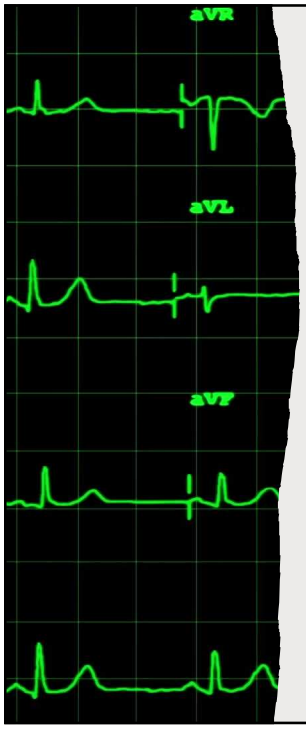

Why We Still Need To talk About This…

- Epidemiology, Patterns of Care, and Mortality for Patients With Acute Respiratory Distress Syndrome in Intensive Care Units in 50 Countries. –JAMA 2016
  - Large observational study- (LungSafe)
    - 29,144 patients (1421 from US)
    - 3022 met ARDS criteria
    - 2377 Developed ARDS within 48 hours
  - Less than two-thirds of patients with ARDS received a tidal volume 8 of mL/kg or less of predicted body weight.
  - Plateau pressure was measured in only 40.1% of patients

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Why We Still Need To talk About This…

- Adoption of low tidal volume ventilation in the emergency department: A quality improvement intervention. AJEM 2019
  - Prior to QI improvement measures geared towards implementing a LTVV strategy, the study showed that in over 2100 patients in the "before" group-
    - Average tidal volume was 9ml/kg IBW (decreased to 7.2)
    - Only 23% of patients received LTVV (increased to 72%)

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Why We Still Need To talk About This…

Locally at a CME course for physicians and mid level practitioners, when asked what tidal volume ARDS patients should initially be placed on….22% answered 8-12 ml/kg IBW

Clearly we have a problem. So, how ***SHOULD*** we be treating these patients?

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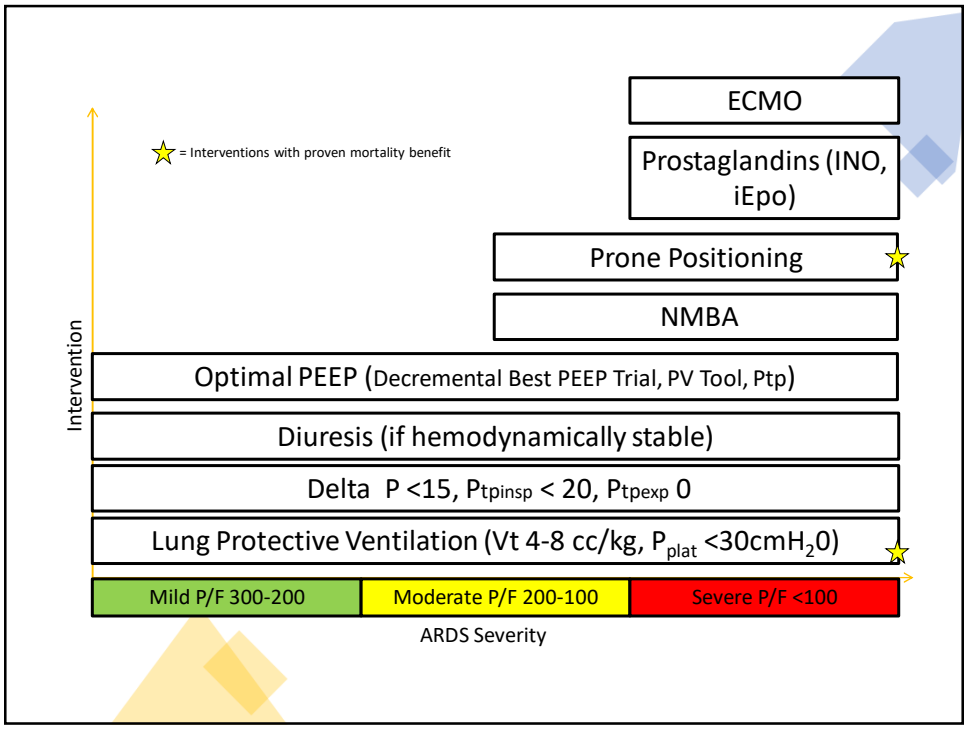

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ARDSnet Protocol

Smaller tidal volumes are less likely to generate alveolar over distension, one of the principal causes of ventilator-associated lung injury.

The ARDS lung (or baby lung)

Target 6 ml/kg of Ideal Body Weight (IBW) based on height and sex.	May decrease to 4 ml/kg or increase to 8 ml/kg as patient condition dictates.

