Hypoxia and cyanosis

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Objectives

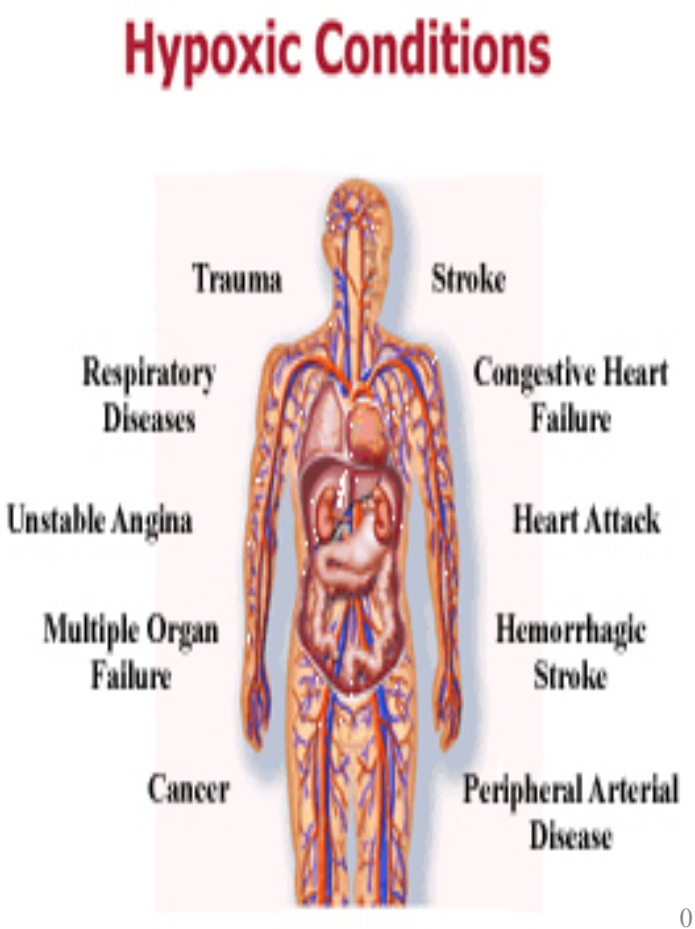
- **By the end of this lecture you should be able to:**

- 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.

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 ($\downarrow Pa_{O_2}$, $\downarrow P_{I_{O_2}}$)	Decreased	Normal	Yes
Hypoventilation ($\downarrow Pa_{O_2}$)	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, O2 therapy is less effective because normal O2 is available in the alveoli but the defect is in transporting O2 to the tissues.
- Also in hypoxia caused by inadequate tissue use of O2, O2 therapy is of no benefit because O2 is available in the alveoli and no abnormality in O2 pickup by the lungs or transport to the tissues but tissue enzyme are incapable of utilizing the O2 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 CO2 movement between the alveoli and the atmosphere is affected. In circulatory deficiency, tissue hypercapnea occurs with tissue hypoxia due to diminished CO2 removal from the tissues.
- When Hypoxia is caused by too little O2 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 CO2 is 20 times more diffusible than O2 and if it begins to occur it will stimulate pulmonary ventilation to correct the hypercapnea.
- If CO2 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 not 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.