

Pulmonary ventilation

- Principles

- **Pulmonary ventilation has two phases :**

1. **Inspiration (inhalation)** is breathing air in

2. **Expiration (exhalation)** is breathing air out of the lung

- Normal respiratory rate in adult is **12-16 cycle /min.**

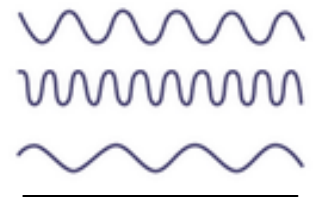
- **Eupneic** breathing is a normal breathing .

- **Tachypnea** is \uparrow in the rate of respiration >16 /min

- **Bradypnea** is \downarrow in the rate of respiration <12 /min

- **Apnea** : arrest of respiration ex: sleep apnea .

- **hyperventilation** is a state of breathing faster and deeper than normal (increase ventilation)



- **Pleura** : is a double –layered serous membrane that covers the lungs and the inner thoracic cage : **Visceral pleura** and **Parietal pleura**

- **Pleural cavity** : is a potential space between the two pleural layers . It contains about 10-15 ml of mucoid pleural fluid , **pleural fluid** Acts as a lubricant .The pressure inside the pleural cavity is negative .

- Respiratory cycle :

- I. **inspiration** : it is an active process. during inspiration, the thoracic cage dimensions \uparrow (Vertical , Anterior-posterior and Transverse dimension)

- **during quiet breathing :**

- 1-Diaphragm is the main muscle , it is responsible for 75% of the intrathoracic volume changes. it is innervated by the phrenic nerve (C3,C4,C5) . When contracts it becomes flat \rightarrow pull the lungs downward \rightarrow lengthen the chest cavity and $\rightarrow\uparrow$ the **vertical dimension**. it has three parts which are the costal fibers ,crural fibers and Central tendon .

Applied aspect :

- ✚ crural and costal fibers are innervated by different parts of phrenic nerve \rightarrow during vomiting , the costal fibers contract $\rightarrow\uparrow$ intra abdominal

pressure, while the crural fibers are relaxed to allow passage of material from stomach through esophagus.

✚ Transaction of spinal cord above **C3** level is **fatal**

2-External intercostal muscles : during contraction → raise the ribs upward → ↑ **anterior –posterior diameter** and the **transverse** diameter

- **During forced inspiration and exercise:** additional muscles are used :
 - **Scalenes** : elevates the first two ribs .
 - **Sternomastoids** : lift the sternum .

II. Expiration :

- During quiet breathing it is a **passive process** driven by
 - a) **Elastic recoil** of the lung .
 - b) **surface tension** of the fluid lining the interior surface of alveoli
 - c) Relaxation of the contracted inspiratory muscles

- In Forceful expiration :

1. **Internal intercostals** : when contracted → pulls the ribs downward → ↓ **anterior posterior diameter** .

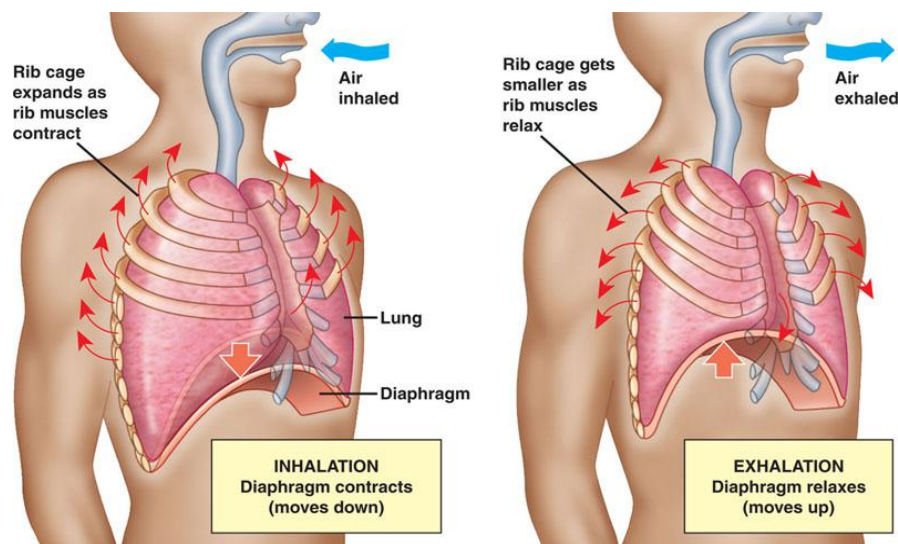
2. **Abdominal muscles**

- **Mechanism of breathing** :

Contraction of inspiratory muscles → Thoracic cage expand → lungs expand → ↑ lung volume → ↓ Alveolar pressure → Air enter into the lungs

Relaxation of inspiratory muscles → Lungs retract → ↓ volume → ↑ Alveolar pressure > atmospheric pressure → Air get out .

