Department of Anesthesia Techniques

Title of the lec1:

Respiratory Physiology: Mechanisms and Functions

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Lecture 1

Title: Respiratory Physiology: Mechanisms and Functions

- **Learning Objectives:**

I. Simple anatomy of the Respiratory System.
II. Respiratory system functions
III. Mechanics of Breathing
IV. Ventilation – perfusion ratio
V. Gas Exchange and Transport.
VI. Pulmonary Function Tests
VII. Pathophysiology of the Respiratory System

- **Respiratory physiology** is the study of functions of respiratory system .

The respiratory system ensures the delivery of oxygen (O_2) to tissues and the removal of carbon dioxide (CO_2) from the body.

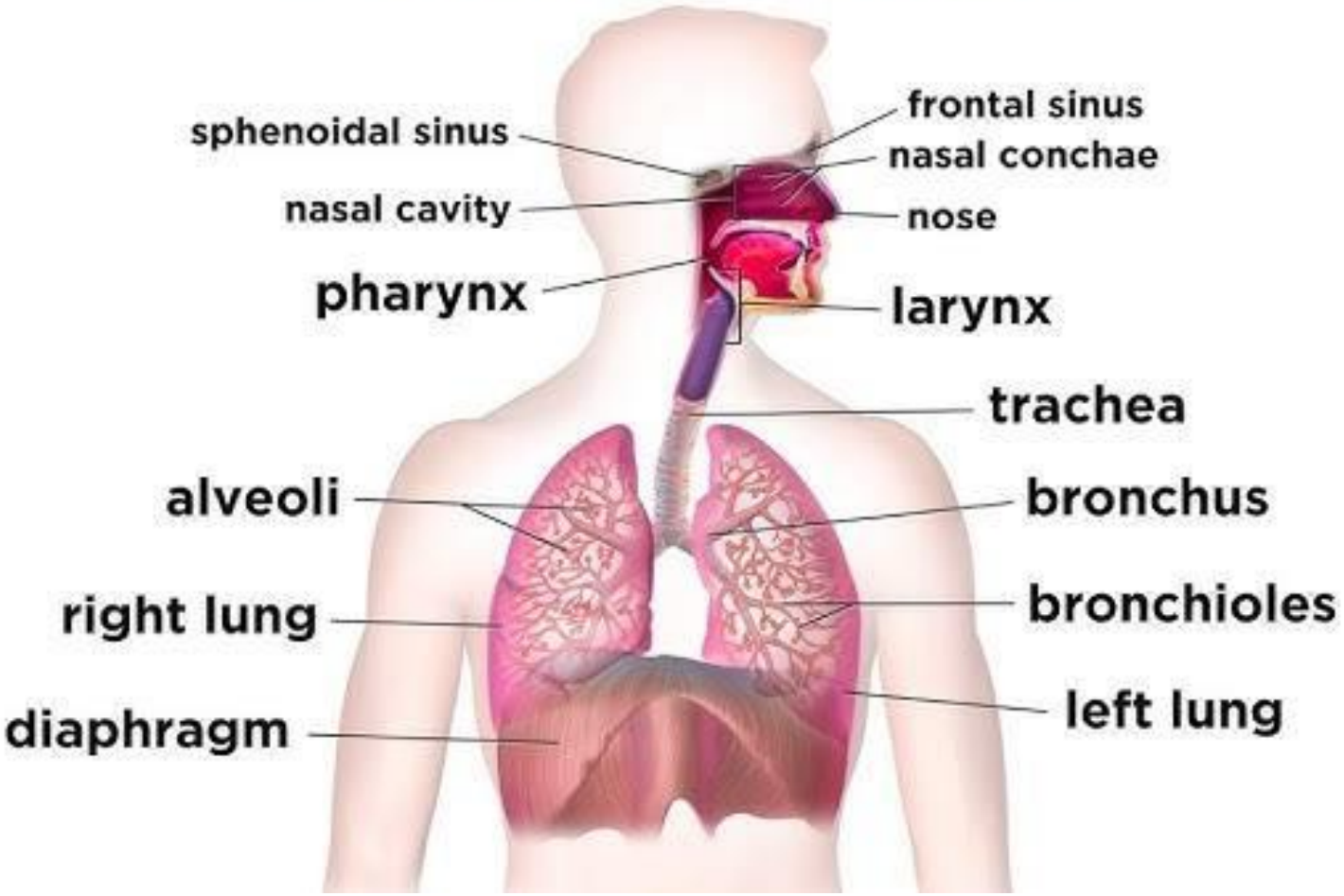
- **Primary functions of respiratory system:**

- Gas exchange: Oxygen uptake, O_2 enters the blood, and CO_2 is expelled.

