PLEURA , INTRAPLEURAL PRESSURE & RELATION TO INTRAPULMONARY PRESSURE
RESPIRATORY SYSTEM PHYSIOLOGY(WEEK 7)

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DATE:5/6/2024

OBJECTIVES

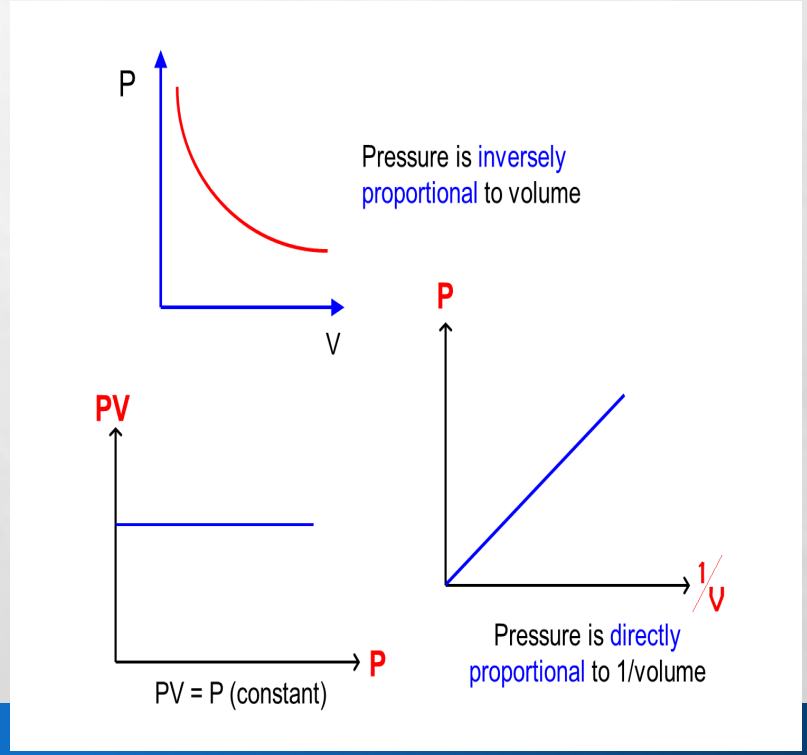
•Define and explain the relationships of intrapleural pressure, transpulmonary pressure, and intrapulmonary pressure relative to atmospheric pressure during breathing.
•Define and explain the role of compliance and elasticity

- **REFERENCES:**
- **1- GUYTON AND HALL TEXTBOOK OF MEDICAL PHYSIOLOGY**
- **2- GANONG REVIEW OF MEDICAL PHYSIOLOGY**

Boyle's law :

