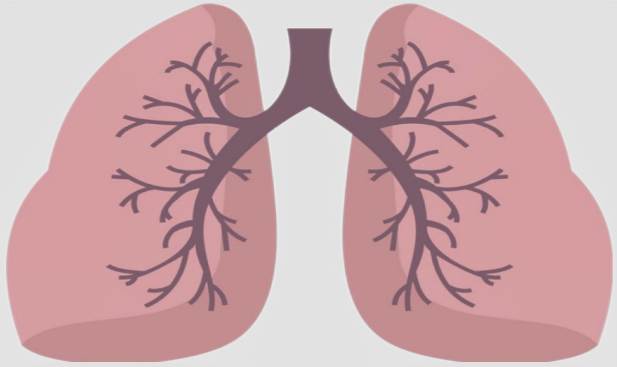
Hypoxia and cyanosis



Respiratory Block

Physiology 439 team work

Editing file

@Physiology_439

- Black: in male / female slides
- Red : important
- Pink: in female slides only
- Blue: in male slides only
- Green: notes
- Gray: extra information
- Textbook: Guyton + Linda

Objectives :

01 Define hypoxia and list its various physiological and pathological causes.

02 Outlines the treatment of hypoxia.

03 Define cyanosis and its clinical presentation

04 Define hypo and hyper-ventilation in terms of arterial PCO2 and PO2.

05 Define hypercapnea and list its causes and manifestations.

Helpful video

Hypoxia

Hypoxia sign not symptom

Hypoxia is defined as deficiency of oxygen in the tissue cells.

Types of hypoxia

- Histotoxic hypoxia
- Anemic hypoxia
- Stagnant hypoxia
- Hypoxic or arterial hypoxia (hypoxemia)

In males slides only
But
Explained by girls' Dr.

Causes of hypoxia

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

- Deficiency of O2 in the atmosphere air (in high attitude)
- Hypoventilation (neuromuscular disorders)

2-Pulmonary diseases:
Causes of pulmonary disease :

- Hypoventilation by increased airway resistance or decreased pulmonary compliance.
- Abnormal alveolar (ventilation/perfusion ratio)
- Diminished respiratory membrane diffusion
  thickness in the respiratory membrane due to pneumonia *accumulation of pus*,fibrosis ,pulmonary Edema

3- Inadequate tissue capability of using O2
Causes :

- Poisoning of cellular oxidation enzymes or toxicity
- Diminished cellular capacity for using oxygen because of vitamin deficiency

4-Inadequate O2 transport to the tissues by the blood
Causes:

- Anemia (decreasing in Hb) or abnormal Hb
- General or localized circulatory deficiency peripheral, cerebral, coronary vessels)
- Tissue edema

5-Venous-to-arterial shunts ("right-to-left" cardiac shunts).

Causes of hypoxia :

Only in female slide

Cause	Mechanism	PaO2
↓Cardiac output	↓ Blood flow	—
Hypoxemia	↓PaO2 ↓O2 saturation of Hb ↓ O2 content of blood	↓
Anemia	↓ Hb concentration ↓Content of blood	—
CO poisoning	↓ Content of blood left shift of O2-Hb curve	—
Cyanide poisoning	↓O2 utilization by tissues	–

Hypoxic or arterial hypoxia

is defined as Reduced arterial PO2 it can be due to :

1

Alveolar hypoventilation

Also the decreasing of O2 in atmospheric air

Ventilation problems can happen due to many reasons like :

1-Neurological problems (e.g Phrenic nerve injury , such as may occur from cardiothoracic surgery, can lead to diaphragmatic paralysis or dysfunction so the air can't get in.

2-Respiratory muscle weakness (muscle fatigue dust to overuse)

3-respiratory center depression (drugs toxicity E.g.morphine).