- Regulation of blood pH through CO_2 elimination. acid-base balance.

- Filtration and humidification of inhaled air.

The Respiratory System



I. Anatomy of the Respiratory System

1. Upper Respiratory Tract:

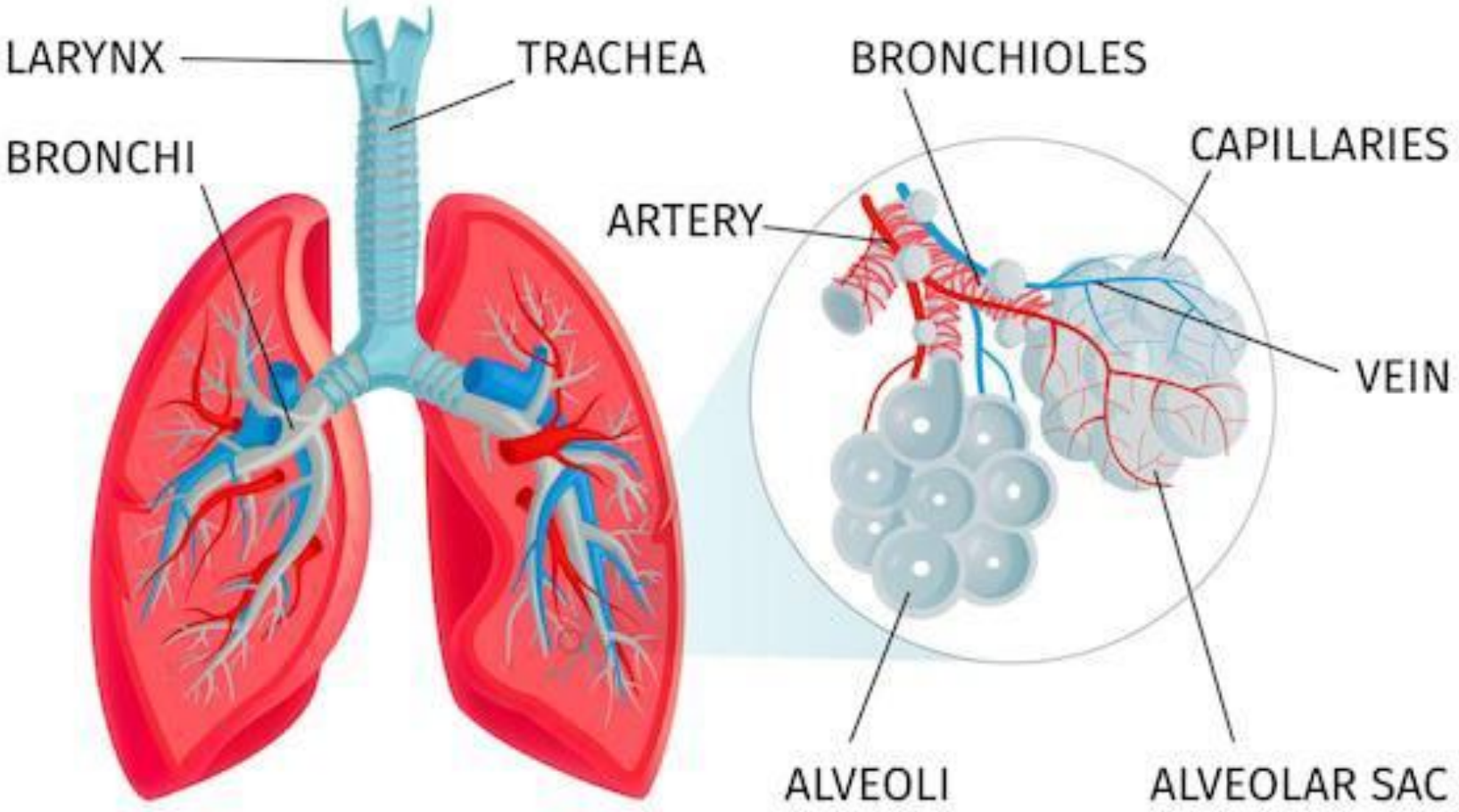
- Nose, nasal cavity, pharynx, and larynx.
- Functions: Air filtration, humidification, and temperature regulation.

