- OBJECTIVES

- Define pulmonary ventilation and differentiate it from alveolar ventilation.
- Describe the respiratory cycle and define respiratory rate.
- Identify the terms: eupenia, tachy- and bradyapnia, and hyper- and hypoapnia.
- Discuss the mechanics (= peripheral mechanism) of normal quiet and forced respiration.
- Discuss and illustrate the pressure relations (intrapulmonary, intrapleural, transpulmonary) that affect pulmonary ventilation.
- Define intrapleural pressure, mention its values, list causes of its negativity and discuss its significance.

• Pulmonary Ventilation

Mechanical process causing gas flow into and out of the lungs according to volume changes in the thoracic cavity. *("Breathing")*

Consists of two phases: Inspiration:

Expiration:

NOTE;-

- Volume changes lead to pressure changes
- Pressure changes lead to flow of gases to equalize pressure

Boyle's Law: (when temp constant)

$P_1V_1 = P_2V_2$

- $P \alpha 1/V$
- P = pressure in mm Hg
- V = volume in cubic mm

- Is the volume of air exchanged between atmosphere and alveoli/min
- NOTE;- more important as it represent new air available for
- gas exchange with blood. f x (TV-DS)

F = frequency (breaths/min.)

TV = tidal volume

DS = dead space

- **because of dead space:**
- **It is more advantageous to increase the depth**
- **of breathing**

- 1. Between 2 membrane
  -Visceral pleura a thin serosal membrane (LUNGS)

  -Parietal pleura lines the inner surface of the chest wall,

- 2. Thin layer of mucoid fluid10-20 ml transudate (interstitial fluid + protein) by Parietal layer
  - A)Acts as a **lubricant** for lungs to slide against chest wall → facilitates change in size and shape of lungs
  - B)Also prevents **frictional irritation** so membranes slide against

each other and are difficult to separate apart

- C) Excess is removed by **lymphatics** constant suction on pleura (-5cmH_2O) of Mediastinum,superior - diaphragm,lateral - of parietal pleural
  ------helps create –ve P_{PL}

D) Protects lungs from external **damage**

- .
  pressure of the fluid in the pleural space <u>always-ve</u>
  Intraoesophageal pressure = intrapleural pressure.

- TRANSMURAL PRESSURE
  pressure inside relative to outside of a compartment.
  Under static conditions, the transmural pressure = the elastic recoil pressure of the compartment.
- Thoracic cavity larger than lungs

- Transmural (Across Lung Wall) pressure gradient holds thoracic wall and lungs in close apposition

- This pressure gradient is balanced by the elastic forces in the alveoli producing equilibrium

• Pressure Relationships in the Thoracic Cavity

1.Intrapulmonary pressure
is the pressure in the alveoli, which rises and falls during respiration, but always eventually equalizes with atmospheric pressure.

2.Intrapleural pressure
is the pressure in the pleural cavity. It also rises and falls during respiration, but is always about 4mm Hg less than intrapulmonary pressure.

- At rest or without air movement.

- Lungs have a natural tendency to recoil inward, or to collapse.
- 2 main static forces :
  - elastic properties of lung tissue
  - surface tension by layer of fluid that is inside of t alveoli

- Chest wall has a natural tendency to move outward, or to expand.
- These two opposing forces tend to cancel each other out, leaving a residual volume of gas in the lungs, known as the FRC.

•INSPIRATION

•

- 75% of inspiratory effort
- Thin dome-shaped muscle attached to lower ribs, xiphoid process, lumbar vertebra
  Innervated by(Phrenic nerve$C_{3,4,5}$)
- contraction of diaphragm
  - Diaphragm moves **down** 1.5 cm during normal inspiration
  - During forced inspiration diaphragm can move down 7.5cm

- Abdominal contents forced **downward** & **forward** causing ↕ in vertically
- Rib margins are **lifted** & **moved** outward causing ↕ transverse diameter

APPLIED I. Obesity(moderate to severe),

2. Pregnancy

3. Tight Clothing

Paradoxical movement of diaphragm when paralyzed

Upward movement with inspiratory drop of intrathoracic pressure

Present **obliquely** b/w ribs in **forward & downward** direction.Responsible for 25% of inspiratory effort Intercostal nerves (T 1-11

2 effects—

I) **T.S+ A.P** ↑by **2** mechanisms—

i) **2–10** rib rotates **upwards and outwards** by a **"bucket-handle movement"** → ↑ T.S

ii) **upper 4 ribs** rotate the sternum in **upward n outward** (**pump-handle movement**) → ↑ in vertically

APPLIED;-

Paralysis does not seriously alter inspiration because diaphragm is so effective but sensation of inhalation is de.