2

Diffusion abnormalities

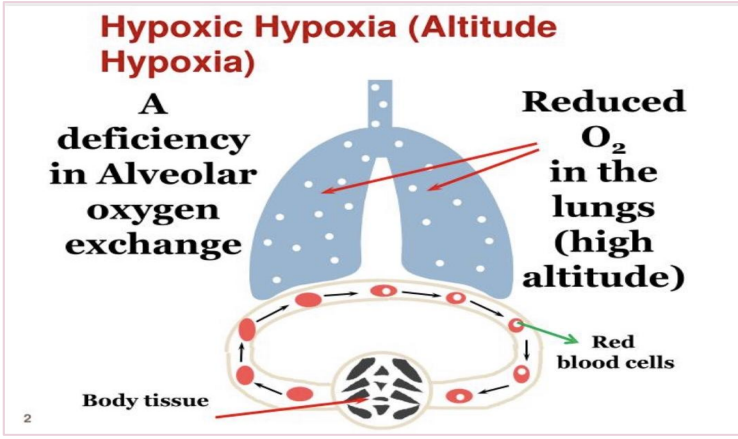
3

Right to left shunt

4

Ventilation-perfusion imbalance

(including increased physiological dead space and physiological shunt).



** increased because The o2 in the alveoli is high but in the arterial blood is low

بكل بساطه لان الهواء يدخل بشكل طبيعي ويتجمع في الalveoli بس ما يقدر يطلع منها والسبب ان فيه Fibrosis بالتالي ماراح ينتقل للدم ف

Po2 in the alveoli / Po2 in the arterial blood increased

الرقم الكبير في البسط والرقم الصغير في المقام طبيعي الRatio يزيد

Causes of hypoxemia :

Ratio
Po2 in the alveoli/Po2 in the arterial blood

Cause	PaO2	A -a gradient	Supplemental O2 helpful?
High altitude (↓PB; ↓PIO2)	Decreased	Normal لان الPo2 في الalveoli قليل وبرضو في ال artiral blood قليل لذالك الratio ماراح تتاثر	Yes
Hypoventilation (↓POA2)	Decreased	Normal	Yes
Diffusion defect (eg. fibrosis)	Decreased	**Increased	Yes
V/Q defect	Decreased	Increased	Yes
Right-to-left shunt	Decreased	Increased	Limited

Anemic hypoxia

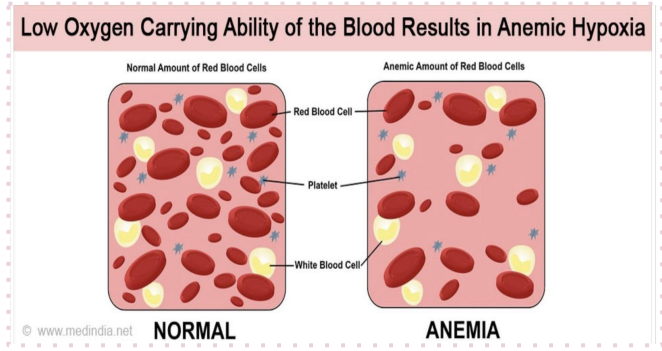
It is caused by **reduction in the oxygen carrying capacity of the blood** due to **decreased amount of Hb** or **abnormal type of Hb** which is unable to carry oxygen.

- The PO2 and %Hb-O2 is normal.

Causes of anemic hypoxia

- **Anemia**
  - Decreasing in RBCs (damage of M.S.C**)due to aplastic anemia or hemolytic anemia
    Or decreasing in HB
- **Abnormal HB**
  - carboxyhemoglobin
  - methemoglobin → -methemoglobin causes increase in the affinity of O2 to bind Hb (shift the curve to left) that cause less amount of O2 go to tissues so hypoxia will occur
  - It Might be due to:
    ↓Fe , ↓B12 , ↓folic acid , Thalassemia or Sickle cell anemia

We should know that the person with anemic hypoxia is normal and can do the normal activity but if he did severe exercise the symptoms of Anemic hypoxia will appear



— ** M.S.C = myeloid stem cell "which found in bone marrow and differentiate to RBCs"

— Normally, each red blood cell contain 300 million of Hb molecules . And each Hb molecules can carry 4 o2 molecules .. So totally, every RBC transports 1 billion of oxygen molecules (that explains how RBCs level & Hb are important in gas exchange process)