2. Lower Respiratory Tract:

- Trachea, bronchi, bronchioles, and alveoli.
- Functions: Air conduction and gas exchange.

3. Supporting Structures: Diaphragm and intercostal muscles, aid in ventilation..

HUMAN RESPIRATORY SYSTEM



II. Mechanics of Breathing

1. Inspiration, breath in (active process):

• Diaphragm and intercostal muscle contraction, increasing intrathoracic volume. • Intrapulmonary pressure drops, air flows into the lungs.

2. Expiration, breath out (passive process):

Normally passive, driven by elastic recoil of the lungs

• Diaphragm relaxes, decreasing thoracic volume.

• Intrapulmonary pressure rises, air flows out of the lungs.

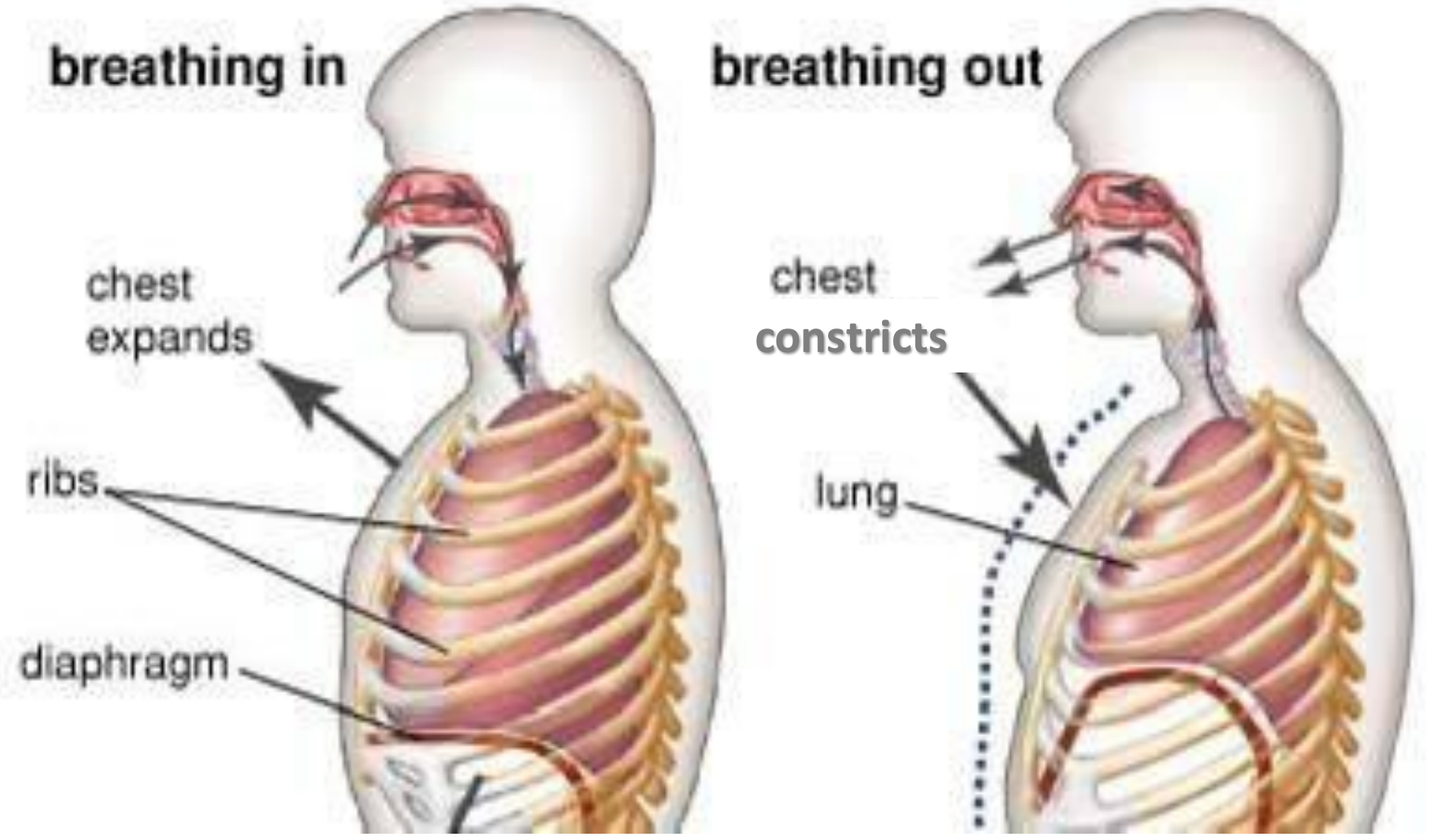
3. Compliance and Resistance:

• **Lung compliance:** Ability of lungs to stretch and expand. Compliance decrease in conditions like fibrosis.

