Respiratory distress syndrome

Eman Farouk Badran
MD. MRCPCH
Professor of Pediatrics
Head division of Neonatology
At Jordan University Hospital

Third year medical students

December/2017

Outlines

- Definition
- Physiology
  - Respiration
  - Surface tension
  - Lung compliance
  - Lung volume
  - surfactant
- Respiratory distress syndrome
  - Pathophysiology
  - Incidence
  - Presentation
  - management

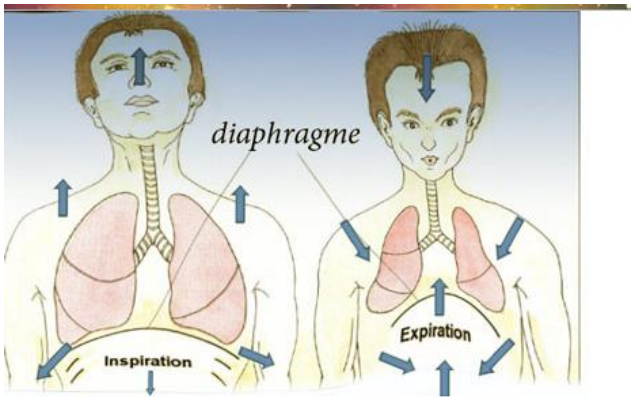
Respiration = the series of **exchanges** that leads to the uptake of oxygen by the cells, and the release of carbon dioxide to the lungs

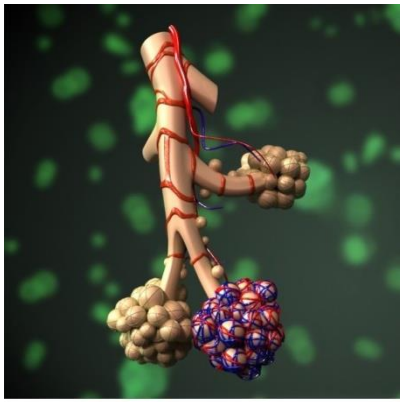
Step 1 = ventilation
- **Inspiration & expiration**

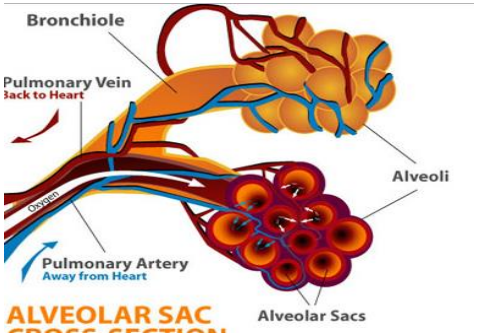
Step 2 = **exchange between alveoli** (lungs) and pulmonary capillaries (blood)
- Referred to as *External Respiration*

Step 3 = **transport of gases** in blood

Step 4 = **exchange between blood and cells**
- Referred to as *Internal Respiration*

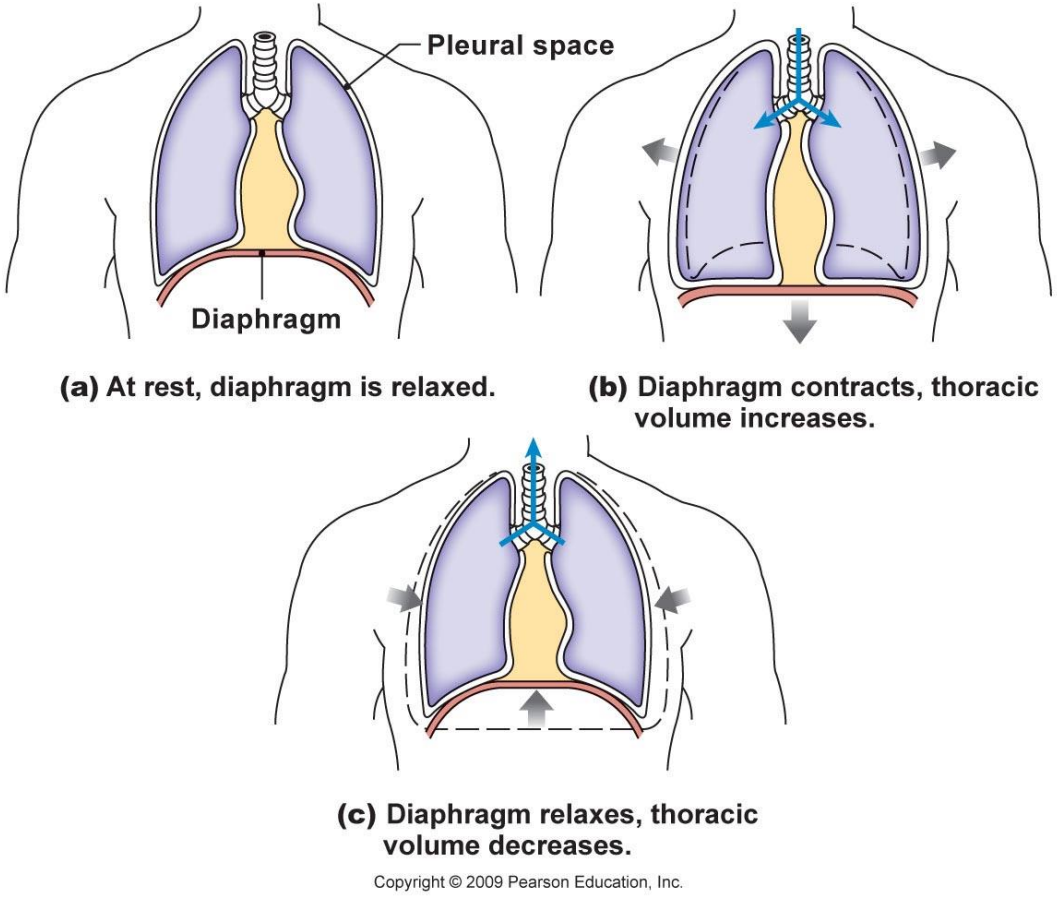






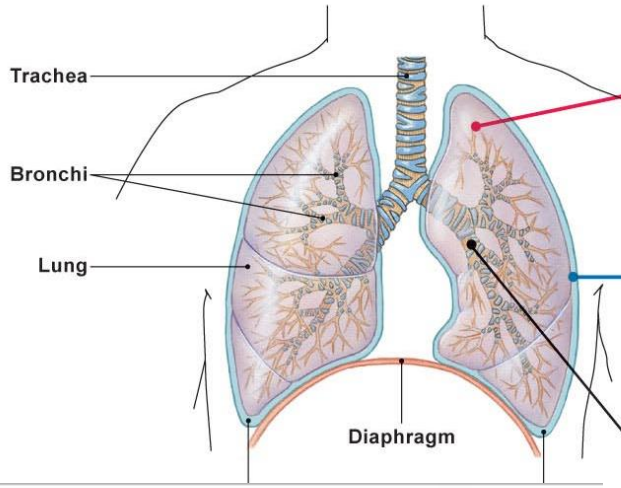
Ventilation = (inspiration + expiration)
responsible muscles

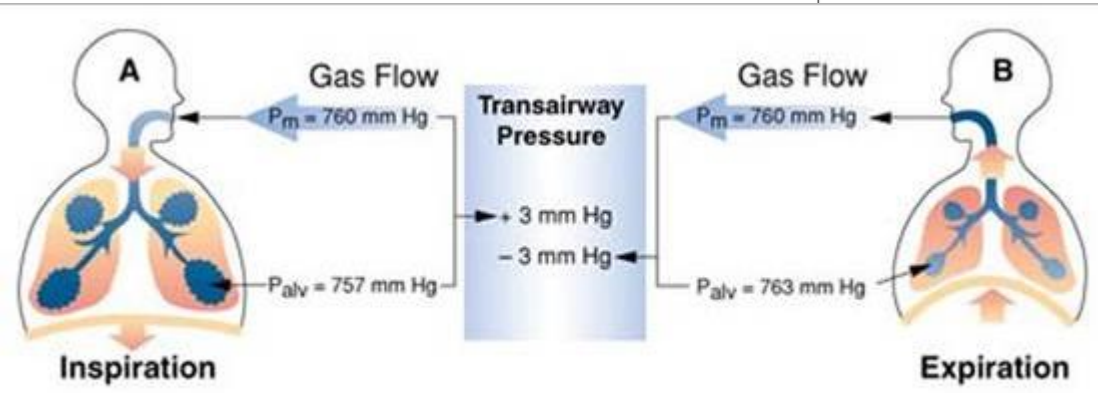
- **The diaphragm (only creates about 60-75% of the volume change during inspiration)**

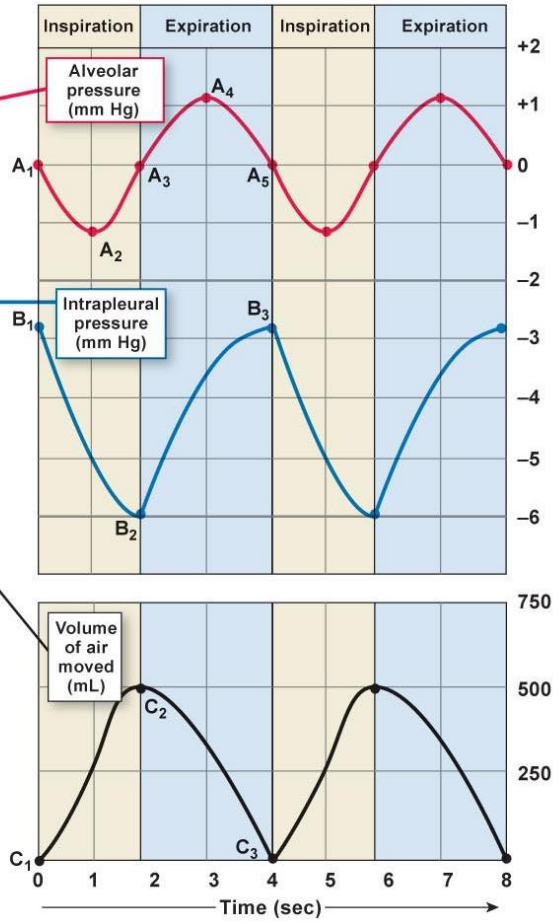


- **The muscles of Inspiration (external intercostals muscles) & muscles of expiration (internal intercostals muscles**

Ventilation





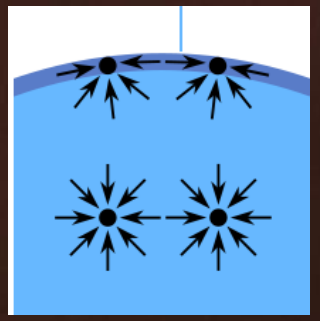


Tidal volume in new born = 4 –6ml / kg

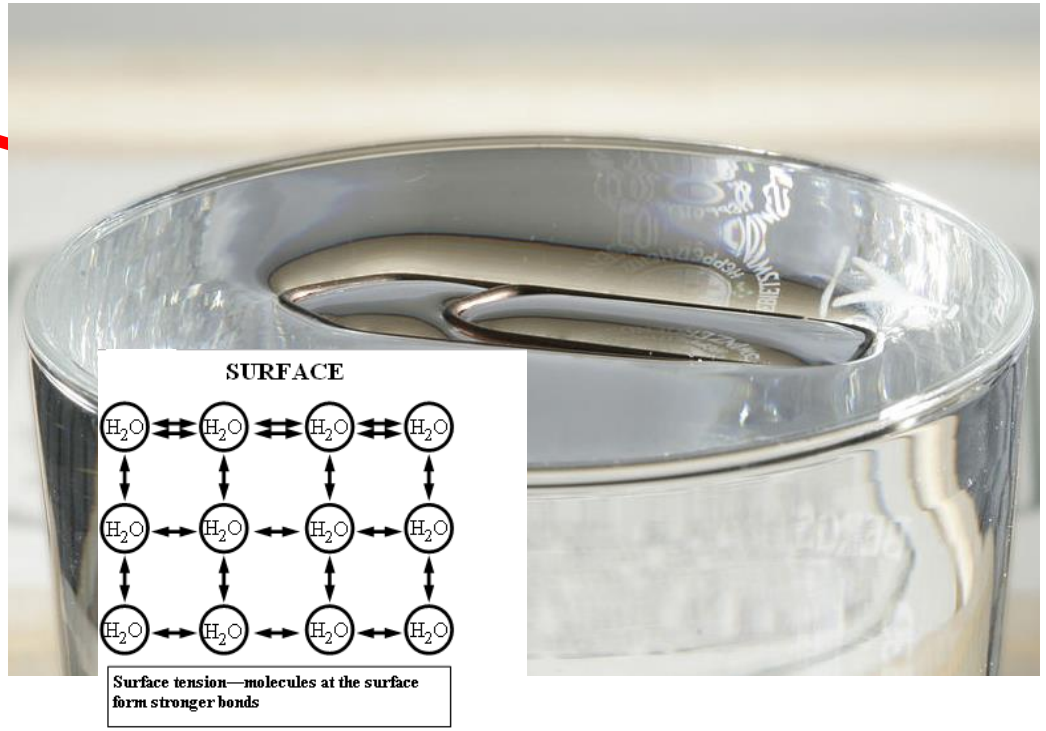
If baby weigh=3kg

TV =12 -18 ml

Surface tension



An air-filled sphere coated with water has a tendency to collapse (reach a minimum volume) due to the pulling force of water surface tension

