Lecture 8 : Elastic properties of the lung

Code: RRS-209

By

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Learning Objectives

Knowledge:

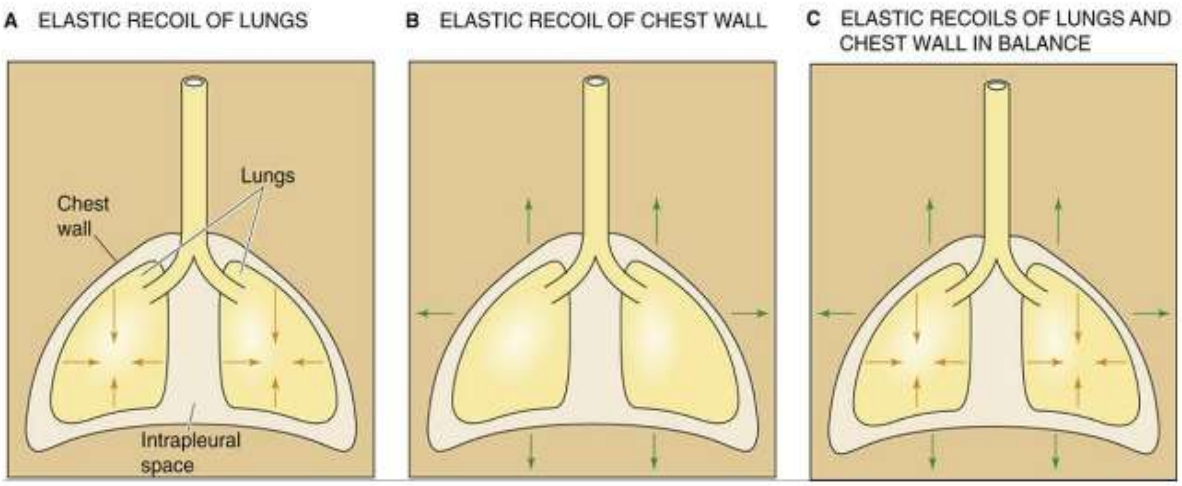
- Describe the normal elastic properties of normal lung compliance.
- Know the function of surfactant and its physiological importance – and its deficiency (Acute respiratory distress syndrome).
- Describe work of breathing.

Intellectual:

- Explore and factors affecting lung compliance.
- Compare between types of work of breathing.

Elastic properties of the lung

- The lungs and the chest wall that surrounds them are **elastic** structures, that is, they return to their original shape if a force that is distorting them is removed.
- These distorting forces are usually those of intrapleural pressure, which becomes more negative to bring about inspiration and then becomes less negative, and the elasticity of the lungs leads to quiet expiration.



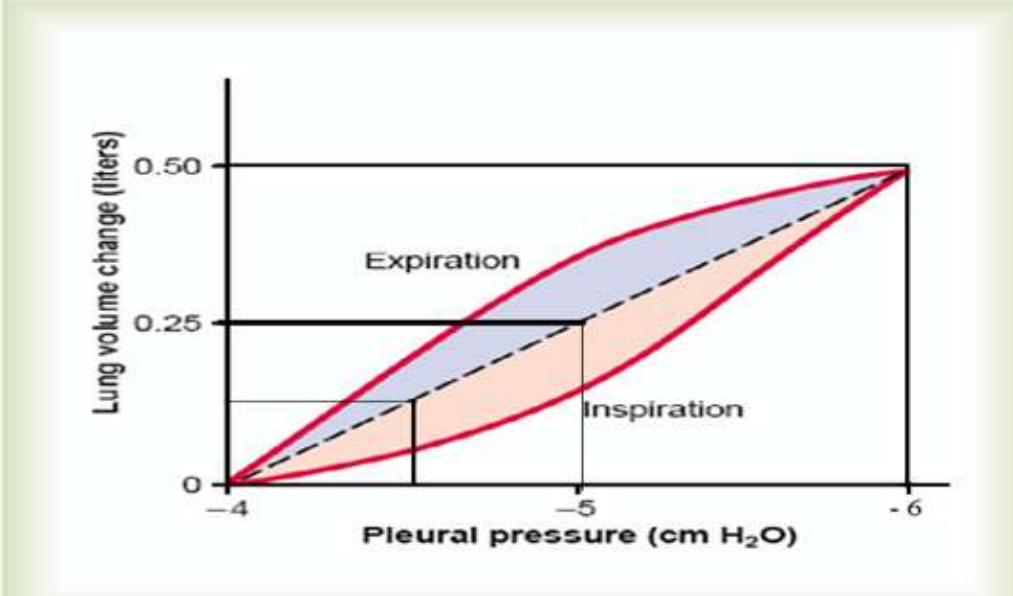
Opposing elastic recoils of the lungs and chest wall.