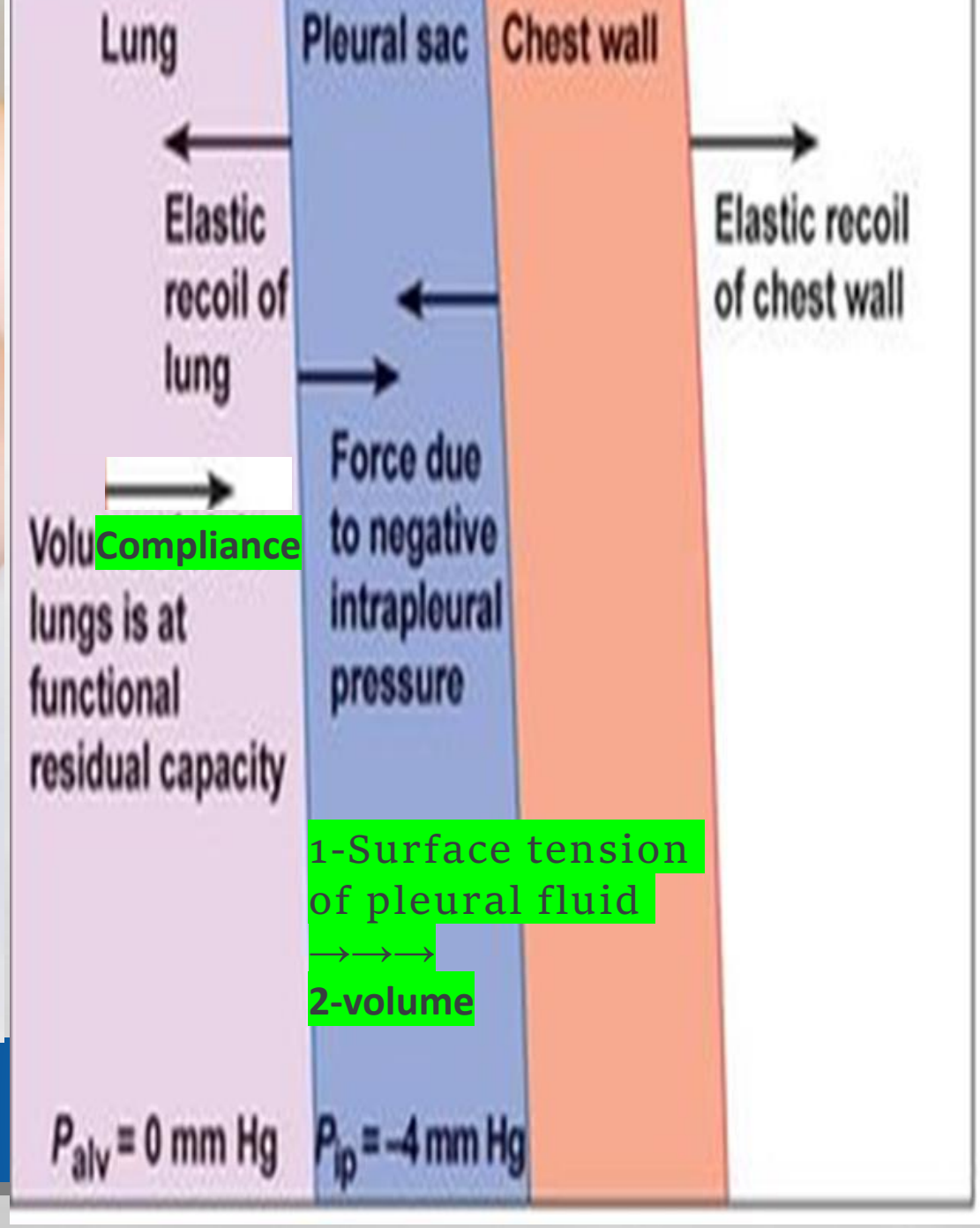
- **PRESSURE IS INVERSELY PROPORTIONAL TO THE VOLUME**
- **I.E.**

• The pressure differences in the pulmonary system are induced by changes in lung volumes.





