HYPOXIA AND CYNOSIS

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HYPOXIA

Hypoxia is defined as an inadequate supply of oxygen to the body tissues.

Types:

- Hypoxic hypoxia
- Anemic hypoxia
- Stagnant hypoxia (Hypokinetic or Ischemic hypoxia)
- Histotoxic hypoxia

HYPOXIC HYPOXIA

Hypoxic hypoxia is also known as arterial hypoxia. This is seen when there is a lack of oxygenation of blood in the lungs, which leads to a low PO_2 in arterial blood. Since less amounts of Hb is converted to oxy-Hb. Hypoxic hypoxia can occur in the following conditions:

- High altitude
- Fluid in the lungs (pulmonary oedema)
- Obstruction in the respiratory passages
- Emphysema

HYPOXIC HYPOXIA

A: Alveolar hypoventilation

- Reduced PO2 in inspired air (high altitude)
- Increased airway resistance
- Reduced lung compliance
- Paralysis of respiratory muscles
- Depressed respiratory centre

B: Diffusion abnormalities: Impaired diffusion from alveolar to pulmonary capillary blood can lead to arterial hypoxia. It is seen in conditions like alveolar-capillary block.

HYPOXIC HYPOXIA

C: Ventilation-perfusion imbalance (including increased physiological dead space and physiological shunt):

If ventilation and blood flow are mismatched in various parts of the lung, impairment of both oxygen and carbon dioxide diffusion.

Ventilation perfusion imbalance may be caused by uneven ventilation. Exemp. obstructive lung conditions, or uneven perfusion, e.g. consolidation of the lung.

HYPOXIC HYPOXIA

D: Right to left shunt: Blood passes from the systemic venous without going through the gas exchanging part of the lungs. This type of hypoxia can be differentiated clinically from other types by giving the subject 100% oxygen to breathe.

Hypoxia because of the shunt will not be abolished while in other types PO2 in the arterial system will improve considerably.

ANEMIC HYPOXIA

This condition is characterized by decreased oxygen carrying capacity of the blood due to decreased hemoglobin level. Anemic hypoxia is seen in haemorrhagic anemia [Decreased RBC / quality, or the failure of hemoglobin to carry its normal concentration of oxygen, as in carbon monoxide (CO) poisoning. Altered haemoglobin formation eg methaemoglobin,s ulphaemoglobin, and carboxyhaemoglobin.

STAGNANT HYPOXIA

Stagnant hypoxia [(Hypokinetic or Ischemic hypoxia] occurs in conditions in which there is a decreased rate of blood flow throughout the body or a part of the body.

It may be caused by congestive heart failure, circulatory shock and arteriosclerosis.

general slowing of circulation [heart failure and shock]

local slowing: vasoconstriction, cold, arterial wall spasm.

HISTOTOXIC HYPOXIA

In histotoxic hypoxia the tissue are unable to use oxygen even though plenty of oxygen is available. This is caused by inhibition of the tissue respiration electron transport chain.

The best example is cyanide poisoning, where tissue cytochrome oxidases are knocked out and tissue is unable to utilize oxygen.

CLINICAL FEATURES

Clinical features depend on how fast and how severely partial pressure of O_2 is decreased.

Fulminant hypoxia: This occurs very rapidly, within seconds. Unconsciousness occurs in 15-20 seconds and brain tissue death occurs in 4-5 minutes.

Acute hypoxia: Body reflexes slowed, slurred speech, unconsciousness, coma and death may occur.

Chronic hypoxia: Fatigue, shortness & difficulty in breathing

Cyanosis, Tachy-cardia and Tachypnea

CYNOSIS

Cyanosis means bluish discoloration of skin and mucous membrane due to the excessive amount of deoxygenated hemoglobin in the skin blood vessels, especially in the capillaries.

This deoxygenated hemoglobin has an intense dark blue-purple color that is transmitted through the skin.

Cyanosis appears whenever the *arterial blood contains more than 5 grams of deoxygenated* hemoglobin in each 100 milliliters of blood.

CYNOSIS

A person with *anemia almost never becomes cyanotic* because there is not enough hemoglobin for 5 grams to be deoxygenated in 100 milliliters of arterial blood.

Conversely, in a person with excess red blood cells, as occurs in *polycythemia vera*, *the great excess of available* hemoglobin that can become deoxygenated leads frequently to cyanosis, even under otherwise normal conditions.

CYNOSIS

Causes of Cyanosis:

i. ***Inadequate oxygenation of blood in the lungs***

•High altitude

•Obstruction of respiratory passages

•Pneumonconiosis

•Emphysema

•CO-poisoning

ii. ***Presence of an aerated shunt between vessels***

•Coaractation of aorta

•Fallots tetrology

iii. ***Other Causes***

• Moderate cold

•Diminished blood flow to tissues

CYNOSIS

Types of cyanosis

- Local cyanosis
- Generalized cyanosis

Local cyanosis

This is seen during decreased blood flow through a part of the body as in Raynauds' disease. In this disease, circulation through the upper limb is impaired, it causing local cyanosis.