- The lungs and the chest wall are ' locked together' by the intrapleural space. The intrapleural space is airtight. So, the lungs are as firmly pressed to the chest wall as a suction cup attached to a window.

Lung Compliance

- This elasticity is a measure of how easily the lungs can be stretched and is conventionally expressed as ***Compliance*.**
- Lung compliance is the volume change that could be achieved in the lungs per unit pressure change.
- Compliance is a measure of the pressure required to inflate the lungs by a certain incremental volume.
- This pressure is acting against forces working to deflate the lung which include the inherent elasticity of the lung (see next)

- The average volume is **200ml/cm** water pressure, While Lung-chest compliance is **110** ml/ cm water *(because there is opposite direction between lung compliance and thoracic wall compliance*).



- ✓ Compliance = $\frac{\text{Change in volume}}{\text{Change in pressure}}$
- ✓ Elastance, also known as the elastic resistance It is a measure of the resistance of a system to expand. *Elastance is the reciprocal of compliance*
- ✓ **Static compliance**: This ' stretchiness ' of the lungs can be measured under static conditions, i.e. by measuring pressure and volume when there are no breathing movements taking place. OR during breathing as **dynamic compliance.**

The elastic properties of the lungs, and their compliance, depends almost equally on:

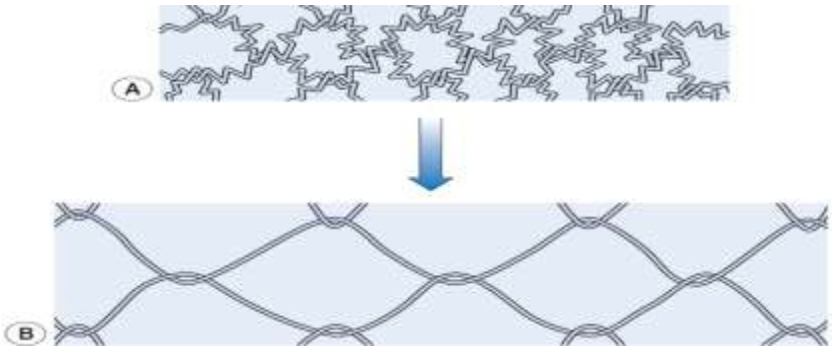
1- The elastic properties of their tissues.

2- The elastic properties of their liquid lining.

1-The elasticity of lung tissues:

- The elastic properties of the lungs are due to the yellow **elastin fibers** of the lung parenchyma.
- In fact, only about half the elastic recoil of the lungs comes from the elastin fibers in the alveolar walls,

- Also present in the lungs are collagen fibers, which are less easily stretched and limit overexpansion of the lung.
- The elastin fibers are kinked and bent round each other, and during inspiration unfold and rearrange in a manner that has been likened to the straightening of the fibers.

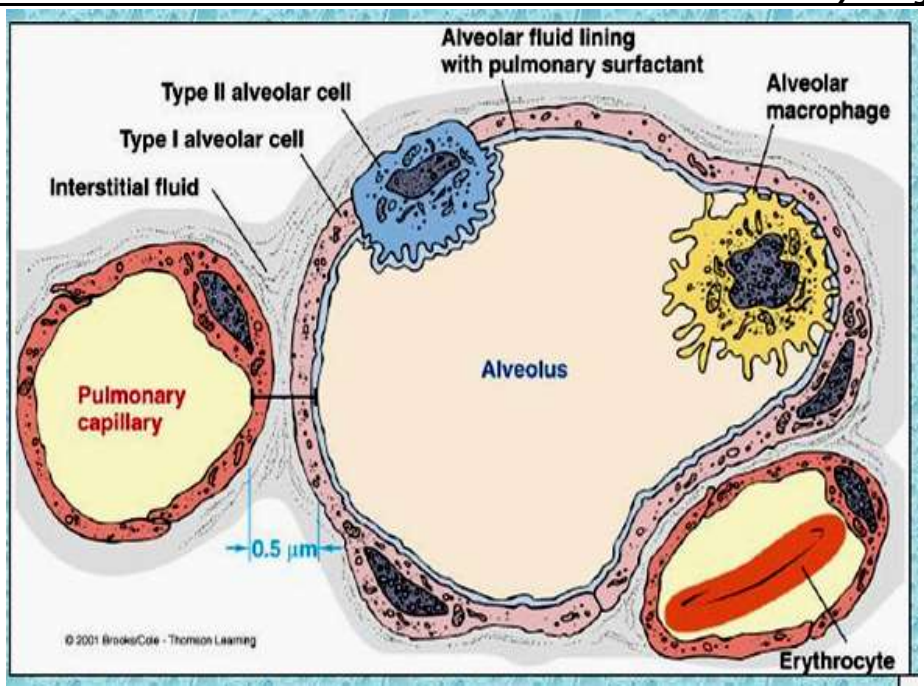


2- The elastic properties of their liquid lining:

- The remaining half of the elastic recoil of the lungs is the force that act to resist distension which is the **surface tension** that is exerted by a very thin film of fluid on the alveolar surface. The **surface tension is opposed by surfactant.**

Surfactant

- The thin film of fluid normally present in the alveolus has a surface tension.
- surfactant is a surface active agent. This means that when it spreads over the surface of a fluid it reduces surface tension.
- It is produced by type II pneumocytes. It is composed of a complex mixture of phospholipids (dipalmitoyl-phosphotidylcholine, apoprotien and calcium). Dipalmitoyl-phosphotidylcholine spreads very slowly over the fluid surface, however, Apoprotien & Ca^{++} increase the rate of its spread, so they increase its effectiveness**.**



Surfactant and surface tension:

- Significant pressures are required to inflate alveoli and hold the lungs at increasing volumes during inflation.
- Firstly, Little increase in volume is measured. As pressure is increased further, the static volume of the lungs similarly increases until a maximum value is reached.
- During deflation, the volume of the lungs remains high until pressure has dropped significantly.
- Surfactant reduces surface tension **renders the lung more compliant**.
- Note that A saline-filled lung is readily inflated, whereas surface tension with an air‑water interface shows reduced compliance.

Physiological importance of surfactant:

a- Surfactant formation starts at 24 weeks of intrauterine life. In absence of surfactant, lung expansion is very difficult. This causes death after birth due to inadequate respiration . This condition is called (hyaline membrane disease) OR respiratory distress syndrome.

b- It prevents collapse of the alveoli (specially small ones).

c- It decreases muscular effort to ventilate the lung.

Increase in Compliance:

Compliance increases due to loss of elastic property of lung tissues, which occurs both in physiological and pathological conditions:

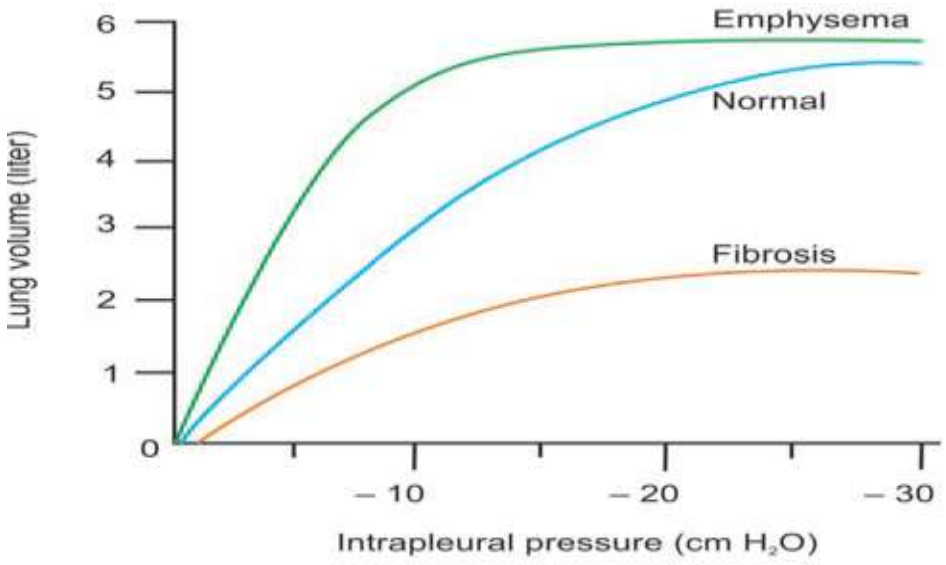
1. Physiological condition: Old age
2. Pathological condition: Emphysema

Decrease in Compliance:

Compliance decreases in several pathological conditions:

1. Deformities of thorax like kyphosis and scoliosis.
2. Lung fibrosis.
3. Paralysis of respiratory muscles.
4. Abnormal thorax such as pneumothorax.
5. Pleural effusion.

What are the effects of these diseases on lung compliance. Explain



➢ Work of Breathing

➢ Work of breathing is the work done by respiratory muscles during breathing to overcome the resistance in thorax and respiratory tract.