ATMOSPHERIC PRESSURE

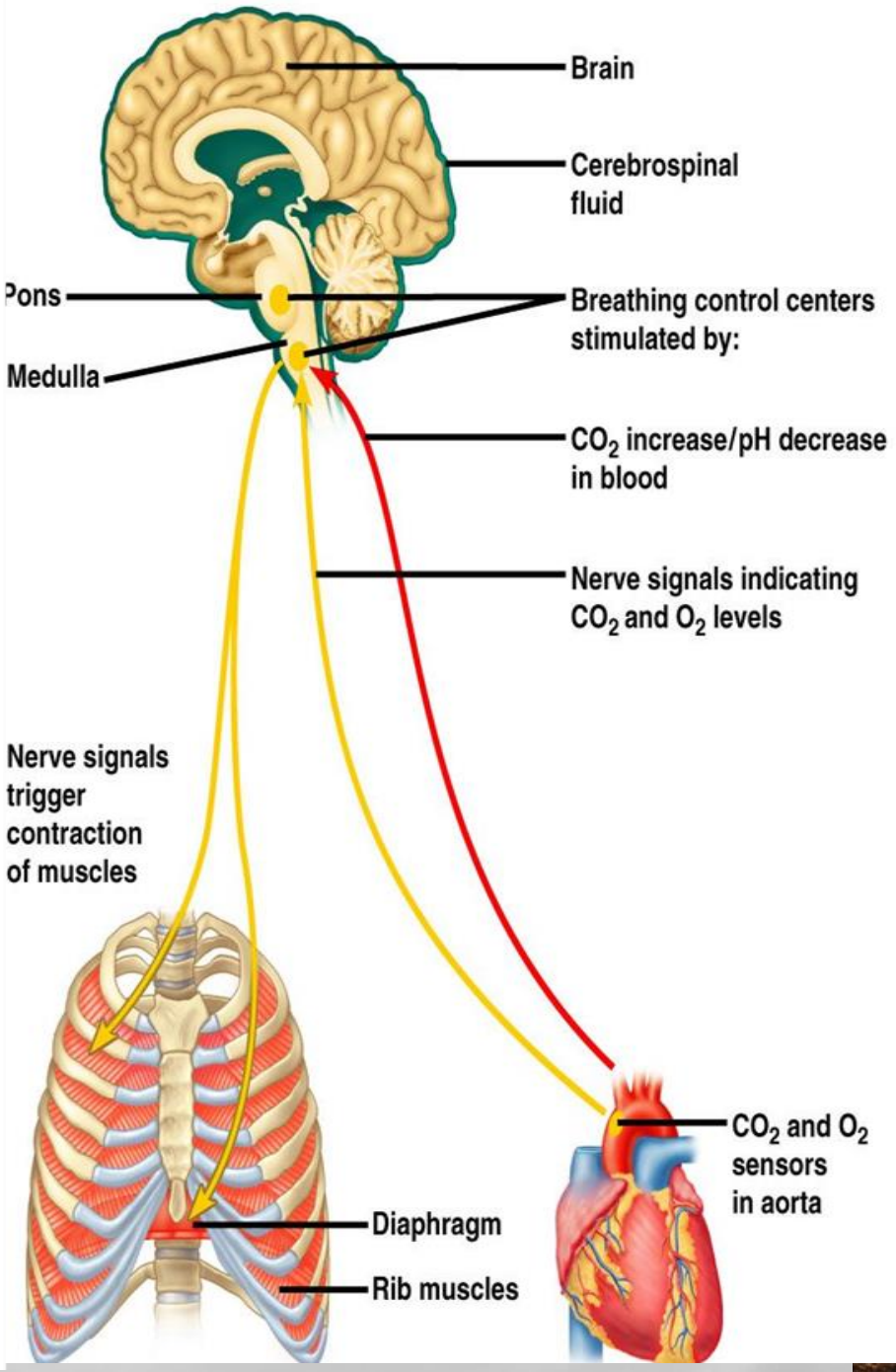


Compliance

1-Surface tension of pleural fluid

→→→

2-volume



The major mechanisms that drive breathing are dependent on:

A- The contraction and relaxation of muscle fibers of both the diaphragm and thorax.

B-The existing differences in the following pressures :

1- The atmospheric pressure (P_{atm}): Atmospheric pressure.

2- The alveolar pressure (P_{alv}): Is the air pressure within the alveoli.

3- The intrapleural pressure (P_{ip}): Is the pressure within the pleural cavity.

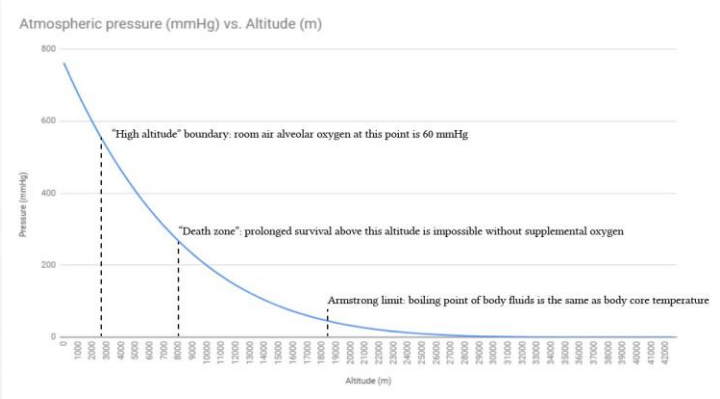
The intrapleural pressures are dependent on certain physical features of the lung :

Compliance (**distensibility**) and

lung Recoil (Elastance).

Typically, respiration pressure values are discussed in relation to atmospheric pressure value. They are values of difference in pressure values rather than true pressure values.