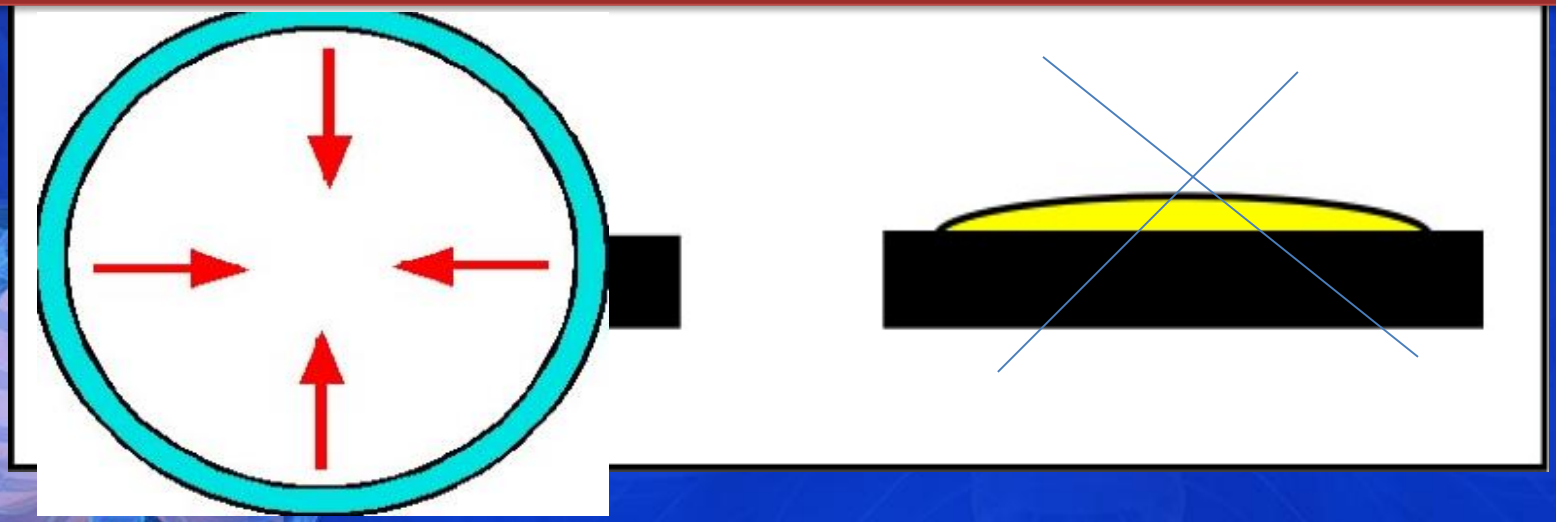


Surface Tension

Water has a VERY HIGH surface tension

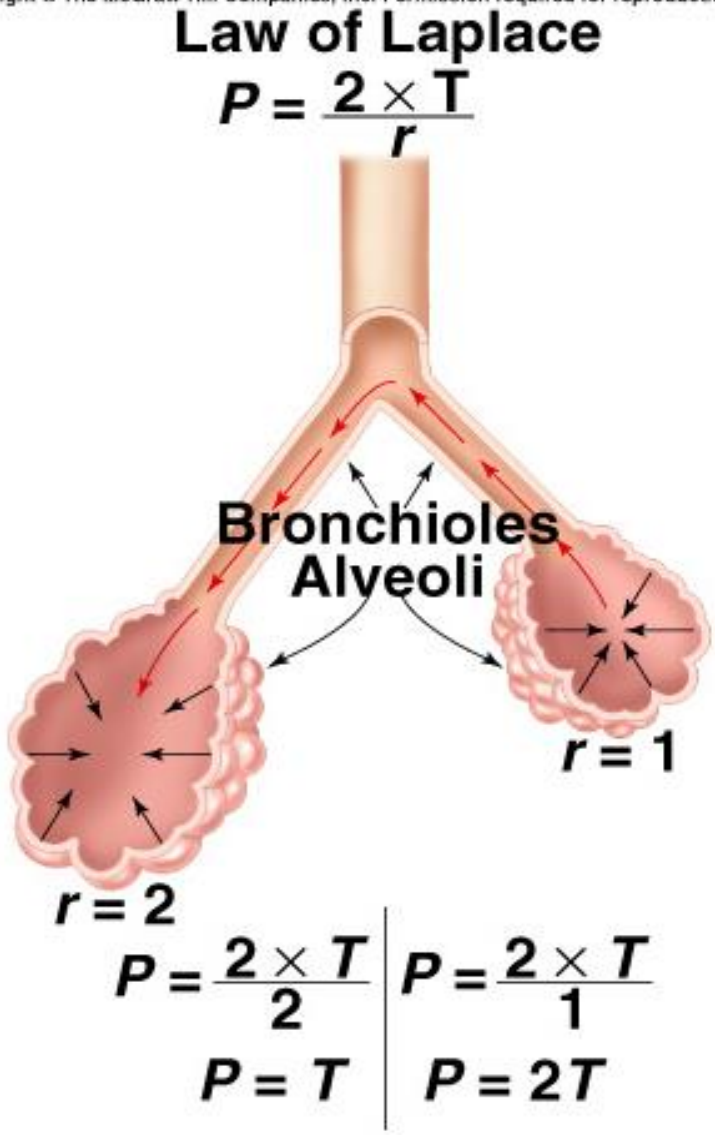
Water will attempt to minimize its surface area in contact with air

Surface tension : Attractive forces between molecule at air water interface



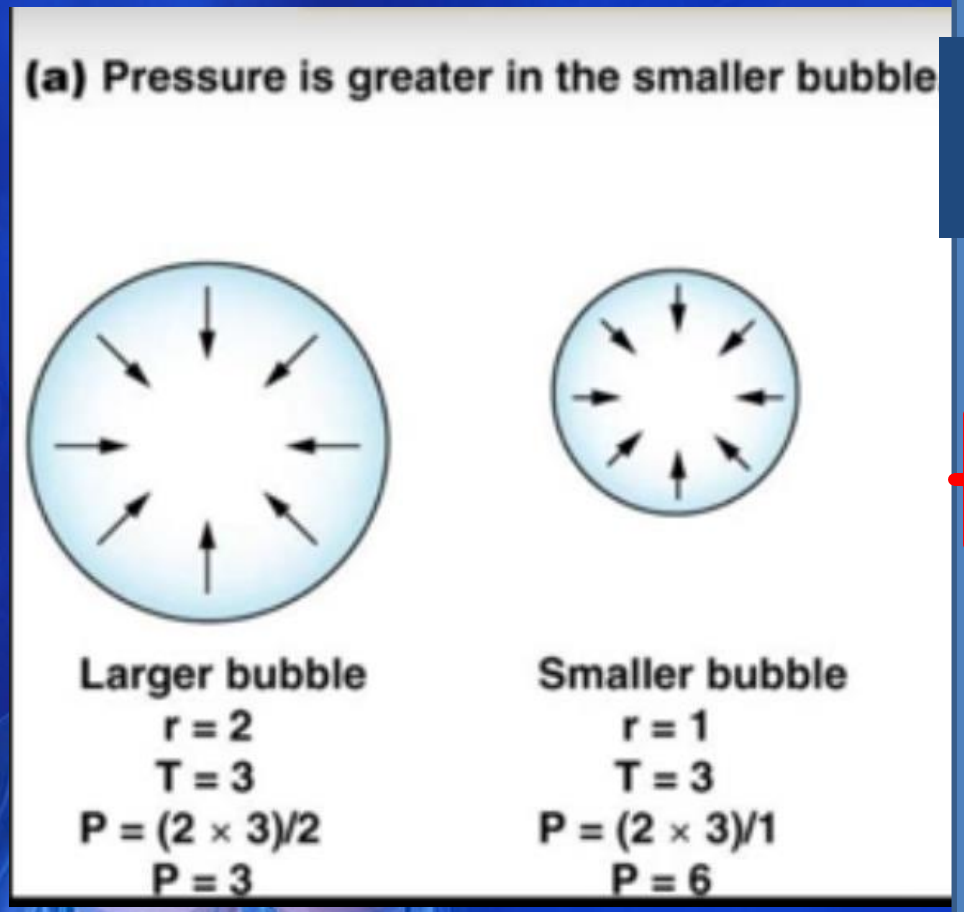
Law of Laplace

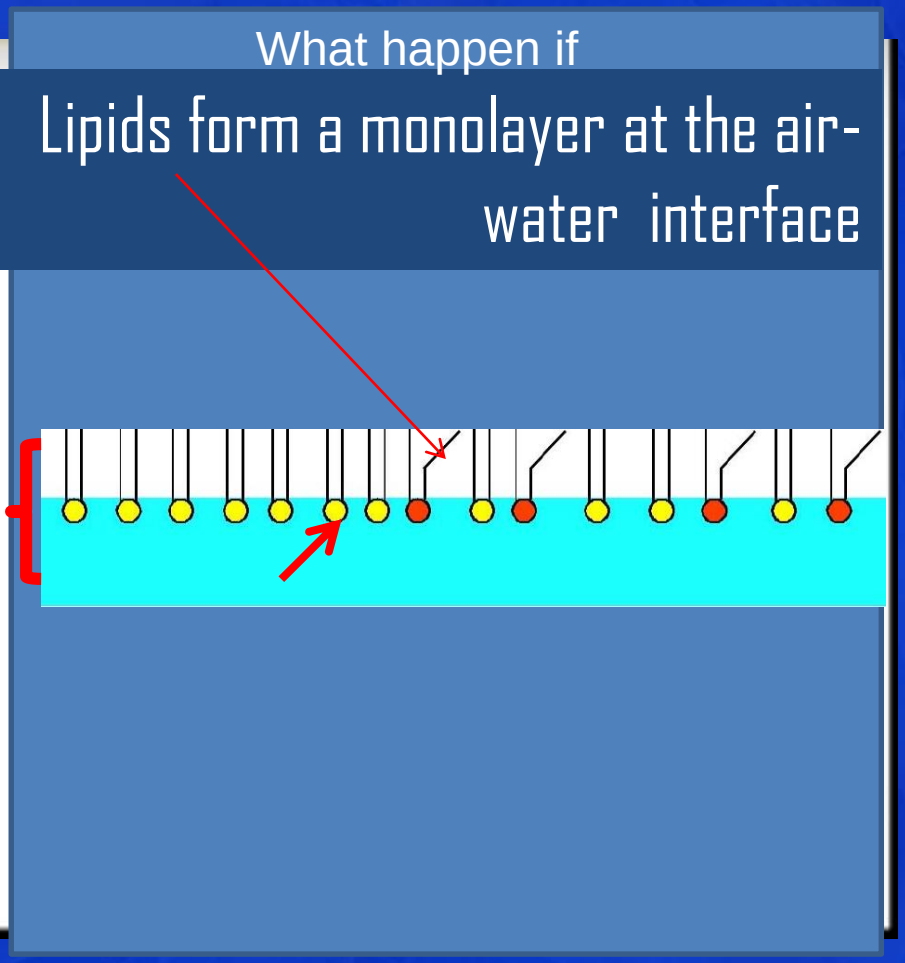
- Collapsing Pressure in alveoli is :
  - directly proportional to surface tension
  - and inversely proportional to radius of alveoli
- The smaller the sphere the more surface tension
  - Pressure in smaller alveolus greater



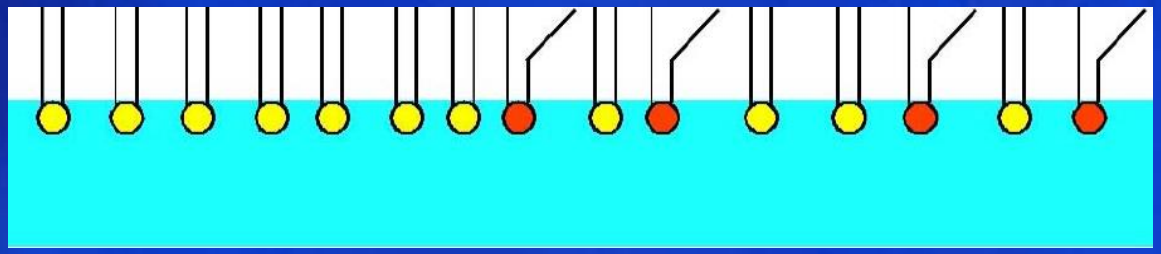
Surface tension

P (collapsing Pressure) = $\frac{2 \times T}{r}$

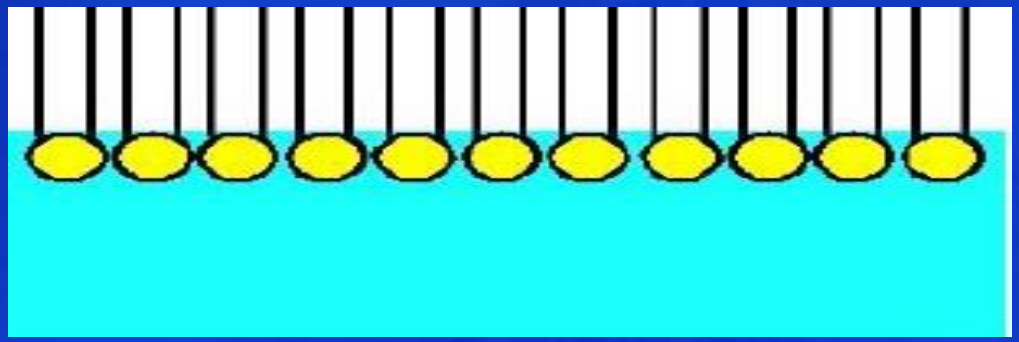




Lipids form a monolayer at the air-water interface

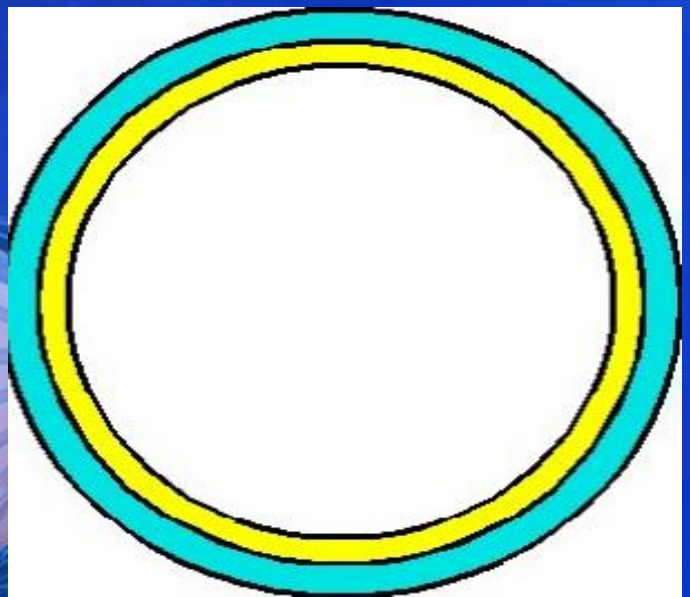


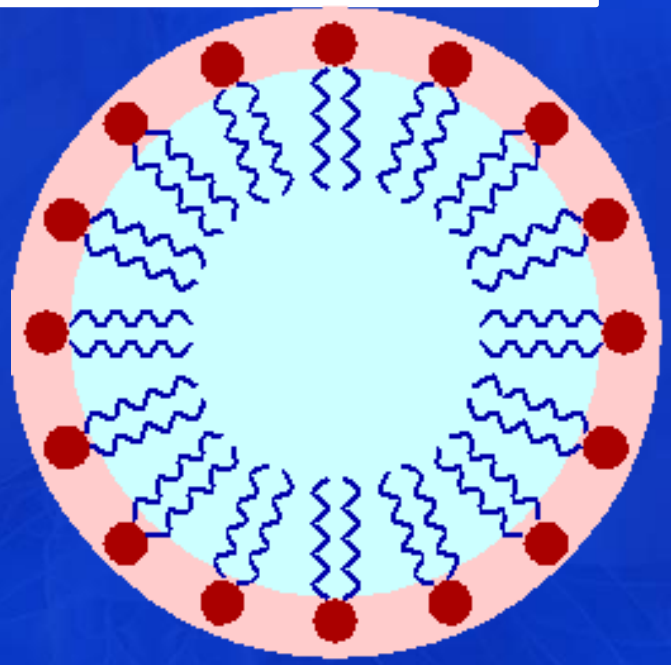
Surface tension decreases as lipid monolayer is compressed



1. Alveoli are coated with lung surfactant in order to reduce the surface tension of water through:
    a) It scatters among the fluid molecule decreasing the attraction between them.
    b) It also spreads over the fluid preventing air-fluid interface.

