Acute Respiratory Distress Syndrome

Dr. Akif A.B

Definition

- It is a clinical syndrome of **severe dyspnea of rapid onset**, **hypoxemia** and **diffuse pulmonary infiltrates** leading to respiratory failure.

- Non cardiogenic pulmonary edema.

Diagnostic criteria

- Diagnosis of ARDS is based on fulfilling 3 criteria:
  - Acute onset (within 1 week)
  - Bilateral opacities on chest x-ray
  - PaO_2/FiO_2 (arterial to inspired oxygen) ratio of ≤300 on positive end-expiratory pressure (PEEP) or continuous positive airway pressure (CPAP) ≥5 cm H_2O

TABLE 322-2 DIAGNOSTIC CRITERIA FOR ARDS

Severity: Oxygenation	Onset	Chest Radiograph	Absence of Left Atrial Hypertension
Mild: 200 mmHg < Pao_2/Fio_2 ≤ 300 mmHg *Moderate:* 100 mmHg < Pao_2/Fio_2 ≤ 200 mmHg *Severe:* Pao_2/Fio_2 ≤ 100 mmHg	Acute	Bilateral alveolar or interstitial infiltrates	PCWP ≤18 mmHg *or* no clinical evidence of increased left atrial pressure

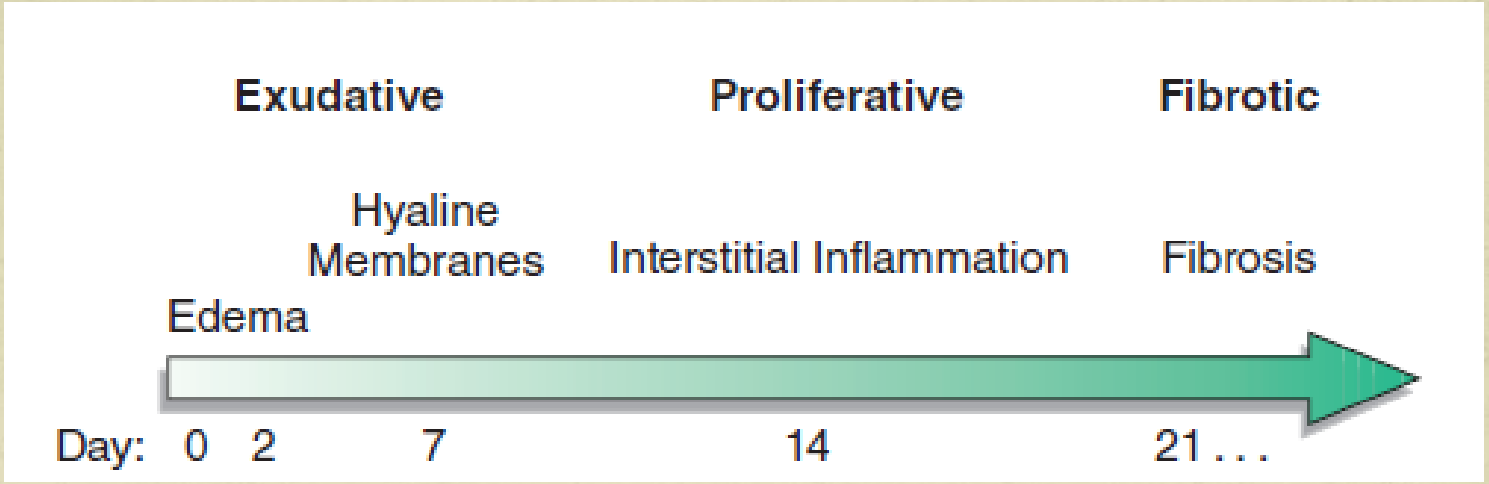
Abbreviations: ARDS, acute respiratory distress syndrome; Fio_2, inspired O_2 percentage; Pao_2, arterial partial pressure of O_2; PCWP, pulmonary capillary wedge pressure.