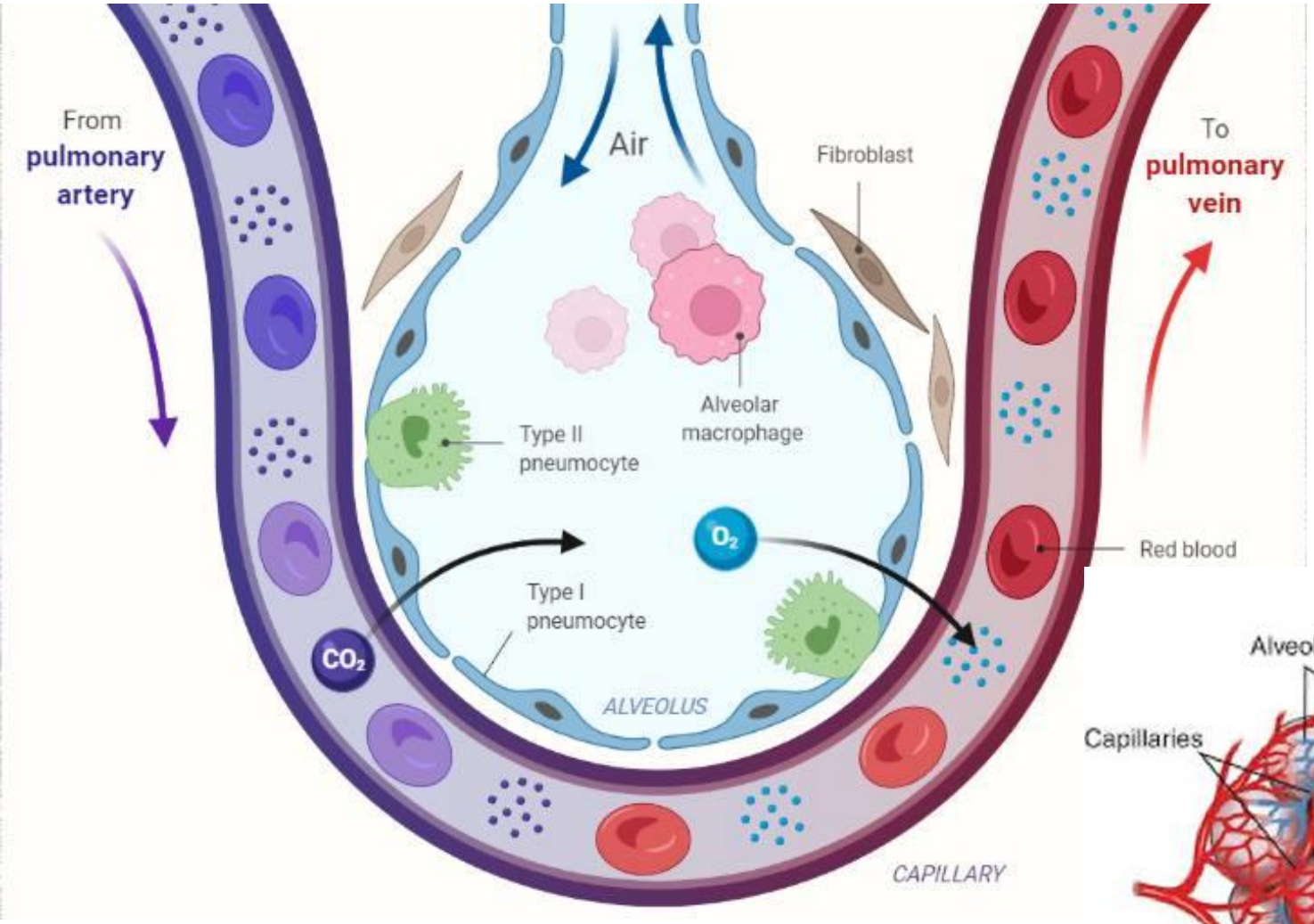
• **Elasticity:** **Tendency of lungs to return to their original shape.**