Dr. Maha's notes to the previous slide

Carboxyhemoglobin :

CO has higher affinity for Hb than O2 (200x), so if it presents it will prevent O2 from binding and also CO will increase the affinity of O2 That still bind to Hb (so the curve shifts to left) that mean decreasing in the amount of O2 which release to tissues

When we'll have carbon monoxide poisoning? In fires or when running heaters

-they named carbon monoxide poisoning the silent killer because it come without any signs (it's painless & without any smell)

The people who have Co poisoning don't have Dyspnea , just a headache

Met-hemoglobin :

It oxidized Hb

The O2 bind to Hemoglobin reversibly

That means when O2 bind to hemoglobin doesn't oxidized the iron (iron stay in the ferrous form)

-normally in our bodies we have small amount of met- hemoglobin (1% of our total Hb) and it get higher when we ingest any medication or drug that causes oxidation so the iron will change from Fe+2 to Fe+3 ! But under normal conditions we have a protective mechanism (such as G-6PD pathway in RBCs which transfer Fe+3 to Fe+2 again

But when we had large amount of met-hemoglobin because of toxins , in this case we don't have enough of protective mechanism are capable to transfer all the ferric to ferrous

-met hemoglobin causes increase in the affinity of O2 to bind Hb (shift the curve to left) that cause less amount of O2 release to tissues so hypoxia will occur

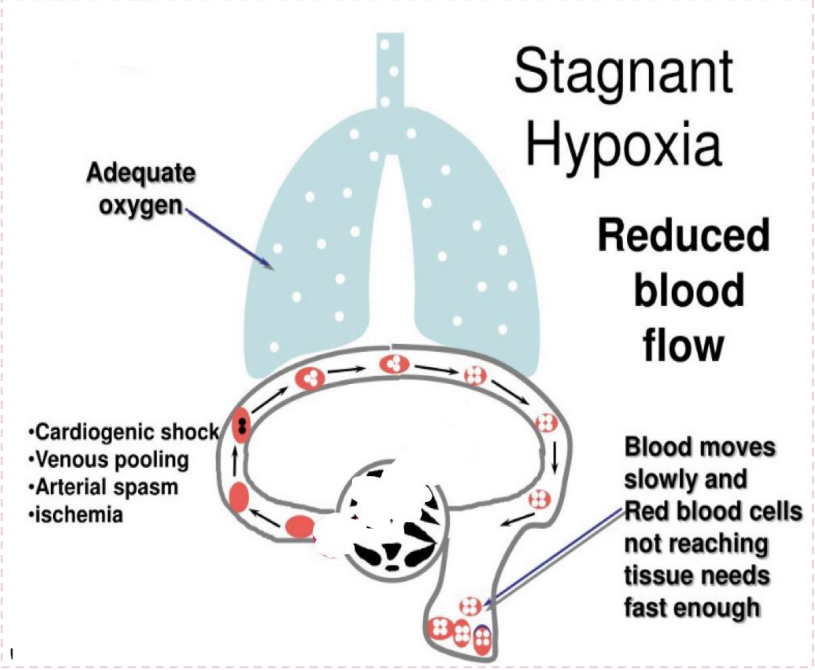
Stagnant hypoxia

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.

The problem in the circulation so it is not a requirement to have low PO2,

Causes of Stagnant hypoxia

- General slowing of the circulation, as in heart failure and shock.
- Local slowing e.g: vasoconstriction, cold, arterial wall spasm.