●

1.Scalene Muscle

- Attach cervical spine to apical rib
- Elevate the first two ribs during forced inspiration

2.Sternocleidomastoid Muscle

- Attach base of skull (mastoid process) to top of sternum and clavicle medially
- Raise the sternum during forced inspiration

3.Neck and Back muscles(PECTORALIS MINOR)

↑ volume in 2 ways—

1. elevate pectoral girdle— ↑in cross-sectional area of thorax

2. they extend back c ↑ vertical length of the thorax

4. **Intrinsic muscles of larynx**

- EXPIRATION

- **Rectus abdominus/abdominal oblique muscles**
  - Contraction raises intra-abdominal pressure to move diaphragm upward
  - Intra-thoracic pressure raises and forces air out from lung

- **Internal intercostals muscles**
  - Assist expiration by pulling ribs downward & inward
  - Decrease the thoracic volume
  - Stiffen intercostals spaces to prevent outward bulging during straining

These muscles also contract forcefully during coughing, vomiting, & defecation

1.Eupnoea：Rhythmic breathing at rest ,rate of 12 - 20 breaths/ min.

2.Tachypnoea：Rapid breathing, more than 20 breaths / min.

3.Bradypnoea：abnormally slow breathing rate, less than 12 / min.

4.Hyperpnoea： depth of breathing when metabolic demands

4.Hypopnoea： depth of breathing when metabolic demands.

5. Dyspnoea Difficult or labored breathing that creates an "air hunger

6. Apnea A period of breathing cessation, (sleep apnea).

7. Hyperventilation- above normal rate+ depth of breathing;

8. Hypoventilation Below normal rate; +. depth of breathing

9. Hypocapnia by abnormally low blood pCO2

10.Hypercapnia in blood carbon dioxide). pCO_2 5 mmHg, V_{AIL} will double.

11. Anoxia severe form/ absence of O_2 deficiency in blood

12. Hypoxia severe form O_2 deficiency in blood

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• Dynamics of lung mechanics

studies physical states in motion.

- As air flows through a tube – a pressure difference exists between the ends of tube
- - difference depends on rate & pattern of air flow
- at low flow rates is laminar
- Turbulence occurs

- at higher flow rates
- changes in air passage way

airway branches
-diameter
-velocity
-direction changes

• Physical nature (types) of flow

flow can be3 types, i.e. laminar, transition and turbulent flow.

Reynolds Number (Re) can be used to characterize these flow.

where ρ = density
□ = dynamic viscosity
□ = kinematic viscosity ($\nu = \mu/$□)
V = mean velocity
D = pipe diameter

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Laminar Flow: Re <2000
Transitional Flow : 2000 - <4000
Turbulent Flow : Re >4000

- Physical Factors Influencing Pulmonary Ventilation

Inspiratory /Expiratory muscles consume energy to overcome 3 factors that hinder air passage and pulmonary ventilation

- Airway resistance
- Alveolar surface tension
- Lung compliance

• Factors affecting pulmonary ventilation

1- Lung compliance: ease with which lungs can be stretched
- Compliance is a measure of the elasticity of lung tissue and the alveolar surface tension

2- Airway resistance: to changes in airway radius (↓radius → ↑resistance)

Pathology

lung disease resulting in stiffness of tissue

no or ↓ surfactant

Asthma
Airway obstruction
COPD

- Most important adjustment is to breath occurs within sec;
- stimulated by:
  - cooling of skin
  - slightly asphyxiated state (elevated CO_2)
3. 40-60 mmHg of –ve P_{pL} necessary to open alveoli on 1st breath