Congenital anomalies of the lungs

Atelectasis

Acute lung injury

Gábor Smuk M.D.

Developmental lung diseases

I.a. Bronchogenic cyst:

- abnormal budding of the tracheobronchial primordium of the primitive foregut
- localization: anterior mediastinum, rarely lung parenchyma
- columnar ciliated inner surface (cartilage is usually present), unilocular

I.b. Congenital lobar emphysema:

- Inborn or aquired
- similar to panacinar emphysema in adults (affects lobe or segments)
- Hypoxia in newborn caused by compression of adjacent lung lobes
- Surgical removal of the abnormal region is curative

Developmental lung diseases

I.c. Sequestration:

Lung area which does not communicate with the airways

Extralobar type:

- It has its own pleural surface and blood supply from systemic arterial circulation.

Intralobar type:

- inside a pulmonary lobe
- Absence of normal bronchovascular pattern in CT or chest x-ray.
- Complication: accumulation of mucus, pneumonia.
- In 50% is associate dwith cystic malformation

Developmental Lung diseases

I.d. Congenital pulmonary airway malformation (CPAM)

- Synonim: Congenital cystic adenomatoid malformation (CCAM)
- Different types related to the size of cysts
- Cysts are lined by pseudostratified ciliated columnar epithelium
- Different types have different prognosis
- May transform into carcinoma (type I)

I.e. Pulmonary hypoplasia

Hypoplasia of the lungs means that the alveoli are reduced in number or size.

It is usually associated with other abnormalities:

- diaphragmatic defects,
- renal anomalies (Potter sequence),
- extralobar pulmonary sequestration
- severe musculoskeletal disorders.

I.e. Pulmonary hypoplasia

Pathogenesis:

1. **Compression of the lungs by intrathoracic masses, as with herniation of abdominal viscera through a congenital diaphragmatic defect**

2. Lack of respiratory movements due to the antenatal onset of neuromuscular diseases such as myotonic dystrophy.

3. **Oligohydramnios**/Loss of lung liquid (Lung provide internal support essential to proper lung development.)

I.f. Pulmonary aplasia (agenesis)

Absence of one lung, of a lobe or of both lungs.

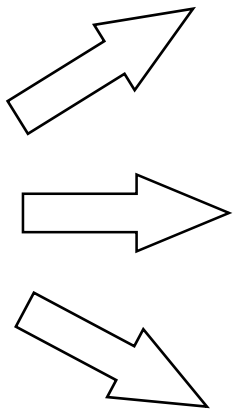
The bronchi may also be absent or there may be a rudimentary stump in case of aplasia.

In unilateral aplasia the single lung is enlarged (number of alveolus ↑)

II. Atelectasis (collapse)

The term **atelectasis** means **imperfect expansion**.

pulmonary collapse (Atelectasis)



Resorption collapse is likely when bronchial obstruction prevents free entry of air into the lungs

Compression collapse may result from external forces exerted by air or fluid in the pleural cavity

Contraction atelectasis a result of generalized or focal pleural or pulmonary fibrosis

II. Atelectasis (collapse)

Causes of absorption collapse

Intraluminal lesions

- Mucus
- Foreign body
- Endobronchial tumour

Mural lesions

- Bronchogenic carcinoma
- Sarcoid

Extrinsic lesions

- Enlarged lymph nodes
- Distended or aneurysmally dilated arteries

II. Morphology of atelectasis

Collapsed lungs are small and firm, and have a deeply wrinkled pleural surface.

III. Acute lung injury (ALI)/ **D**iffuse **A**lveolar **D**amage (DAD)

- Acute alveolar injury may be caused by a wide range of pulmonary insults
- Rapid development of hypoxaemia and bilateral infiltrate on chest x-ray
- pulmonary vascular permeability ↑, edema and epithelial cell death
- Diffuse alveolar damage resulted from extensive and severe acute lung injury (DAD is the prototype of acute lung injury)
- Clinical manifestation called Acute Respiratory Distress Syndrome (ARDS)
- common condition with high mortality (40-50%)
- Newborns have Neonatal RDS (NRDS) related to immature lung

Acute **R**espiratory **D**istress **S**yndrome (ARDS)

ARDS is a **fulminant** form of **respiratory failure**

- **refractory hypoxaemia** and bilateral opacification on chest x-ray or CT
- **widespread alveolar collapse** and **exudation**

Etiology of DAD

Sepsis

Radiation exposure

Acute massive aspiration

Acute pancreatitis

Burn

Shock

- Traumatic (head injury!)
- Hemorrhage
- Neurogenic
- Cardiogenic

Inhalants

- Nitric acid fumes
- Nitrogen dioxide
- Paint remover
- Smoke
- Smoke bomb

Infection

immunosuppressed patient!!!