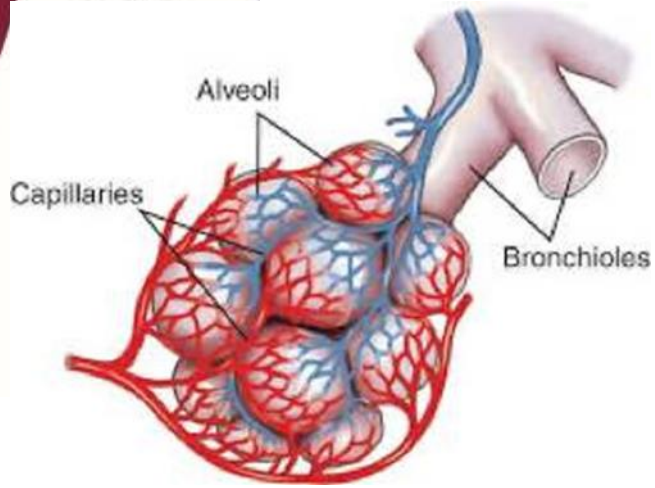
• **Airway resistance:** resistance to airflow is primarily in the medium-sized bronchi.

Resistance Influenced by bronchoconstriction (e.g., asthma) and bronchodilation (e.g., during exercise).


breathing in
chest
expands
ribs
diaphragm
breathing out
chest
constricts
lung

alveolus


From
pulmonary
artery
Air
Fibroblast
To
pulmonary
vein
Alveolar
macrophage
Type II
pneumocyte
O_2
Red blood
Type I
pneumocyte
CO_2
ALVEOLUS
CAPILLARY


Alveoli
Capillaries
Bronchioles

Ventilation-Perfusion Ratio

Ventilation (V):

- Refers to the movement of air in and out of the lungs.
- It ensures oxygen delivery to the alveoli and removal of carbon dioxide.
- Normal ventilation depends on an open airway and effective respiratory muscle function.

Perfusion (Q):

- Refers to blood flow through the pulmonary capillaries.
- It delivers deoxygenated blood to the alveoli for gas exchange.
- Perfusion relies on an intact cardiovascular system and pulmonary circulation.
- **For optimal gas exchange, there needs to be a balance between ventilation and perfusion.**

Ventilation-Perfusion V/Q Ratio

The V/Q Ratio

represents the relationship between alveolar ventilation (V) and pulmonary blood flow or perfusion (Q).

- Normal alveolar ventilation: ~4 L/min
- Normal pulmonary blood flow (perfusion): ~5 L/min
- **Normal V/Q ratio = 0.8**

Ventilation-Perfusion V/Q Mismatch

A mismatch or unbalance between ventilation and perfusion leads to inefficient gas exchange.

There are two primary types of V/Q mismatch:

A. Low V/Q Ratio:

- Cause: Poor ventilation relative to perfusion.
- Examples: Airway obstruction (e.g., asthma, COPD).

B. High V/Q Ratio:

- Cause: Poor perfusion relative to ventilation.
- Examples: Pulmonary embolism.

III. Gas Exchange and Transport

Gas exchange occurs in the alveoli and involves diffusion of gases between air and blood.

Partial Pressure: is the pressure exerted by O2 or CO2 in the alveoli and lung capillaries, it detects the direction of gas transportation between lungs and blood (from **higher** concentration towards **low** conc.)

- **Oxygen pp (*Po_2*) : Higher in alveoli (~100 mmHg) than in venous blood (~40 mmHg).**

- **Carbon dioxide pp (*Pco_2*): Higher in venous blood (~46 mmHg) than in alveoli (~40 mmHg).**