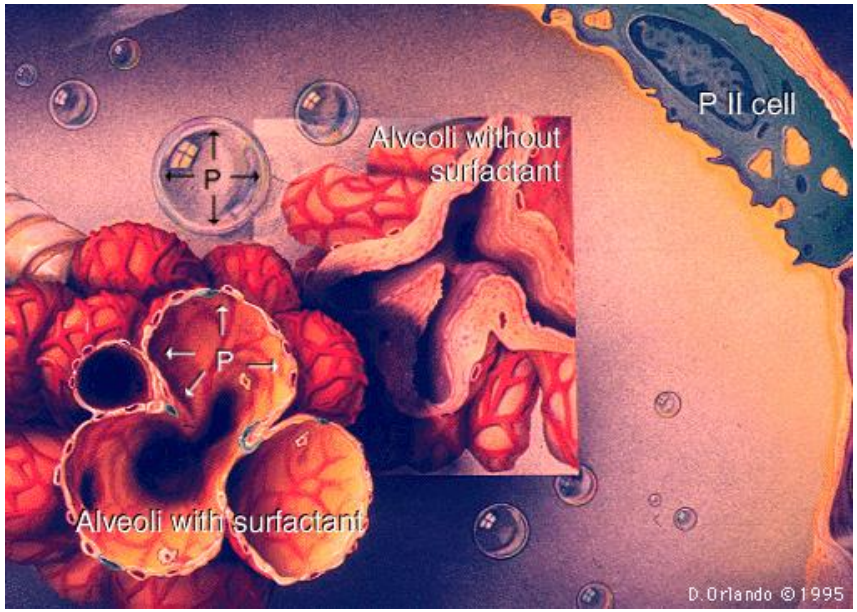
thus preventing collapse (atelectasis) upon exhalation and decreasing the force necessary to expand the alveoli upon inhalation





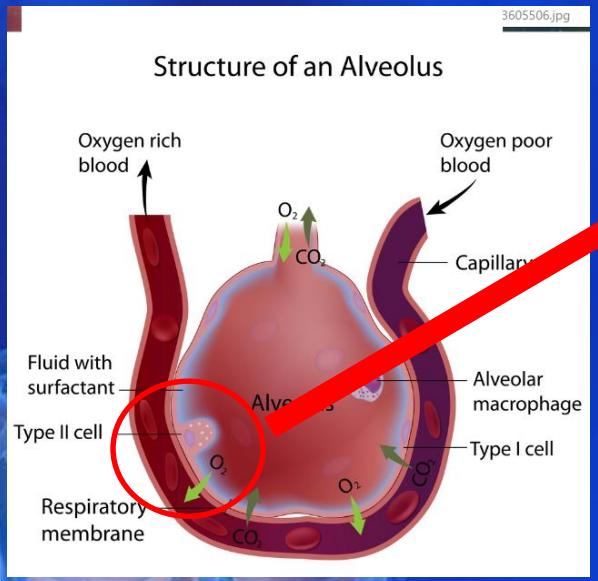
Lung Function in respiratory distress syndrome (RDS)

- Reduction in Functional residual capacity (FRC)



Surfactant

- produced by alveolar type II cells



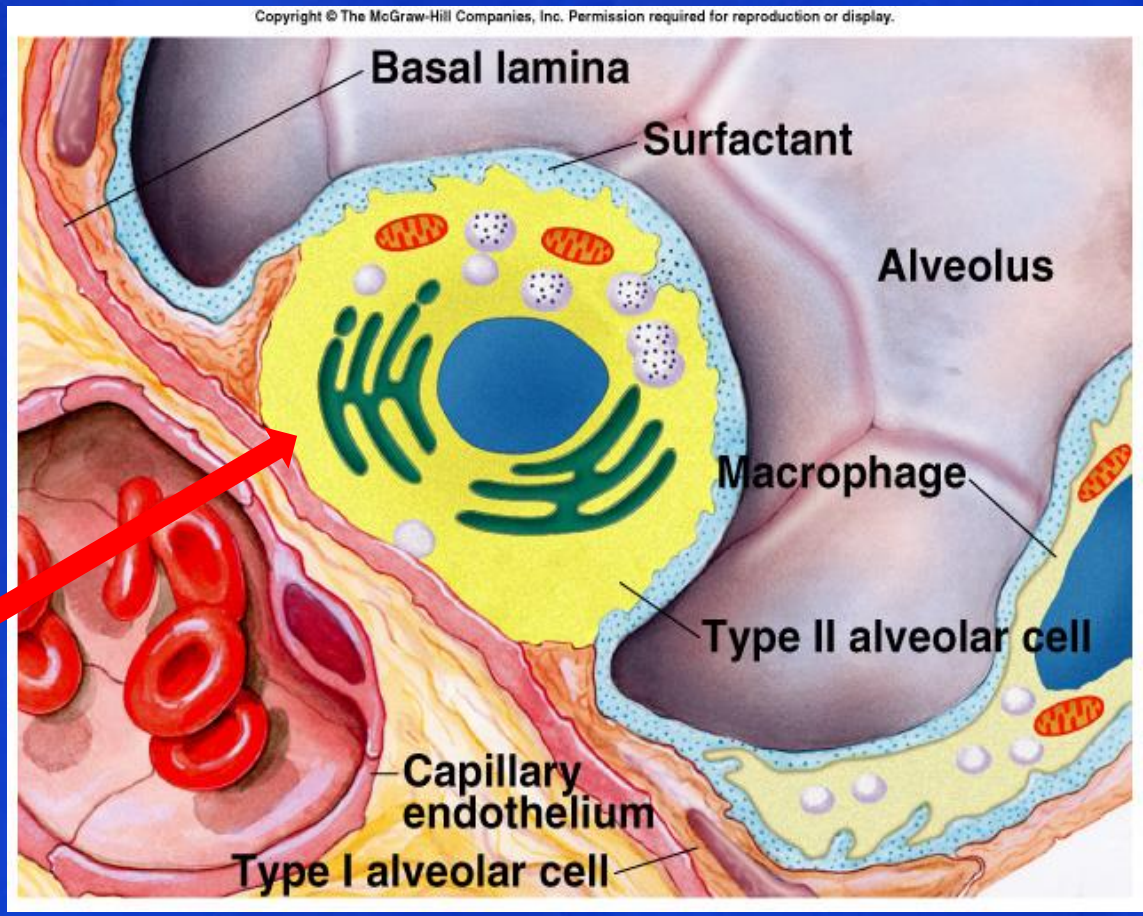


Figure 16.12

Endogenous Surfactant composition and functions

- **Major Lipids (~90%)**
  - Saturated Phosphatidylcholine **DPPC** (***Lecithin)*** 60-80%
  - Unsaturated Phosphospholipids
  - Phosphatidylglycerol (**PG**) ~10%
- **Proteins (~10%)**
  - SP-A

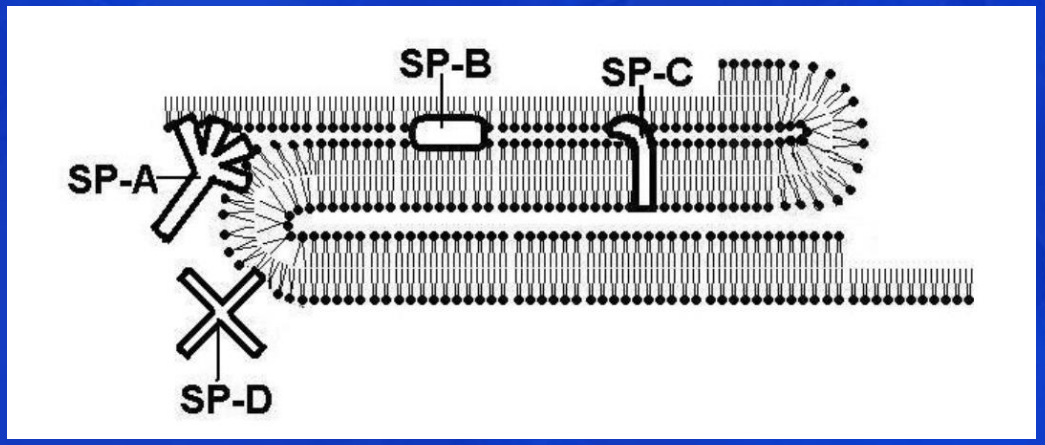
    Hydrophilic, Host defense

    Surfactant homeostasis
  - SP-B
    - **Hydrophobic**, Spreading, ↓ surface tension
  - SP-C
    - Hydrophilic , Adsorption
  - SP-D: ? Phagocytic function

Surfactant proteins

Surfactant proteins are divided into 2 groups:

- **Large and water-soluble SP-A and SP-D proteins**
- **small, hydrofobic SP-B and SP-C proteins.**



Are of great importance to immune defense mechanisms of the lung

-ability to bind to bacteria, viruses and other pathogens ……(**Mainly protein A)**

- well as to activate alveolar macrophages

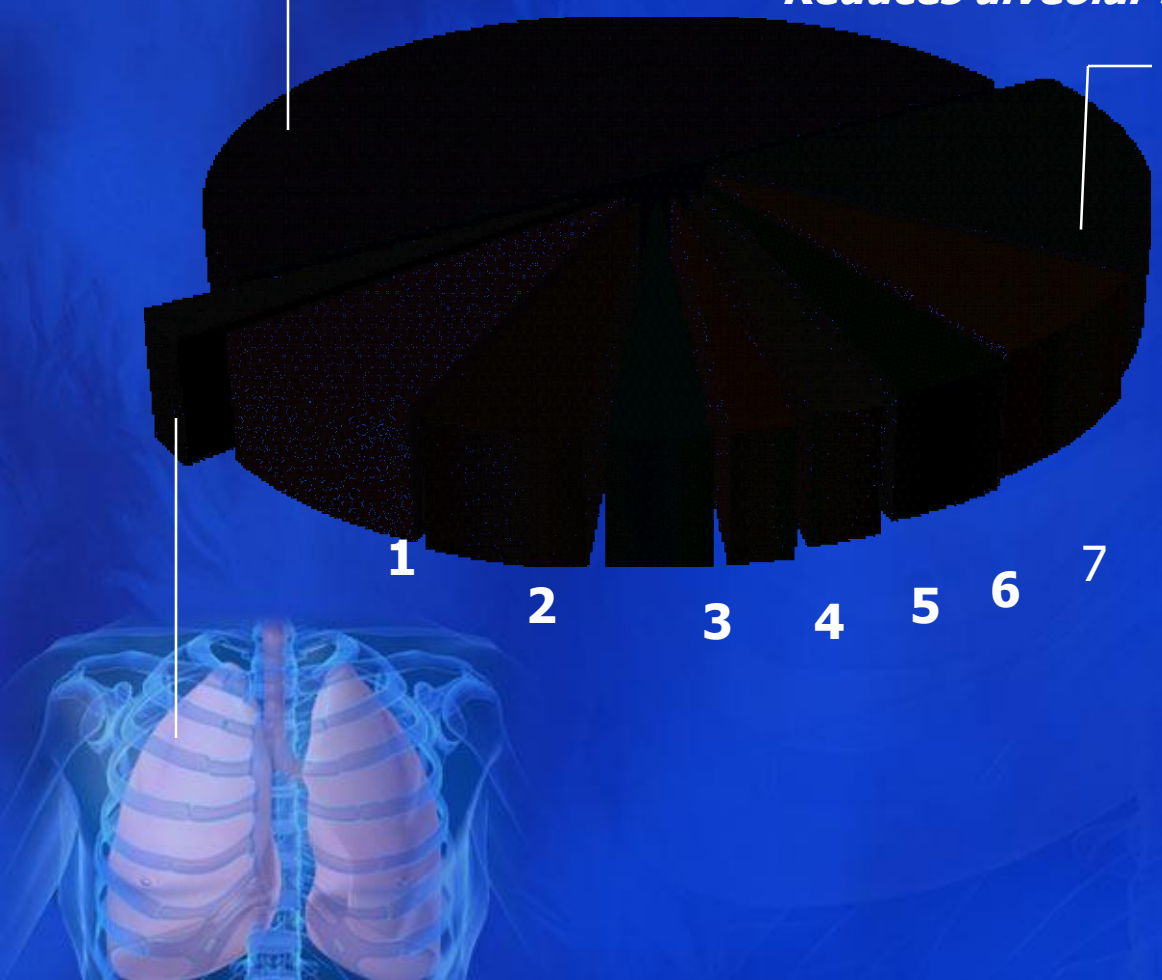
Surfactant Composition

DPPC - dipalmitoylphosphatidylcholine 60%*

- ***Reduces alveolar surface tension***

PG - phosphatidylglycerol 7%*

- ***Promotes the spreading of surfactant throughout the lungs***



1. Serum proteins 10%
2. 2. Other lipids 5%*
3. Other phospholipids 3%*
4. Phosphatidylinositol 2%*
5. Sphingomyelin 2%*
6. Phosphatidylethanolamine 4%*
7. Unsaturated Phosphatidylcholine 17%*

** By molecular weight*

Prenatal diagnosis

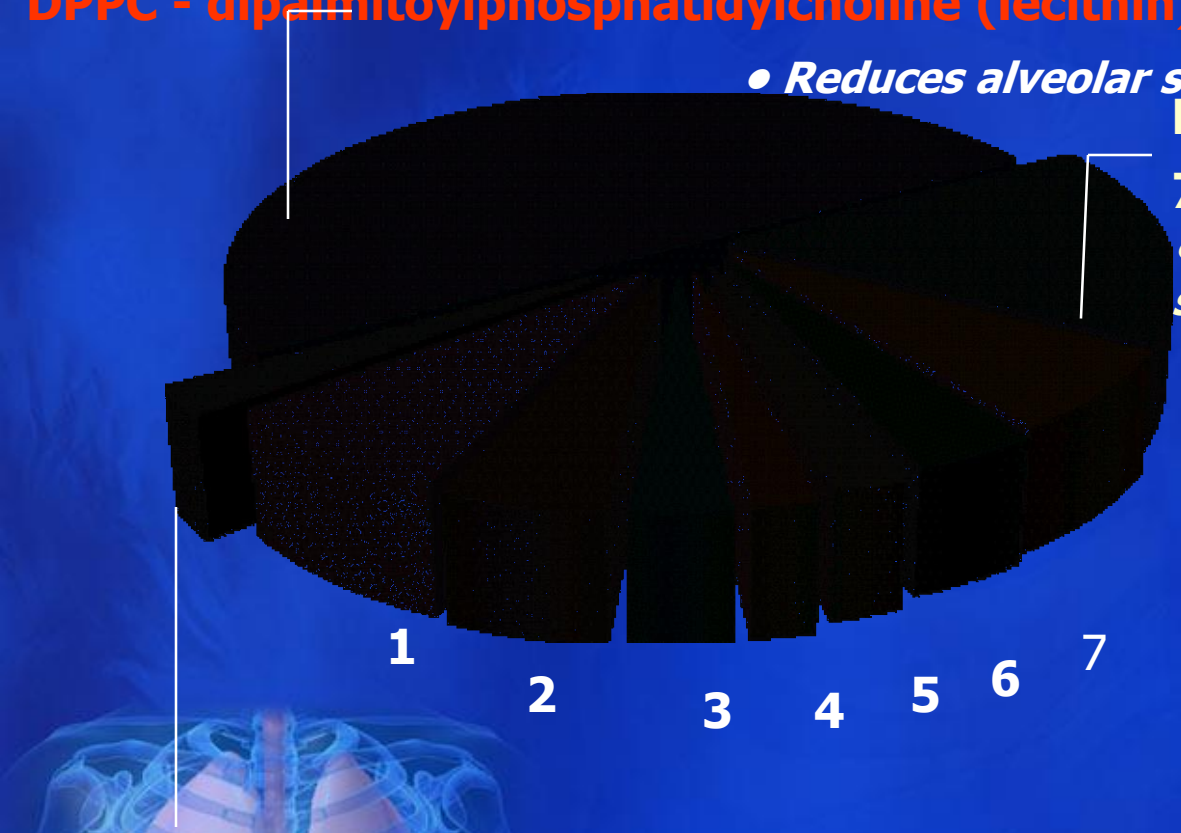
- Lecithin and sphingomyelin ratio in the amniotic fluid, if ratio is more than 2 indicates adequate lung maturity