1- ATMOSPHERIC PRESSURE



It is the force exerted by gases in the air surrounding any given surface, such as the body.
Atmospheric pressure can be expressed in the unit atmosphere, abbreviated atm, or millimeters of mercury (mm Hg).
One atm = 760 mm Hg at sea level.
Atmospheric pressure changes according to sea level.
A pressure that is equal to the atmospheric pressure is expressed as zero.

It is better to name it as a pressure difference rather than areal pressure !!.

- **High altitude → ↓ atmospheric pressure (Patm) and ↓ alveolar PO_2 Ventilation**

↓ alveolar PO_2 → ↑ respiratory rate (hyperventilation)

What are lung volume and thoracic cage acclimatization (تأقلم) to a high altitude?

Typically, respiration pressure values are discussed in relation to atmospheric pressure value. They are values of difference in pressure values rather than true pressure values.

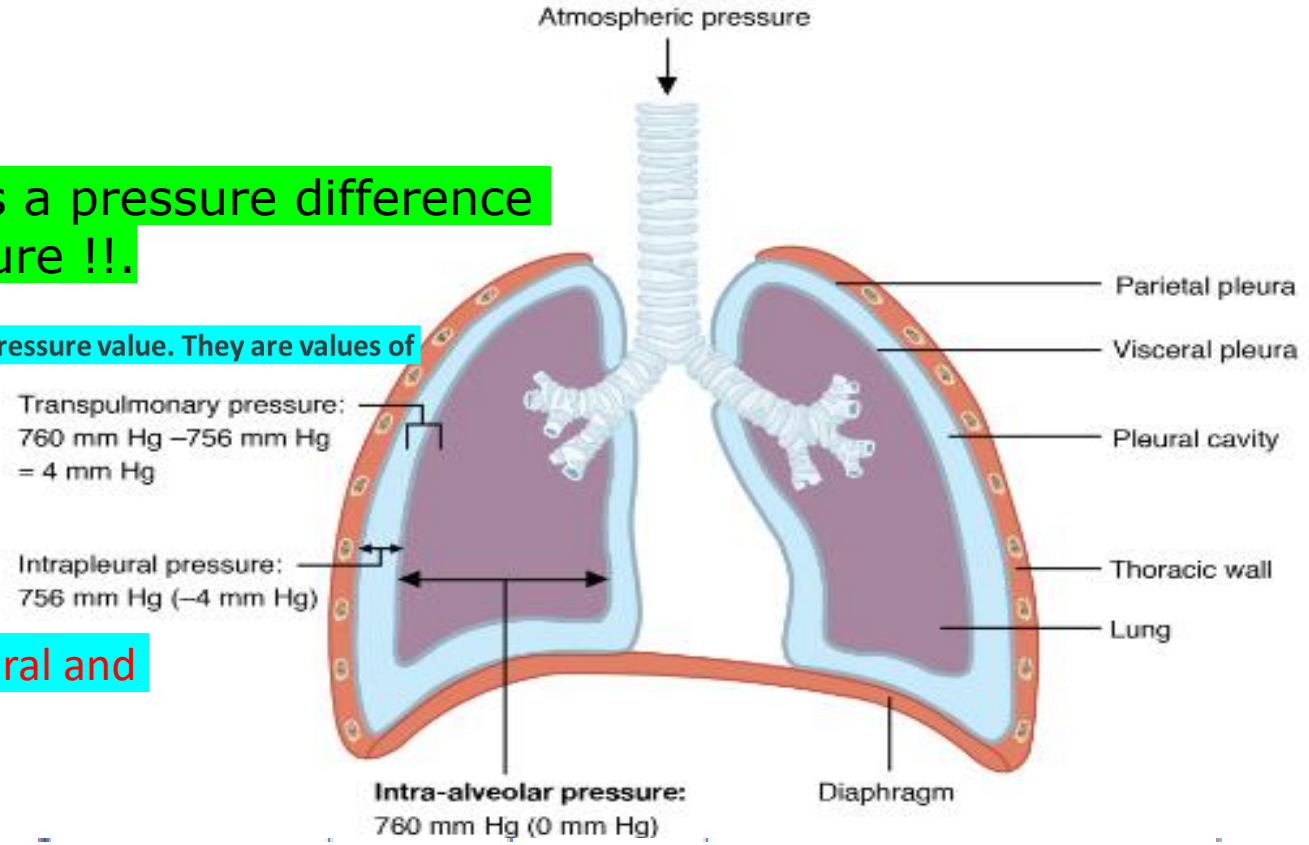
2- INTRA-ALVEOLAR PRESSURE

The interpulmonary pressure of the alveoli equalizes with the atmospheric pressure ±1.