Generalized cyanosis

Generalized impairment of circulation as in the case of heart failure leads to generalized cyanosis. It also occurs in hypoxic hypoxia

CYNOSIS

Causes of central cyanosis

- Cyanotic congenital heart-disease
- Fallot tetralogy
- Tricuspid atresia
- Pulmonary arteriovenous fistula
- Pulmonary diseases
- Acute pulmonary embolism
- Pneumonia
- Chronic Obstructive airway disease
- Restrictive lung disease
- Hemoglobin abnormalities

CYNOSIS

Causes of peripheral cyanosis

- Reduced cardiac output, as in congestive heart failure,
- Mitral stenosis
- Exposure to cold
- Arterial obstruction
- Venous obstruction
- Raynauds disease
- Polycythemia vera

VENTILATION-PERFUSION RATIO (V/Q)

Ventilation-Perfusion Ratio (VA/Q): This is the ratio of alveolar ventilation to the pulmonary blood flow per minute.

Ventilation-perfusion ratio is expressed as VA/Q

When VA (alveolar ventilation) is normal for a given alveolus and Q (blood flow) is also normal for the alveolus, the ventilation-perfusion ratio (VA/Q) is also said to be normal.

VENTILATION-PERFUSION RATIO (V/Q)

Ventilation - Perfusion Ratio (V/Q): The alveolar ventilation at rest is about (4.2 L/minute)

Calculated as: Alveolar ventilation = respiration rate x (tidal volume – dead space air)

The pulmonary blood flow is equal to right ventricular(5 L/min) output. Hence ventilation perfusion ratio is

Perfusion Ratio = 4.2/ 5= 0.84

VENTILATION-PERFUSION RATIO (V/Q)

VENTILATION-PERFUSION RATIO (V/Q)

Ventilation (V) Alveolar
Minute ventilation = 4 to 6L

Perfusion (Q) Normal
cardiac output = 5 L

Normal ventilation / perfusion
ratio (V/Q ratio) = 0.8 to 1.2

Ventilation and perfusion must be matched at the alveolar capillary level

VENTILATION-PERFUSION RATIO (V/Q)

Increased in Ventilation / Perfusion Ratio

Alveolar PO2 will rise

Alveolar PCO2 will fall

Decreased in ventilation perfusion ratio

Alveolar PO2 will fall

Alveolar PCO2 will rise

ALVEOLAR PO_2 AND PCO_2

PO_2 and PCO_2 are inversely related through alveolar ventilation.

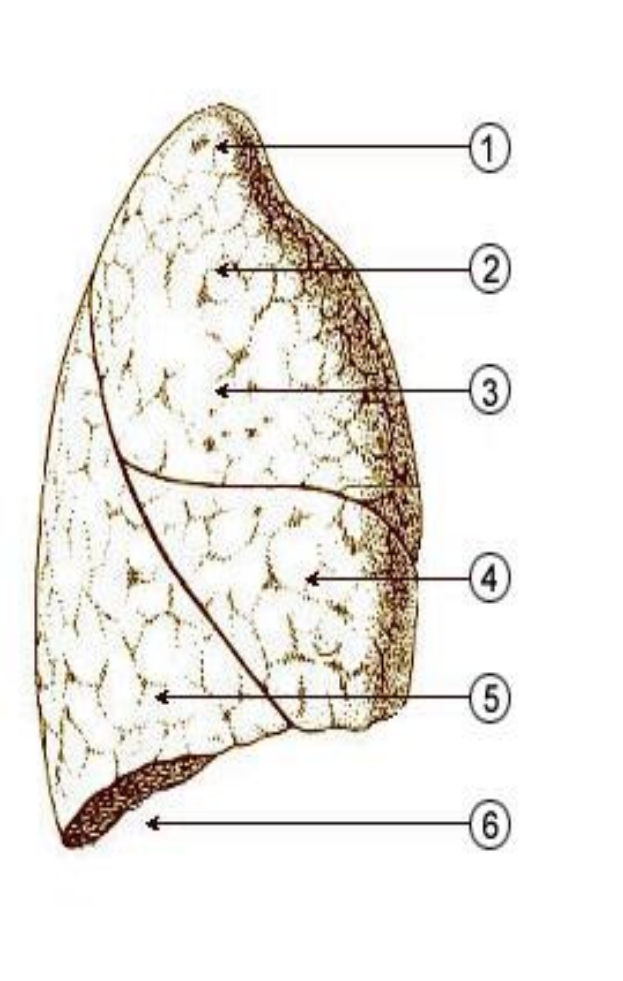
Increasing V/Q produces higher P_AO_2 and lower P_ACO_2.