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ARDSNet Protocol

Maintain	Maintain Pplat <30 cmH20
Monitor	Monitor respiratory rate for intrinsic PEEP. At higher rates this can have a negative impact on hemodynamics and cardiac function, but is sometimes necessary to provide ventilation.
PEEP	PEEP, being lung protective, is preferential to FiO2, for treating hypoxia.
Keep	Ideally, keep FiO2 at 60% or lower.

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Plateau Pressure Goals

Plateau Pressure Goal: ≤ 30 cm H_2O

Check P_{plat} (1 second minimum inspiratory pause), at least q4h and after each change in PEEP or tidal volume.

If P_{plat} > 30 cm H_2O: decrease Vt in 1ml/kg decrements (to a minimum of 4 ml/kg).

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Plateau Pressure Goals

- If P_{plat} < 30 and breath stacking or dyssynchrony occurs: may increase Vt in 1ml/kg increments to 7 or 8 ml/kg if P_{plat} remains < 30 cm H_2O.
- P_{plat} is the key indicator for over distension and should be monitored closely.
- Higher P_{plat} is acceptable with safe P_{tp} measurements (if used) or with acceptable driving pressure (<15)

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Target PEEP and FiO_2 Goals

- FiO_2 should be weaned to < or = 60% as soon as tolerated.
- In most ARDS patients, PEEP should be confirmed with an esophageal balloon, PV loop/curve (these are coming), decremental or incremental PEEP titrations.
- Secondary to lower chest wall compliance and higher extrinsic pressures in obese patients, higher PEEP is required to maintain a safe transpulmonary pressure. (Don't fear the PEEPer)

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Target PEEP and FiO_2 Goals

Best PEEP can be determined in several ways:

- A decremental PEEP trial
- Transpulmonary pressure monitoring
- Incremental PEEP trial
- PV Tool calculation on the G-5

These different tools can, and should be used in conjunction with one another to ensure continual best PEEP.

A Venous blood gas CANNOT be used as a marker to identify oxygen deficiency.

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Driving Pressure

- A retrospective study of over 3000 patients published in The New England Journal in 2015 showed a dramatic correlation between driving pressure and mortality.
- When driving pressure was kept below 15, there was a clear improvement in mortality.
- Driving pressures above 15 were associated with an increase in mortality.
- This is an important marker to maintain in all mechanically ventilated patients.

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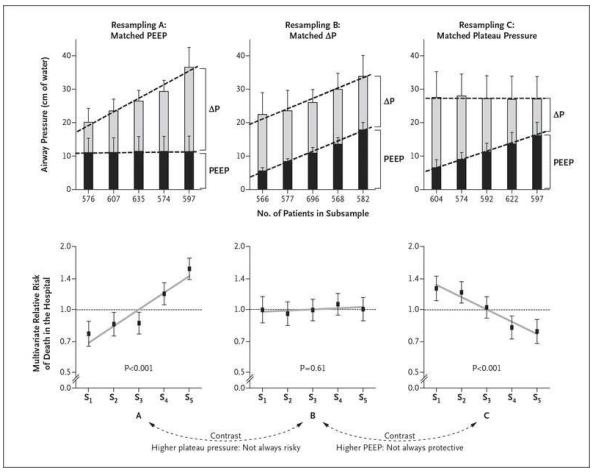
Effect of Driving Pressure on Risk of Death



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Treating Lab Values in ARDS

- Facilities should follow the guidelines established in the ARDSnet protocol, which are:
- PaO_2 55-80 mmHg
- SpO_2 88-95%
- As long as lab values are within these ranges, changes to PEEP and FiO2 are not warranted and could lead to further injury.
- Do not ventilate ABGs to normal values as this has been shown to damage the lungs.

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Treating Lab Values in ARDS

pH GOAL: 7.30-7.45 **(7.20 in many facilities)**

CO_2 goal to maintain target pH. Permissive hypercarbia is tolerated. The pH is the key value and should be the driving factor in changes in MV, not CO2.

If lab values fall within these ranges, no vent changes are warranted.

DO NOT VENTILATE ABGS TO NORMAL VALUES

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Changes

Vent	In ARDS patients, vent changes should be made carefully and slowly.
Check	Always check a follow up ABG when making changes to ventilation/oxygenation.
Make	When addressing an abnormal ABG, make small changes at a time.
Contact	Contact your respiratory therapist for all changes that need to be made.

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Take Away…

- ARDS is a complex progressive disease with a high mortality rate despite increased knowledge regarding how to treat it and decrease mortality.
- The ARDS lung is delicate and stressed, it should be treated like a little flower.
- DO NOT VENTILATE ABG'S TO NORMAL VALUES

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Take Away…

- Plateau pressure needs to be checked often and be kept <30 cmH20
- Driving pressure needs to be <15
- Best PEEP must be measured and applied early and must be checked to ensure it is still ok.
- Do not ventilate ABG's to normal values

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Things to do…

- Be an advocate and an educator
- There is no reason why you can't be the smartest person in the room when it comes to what you do.
- Do not ventilate ABG's to normal values

- Questions?

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