It is better to name it as a pressure difference rather than areal pressure !!.

Typically, respiration pressure values are discussed in relation to atmospheric pressure value. They are values of difference in pressure values rather than true pressure values.

They mean by intrapulmonary pressure, intrapleural and transpulmonary pressure a pressure difference.



Alveolar pressure changes during the different phases of the cycle. It equalizes at 760 mm Hg but does not remain at 760 mm Hg.

Intra-alveolar Pressure

At sea level, atm. pressure is 760 mmHg and all pressures in the respiratory system are expressed relative to atmospheric pressure.

-During inspiration Palv. = - 1 mmHg I.e Pressure difference

-During expiration Palv. = + 1 mmHg I.e Pressure difference

-At ends of inspiration & expiration= 0 mmHg I.e Pressure difference

Changes in intra-alveolar pressure are caused by changes in volumes of lungs.

- Compliance — it is the expansion of the lung.
- Elastic recoil means lungs come back to normal size [during expiration].

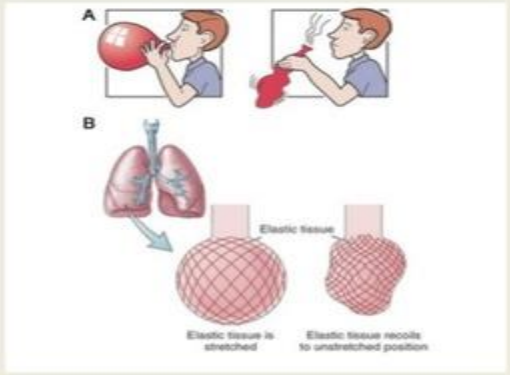
- **Negative intrpleural: pressure can cause alveoli to expand changing Alveolar Volume.**

- **Compliance (distensibility) :is the reciprocal of elastance, is a measure of the ease of inflation .**
- **Surface tension by Surfactant: Reduces the tendency of lungs to collapse (increase compliance).**

- **Lung recoil (elastance) Causes alveoli to collapse resulting from Elastic recoil forces.**

Elastic Recoil

- Lung and balloon want to return to unstretched shape.
- Result of arrangement of fibers.



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Compliance Vs Elastance

- Compliance is a measure of distensibility
- Elastance is a measure of elastic recoil
- These both oppose each other!
  - Compliance decreases as Elastance increases:
    - Pulmonary fibrosis (restrictive lung disease)
    - Pulmonary hypertension/congestion
    - Decreased surfactant – increased surface tension (prematurity, artificial ventilation)
  - Compliance increases as Elastance decreases
    - Normal ageing (alteration in elastic tissue)
    - Asthma (unknown reason)
    - Emphysema* (obstructive lung disease)