TABLE 322-1 CLINICAL DISORDERS COMMONLY ASSOCIATED WITH ARDS

Direct Lung Injury	Indirect Lung Injury
Pneumonia	Sepsis
Aspiration of gastric contents	Severe trauma
Pulmonary contusion	Multiple bone fractures
Near-drowning	Flail chest
Toxic inhalation injury	Head trauma
	Burns
	Multiple transfusions
	Drug overdose
	Pancreatitis
	Postcardiopulmonary bypass

Pathophysiology

- Exudative phase
- Proliferative phase
- Fibrotic phase


Exudative
Proliferative
Fibrotic
Hyaline Membranes
Interstitial Inflammation
Fibrosis
Edema
Day: 0 2 7 14 21 . . .

Exudative phase

- Alveolar capillary endothelial cells and Type 1 Pneumocytes (Alveolar epithelial membrane) gets damaged.

- Edema fluid rich in protein accumulates in alveolar and interstitial space (Mainly in dependent areas)

- Cytokines like IL-1, 8 and TNF-α gets activated

- Leucocytes accumulates at alveolar space

- Dysfunctional surfactant cell leads to formation of Hyaline membrane
- Decreased gas exchange
- Dyspnea
- Hyperventilation
- Respiratory fatigue
- Respiratory Failure