DPPC - dipalmitoylphosphatidylcholine (lecithin)60%-80%*

- ***Reduces alveolar surface tension***

PG - phosphatidylglycerol 7%*

- ***Promotes the spreading of surfactant throughout the lungs***



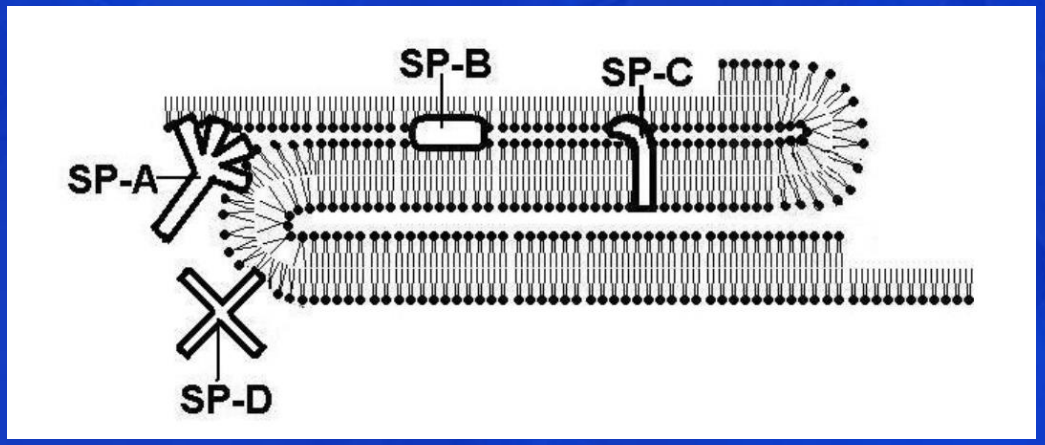
1. **Serum proteins 10%**
2. **2. Other lipids 5%***
3. **Other phospholipids 3%***
4. **Phosphatidylinositol 2%***
5. ***Sphingomyelin 2%****
6. **Phosphatidylethanolamine 4%***
7. **Unsaturated Phosphatidylcholine 17%***

**** By molecular weight***

Surfactant proteins

Surfactant proteins are divided into 2 groups:

- **Large and water-soluble SP-A and SP-D proteins**
- **small, hydrofobic SP-B and SP-C proteins.**

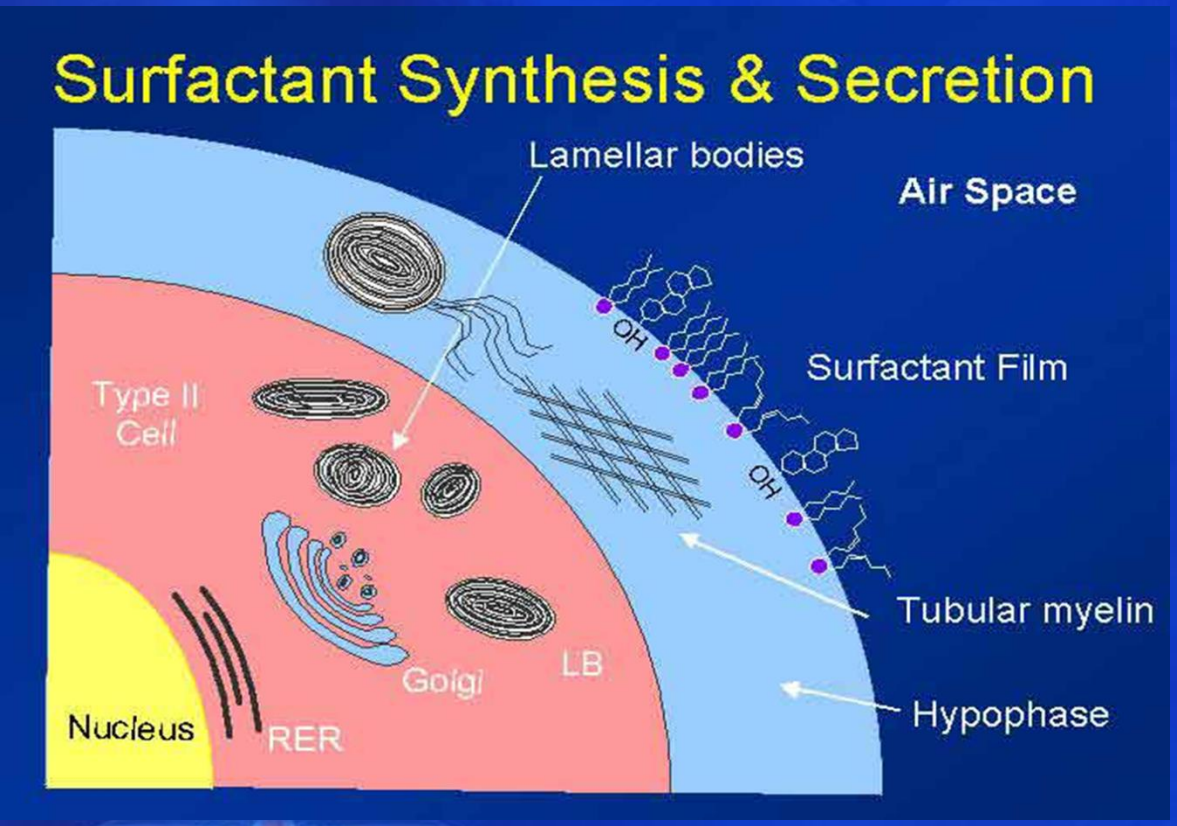


Are of great importance to immune defense mechanisms of the lung

-ability to bind to bacteria, viruses and other pathogens ……(**Mainly protein A)**

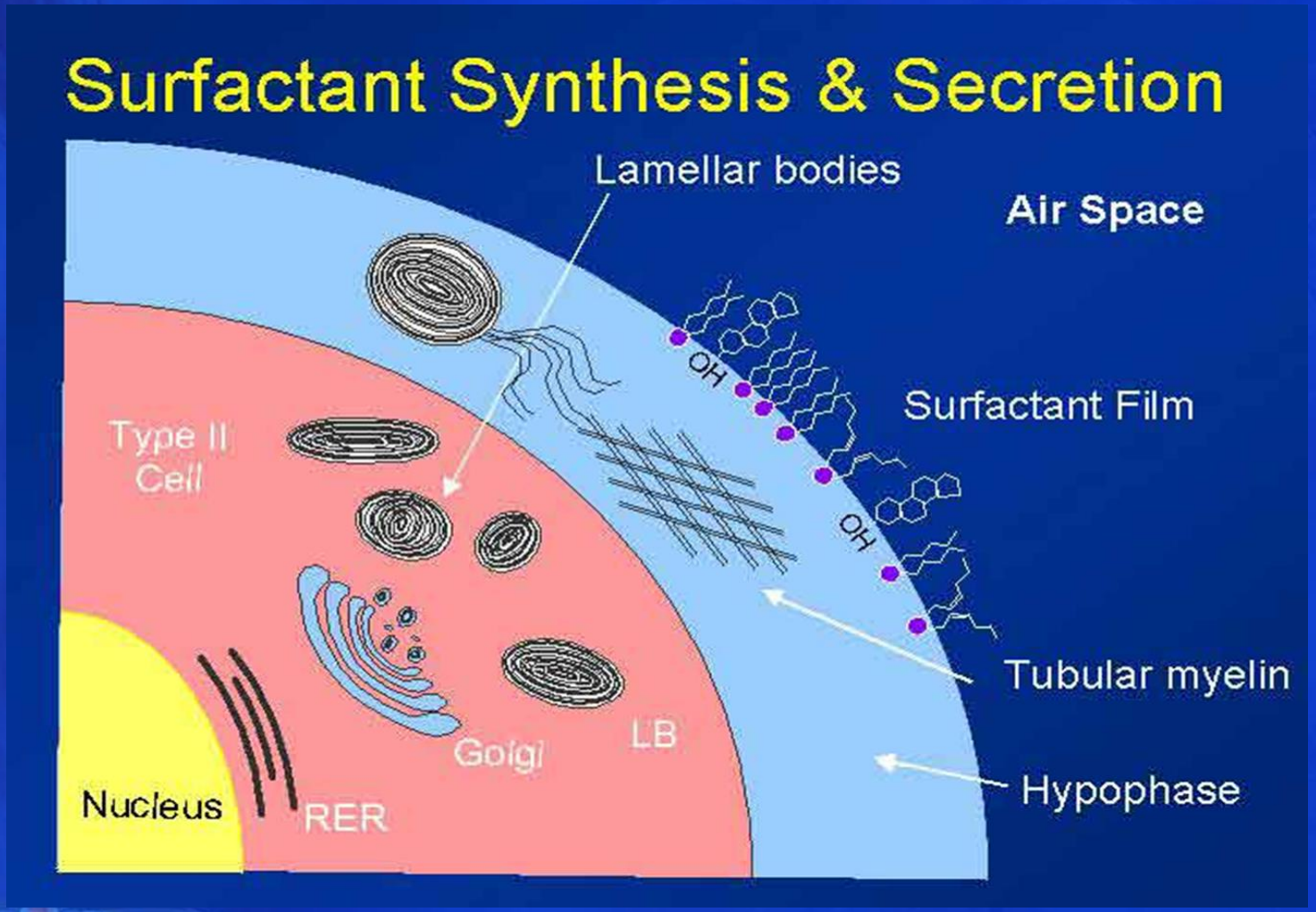
- well as to activate alveolar macrophages

Component



1-Lipid

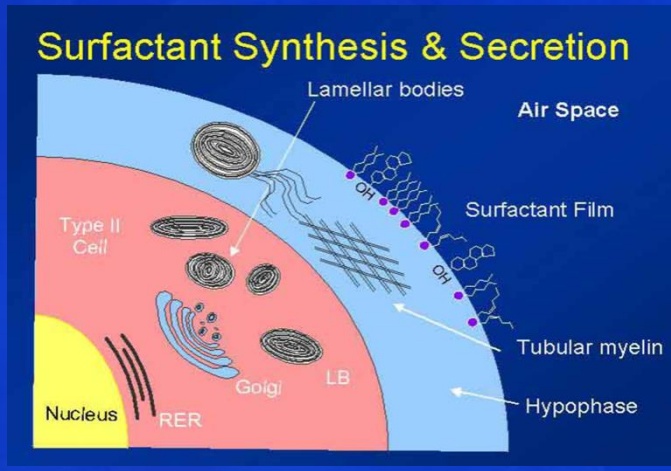
- **Synthesized in the smooth endoplasmic reticulum moved to Golgi apparatus**



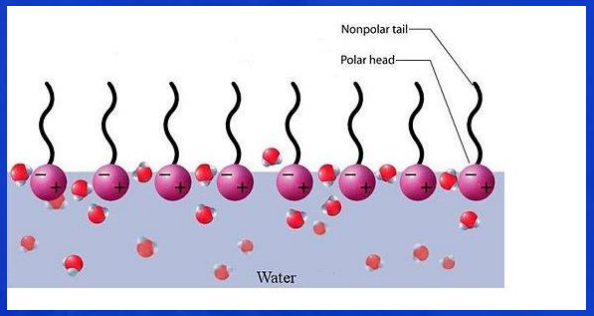
- Surfactant is synthesized by ***type II alveolar cells*** from fatty acids that either reach the lung from blood or formed (de novo) inside it. It is stored in organelles know as ***"lamellar bodies"***.

Component

Lipid

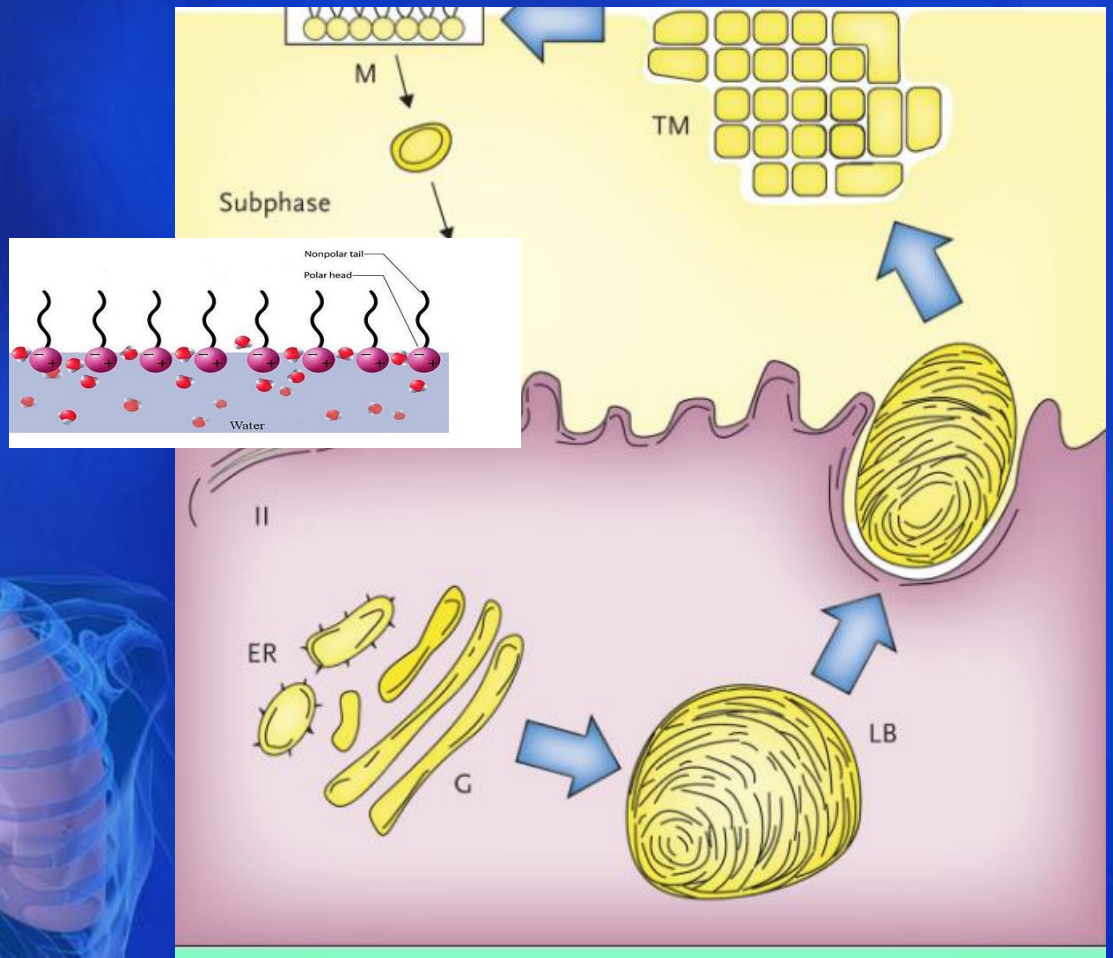


- **The main constituent of the monolayer dipalmitoylphosphatidylcholine (DPPC), which is a bipolar lipid (it has a hydrophilic 'head' and a lipophilic 'tail')**