3-INTRAPLEURAL PRESSURE

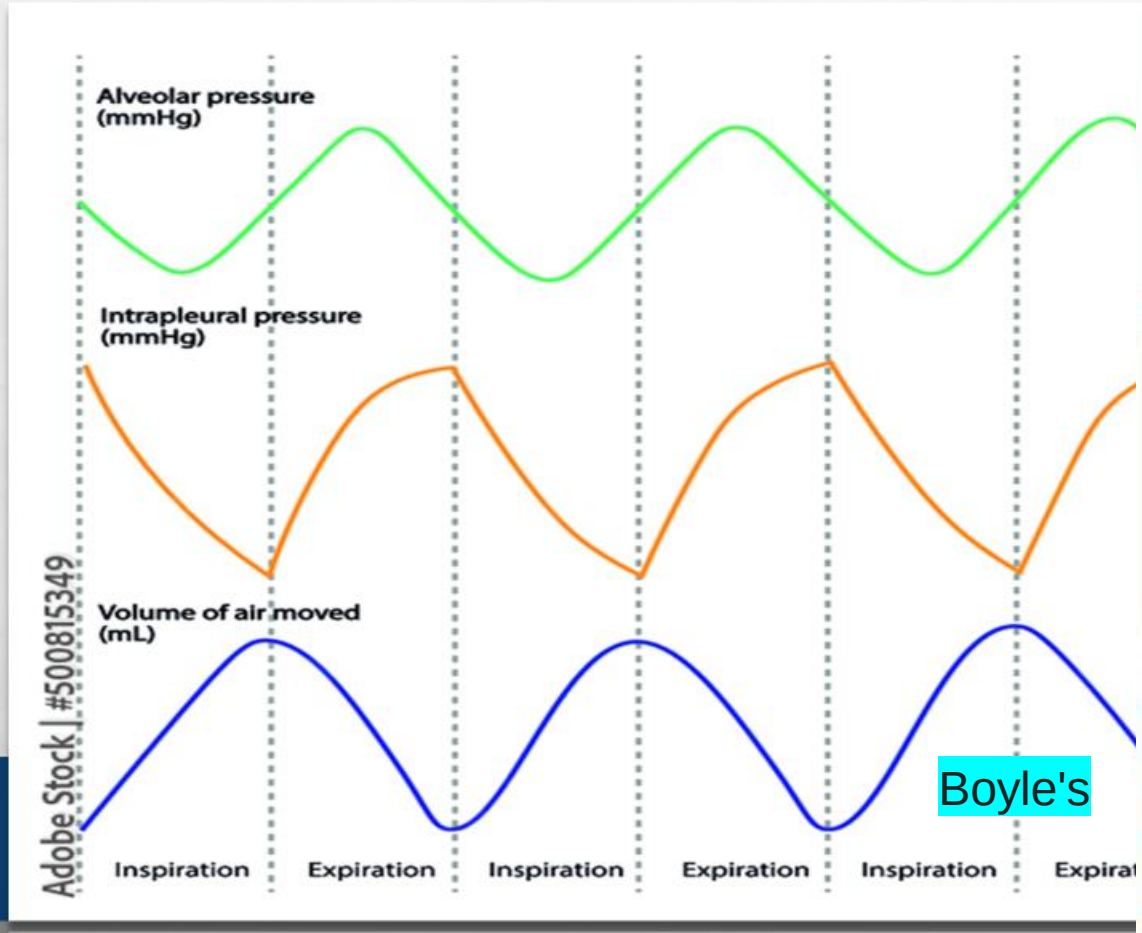
- This is sub-atmospheric pressure within pleural space, which is *negative* relative *to atmospheric* and *intrapulmonary* pressure.

- The negative pressure will be *lost* if air, blood, pus or more than afew millilitres fluid accumulate in this space and the affected lung will be unable to *expand fully*.

↑Pleural Fluid Volume (Pleural Effusion)=
pulls the lungs inward& vice versa

Intrapleural pressure remains approximately –4 mm Hg throughout the breathing cycle.
Competing forces within the thorax cause the formation of negative intrapleural pressure:
A-Lung forces that pull the lungs inward:
1- Elastic tissue pulls the lungs inward, away from the thoracic wall.
2- The surface tension of the alveolar fluid creates an inward pull of the lung tissue.
B- Pleural fluid and thoracic wall forces that pull the lungs outwards:
1-Surface tension within the pleural cavity pulls the lungs outward.
2-To much or too little pleural fluid would hinder the creation of negative intrapleural pressure.
3- Since the parietal pleura is attached to the thoracic wall, the chest wall's natural elasticity opposes the lungs' inward pull.
Ultimately, the outward pull is slightly greater than the inward pull, creating the –4 mm Hg intrapleural pressure relative to the intra-alveolar pressure.

ALVEOLAR AND INTRAPLEURAL PRESSURE CHANGES DURING RESPIRATORY CYCLES.