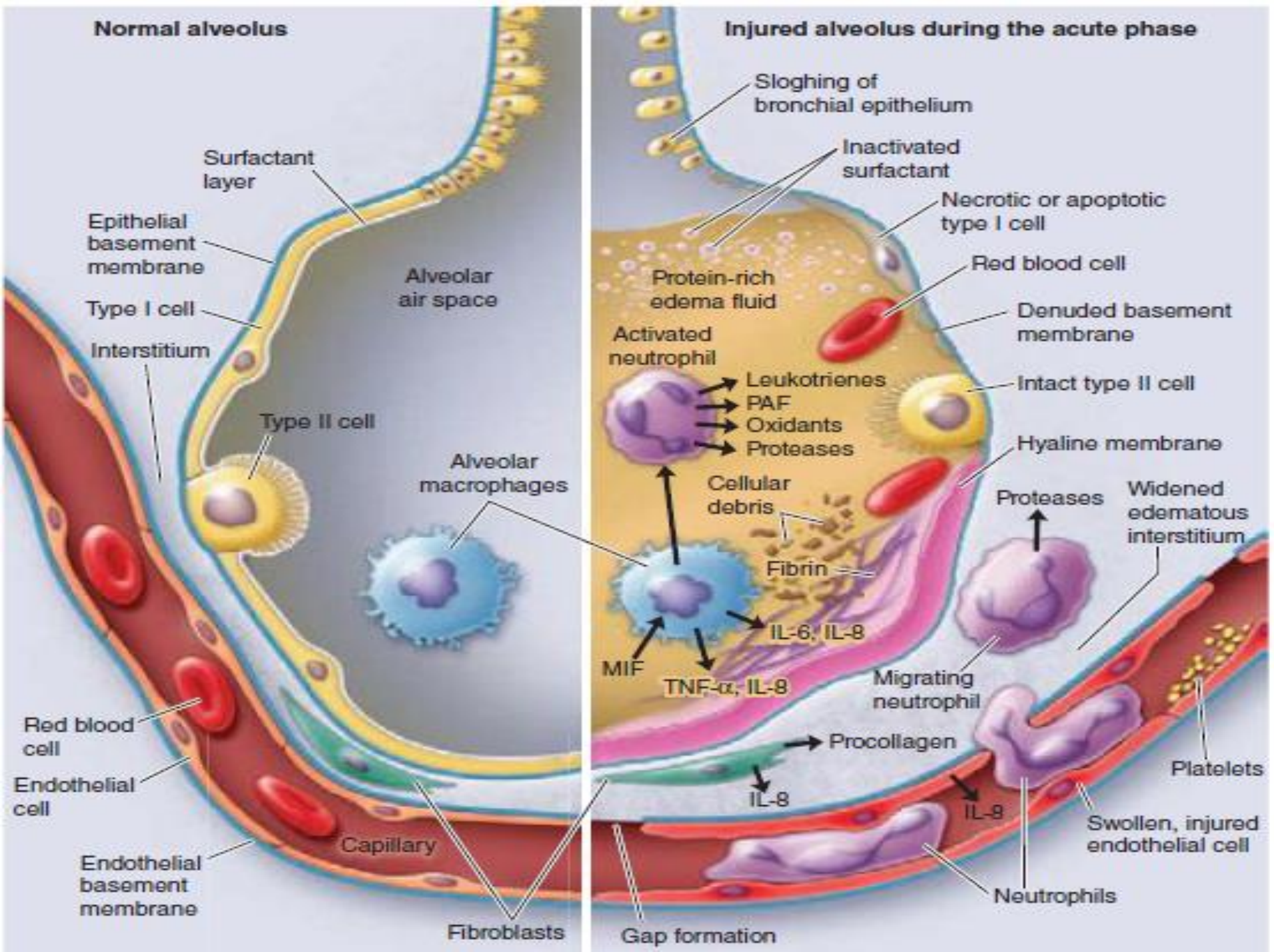

Normal alveolus
Surfactant layer
Epithelial basement membrane
Type I cell
Interstitium
Alveolar air space
Type II cell
Alveolar macrophages
Red blood cell
Endothelial cell
Capillary
Endothelial basement membrane
Fibroblasts
Injured alveolus during the acute phase
Sloghing of bronchial epithelium
Inactivated surfactant
Necrotic or apoptotic type I cell
Red blood cell
Protein-rich edema fluid
Denuded basement membrane
Activated neutrophil
Leukotrienes
PAF
Oxidants
Proteases
Intact type II cell
Hyaline membrane
Cellular debris
Proteases
Widened edematous interstitium
Fibrin
IL-6, IL-8
MIF
TNF-α, IL-8
Migrating neutrophil
Procollagen
Platelets
IL-8
IL-8
Swollen, injured endothelial cell
Neutrophils
Gap formation

FIGURE 322-3 The normal alveolus (*left*) and the injured alveolus in the acute phase of acute lung injury and the acute respiratory distress syndrome (*right*). In the acute phase of the syndrome (*right*), there is sloughing of both the bronchial and alveolar epithelial cells, with the formation of protein-rich hyaline membranes on the denuded basement membrane. Neutrophils are shown adhering to the injured capillary endothelium and transmigrating through the interstitium into the air space, which is filled with protein-rich edema fluid. In the air space, an alveolar macrophage is secreting cytokines—i.e., interleukins 1, 6, 8, and 10 (IL-1, -6, -8, and -10) and tumor necrosis factor α (TNF-α)—that act locally to stimulate chemotaxis and activate neutrophils. Macrophages also secrete other cytokines, including IL-1, -6, and -10. IL-1 can also stimulate the production of extracellular matrix by fibroblasts. Neutrophils can release oxidants, proteases, leukotrienes, and other proinflammatory molecules, such as platelet-activating factor (PAF). A number of antiinflammatory mediators are also present in the alveolar milieu, including the IL-1-receptor antagonist, soluble TNF-α receptor, autoantibodies to IL-8, and cytokines such as IL-10 and IL-11 (not shown). The influx of protein-rich edema fluid into the alveolus has led to the inactivation of surfactant. MIF, macrophage inhibitory factor. *(From LB Ware, MA Matthay: N Engl*

Proliferative phase

- 7-21 days
- **With intervention (mechanical ventilation) there is clearance of alveolar fluid**
- **Soluble proteins are removed by diffusion between alveolar epithelial cells**
- **Insoluble proteins are removed by endocytosis and transcytosis through *epithelial cells and phagocytosis through macrophages***

- **Type II cells begin to differentiate into Type I cells and reepithelialize denuded alveolar epithelium**