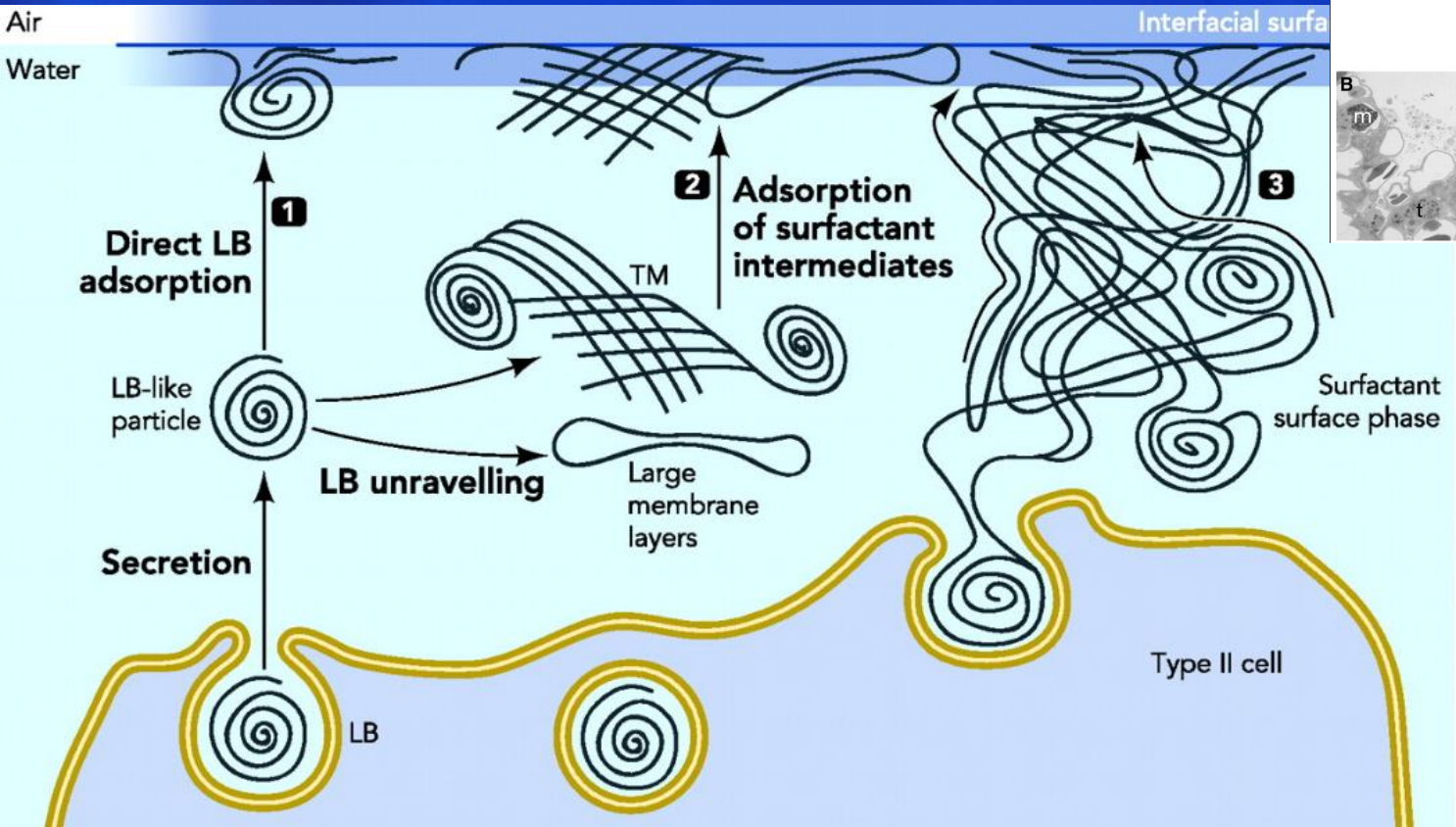
Surfactant synthesis

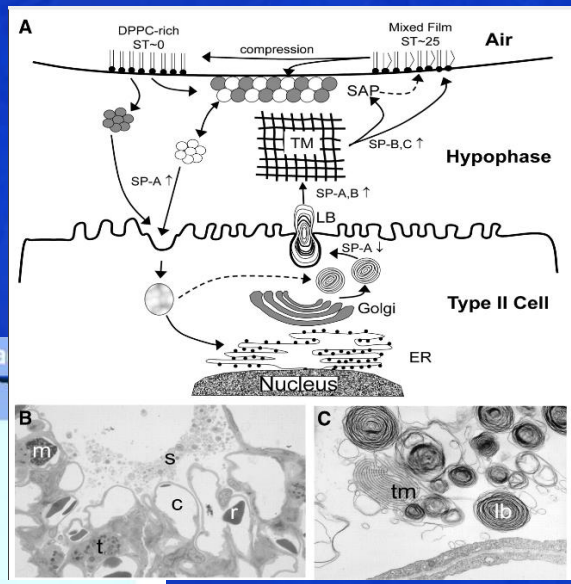
monomolecular surfactant



Surface Tension

- Surfactant **Lipoprotein complex** that lowered the surface tension synthesized by Type II pnuemocyte





Functions of surfactant:

1-This decreased surface tension:

Roles of Lung surfactant

surfactant decreases surface tension

- ↑ pulmonary compliance
- ↓ alveolar collapse
- Respiratory distress syndrome (RDS)

prevention

TO TEST

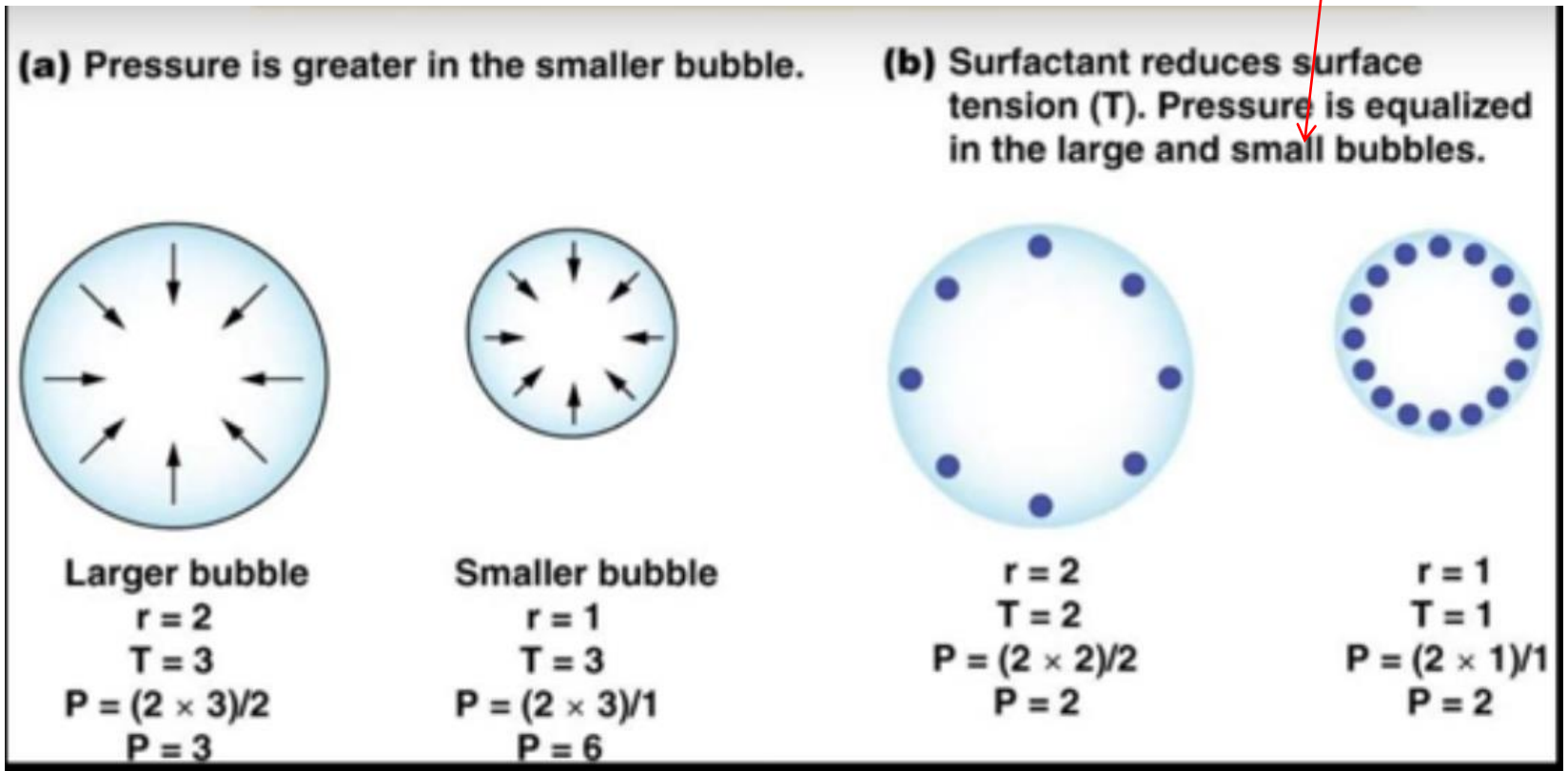
Fetal lung maturity

- L/S ratio ⟶
- phosphatidylglycerol
- foam stability or shake test

L/S < 1.5	immature
L/S 1.5-1.9	intermediate
L/S ≥ 2	lung maturity

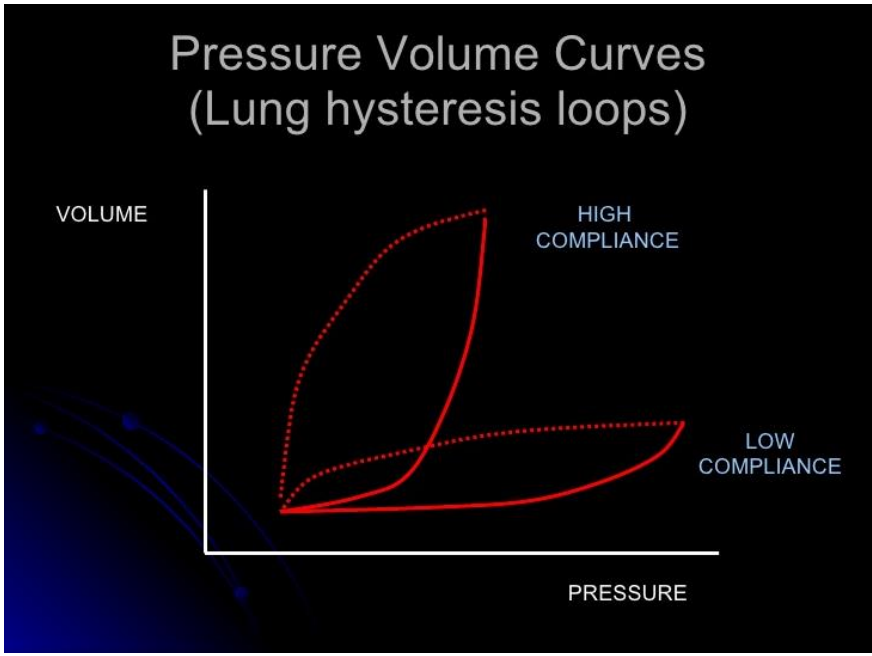
Ventilation in the presence of surfactant

- Disrupts the surface tension & cohesion of water molecules
- Impact?
  - prevents alveoli from sticking together during expiration



Functions of surfactant:

- This decreased surface tension:
  - Increase the lung compliance
    - Helps lung expansion during inspiration



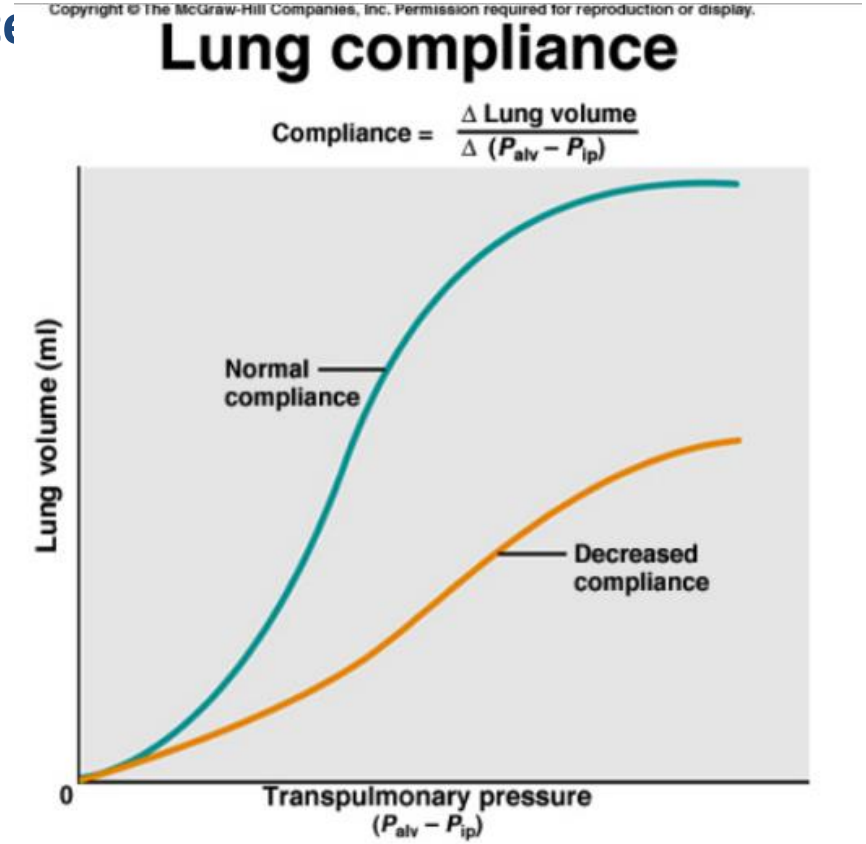
Functions of surfactant:

This decreased surface tension:

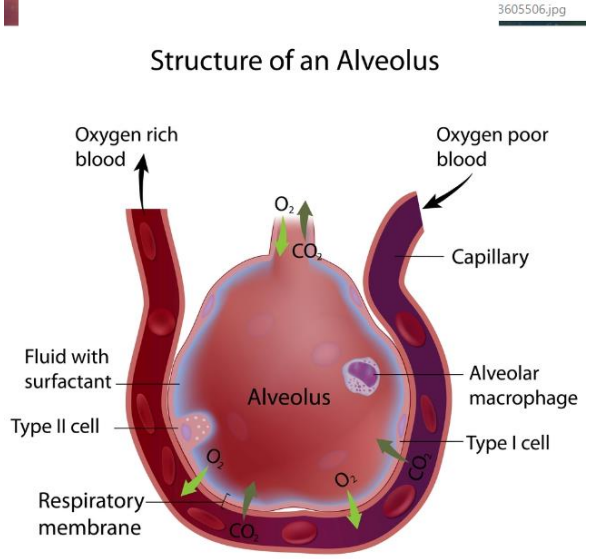
- Increase the lung compliance
  - Helps lung expansion during inspiration
  - stabilize the alveoli :

This protects the alveoli from

- ❑ Collapse during expiration
- ❑ over distention during inspiration
- ❑ Prevent collapse during expiration (atalactasis)



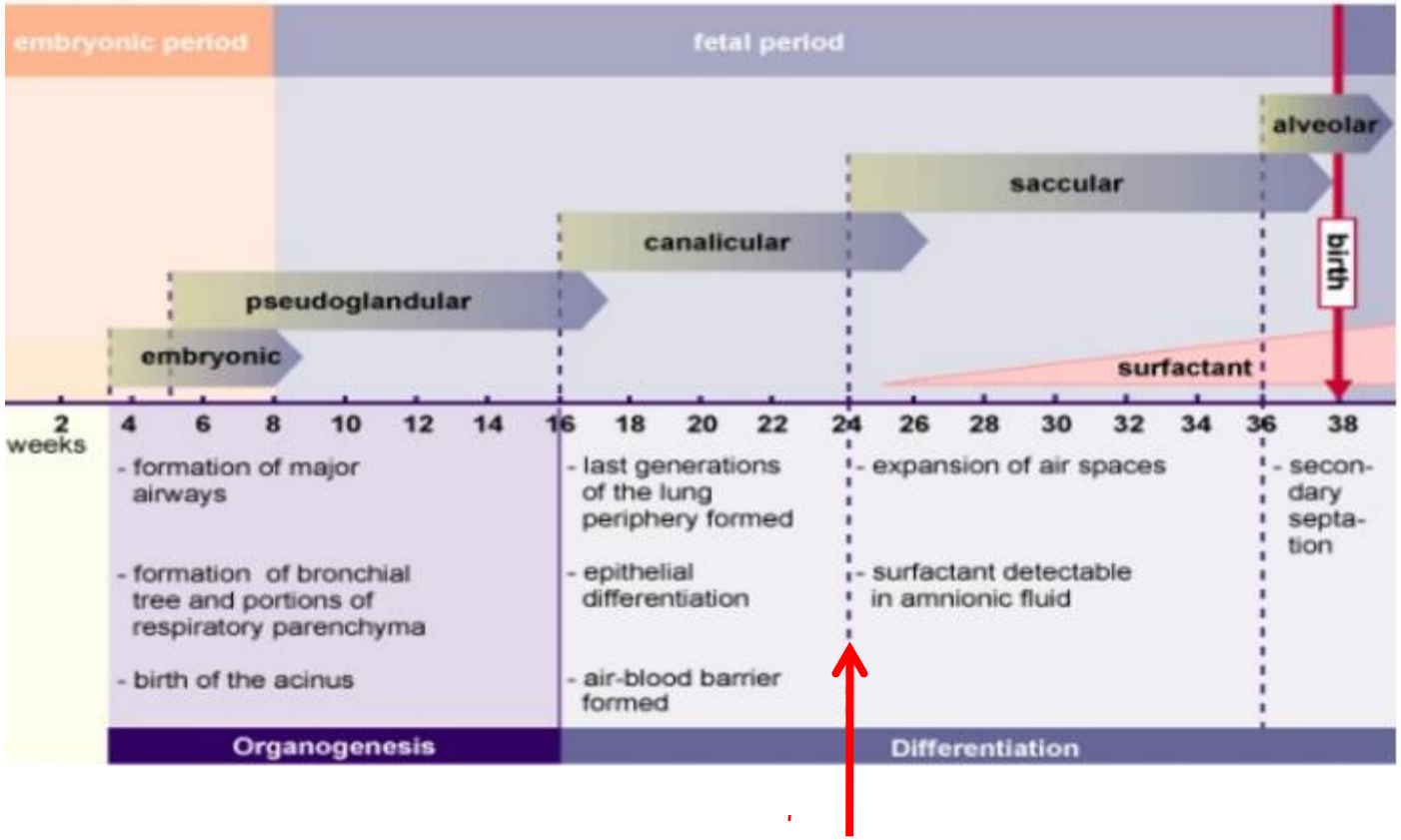
Functions of surfactant:



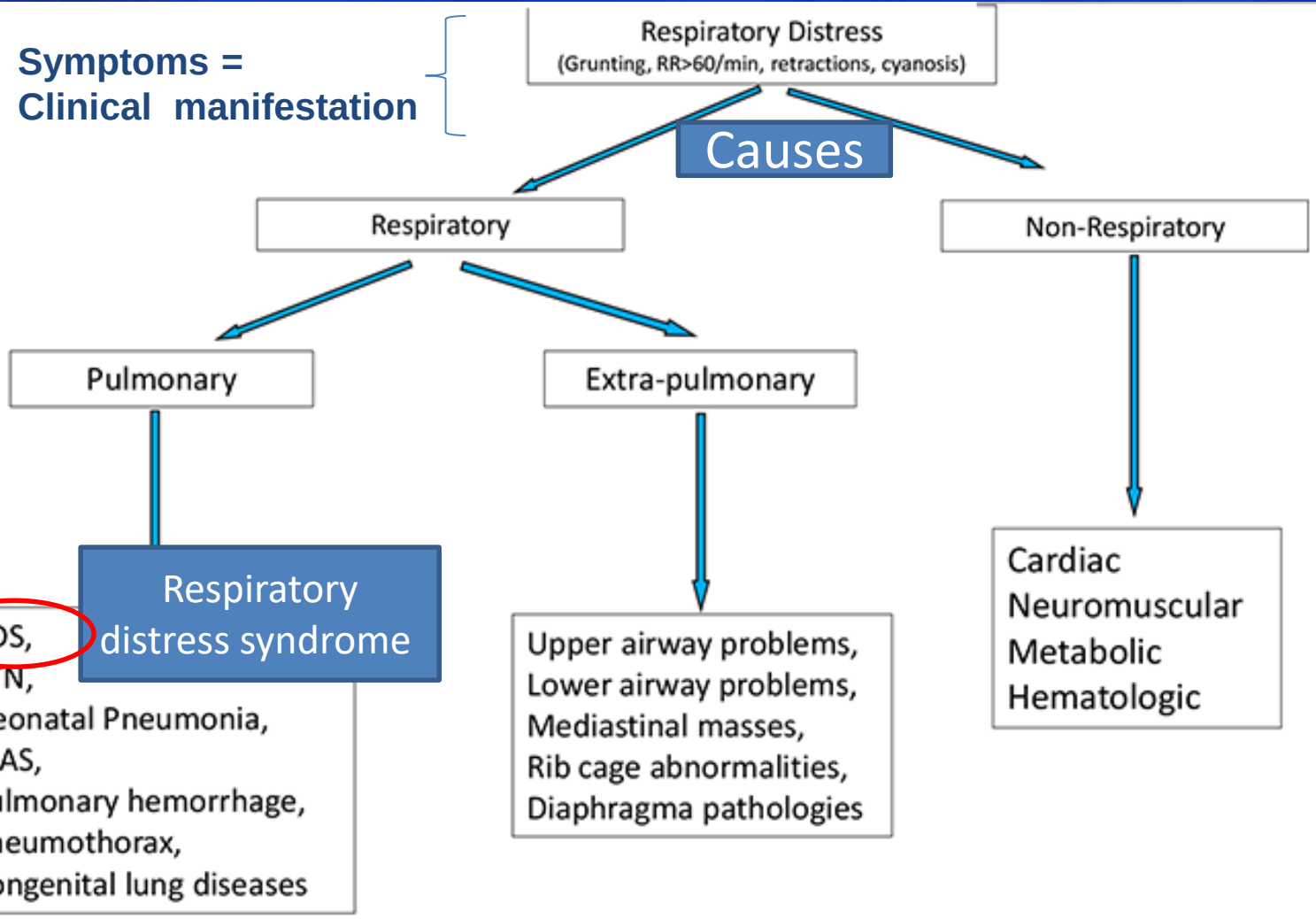
This decreased surface tension:

- **Protects against pulmonary edema as it decreases the filtration forces for the fluid from pulmonary capillaries into alveoli.**

Phases of Lung Development



Symptoms =
Clinical manifestation

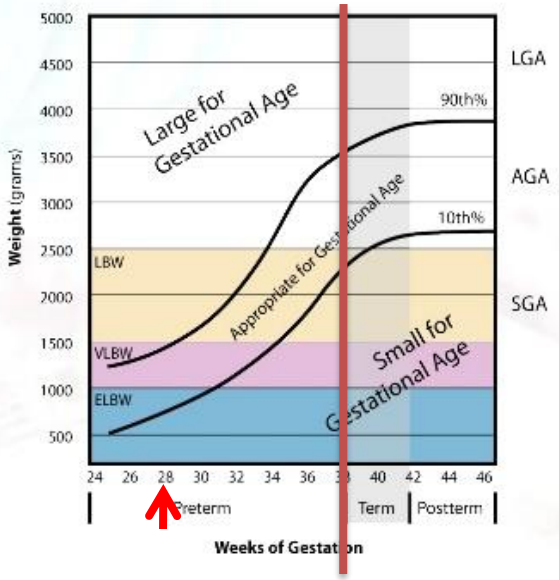


Case

- Baby born preterm at 28 week

Define preterm

Gestation age < 37 weeks from Last menstrual period



Gestational Age

Classification of Size

- SGA- small for gestational age-weight below 10th percentile
- AGA-weight between 10 and 90th percentiles (between 5lb 12oz (2.5kg) and 8lb 12 oz (4kg).
- LGA-weight above 90th percentile
- IUGR-deviation in expected fetal growth pattern, caused by multiple adverse conditions, not all IUGR infants are SGA, may or may not be "head sparing"

Respiratory distress syndrome (RDS)

What Next ?

Preterm baby
Excepted to
have RDS

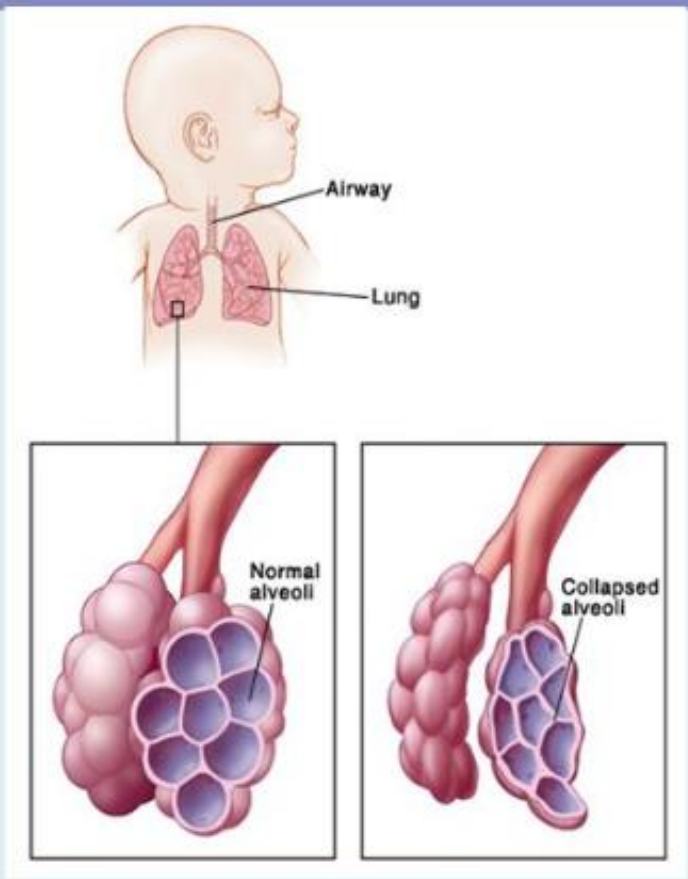
CLINICAL MANIFESTATION

- Tachypnea
- Nasal flaring
- Intercostal, sternal recession
- Grunting; closure of glottis during expiration
- Cyanosis

DEFINITION • Acute lung disease of the newborn

Respiratory Distress Syndrome (RDS)

- Also called hyaline membrane disease.
- Most common cause of respiratory distress in preterm infants.
- Due to structural and functional immaturity of lungs.
  - Underdeveloped parenchyma
  - Surfactant deficiency
    - Type II pneumatocytes
- Results in decreased lung compliance, unstable alveoli

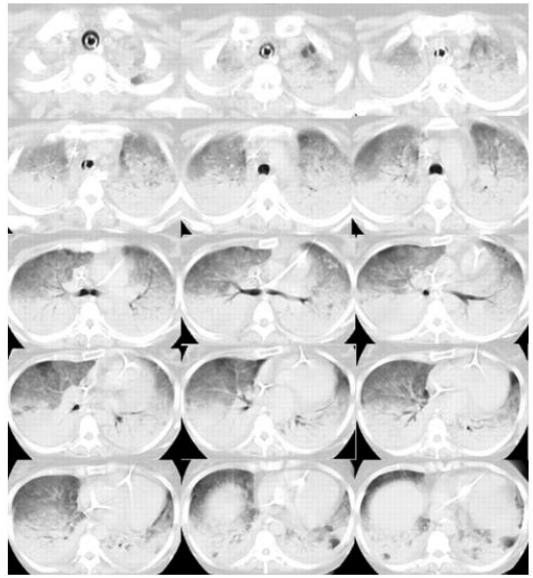


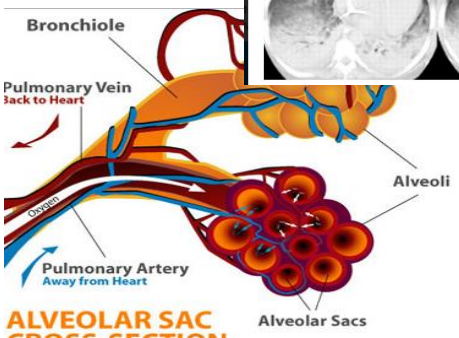
pathophysiology

- Instability of terminal airspaces (difficult to expand during inspiration and atelectasis at expiration) due to elevated surface forces at liquid-gas interfaces (elevated surface tension)

Diminished surfactant :