1. Alveolar Gas Exchange:

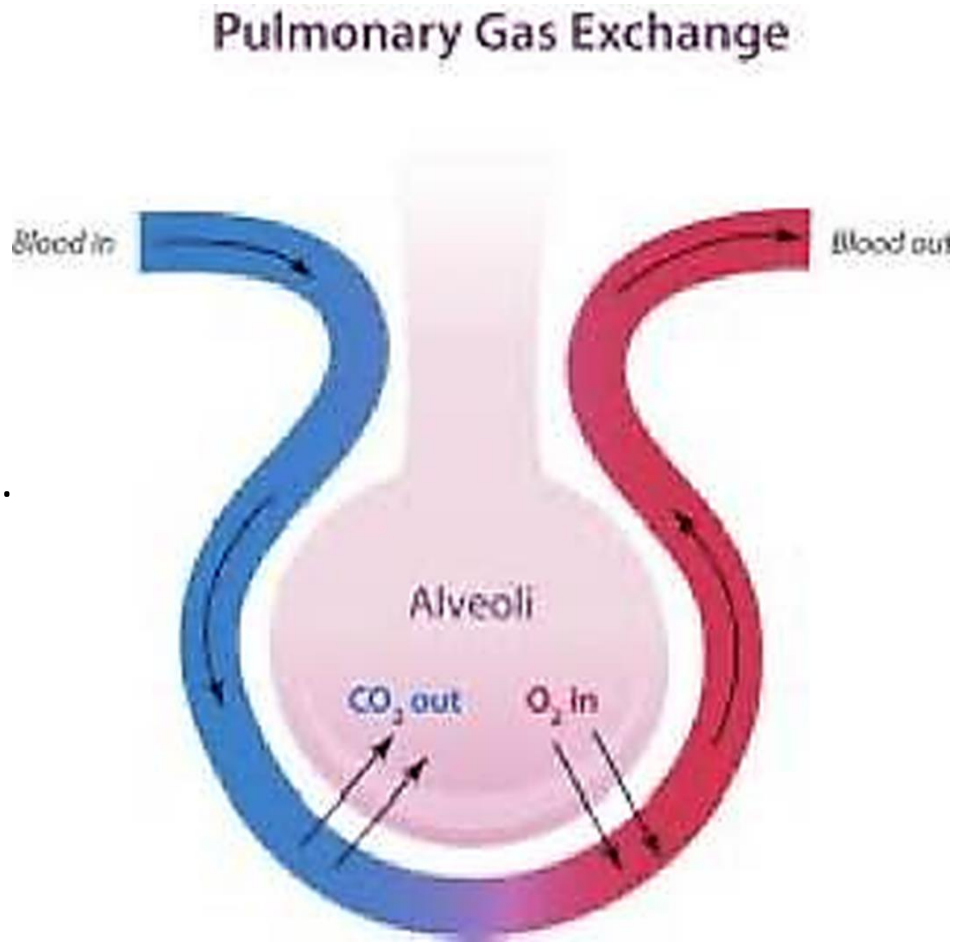
- Occurs in alveoli via **simple diffusion.**
- Partial pressure gradients drive oxygen into the blood and carbon dioxide out.

2. Oxygen Transport:

- 98% bound to hemoglobin.
- Dissolved in Plasma: ~2%.

3. Carbon Dioxide Transport:

- 70% as bicarbonate ions ($HCO3^-$).
- 20% bound to hemoglobin as carbaminohemoglobin.
- 10% dissolved in plasma.



Hypoxia and Hypercapnia

Hypoxia

Hypoxia refers to a condition where there is an inadequate oxygen supply to the tissues of the body to support normal physiological functions.

Types of Hypoxia:

1. Hypoxic Hypoxia: Insufficient oxygen in the blood (e.g., high altitudes).

2. Anemic Hypoxia: Reduced oxygen-carrying capacity of the blood due to low hemoglobin levels.

3. Circulatory Hypoxia: Impaired blood flow to tissues, often caused by shock or vascular obstruction.

Hypercapnia

Hypercapnia is a condition characterized by elevated levels of carbon dioxide (CO_2) in the blood, typically caused by hypoventilation or inadequate clearance of CO_2.

Clinical Implications

1. Adaptations to High Altitude:

- Hypoxia stimulates increased ventilation.

ليش اهل الشمال غالبا وجوههم حمر ؟

- Long-term adaptations: Increased red blood cell production and capillary density **بسبب زيادة عدد كريا ت الدم الحمراء حتى تحمل اوكسجين اكثر**

2. Respiratory Acidosis and Alkalosis:

- **Acidosis**: Due to hypoventilation and **CO_2** retention.
- Alkalosis: Due to hyperventilation and excessive CO_2 elimination.

Pathophysiology of the Respiratory System

1. Obstructive Diseases:

- Examples: Asthma, chronic obstructive pulmonary disease (COPD).
- Features: Increased airway resistance and reduced airflow.

2. Restrictive Diseases:

- Examples: Pulmonary fibrosis, pneumothorax.
- Features: Decreased lung compliance and reduced lung volumes.

3. Vascular Disorders: Pulmonary embolism.

. Pulmonary Function Tests

PFTs assess respiratory function and help diagnose diseases.

1. Spirometry:

- Measures lung volumes (e.g., tidal volume, vital capacity) and flow rates.
- Identifies obstructive (e.g., asthma, COPD) and restrictive (e.g., fibrosis) patterns.

2. Arterial Blood Gas (ABG) Analysis:

- Evaluates arterial O_2, CO_2 levels, and pH.


THANK YOU