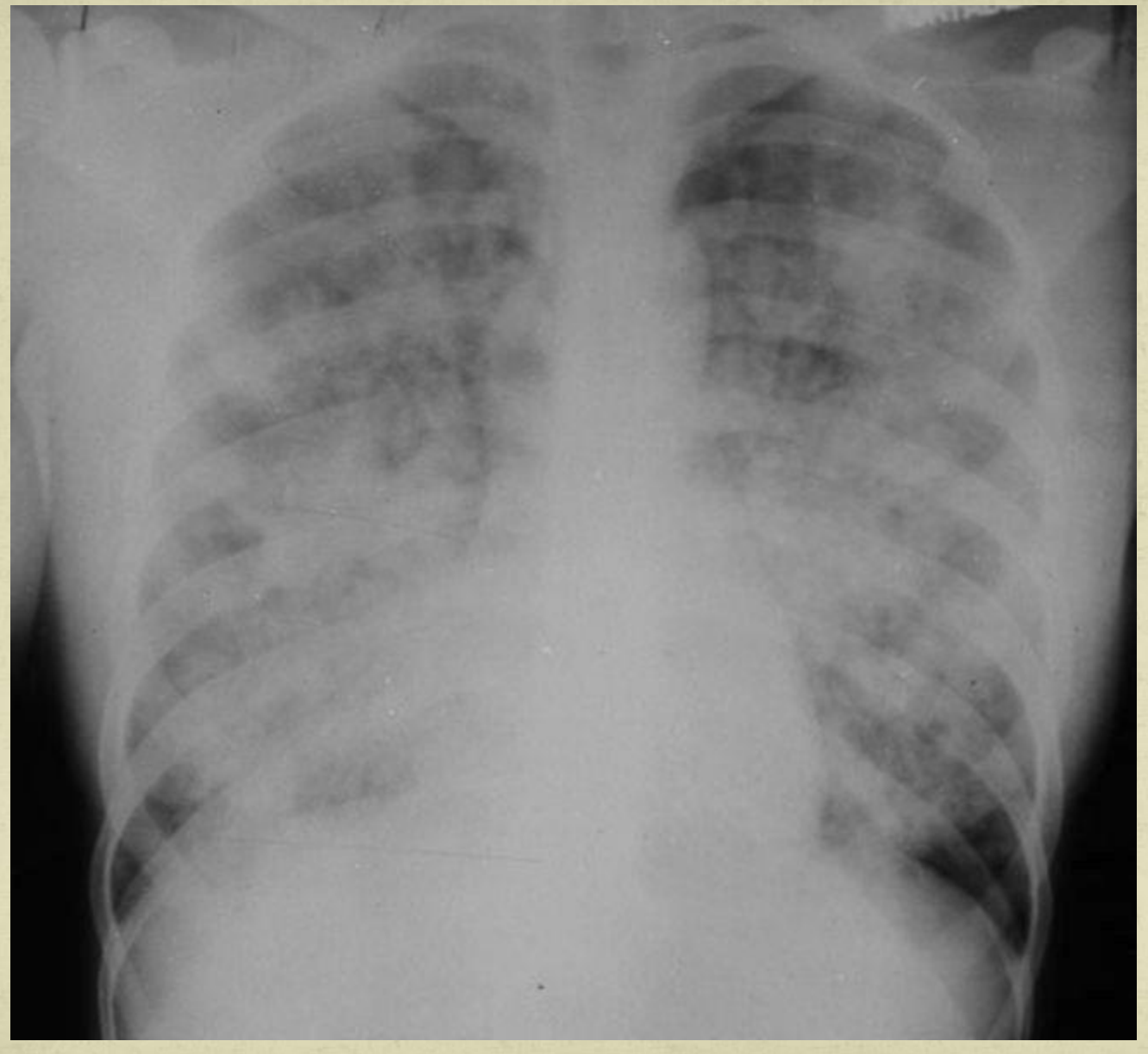
- **Further epithelialization leads to increased alveolar clearance**

FIBROTIC PHASE

- Many patients of ARDS recover in 3-4weeks
- Few patients develop fibrosis of alveoli and interstitial space
- Thus requiring long term ventialtion or oxygen therapy.

Diagnostic tests

- Chest X-ray : Diffuse Bilateral infiltrates
- CXR is **100% sensitive**.
- **Specificity is poor**
  - because other conditions may cause bilateral pulmonary infiltrates, including
    - cardiogenic pulmonary oedema
    - diffuse alveolar haemorrhage.