- Viral infection: adenovirus, influenzavirus, herpesvirus, **CMV,**
- **SARS**; **RSV** infections,
- ***Legionella*** infection
- *Mycoplasma*/*Chlamydia* infection
- Rickettsial infection
- ***Pneumocystis jiroveci***

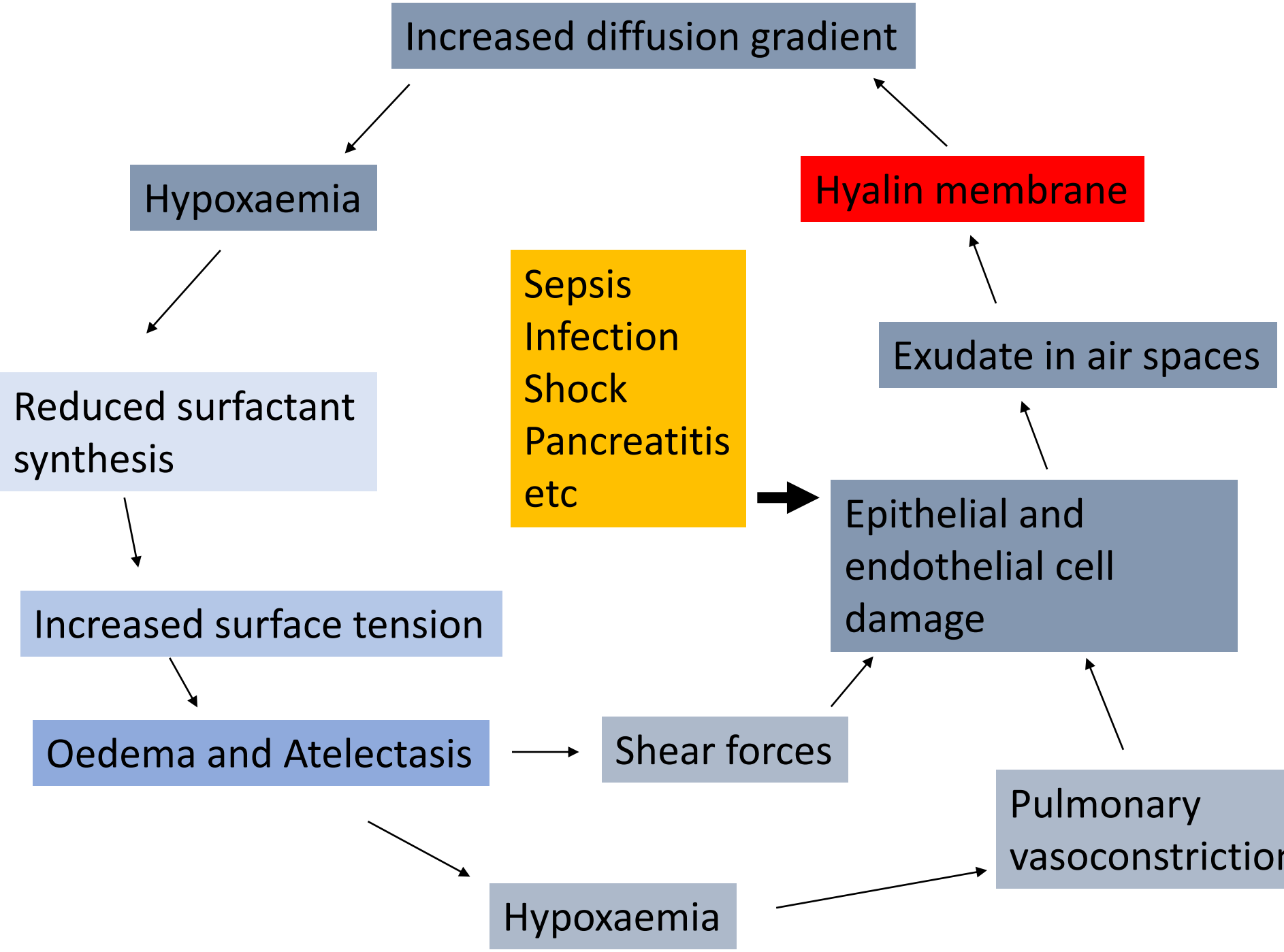
Drugs

Chemotherapeutic drugs: busulfan, bleomycin, methotrexate, azathioprine,

- Amiodarone
- etc

Idiopathic

- Acute interstitial pneumonia


Increased diffusion gradient
Hypoxaemia
Reduced surfactant synthesis
Increased surface tension
Oedema and Atelectasis
Hypoxaemia
Shear forces
Sepsis
Infection
Shock
Pancreatitis
etc
Epithelial and endothelial cell damage
Exudate in air spaces
Hyalin membrane
Pulmonary vasoconstriction

III. **D**iffuse **A**lveolar **D**amage (DAD)

The lungs respond to various types of injury in a similar way.

The endothelial and alveolar epithelial cell injury is followed by exudation (fluid and cellular components). Subsequent reparative fibroblastic proliferation is combined with type II pneumocyte hyperplasia.

III.a. **Exudative phase** (hyaline membrane formation)

- injury to type I alveolar epithelial cell and the capillary endothelial cell
- necrosis of epithelial cells resulting in denudation of the basement membrane.
- fibrin-rich exudates accumulates in air spaces,
- loss of the surfactant,pulmonary collapse
- exudate heals by resolution or repair

Diffuse **a**lveolar **d**amage (DAD)

III.b. **Regenerative (proliferative) phase**

- 1–2 weeks after the initial injury the type II alveolar epithelial cell proliferate and differentiate into type I cells in purpose to re-epithelialise the denuded basement membranes.
- Squamous metaplasia may develop instead of orderly differentiation into type I cells resembling squamous cell neoplasia.
- The regenerating epithelium usually grows beneath the exudates lining the denuded basement membrane, casting the hyaline membranes off into the air space
- Hyaline membrane can be incorporated into the interstitium.
- Thrombosis can develop on the ground of endothelial cell injury.

III. **D**iffuse **a**lveolar **d**amage (DAD)

III.c. **Repair phase**

- Connective tissue formation will lead to distortion of the bronchioloalveolar architecture and **shrinkage of the lungs**
- Epithelial cells grow over the newly formed connective tissue.
- A new basement membrane **incorporates the collagen into the interstitium**.
- Intra-alveolar pattern of repair is particularly found when generalised sepsis is the cause of the initial damage
- Interstitial fibrosis is more characteristic in case of the injury is caused by cytotoxic drugs and the idiopathic cases.