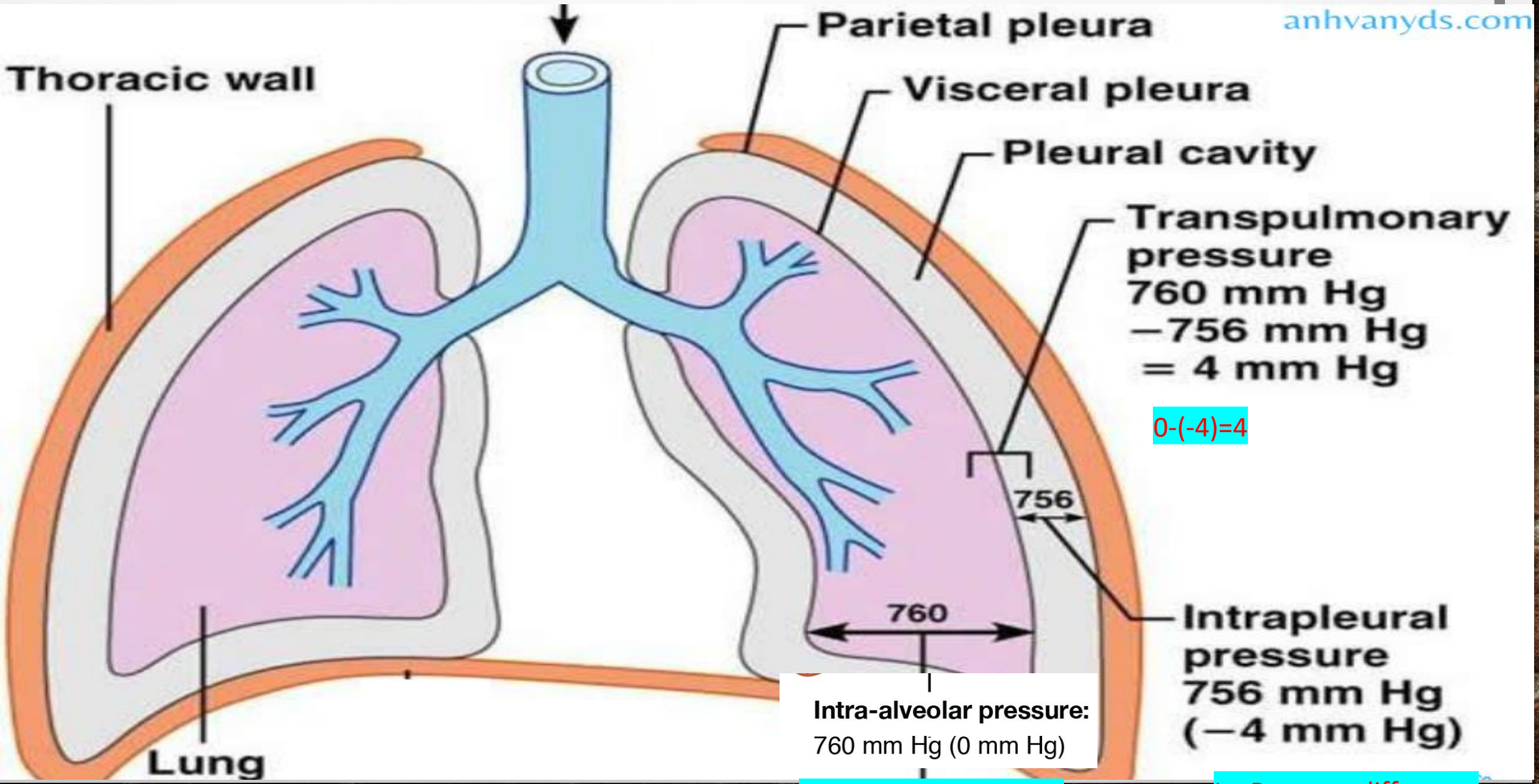


Intrapulmonary pressure. Pressure inside lung decreases as lung volume increases during inspiration; pressure increases during expiration.

Intrapleural pressure. Pleural cavity pressure becomes more negative as chest wall expands during inspiration. Returns to initial value as chest wall recoils.

Volume of breath. During each breath, the pressure gradients move 0.5 liter of air into and out of the lungs.

Boyle's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Thoracic wall
Parietal pleura
Visceral pleura
Pleural cavity
Transpulmonary pressure 760 mm Hg −756 mm Hg = 4 mm Hg
0-(-4)=4
756
760
Intrapleural pressure 756 mm Hg (−4 mm Hg)
Lung
Intra-alveolar pressure:
760 mm Hg (0 mm Hg)
I.e Pressure difference
I.e Pressure difference

Transpulmonary pressure increases during inspiration and decreases during expiration .