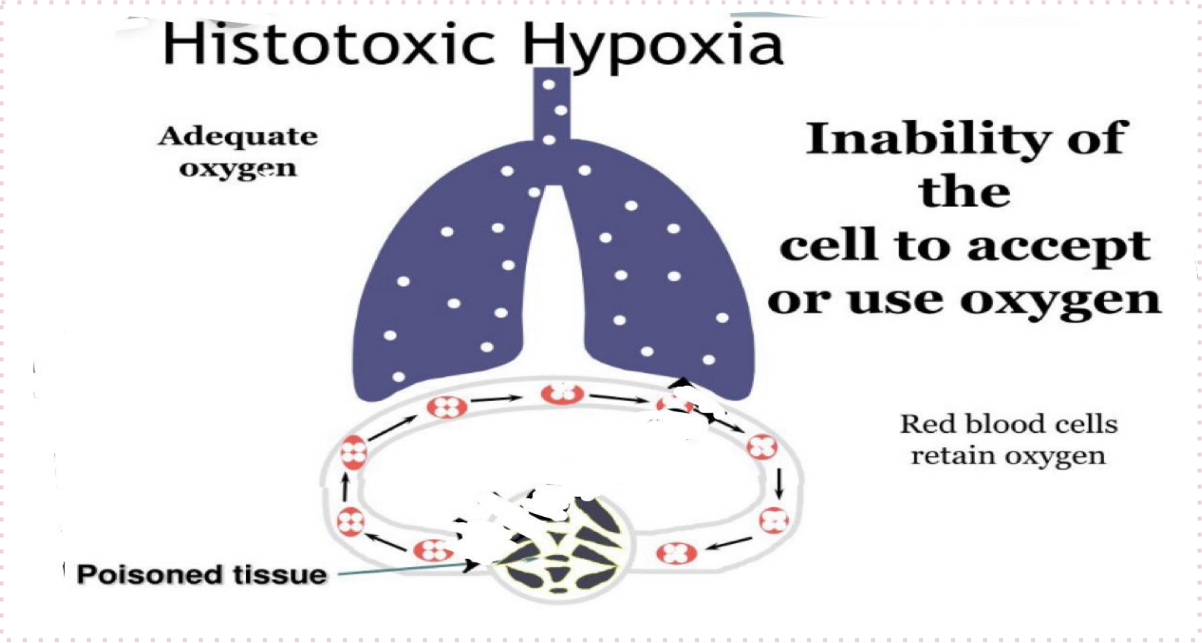
Histotoxic hypoxia

Inability of the tissues to use oxygen due to inhibition of the oxidative enzyme activity.

Here everything is normal except the tissues because it's not capable to use O2 because of toxic effect

E.g: cyanide poisoning causing **blockade of the cytochrome oxidase activity**.

يعطل الميتوكندريا ويصير لما يجيها أكسجين ما تقدر تستخدمه



Effects of hypoxia

According to the degree of hypoxia it could lead to :

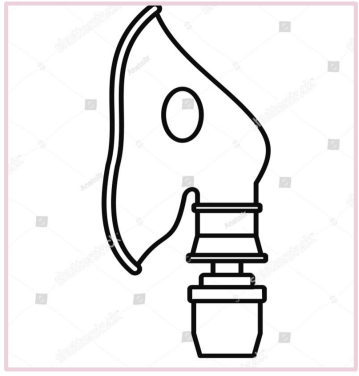
- impairment of judgment
- inability to perform complex calculations
- headache, nausea, irritability, dyspnea, increased heart rate
- reduction in muscle working capacity
- even coma and death may result.

Treatment of hypoxia

Is by giving oxygen therapy in :

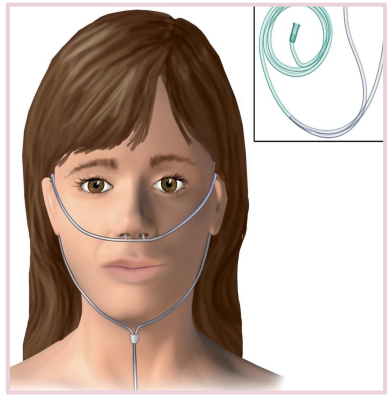
1. placing the patient's head in a tent that contains air fortified with O2

2. high oxygen tension mask by allowing the patient to breathe either pure O2 or high concentrations of O2



3. administering O2 through an intranasal tube.

"Females slides:Nasal cannula"



- This is useful in hypoxic hypoxia, but of less value in other types of hypoxia .
- Histotoxic hypoxia will not benefit from O2 therapy.