- Respiratory muscles work only during inspiration.
- During the work of breathing, the energy is utilized to overcome three types of resistance:

1. Elastic resistance of lungs and thorax
2. Airway resistance.
3. Non elastic viscous resistance.

1. **Compliance Work:**

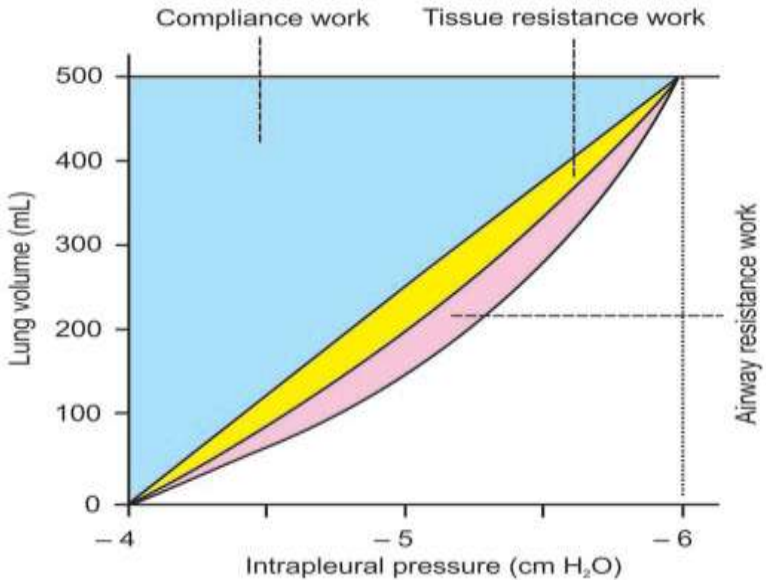
- Energy is required to expand lungs and thorax against their elastic resistance. Work done to overcome this elastic resistance is called **Compliance Work**

2. *Airway Resistance*

- Airway Resistance increases during bronchiolar constriction, which increases the work done by the muscles during breathing.
- Work done to overcome the airway resistance is called **airway resistance work.**

3. ***Tissue resistance work:***

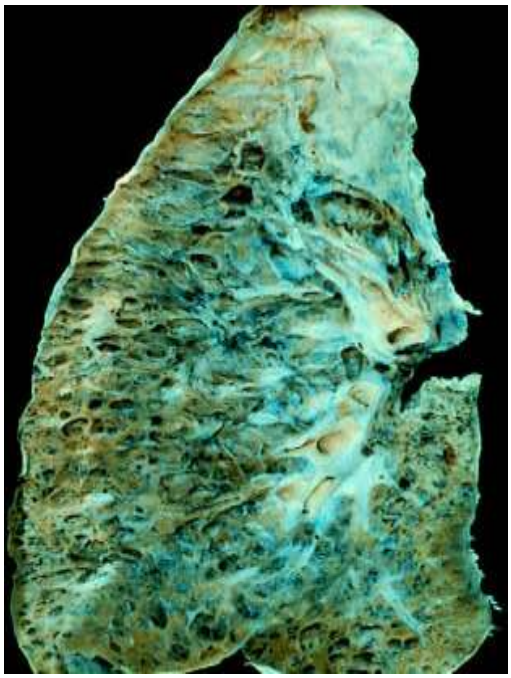
- Energy is also required to overcome the viscosity of lung tissues and tissues of thoracic cage. Work done to overcome this viscous resistance is called ***Tissue resistance work***

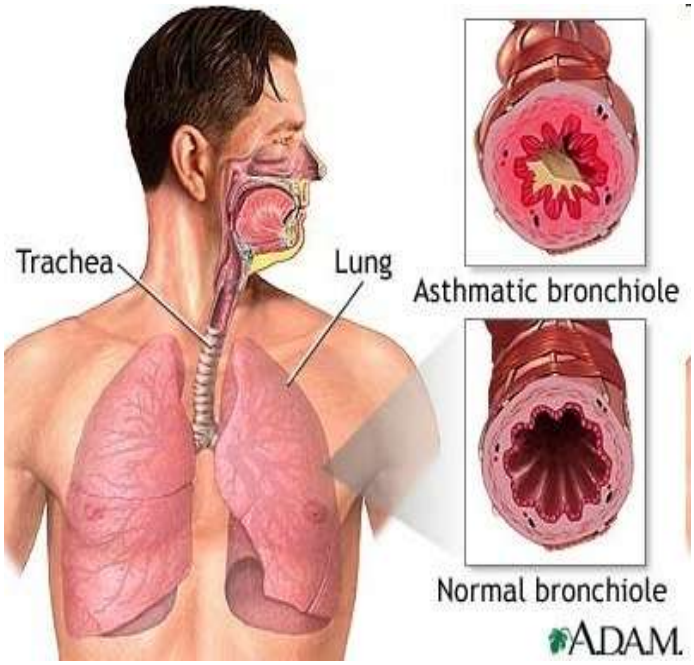


Important notes to remember:

- Only about half the elastic recoil of the lungs is due to their elastic fibers, the rest is due to their liquid lining.
- Air/liquid surfaces tend to contract, this is called surface tension. The lung is lined with a liquid with important surface tension.
- Because of differences in radius the small alveoli would tend to collapse into the large ones.
- Type II pneumocytes produce surfactant which make it easier to inflate the lungs and prevent this tendency to collapse.

Which Type Of Work Will Increase In These Diseases





End of the lecture