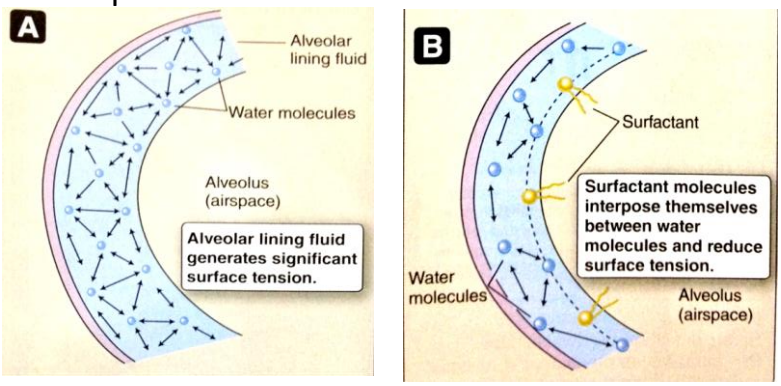
surface tension ,Surfactant and lung compliance

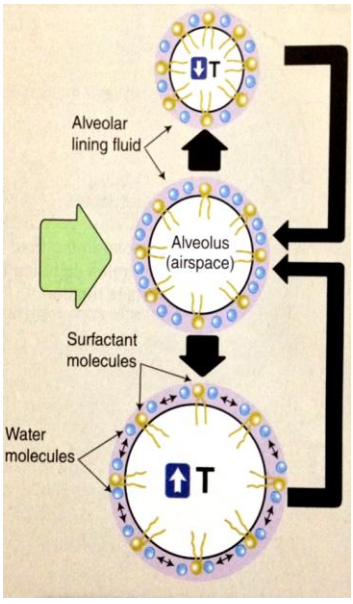
Surface tension :

- is the property of the liquid in which the water molecules tends to attract each other at the fluid –air surface to minimize the area of the exposed surface .
- Each alveolus is moistened with a thin film of alveolar lining fluid .
- it tends to collapse the alveoli .



Surfactant :

- It is a complex mixture of several phospholipids,protein and ions .it is secreted by type II pneumocytes .
- **Dipalmitoylphosphatidylcholine (DPPC) is the main phospholipid component**
- **phospholipid interpose themselves between adjacent water molecules** with **hydrophilic** head groups in the water and the **hydrophobic** tails facing towards the air **thereby weakening surface tension**
- Functions :
  i. **Stabilizing alveolar size** : Alveolar surface tension is inversely proportional to the number of surfactant molecules per unit area.
  During inspiration : ↑ alveolar Diameter →↓surfactant →↑surface tension → alveolar size return to its normal size



During expiration :↓ alveolar Diameter → ↑surfactant → ↓ surface tension → alveolar size return to its normal size

ii. **Keeping lungs dry** .
iii. **surfactant ↓ the effort required by the respiratory muscles to expand the lung**
iv. **Increases lung stretching ability (compliance).**

Hormones affecting surfactant production :

1) **Thyroid hormone** stimulates type II cells .
2) **Glucocorticoid hormone s**timulate production and maturation of surfactant

Lung compliance: is a measure of the stretching ability of the lung and it is equal to the change in lung volume per unit change in transpulmonary pressure ($\Delta V/\Delta P$).

- Compliance =1/ elasticity (recoil)

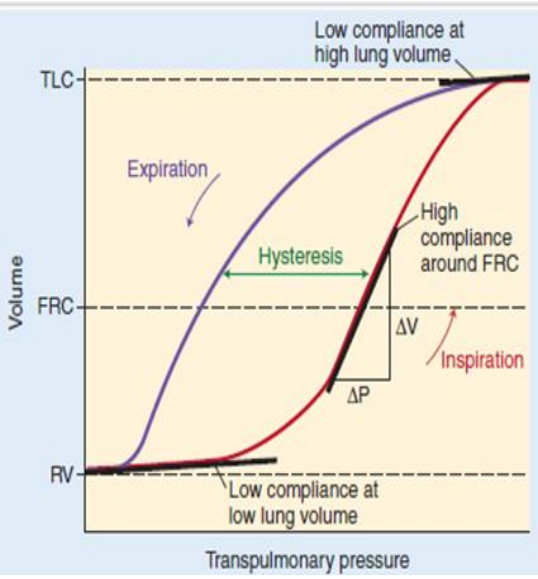
Lung compliance is 0.2 L/ cm H2O . If we measure the changes in lung volume with a gradual changing in transpulmonary pressure for the lung alone during inspiration and expiration ,we will have the **Pressure – volume curve (dynamic compliance diagram) of the lung** which has two different curves :

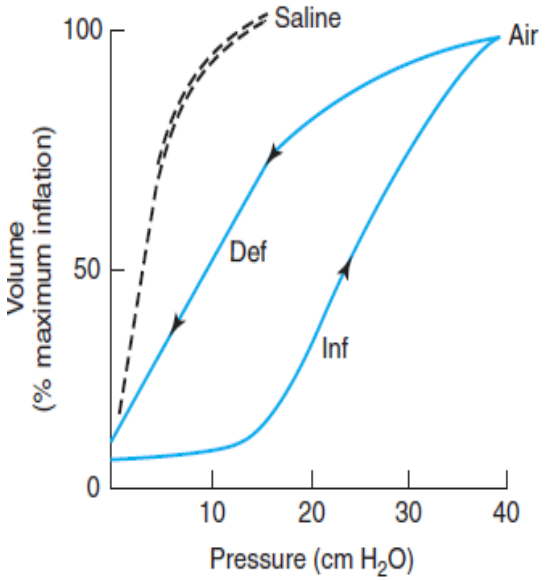
i. Inspiratory compliance curve
ii. Expiratory compliance curve

- Lung compliance curve is controlled by :
  i. Elastic force of the lung tissue (1/3)caused by lung elastin and collagen fiber
  ii. Surface tension of the fluid lining the inner surface of the alveoli (2/3) .
    - Surface tension force on compliance diagram can be demonstrated by measuring the pressure needed to inflate lung filed with saline . Saline filled lung needs only 1/3 the pressure needed to inflate air filled lung This means :

surface tension decreases compliance(difficult to inflate) .
Surfactant →Weakens surface tension →improve compliance .

- The different curve pattern in inspiration and expiration called (**hysteresis**)





Compliance is affected by :

1) lung volume : Low compliance at high and low lung volumes , Deflated lung compliance > inflated lung compliance (expanded lung is stiffer) .
   Best compliance is at Functional residual capacity
2) Lung tissue factors :
   - ↓compliance : stiff lung →↓compliance ex : pulmonary fibrosis .
   - ↑ compliance : loss of elastic tissue→ less recoil force → more compliance ex : emphysema , aging
3) Thoracic cage disorder : ↓ compliance

<u>Resistance to air flow :</u>

Factors affecting resistance: R = (8 x viscosity x length)/ π x radius^4

1. Resistance is proportional to
   - **Airway length**
   - **Gas viscosity** .

2. Resistance is inversely proportion to the **forth power of airway radius 1/ r^4** (if the airway radius decreases to the half →↑resistance 16 times)

The site of greatest resistance in the lung is in the pharynx and larger airways not in the small airways ,why ?

- Total cross sectional area of the branching airways arranged in parallel increases and overall resistance is decreased → lessen the effect of decreasing radius .