Acute Respiratory Distress Syndrome

Acute respiratory distress syndrome (ARDS) also known as noncardiogenic pulmonary oedema is an inflammatory disease process of the lungs caused by permeability pulmonary oedema resulting from endothelial damage due to a cascade of inflammatory events in response to direct or indirect insult.

It is characterized by severe hypoxemia, reduced lung compliance and bilateral radiographic infiltrates.

ARDS is not a single entity but represents the severe end of a spectrum of acute lung injury due to many different insults. Therefore ARDS is a complication rather than cause.

Causes of acute respiratory distress syndrome

There are many causes of pro-inflammatory mediator release sufficient to cause ARDS and there may be more than one present.

The common causes in order of prevalence are:

- Sepsis/pneumonia; secondary risk factors for developing ARDS, when septic, are alcoholism and cigarette smoking
- Gastric aspiration
- Trauma/burns, via sepsis, lung trauma, smoke inhalation, fat emboli, and possibly direct effects of large amounts of necrotic tissue.

Less common causes

- Transfusion-related acute lung injury (TRALI), caused by any blood transfusion.
- Transplanted lung, worse if the lung poorly preserved
- Post-bone marrow transplant as bone marrow recovers
- Drug overdose, e.g. tricyclic antidepressants, opiates, cocaine, aspirin
- Acute pancreatitis
- Near drowning
- Following upper airway obstruction

Pathogenesis of Acute Respiratory Distress Syndrome

In most situations, pulmonary oedema arises as a result of increased pulmonary capillary pressure (e.g. left ventricular failure) but in ARDS it arises because of increased alveolar-capillary permeability.

Pressure pulmonary oedema

In the normal situation, the hydrostatic pressure and the osmotic pressure exerted by the plasma

proteins are in a state of equilibrium between the pulmonary capillaries and lung alveoli.

The most common cause of pulmonary oedema is an increase in hydrostatic pressure and this typically occurs secondary to elevated left atrial pressure from left ventricular failure (e.g. after myocardial infarction). Volume overload may also increase pulmonary capillary pressure and this may arise from excessive intravenous fluid administration or fluid retention (e.g. renal failure).

Reduced osmotic pressure may contribute to pulmonary oedema and this occurs in hypoproteinaemic states for example in patients having nephrotic syndrome with renal protein loss.

In the early stages of pulmonary oedema, there is an increase in the fluid content of the interstitial space between the capillaries and alveoli but as the condition deteriorates flooding of the alveoli occurs.

Permeability pulmonary oedema

In acute respiratory distress syndrome, a cascade of inflammatory events arises over a period of hours from a focus of tissue damage.

These inflammatory events cause damage to the alveoli, either by locally produced pro-inflammatory mediators, or remotely produced pro-inflammatory mediators arriving in the lungs via the pulmonary artery.

The change in pulmonary capillary permeability allows fluid and protein leakage into the alveolar spaces with pulmonary infiltrates. The alveolar surfactant is diluted with loss of its stabilizing effect, resulting in diffuse alveolar collapse and stiff lungs.

In the ARDS lung, an in?ux of protein-rich oedema ?uid into the air spaces occurs as a consequence of increased permeability of the alveolar-capillary barrier.

Specifically, activated neutrophils aggregate and adhere to endothelial cells, releasing various toxins, oxygen radicals and mediators like histamine and kinins.

This systemic inflammatory response may be initiated by a variety of injuries or illnesses and gives rise to acute lung injury as one of its earliest manifestations, with the development of endothelial damage and increased alveolar-capillary permeability.

> The normal alveolar epithelium has two types of cells. The type I cells makeup 90% of the alveolar surface area and are easily injured.
>
> The type II cells make up the remaining 10% of the alveolar surface area and are more resistant to injury; their functions include surfactant production, ion transport, and proliferation and differentiation to type I cells after injury.

The alveoli become filled with a protein-rich exudate containing abundant neutrophils and other inflammatory cells and the airspaces show a rim of proteinaceous material known as the hyaline

membrane.

The characteristic feature of permeability pulmonary oedema in ARDS is that the pulmonary capillary wedge pressure is not elevated.

The measurement of pulmonary capillary wedge pressure reflects left atrial pressure and in ARDS it is typically 18 mmHg, whereas in cardiogenic pulmonary oedema it is elevated.

What are the effects of loss of epithelial integrity in ARDS?

The effects that may arise due to loss of epithelial integrity include:

1. Under normal conditions, the epithelial barrier is much less permeable than the endothelial barrier; thus epithelial injury can contribute to alveolar ?ooding.
2. The loss of epithelial integrity and injury to type II cells serve to disrupt normal epithelial ?uid transport, impairing the removal of oedema ?uid from the alveolar space.
3. Injury to type II cells reduces the production and turnover of surfactant.
4. Loss of epithelial barrier can lead to sepsis in patients with bacterial pneumonia.
5. In severe alveolar epithelium injury, pulmonary fibrosis can develop.

Phases of acute respiratory distress syndrome

Phase 1 is the early period of alveolar damage and hypoxaemia with pulmonary infiltration.

Phase 2 develops after a week or so as the pulmonary infiltrates resolve, and on histology seems to be associated with an increase in type II pneumocytes, myofibroblasts, and early collagen formation.

Phase 3 if the patient survives, is the fibrotic stage that leaves the lung with cysts, deranged micro-architecture, and much fibrosis on histology.

Clinical features of acute respiratory distress syndrome

Acute respiratory distress syndrome develops in response to a variety of injuries or illnesses that affect the lungs either directly (e.g. aspiration of gastric contents, severe pneumonia, lung contusion) or indirectly (e.g. systemic sepsis, major trauma, pancreatitis).

About 12–48 hours after an initiating event the patient develops respiratory distress with increasing dyspnoea and tachypnoea.

Arterial blood gases show deteriorating hypoxaemia that responds poorly to oxygen therapy.

Diffuse bilateral infiltrates develop on chest X-ray in the absence of evidence of cardiogenic pulmonary oedema.

ARDS is the most severe end of the spectrum of acute lung injury and is characterised by the following features:

A history of an initiating injury or illness

- Hypoxaemia refractory to oxygen therapy. In ARDS Po2/Fio2 is < 26 kPa (200 mmHg);
- Bilateral diffuse infiltrates on chest X-ray;
- No evidence of cardiogenic pulmonary oedema (e.g. pulmonary capillary wedge pressure < 18 mmHg).
- Coarse crackles in the chest

Patients who subsequently develop ARDS may appear deceptively well in the initial stages of their illness. Early recognition and careful observation of at-risk patients is of crucial importance in detecting the signs of deterioration and in identifying the need for intensive therapy unit (ITU) care.

Certain warning signs are applicable in a wide variety of clinical circumstances because there is often a common physiological pathway of deterioration in the severely ill that can be detected by simple observations of the pulse rate, respiratory rate, blood pressure, temperature, urine output and level of consciousness.

Arterial blood gas measurements provide useful additional information about gas exchange and the metabolic state of the patient.

Treatment of acute respiratory distress syndrome

The treatment of ARDS consists of optimal management of the initiating illness or injury combined with supportive care directed at preserving adequate oxygenation, maintaining optimal haemodynamic function and compensating for multiorgan failure; which often supervenes.