IV. Neonatal Respiratory Distress Syndrome (NRDS)/ I.a. Hyalin membrane disease

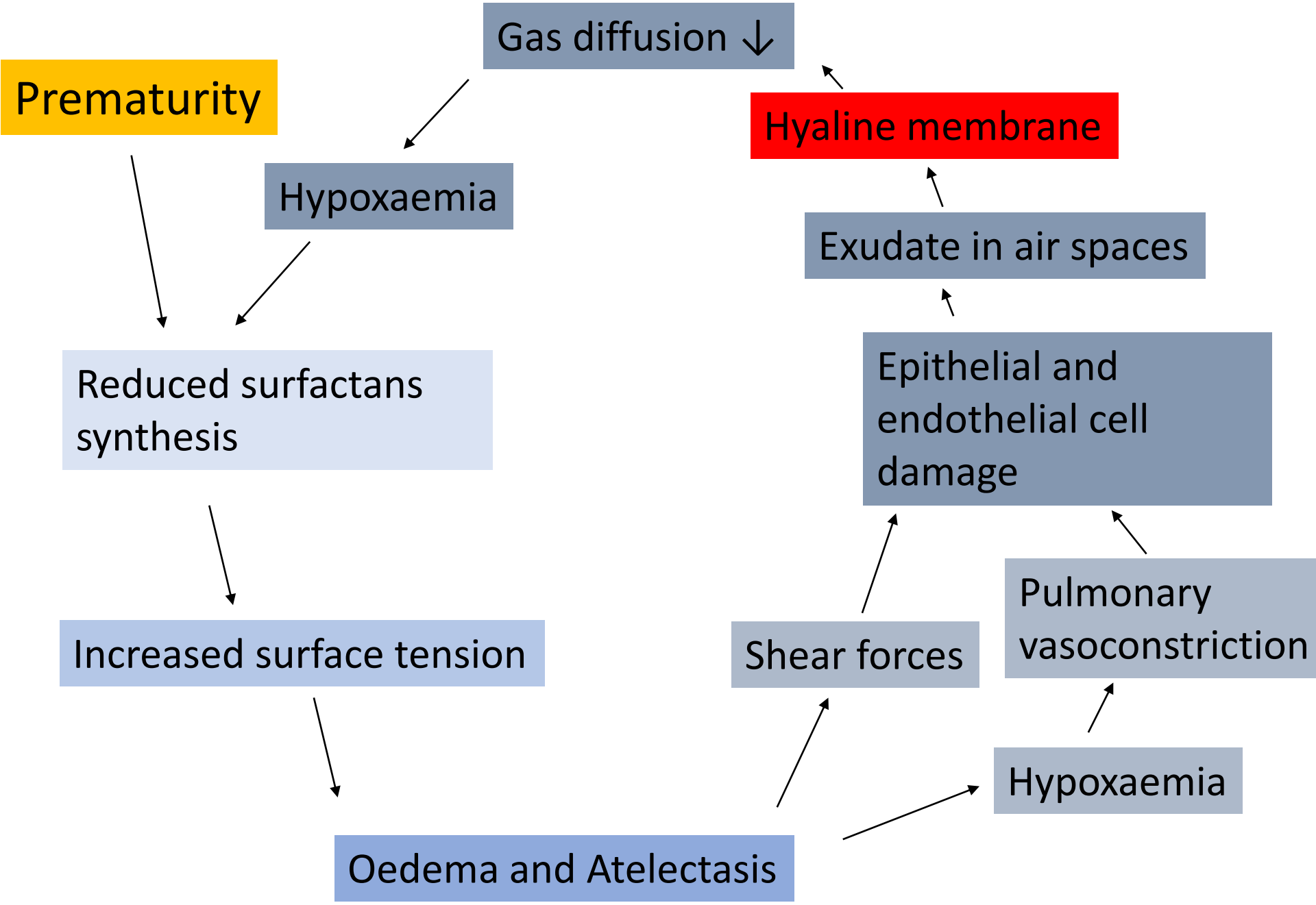
In preterm infants, appropriate for gestational age. Develops in 60% infants < 28 weeks of gestation

