Hypoxia and cyanosis

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Objectives

- **By the end of this lecture you should be able to:**

- Define hypoxia and list its various physiological and pathological causes.
- Outlines the treatment of hypoxia.
- Define hypercapnea and list its causes and manifestations.
- Define hypo and hyper-ventilation in terms of arterial PCO2 and PO2.
- Define cyanosis and its clinical presentation

Hypoxia

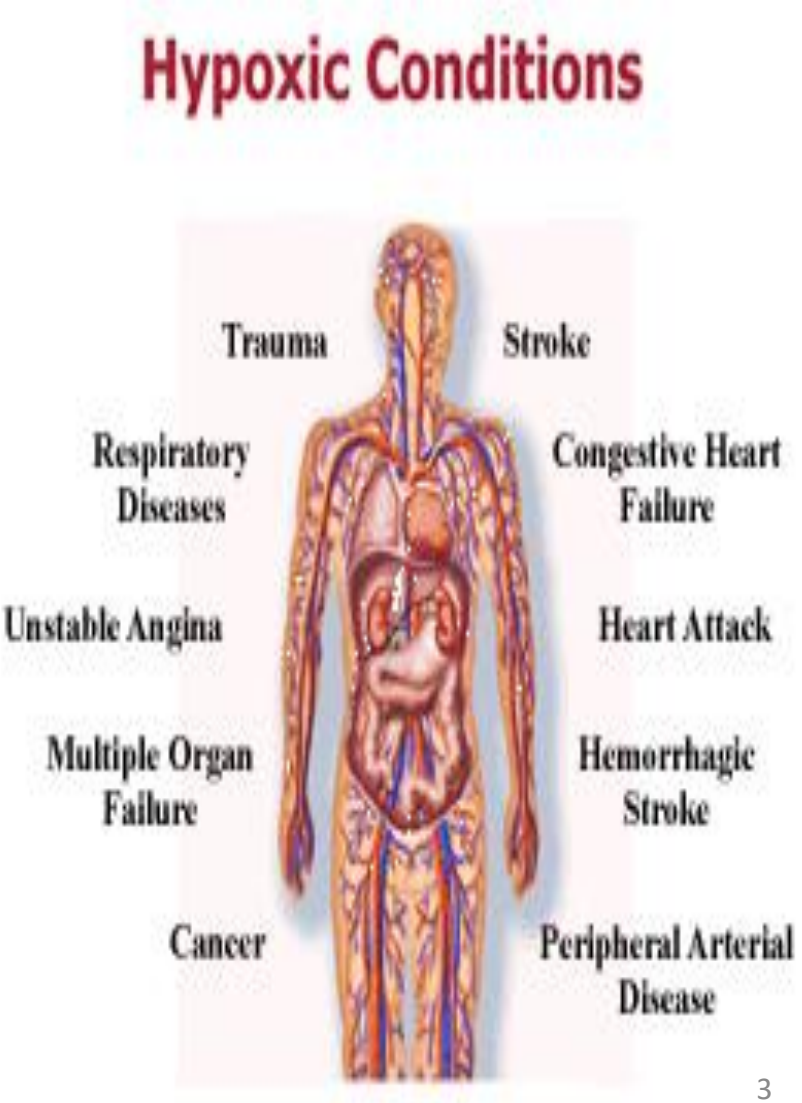
- Is defined as deficiency of oxygen in the tissue cells.
- It can be classified into the following groups:-

1.Hypoxic or arterial hypoxia

2.Anemic hypoxia

3.Stagnant hypoxia

4.Histiotoxic hypoxia



Causes of Hypoxia

1. Inadequate oxygenation of the blood in the lungs because of extrinsic reasons:

a. Deficiency of O2 in the atmosphere.

b. Hypoventilation (neuromuscular disorders).

2. Pulmonary disease:

a. Hypoventilation by increased airway resistance or decreased pulmonary compliance.

b. Abnormal alveolar ventilation/perfusion ratio.

c. Diminished respiratory membrane diffusion.

3. Venous-to-arterial shunts (“right-to-left” cardiac shunts).

4. Inadequate O2 transport to the tissues by the blood:

a. Anemia or abnormal hemoglobin.

b. General or Localized circulatory deficiency (peripheral, cerebral, coronary vessels).

d. Tissue edema.

5. Inadequate tissue capability of using O2:

a. Poisoning of cellular oxidation enzymes or toxicity.

b. Diminished cellular capacity for using oxygen because of vitamin deficiency.

I-Hypoxic or arterial hypoxia

Reduced arterial PO2. It can be due to:

- Alveolar hypoventilation
- Diffusion abnormalities
- Right to left shunt
- Ventilation-perfusion imbalance (including increased physiological dead space and physiological shunt).