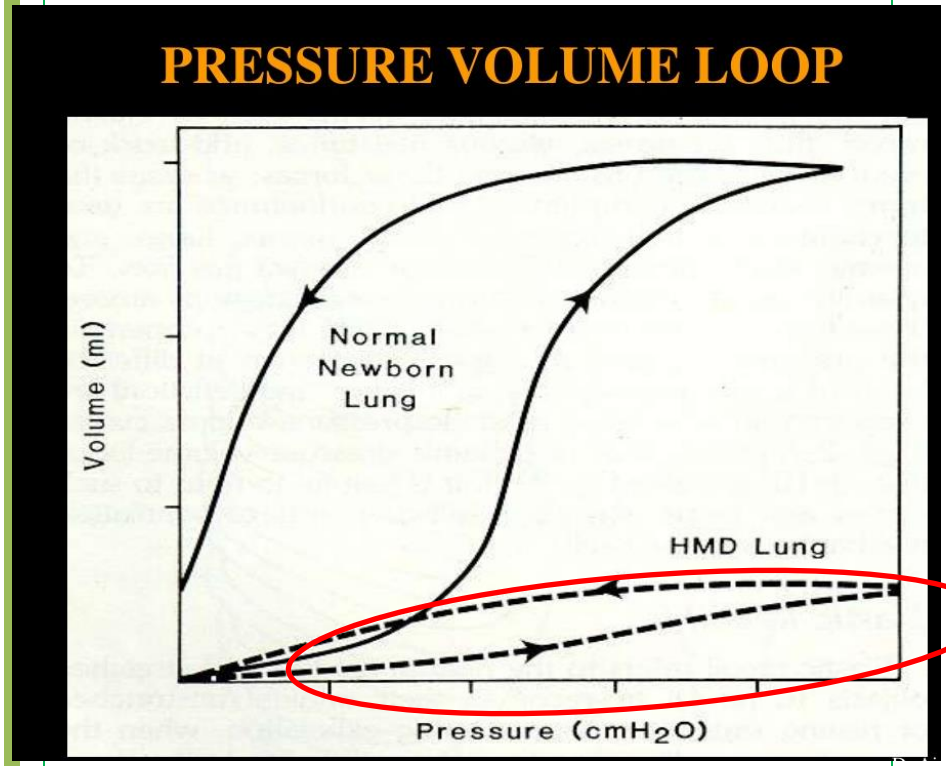
- Progressive Atelectasis
- Loss of functional residual capacity
  - Small lungs and small tidal volume
- Alterations in ventilation perfusion ratios
- Uneven distribution of ventilation





Lung compliance in RDS

- Lung Compliance is also reduced: from 1-2 to 0.2 - 0.5 ml/cmH_2O/kg

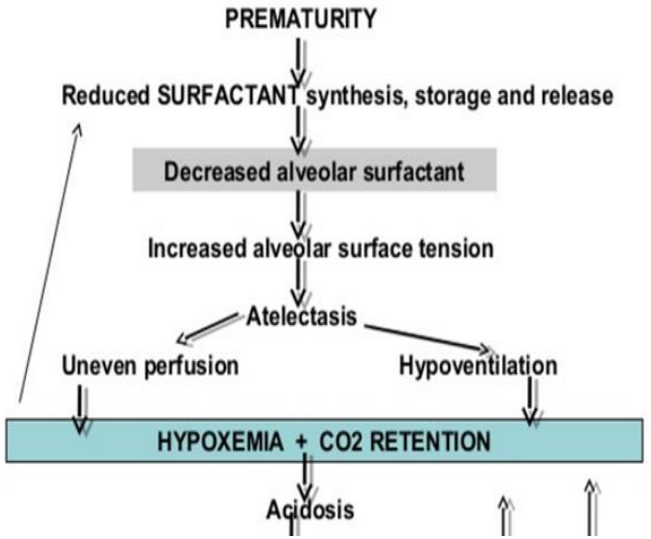


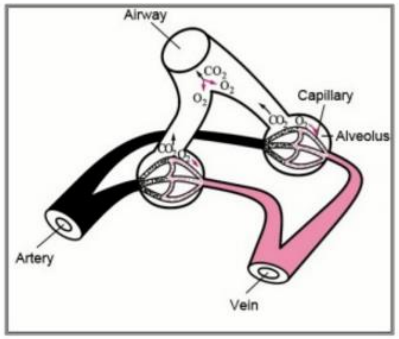
RDS: clinical picture

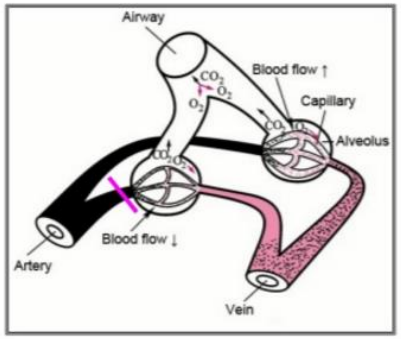
- At admission of the baby he has
  - Cyanosis
    - ↓ **Pulse Oximeter 75% (normal > 95%**

<u>Blood gas:</u>

- ↓ **PaO2 = 45% mmHg (normal 80-108)**
- ↓ **Ph= 7.2 (normal 7.35-7.45)**
- ↑ **CO2 = 65 mmHg (normal 35-45)**







Lung hypo perfusion V/Q mismach

PREMATURITY

Reduced SURFACTANT synthesis, storage and release

Decreased alveolar surfactant

Increased alveolar surface tension

Atelectasis

Uneven perfusion

Hypoventilation

HYPOXEMIA + CO2 RETENTION

Acidosis

Pulmonary Vasoconstriction

Pulmonary hypoperfusion

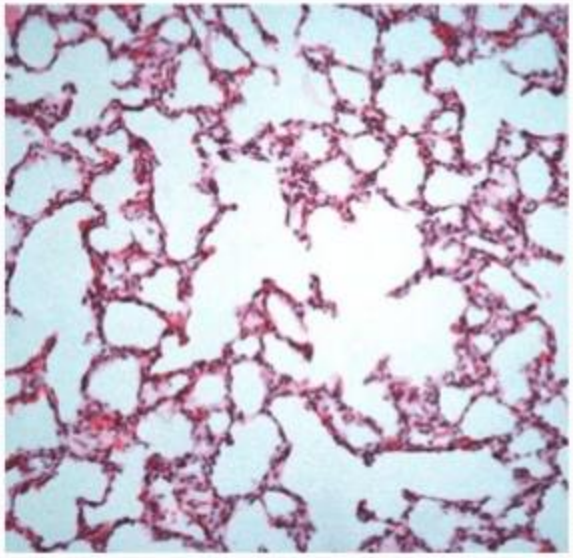
Endothelial damage + Epithelial damage

Plasma leak into alveoli

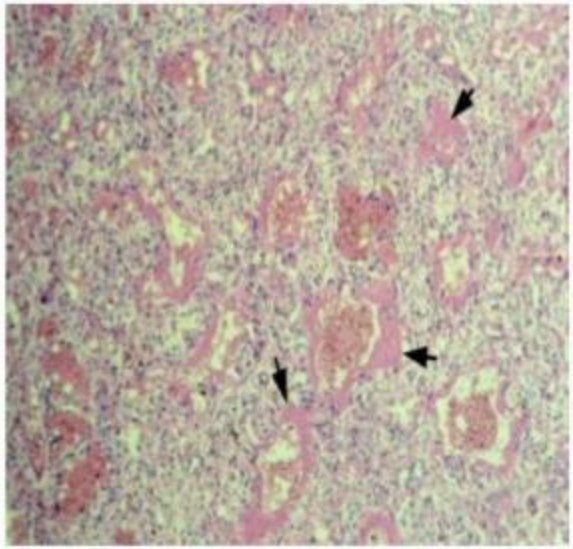
FIBRIN + NECROTIC CELLS (HYALINE MEMBRANE)

Increased diffusion gradient

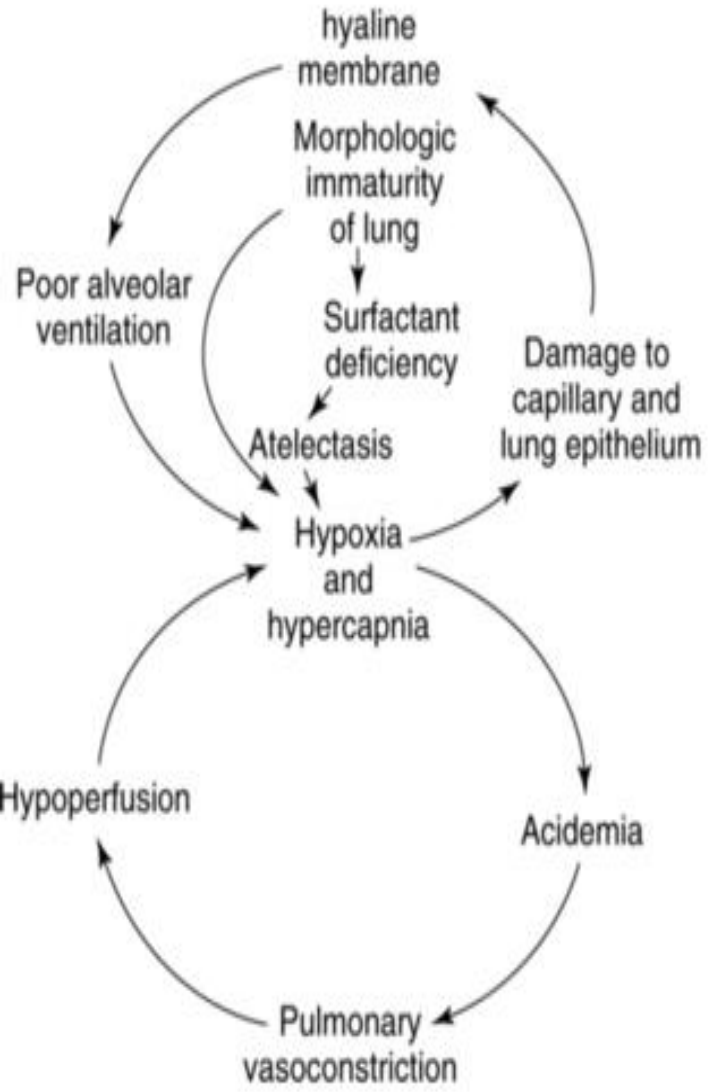
Normal Lung



Hyaline Membranes



- Hyaline membrane- combination of sloughed epithelium, protein & edema.



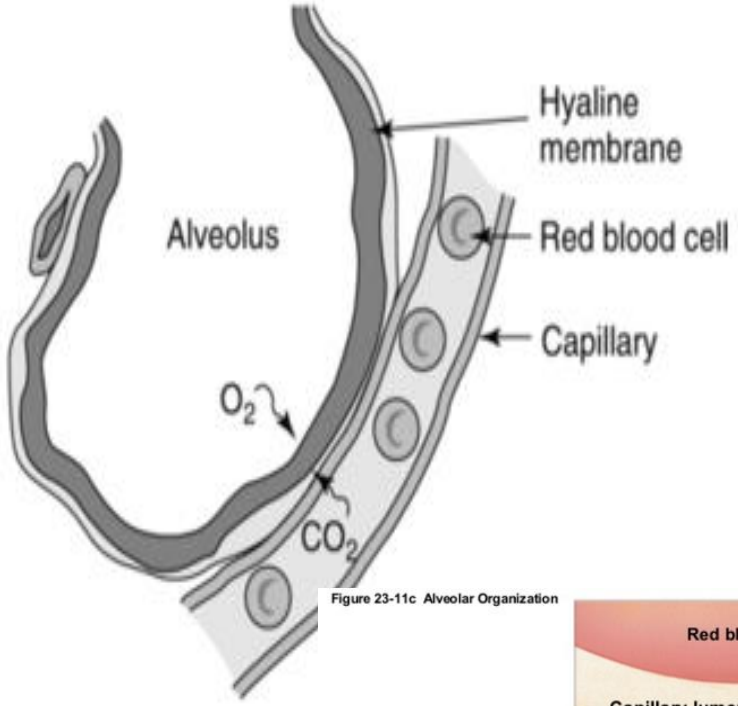
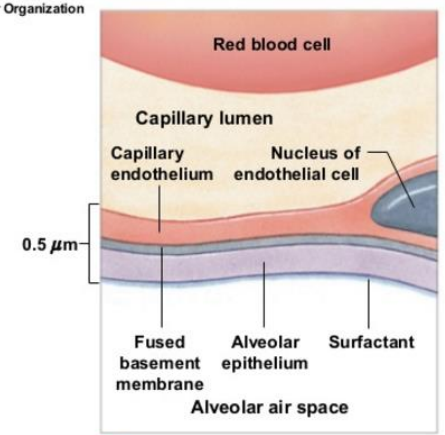
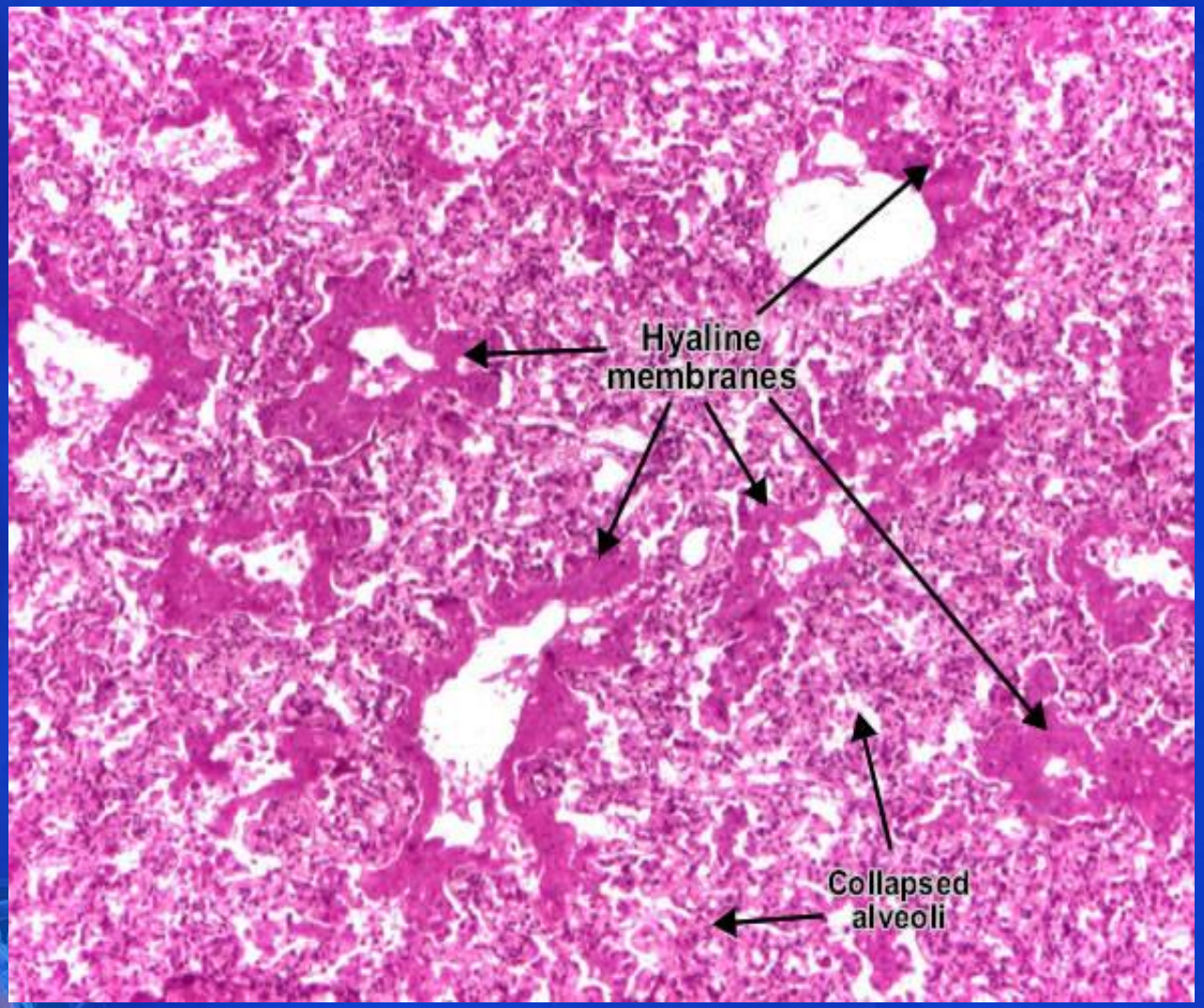