Symptoms

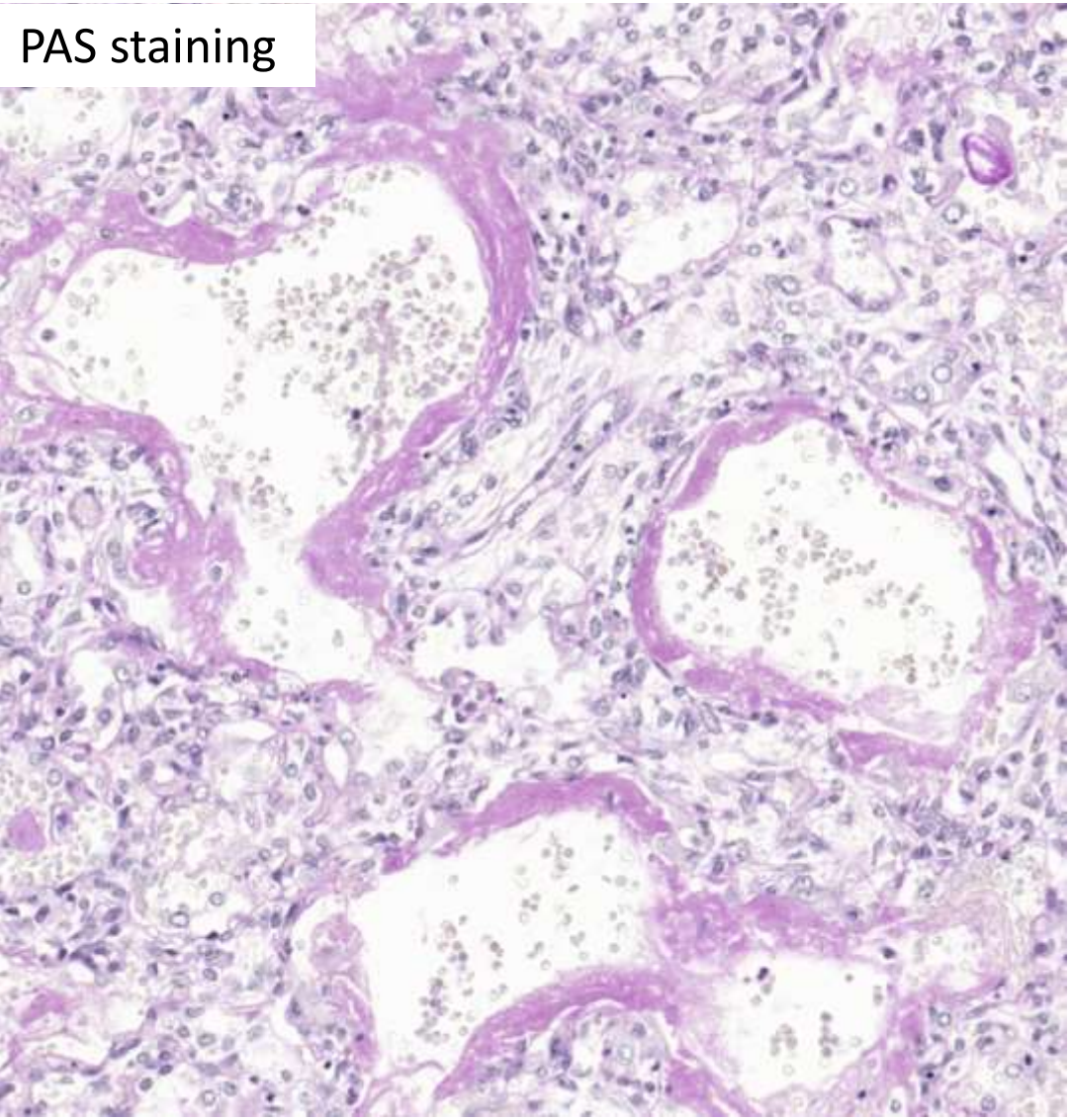
- Difficulty of breathing develops in the first hour of life, cyanosis is observable
- Respiratory failure may lead to death of infant in absence of therapy

Pathogenesis

1. deficiency of pulmonary surfactant
2. lungs collapse after each breath → progressive atelectasis and reduced lung compliance
3. alveoli become injured as a result of shear stresses on the alveolar walls
4. protein-rich, fibrin-rich exudation leads to hyaline membran formation
5. Gas exchange↓ → hypoxaemia → surfactant production ↓


Gas diffusion ↓
Prematurity
Hyaline membrane
Hypoxaemia
Exudate in air spaces
Reduced surfactans synthesis
Epithelial and endothelial cell damage
Increased surface tension
Shear forces
Pulmonary vasoconstriction
Hypoxaemia
Oedema and Atelectasis

IV.a. Hyalin membrane disease



Macroscopic appearence

Firm and red lung parenchyma

Microscopic appearence

- homogeneous lightly eosinophilic linear material
- hyalin membran is adherent to the alveolar surface
- composed of dead cell cytoplasm, nuceoplasm, and plasma transudate
- PAS positive
- neutrophils are not present in significant number, only in case of infection

IV. Neonatal Respiratory Distress Syndrome

IV.b. Complications of ventilator-administered oxygen

Retrolental fibroplasia

hyperoxic phase: **VEGF** ↓ ⇨ hypoxic phase after therapy: **VEGF**↑

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endothelial cell necrosis — neovascularization

Bronchopulmonary dysplasia

- occurs in a proportion of children who require respiratory support
- in “classic” BPD alternating areas of alveolar fibrosis with collapse and overdistention are present
- In current protocol lower leves of oxygen applied preventing fibrosis
- ↓ alveolar septation → ↓ absolute numbers of alveoli
- vascular maldevelopment - dysmorphic capillary configuration