Cause	Pa_{O_2}	A - a Gradient	Supplemental O_2 Helpful?
High altitude ($\downarrow P_B$; $\downarrow P_{I_{O_2}}$)	Decreased	Normal	Yes
Hypoventilation ($\downarrow P_{A_{O_2}}$)	Decreased	Normal	Yes
Diffusion defect (e.g., fibrosis)	Decreased	Increased	Yes
$\dot{V}/\dot{Q}$ defect	Decreased	Increased	Yes
Right-to-left shunt	Decreased	Increased	Limited

II-Anemic hypoxia

- It is caused by reduction in the oxygen carrying capacity of the blood, due to decreased amount of Hb or abnormal type of Hb which is unable to carry oxygen.

Causes:

1- Anemia

2-Abnormal Hb e.g methemoglobin, carboxyhemoglobin.

III-Stagnant hypoxia:

- Caused by reduced blood flow through the tissues:

  more and more oxygen is extracted from the blood, and due to slow circulation less oxygen is carried by the blood at the lung , leading to hypoxia.

- **Causes:**

1-General slowing of the circulation, as in heart failure and shock.

2-Local slowing e.g: vasoconstriction, cold, arterial wall spasm.

IV- Histiotoxic hypoxia

- Inability of the tissues to use oxygen due to inhibition of the oxidative enzyme activity.
- E.g: cyanide poisoning causing blockade of the cytochrome oxidase activity.

Effects of hypoxia

- According to the degree of hypoxia, it could lead to:

  impairment of judgment, inability to perform complex calculations, headache, nausea, irritability, dyspnea, increased heart rate, reduction in muscle working capacity.
- Even coma and death may result.

Treatment of hypoxia

O2 can be administered by:

(1)placing the patient's head in a "tent" that contains air fortified with O2.

(2)allowing the patient to breathe either pure O2 or high concentrations of O2 from a mask.

(3)administering O2 through an intranasal tube.

Benefits of oxygen therapy to different type of hypoxia

- Recalling the basic physiological principles of the different types of hypoxia, one can readily decide when O2 therapy will be of value.
- In atmospheric hypoxia, O2 therapy can completely correct the depressed O2 level in the inspired gases and, therefore, provides 100 % effective therapy.
- In hypoventilation hypoxia, a person breathing 100 percent O2 can move five times as much O2 into the alveoli with each breath as when breathing normal air.
- In hypoxia caused by anemia or abnormal hemoglobin, O_2 therapy is less effective because normal O_2 is available in the alveoli but the defect is in transporting O_2 to the tissues.
- Also in hypoxia caused by inadequate tissue use of O_2, O_2 therapy is of no benefit because O_2 is available in the alveoli and no abnormality in O_2 pickup by the lungs or transport to the tissues but tissue enzyme are incapable of utilizing the O_2 that is delivered.

Hypercapnea
(excess of CO2 in the body fluids)

- PCO2 increases above 52 mmHg which decreases the PH. It occurs in association with hypoxia which is caused by hypoventilation or circulatory deficiency. hypercapnea occurs with hypoxia because CO_2 movement between the alveoli and the atmosphere is affected. In circulatory deficiency, tissue hypercapnea occurs with tissue hypoxia due to diminished CO_2 removal from the tissues.
- When Hypoxia is caused by too little O_2 in the air, too little Hb, or poisoning of oxidative enzymes, hypercapnea isn't concomitant of these types of hypoxia.
- If hypoxia caused by poor diffusion through the pulmonary membrane, hypercapnea doesn't occur because CO_2 is 20 times more diffusible than O_2 and if it begins to occur it will stimulate pulmonary ventilation to correct the hypercapnea.
- If CO_2 rises from 80-100mmHg, the person becomes lethargic and semicomatose

Features of hypercapnea

- Air hunger Dyspnea (A PCO2 between 60-70 mmHg)
- Peripheral vasodilatation
- Sweating
- Warm extremities and bounding pulse
- Muscle twitching
- Headache, drowsiness and semicoma (PCO2 rises to 80 to 100 mm Hg)
- Papilledema (swelling of optic disc).
- Death can result when the PCO2 rises to 120 to 150 mm Hg (due to depression of the respiratory center).
- At these higher levels of PCO2, the excess CO2 now begins to depress respiration rather than stimulate it, thus causing a vicious circle:

  (1) more CO2.

  (2) further decrease in respiration.

  (3) then more CO2, and so forth—culminating rapidly in a respiratory death.

Cyanosis

Cyanosis

- Blue discoloration of the skin and mucus membrane due to more than 5 g/dl of deoxygenated hemoglobin in blood.
- A person with anemia will develop cyanosis due to low amount of Hb for 5 grams to be deoxygenated /100ml blood.
- In polycythemia, excess Hb that can become deoxygenated can cause cyanosis even under normal conditions.