



Mechanics of Pulmonary Ventilation

OBJECTIVES

- List the muscles of respiration and describe their roles during inspiration and expiration.
- Understand the importance of the following pressures in respiration: atmospheric, alveolar, intrapleural, and transpulmonary.
- Explain why intrapleural pressure is always subatmospheric under normal conditions, and the significance of the thin layer of the intrapleural fluid surrounding the lung.
- Define lung compliance and list the determinants of compliance.

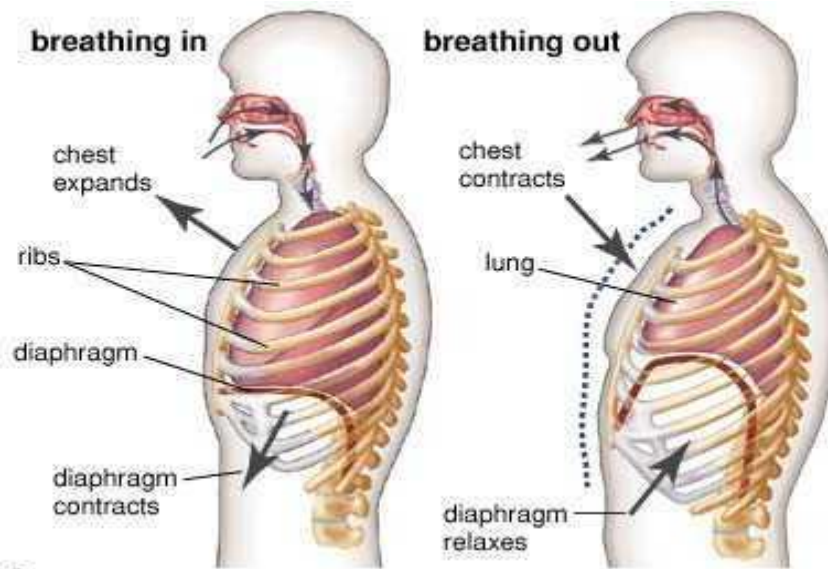
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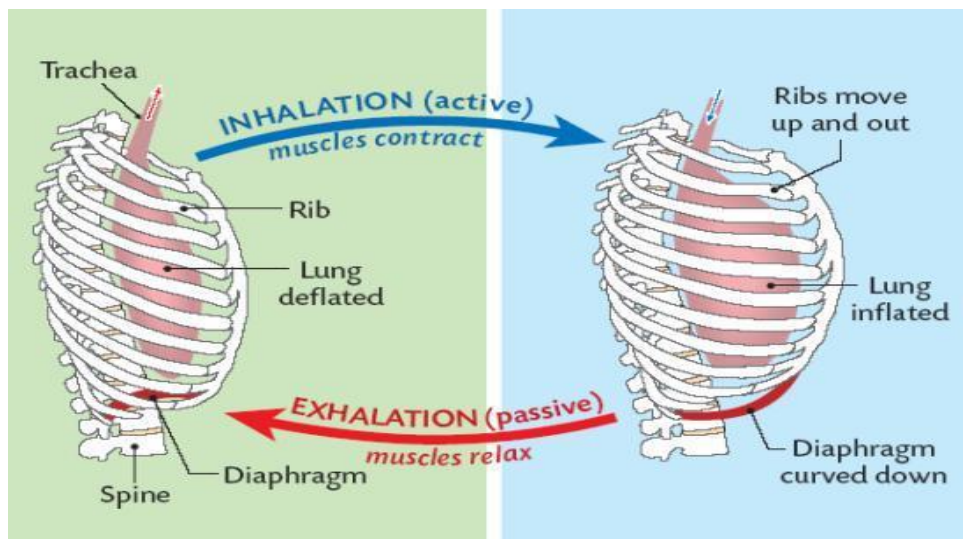
- Red = important
- Grey = additional notes

1-MUSCLES IN LUNG EXPANSION AND CONTRACTION:



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Expansion	Depression
<u>Downward</u> movement of the diaphragm to <u>increase</u> the <u>vertical / longitudinal</u> diameter of the chest cavity.	<u>Upward</u> movement of the diaphragm to <u>decrease</u> the <u>vertical / longitudinal</u> diameter of the chest cavity.
By <u>elevation</u> of the ribs to <u>increase</u> the <u>anteroposterior and lateral / transverse</u> diameter of the chest cavity.	By <u>depression</u> of the ribs to <u>decrease</u> <u>anteroposterior and lateral / transverse</u> diameter of the chest cavity.



2-

RESPIRATORY MUSCLES

Inspiratory Muscles

(Resting- forced/deep)

All muscles that **expand** "elevate" the chest cage are classified as muscles of inspiration.

relaxed Inspiration

Contraction of the **diaphragm** and **external intercostal** muscles

Deep Inspiration

Relaxed inspiration muscles + accessory muscles of inspiration to increase the size of thoracic cavity , those are :

Sternocleidomastoid

Elevate sternum

Scalene

Elevate 1st & 2nd ribs

Pectoralis Minor²

Elevate 3rd, 4th and 5th ribs

Expiratory Muscles

(Forced)¹

All muscles that **depress** the chest cage are classified as muscles of expiration.