Diagnostic tests

- **Arterial Blood Gas (ABG)**

- A PaO_2/FiO_2 (inspired oxygen) ratio of ≤300 on positive end expiratory pressure (PEEP) or continuous positive airway pressure (CPAP) ≥5 cm H_2O is part of the diagnostic criteria for ARDS

- **Sputum, Blood, Urine culture** : To look for underlying infection

- **Amylase and Lipase** : To rule out Acute pancreatitis

Other tests to consider

- **Beta Natriuretric Peptide (BNP)**
  - BNP levels <100 nanograms/L (<100 picograms/mL)
  - Rules out Heart failure and thus Cardiogenic Pulmonary edema
- **2D-Echo**
  - Helps in ruling out cardiogenic pulmonary edema
- **Pulmonary artery Wedge pressure**
  - <18mmHg
- **Bronchioalveolar Lavage or CT scan of thorax**
  - To look for pulmonary causes of ARDS

TREATMENT

- Oxygenation and Ventilation
- Prone positioning
- Intravenous fluids
- Antimicrobials + identification and treatment of source of infection
- Supportive care

Oxygenation and Ventilation

- Oxygen saturation should be maintained **between 88% and 95%**, which usually requires mechanical ventilation with titration of inspired oxygen (FiO_2)

- Occasionally patients can be managed with **non-invasive ventilation**, but the failure rate is high and the majority will require endotracheal intubation.

- Ventilator-associated lung injury may be limited by the use of a **low tidal volume**.

Tidal Volume

- normal **volume** of air displaced between normal inhalation and exhalation when extra effort is not applied.

- In a healthy, young human adult,**tidal volume** is approximately 500 mL per inspiration or 7 mL/kg of body mass.

Positive-End Expiratory Pressure (PEEP)

- **Positive end-expiratory pressure** (**PEEP**) is the pressure in the lungs (alveolar pressure) above atmospheric pressure (the pressure outside of the body) that exists at the end of expiration.

- The two types of PEEP are:
  - Extrinsic PEEP (PEEP applied by a ventilator)
  - Intrinsic PEEP (PEEP caused by an incomplete exhalation).

FiO_2

- **Fraction of inspired oxygen** (***Fi*O$_2$**) is the fraction of oxygen in the volume of air being measured.
- Medical patients experiencing difficulty breathing are provided with **oxygen-enriched air**, which means a higher-than-atmospheric *Fi*O$_2$.
- Natural air includes 21% oxygen, which is equivalent to *Fi*O$_2$ of 0.21.
- Oxygen-enriched air has a higher *Fi*O$_2$ than 0.21; up to 1.00 which means 100% oxygen.
- *Fi*O$_2$ is typically maintained **below 0.5** even with mechanical ventilation, to avoid oxygen toxicity.

- Respiratory acidosis, which is a common complication of low tidal volume ventilation, is treated by increasing the respiratory rate.

Prone Positioning

- Prone positioning can improve oxygenation in patients with ARDS and has been shown to reduce mortality in patients with severe ARDS (PaO_2/FiO_2 <150).

- Complications of prone positioning, includes :
  - facial oedema, pressure sores, and dislodgement of catheters and endotracheal tubes,

- prone positioning should only be considered in patients with severe ARDS (PaO_2/FiO_2 <150).

Intravenous fluids

- The patient's fluid balance should be maintained as slightly negative or neutral (providing the patient is not in shock).
- A central line is recommended to measure the central venous pressure (CVP), with regular assessments of fluid status.
- The goal is to keep the CVP <4 cm H_2O.

antimicrobials + identification and treatment of source of infection

- In patients who have an infectious cause for ARDS (e.g., pneumonia or sepsis), the prompt initiation of antimicrobials is important.
- Empirical antibiotics targeted at the suspected underlying infection should be used as soon as possible after obtaining appropriate cultures including blood, sputum, and urine cultures.
- Once culture results are available, the antimicrobial regimen can be tailored for the identified organism.

Supportive Care

- Prevention of deep vein thrombosis
- Blood glucose control
- Prophylaxis against stress-induced gastrointestinal Bleeding
- Haemodynamic support to maintain a **mean arterial pressure >60 mmHg**
- **Transfusion of packed red blood** cells in patients with Hb <70 g/L (<7 g/dL).

- Nutrition should be provided enterally where possible.
- Inhaled or intravenous beta-adrenergic agonists to promote alveolar fluid clearance and resolution of pulmonary oedema are **not recommended**.
- Neither early nor late administration of corticosteroids has been shown to improve mortality in patients with ARDS, and their routine use is not recommended.

Thank you