The duration of each normal respiratory cycle is 4-5 seconds



- **Respiratory pressures** : are three types

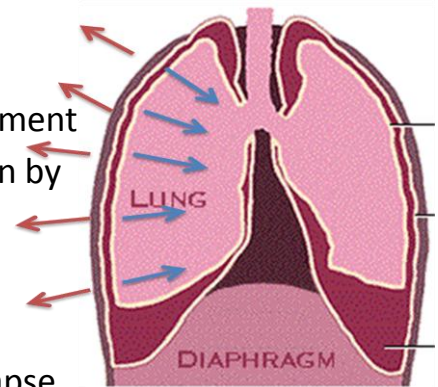
i. Intra-pleural pressure : -5cm H₂O (negative pressure) why ?

Normally ,each lung is subjected to two opposite forces :

- **Inward force** : lung elastic recoil and surface tension
 - **Out ward force**: muscle of respiration and elastic element of the rib cage (at rest) favor outward movement
- In addition there is continuous pleural fluid absorption by capillaries and lymphatics

- **Importance of Negative Intrapleural Pressure** :

- 1) It increases venous return.
- 2) Maintains alveolar stability and prevent lung collapse.
- 3) Keeps the airways open.



- **Note** :

- if either pleura is punctured → air enter into the pleural space →lung collapse , the other lung is not affected (separate plural cavity)
- If the lung loss its elasticity →the chest expand →barrel chest

ii. Alveolar P_A pressure : is the pressure inside the alveoli . Between breaths = 0 cm H₂O.

During inspiration: **-1 cm H₂O**

During expiration : **+1 cm H₂O**

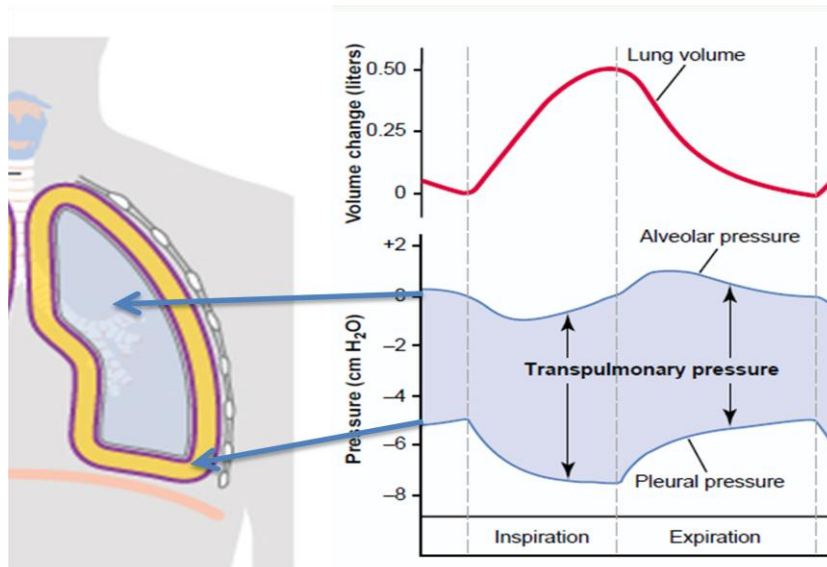
iii. Transpulmonary (transmural) pressure (P_L): is the differences between intraalveolar (P_A) and intrapleural pressure (P_L = P_A - P_{pl}).

P_L = 0 - -5 = +5 mmHg

It is a measure of the recoil forces of the lung (elastic force) → called Recoil pressure .

↑ During inspiration

↓ During expiration



A. Pressure changes during respiratory cycle :

- Between breaths, intrapleural pressure(-5 cm H₂O) and the Alveolar pressure equals (0 cm H₂O).
- During inspiration : intrapleural pressure becomes more negative (-7.5 cm H₂O) → pull the lung and expand the alveoli → ↓alveolar pressure (-1 cm H₂O) (Boyle's law) →Pressure gradient is created between atmospheric and alveolar pressure →air flow into the lung
- During expiration : intrapleural pressure becomes less negative by the effect of elastic recoil of the lung and the chest→ compress the lung →increase alveolar pressure(+1 cm H₂O) above atmospheric pressure →air get out of the lungs.