Deep Inspiration

- Expiration during forceful breathing is active process
- Muscles of exhalation increase pressure in abdomen and thorax

Abdominal
muscles

Internal
intercostal

¹ Only forced because resting expiration is a passive process , no muscle contraction is needed (relaxation of diaphragm)

² In addition to pectoralis major which increase the AP diameter when arm is fixed

3-PRESSURE CHANGES IN THE LUNGS DURING BREATHING:

The types of pressure changes in the lungs are:

- Intra-alveolar "intrapulmonary pressure" (Palv)
- Intrapleural pressure (IPp).
- Transpulmonary pressure (TPp)

- **Intra-alveolar "intrapulmonary pressure" (Palv):**

Refers to the pressure of the air inside the lung alveoli.

- **Intrapleural pressure (IPP)³:**

Refers to the pressure within the pleural cavity (fluid in space between lung pleura and the chest wall pleura) slightly less than the atmospheric pressure, also known as *negative pressure*.⁴



- ✓ Before inspiration (resting state)= **-5 cmH₂O**
- ✓ During resting inspiration it becomes more -ve and reach **-7 cmH₂O**
- ✓ By deep inspiration (Forced) will reach **between -20 to -40 cmH₂O**
- ✓ After resting expiration will reverse
- ✓ By deep expiration (forced) will reach **+ 30 cmH₂O**

Why it is negative!!!

1. The surface tension of the alveolar fluid.
 2. The abundant elastic tissue in the lungs tends to recoil and pull the lung inward.
 3. The elastic thoracic wall tends to pull away from the lung
- **((2+3 -> opposing forces))

- **Transpulmonary pressure (TPp):**

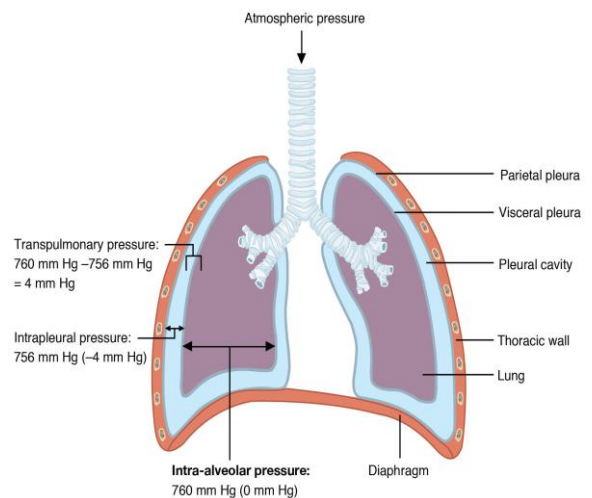
Refers to the difference between the alveolar pressure (Palv) and the pleural pressure (Ppl)

$$TPp = Palv - Ppl$$

→ it is always positive + TPp prevents lung collapse

It measures the elastic forces in the lungs that gives the lung the tendency to collapse (the recoil pressure)

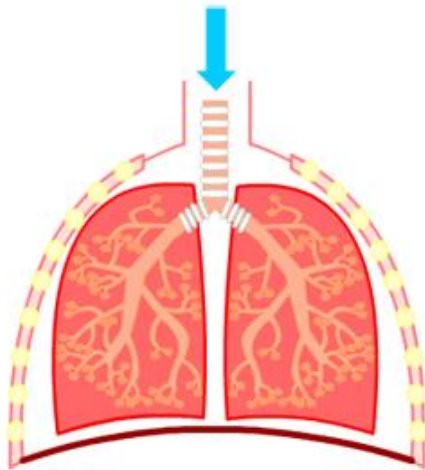
The bigger the volume of the lung the higher will be its tendency to recoil !!



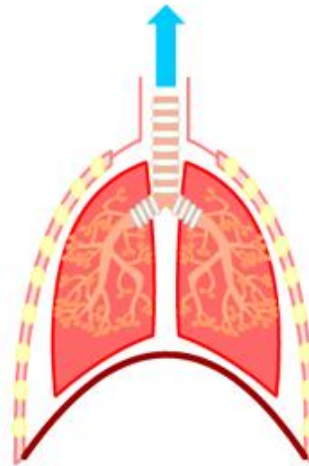
³ The pressure in the plural cavity between visceral pleura and partial pleura.