Figure 23-11c Alveolar Organization

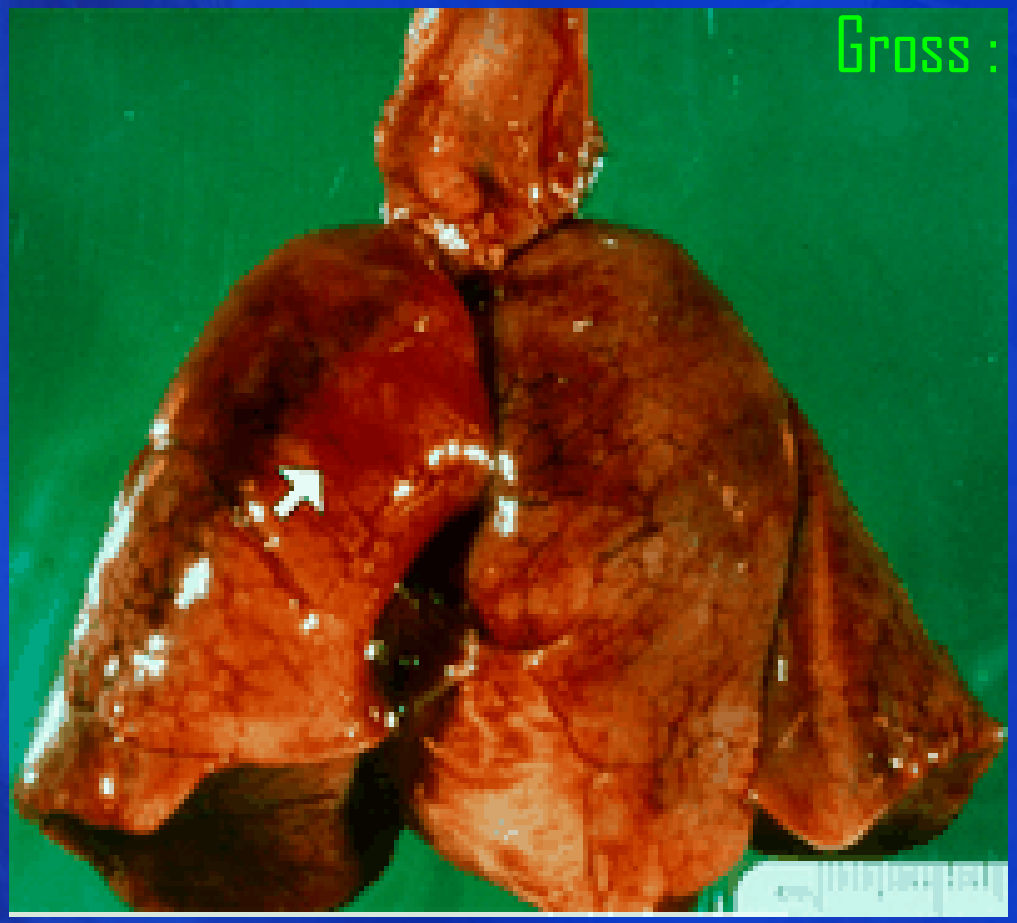


c The respiratory membrane, which consists of an alveolar epithelial cell, a capillary endothelial cell, and their fused basement membranes.

- Hyaline membrane- combination of sloughed epithelium, protein & edema.



- Hyaline membrane- combination of sloughed epithelium, protein & edema.



Gross : Lung firm, red, liverlike

- Photograph of an autopsy specimen demonstrates small atelectatic lungs with focal hemorrhage (arrow) visible on the pleural surface.

Incidence

Respiratory Distress Syndrome (RDS)

- Also known as **Hyaline Membrane Disease (HMD)**
- Commonest cause of preterm neonatal mortality
- RDS occurs primarily in premature infants; its incidence is inversely related to gestational age and birth weight

Gestational age	Percentages
Less than 28 wks	60-80%
32-36 wks	15-30%
37-39 wk	5%
Term	Rare

Nelson Textbook of Pediatrics, 18th Ed.

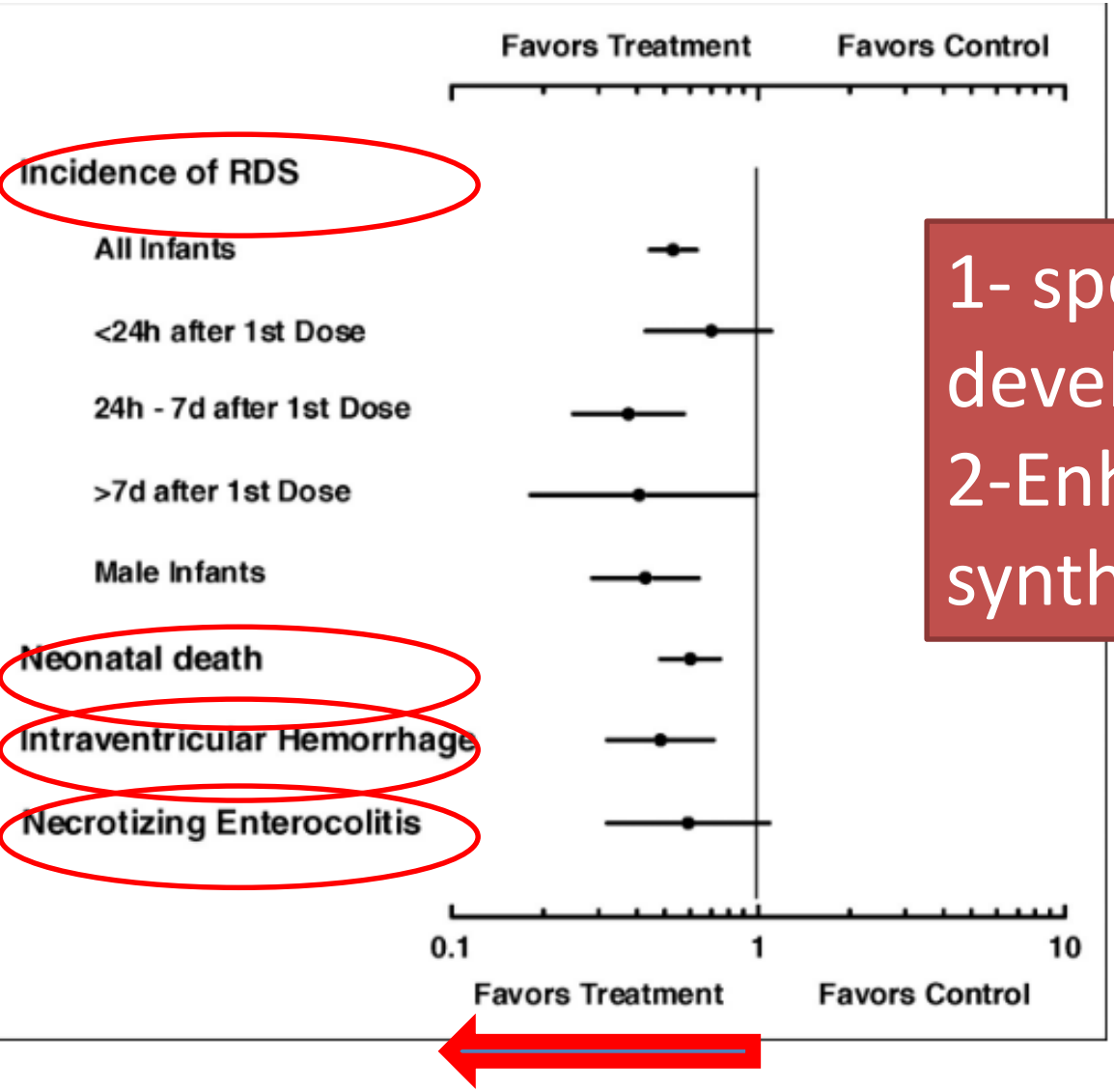
Risk Factors

Increased Risk	Decreased Risk
• Maternal diabetes • multiple births • cesarean section delivery • perinatal asphyxia • cold stress • history of previously affected infants	• Chronic or pregnancy-associated hypertension • maternal heroin use • prolonged rupture of membranes • antenatal corticosteroid prophylaxis

Genetic Predisposition to RDS

- Susceptibility to RDS is interaction between genetic, environmental and constitutional factors
- ***Very preterm infants***
  - Common allels preddicts RDS: **SP- A** 642, Sp-B121, Sp-C 186 ASN.
- Term Infants: Loss of function mutation of **SP-B, SP-C**, phospholipids transporter ABCA3

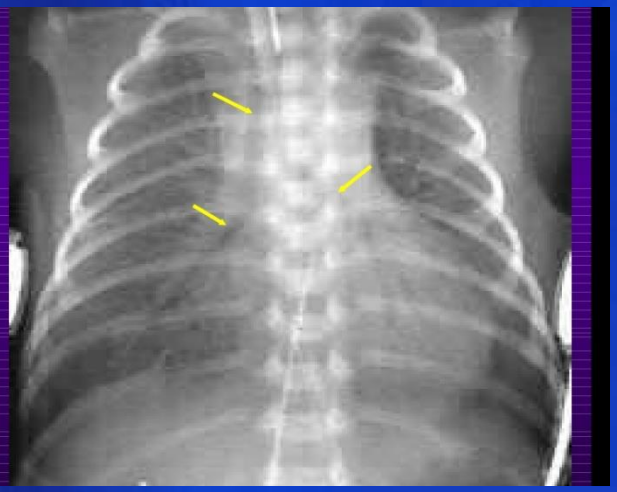
Antenatal Corticosteroid Effects

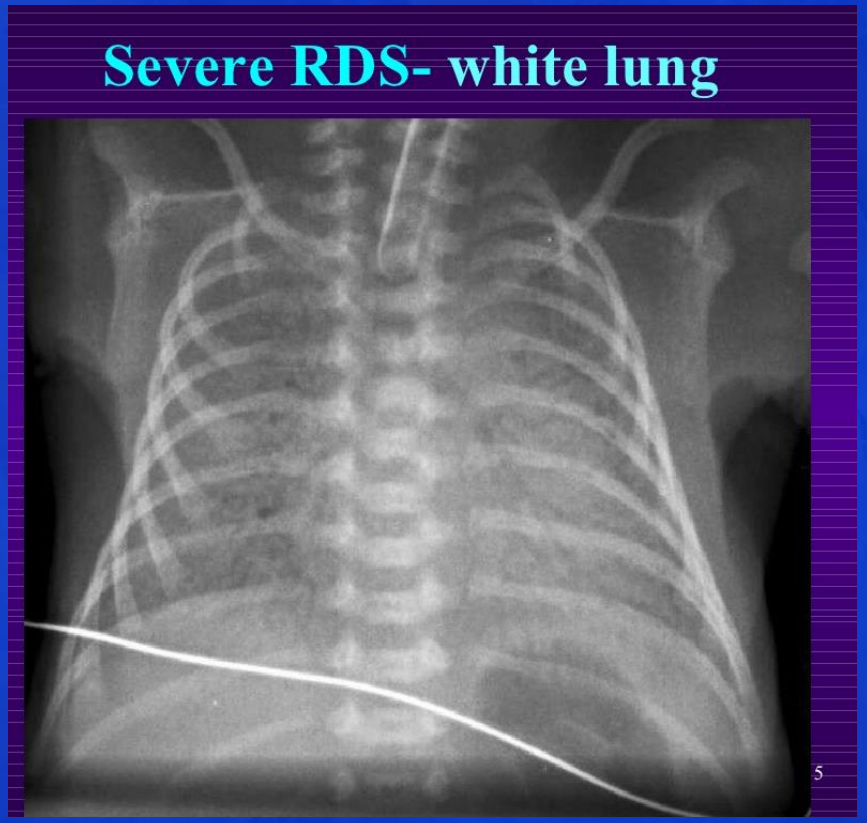


1- speed up lung development
2-Enhance surfactant synthesis

CXR

- **ground glass change** (fine reticular granularity of the parenchyma)
- **air bronchogram**
- **white lung**





➢Chest radiograph: air bronchogram, reticular/ ground-glass appearance after 6-12 hrs to full opacity later on.

Grade 4 - severe case, complete white-out of the lung fields with obscuring of the cardiac border

Prevention

- Prevention of prematurity
- Antenatal corticosteroid therapy

  Dexamethasone or betamethasone

  ↓RDS mobidity and mortality

- PS prophylatic therapy

RDS - Treatment

- Oxygen
- CPAP
- Mechanical ventilation
- Surfactant replacement
- Supportive Care

Respiratory support

Treatment

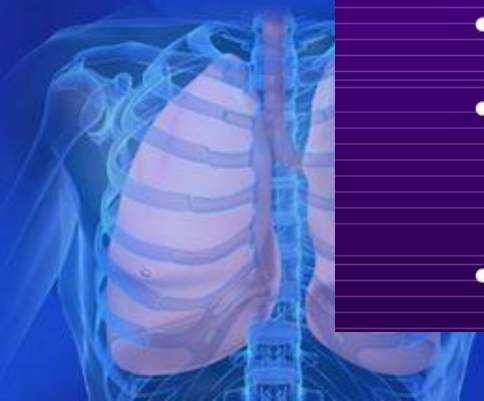
Oxygen therapy and assist ventilation

1.oxygen therapy

- nasal cannula, mask or headbox oxygen
- keep PaO_2 50-70mmHg, S_aO_2 90-95%

2. CPAP (continuous positive airway pressure)

- Prevent alveolar collapse at end expiration
- Indication: $FiO_2 > 0.4$, $PaO_2 < 50$ mmHg or $S_aO_2 < 85\%$
- Pressure: 4-6 cmH_2O



CPAP

PS replacement therapy

PS

Antenatal steroid and Surfactant goes hand in hand