- Hyperventilation defined as $P_ACO_2 < 40$

Decreasing V/Q produces lower P_AO_2 and higher P_ACO_2.

- Hypoventilation defined as $P_ACO_2 > 40$

VENTILATION-PERFUSION RATIO (V/Q)

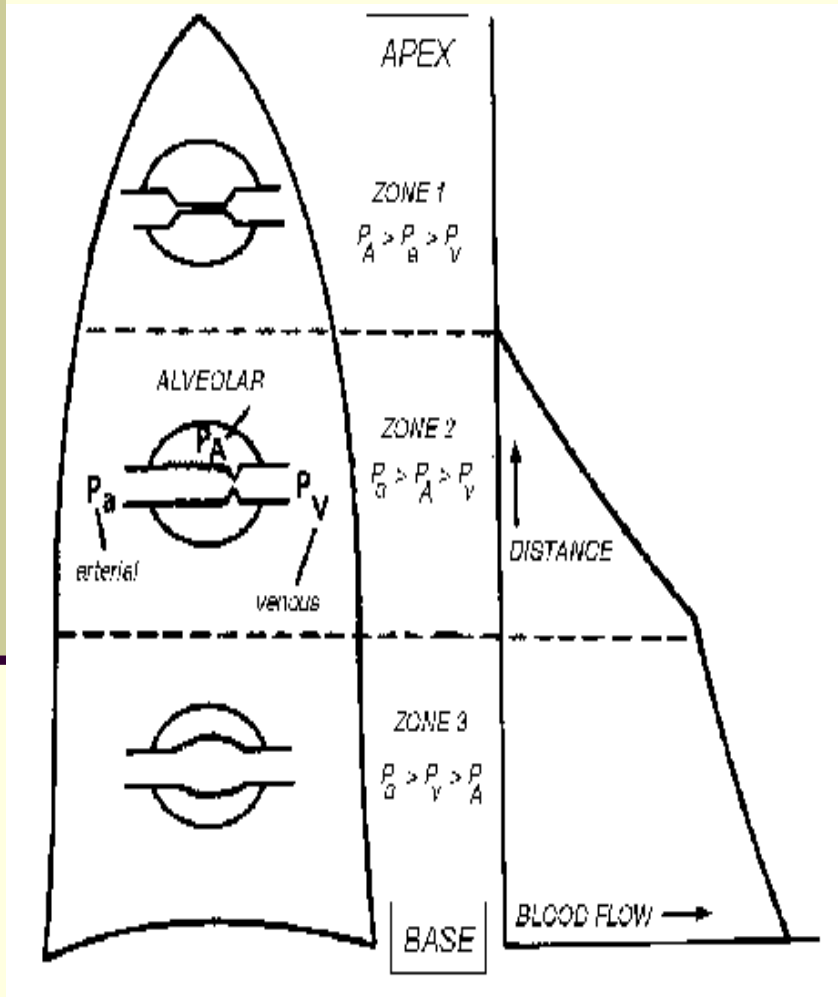


As lung is centered vertically around the heart , part of the lung is superior to the heart, and part is inferior. This has a major impact on the V/Q ratio

- Apex of the lungs: higher

  Base of the lungs: lower

REGIONAL BLOOD FLOW DISTRIBUTION



Zone 1: Alveolar air pressure greater than either pulmonary arterial of venous pressures, so vessels collapsed and flow close to zero (Note: does not exist in normal lung, but can occur in pulmonary hypotension)

Zone 2: Alveolar air pressure less than pulmonary arterial pressure but greater than pulmonary venous pressure, so vessels partially collapsed and flow is low

Zone 3: Alveolar air pressure less than both pulmonary arterial and venous pressures, so vessels open for full length and flow highest

VENTILATION-PERFUSION RATIO (V/Q)

Causes of V/Q Mismatching

Causes of non uniform ventilation

Uneven resistance to airflow

Collapsed airways (Emphysema)

Bronchoconstriction (Asthma)

Inflammation (Bronchitis)

Non-uniform compliance throughout the lung

Fibrosis

Pulmonary vascular congestion

Atelectasis

REGIONAL BLOOD FLOW DISTRIBUTION

A. Upright Posture: In the upright posture, pulmonary vascular hydrostatic pressure decreases at increasing heights above the lung because of the effect of gravity. Thus, blood flow is highest at the base of the lungs and decreases toward the apex

Prone or supine Posture (lying down): In the prone posture, all lung regions are near heart level, so the effect of gravity is much less and the pulmonary flow is more uniform

VENTILATION-PERFUSION RATIO (V/Q)

At the apex of the lung: At apex relatively less blood (gravity pulls it down) and relatively high ventilation so **high V/Q ratio.**

This leads to an **increase** in alveolar and arterial oxygen levels while **decreasing** the carbon dioxide.

THANK YOU