⁴ كل هذه العوامل راح تجعل هذا التجويف أكبر ، و بزيادة الحجم يقل الضغط

4-HOW INSPIRATION AND EXPIRATION OCCUR

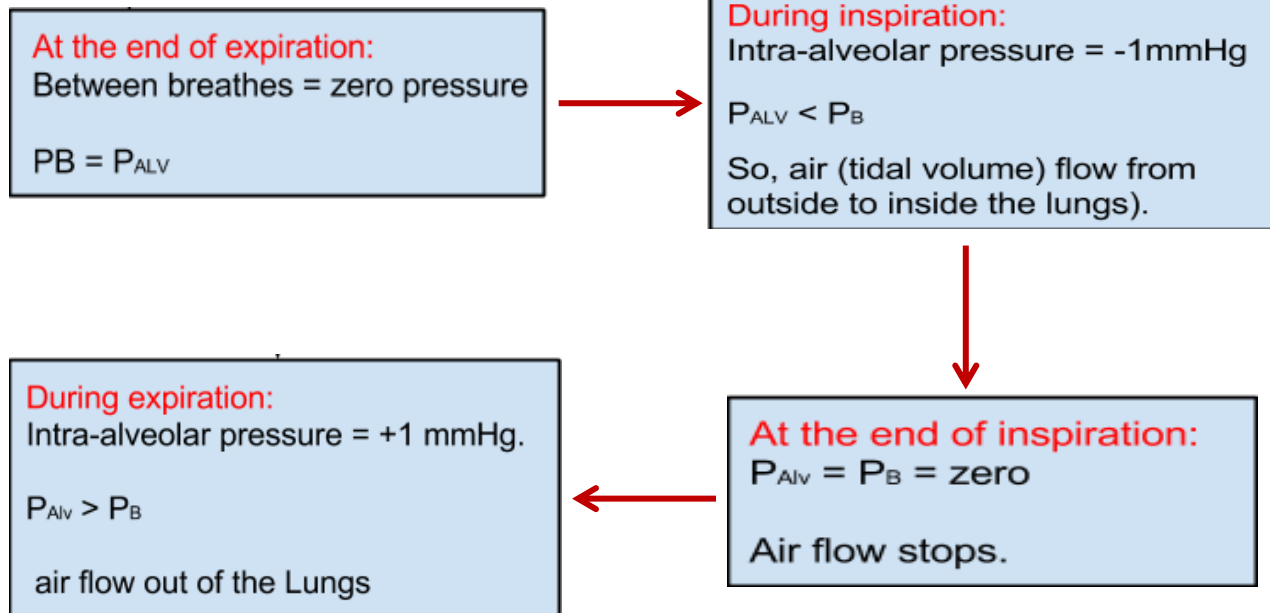


As the volume of chest increases, the pressure inside the chest is lowered. Atmospheric pressure forces air in to the lungs. The lungs expand until the pressure is equal inside and out.



As the volume of the chest decreases, the pressure increases. Air is forced out of the lungs until the air pressure inside and out of the chest is equal again.

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5-PULMONARY COMPLIANCE (OR LUNG COMPLIANCE)

Is defined as, the ratio of the change in the lung volume produced per unit change in the distending pressure. **it's a measure of the lung's ability to stretch and expand.**

$$CL = \frac{\Delta V}{\Delta P}$$

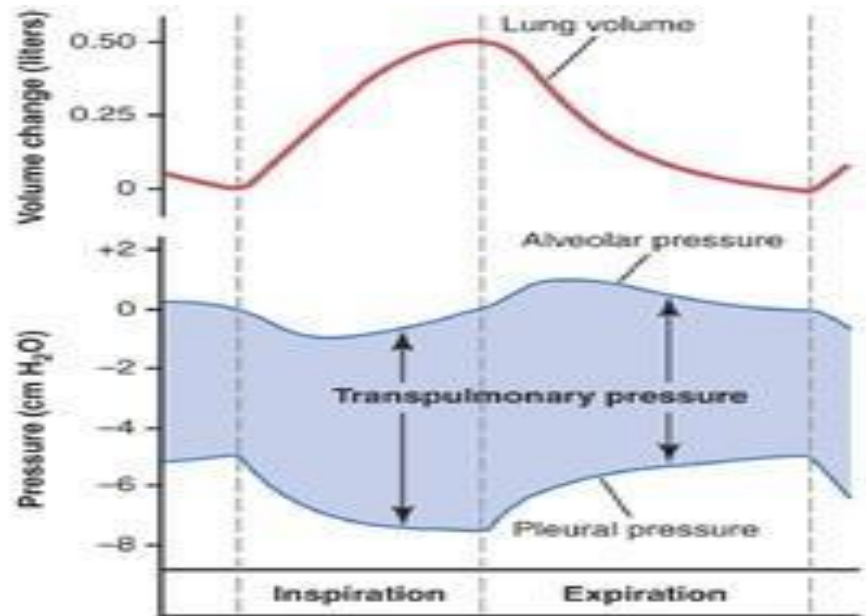
Volume change

Transpulmonary pressure change

Increase as the lung expand

→ For both **lungs** in adult = **200 ml** of air /cm H₂O.

→ For **lungs and thorax together** = **110 ml/cm H₂O**.



- ✓ pulmonary compliance is reduced in pulmonary fibrosis, pulmonary edema, diseases of the chest wall (kyphosis, scoliosis).

This is clear because pulmonary fibrosis decrease the elasticity of the lung!!

- ✓ Emphysema increases the compliance of the lungs because it destroys the alveolar septal tissue which is rich with elastic fibers that normally opposes lung expansion.



The video is a bit long but it gives you a great
Overview on the whole lecture

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