Benefits of oxygen therapy to different types of hypoxia

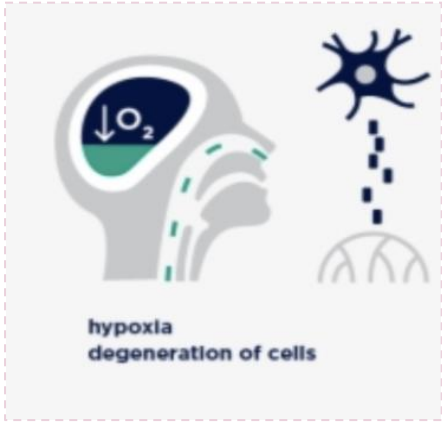
In males slides only
But
Explained by girls' Dr.

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.

Benefits of oxygen therapy for different kinds of hypoxia :
1)hypoxic or arterial hypoxia: more benefit compare to any type , if the causes is Hypoventilation or problem in Atmospheric air they will completely benefit, but if the causes is problem in perfusion or diffusion, ,mismatch , shunt, there is a benefit but the benefit either complete or not so depends on the severity.
2)stagnant hypoxia: also not that much benefit but The increase in dissolved O2 will help in there case but also we must treat the circulatory failure by support the heart , blood transfusion etc..

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:
Anemic hypoxia
O2 therapy is less effective because normal O2 is available in the alveoli but the defect is in transporting O2 to the tissues.
How they benefit? they will benefit because the dissolve O2 will increase.
The carboxyhemoglobin: we treat them by give them O2 thereby because the CO bind reversibly to Hb so if we increase the O2 concentration the CO will release From Hb

in hypoxia caused by inadequate tissue use of O2
Histotoxic hypoxia
O2 therapy has 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.
we must treat the toxicity.

hypercapnia

- Excess of CO2 in body fluids, it usually occurs with hypoxia, PCO2 increases above 52 mmHg, it decreases the PH.

- When Hypoxia is caused by too little O2 in the air, too little Hb, or poisoning of oxidative enzymes, hypercapnia isn't concomitant of these types of hypoxia. Explained by girls' Dr.

- If hypoxia caused by poor diffusion through the pulmonary membrane, hypercapnia 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 hypercapnia. Explained by girls' Dr.

- If CO2 rises from 80-100mmHg, the person becomes lethargic and semicomatose

Lethargic: relating to, or characterized by laziness or lack of energy.
semicomatose: in a state of partial coma.

Hypoxia is associated with hypercapnia when it's caused by :

In hypoxia caused by hypoventilation, CO2 transfer between the alveoli and the atmosphere is affected as much as is O2 transfer. Hypercapnia then occurs along with the hypoxia.

circulatory deficiency, diminished flow of blood decreases CO2 removal from the tissues, resulting in tissue hypercapnia in addition to tissue hypoxia.

However, the transport capacity of the blood for CO2 is more than three times that for O2, and thus the resulting tissue hypercapnia is much less than the tissue hypoxia.

بمعنى صح بيكون فيه هايبركابنيا لكن اخف من الهايبوكسيا

-Note:

Deficiency of O2 in the atmospheric air, there is no risk of developing hypocapnia

Some of the causes of hypercapnia include:

1)hypoventilation(which could be associated with hypoxia)

2)circulatory failure(which could be associated with hypoxia).

3)depression of respiratory center.

4)increase in the production of Co2; Example: an increase in the carbohydrates in someone diet, or fever "Increase one degree of body temperature will cause increase 30% of the production of CO2 ",but normally if the respiratory center is normal and we can increase the ventilation this cause will not show hypercapnia .

even though Exercise produce large amount of Co2 but it will not cause hypercapnia because you will wash up the Co2 by hyperventilation

-in mild poor diffusion hypoxia will not associated with with hypercapnia because the co2 diffuse 20 times more than O2 but if it severe both will occur.

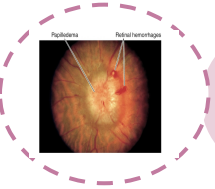
Histotoxic hypoxia will never associate with hypercapnia because it doesn't use O2 at all to produce CO2

Features of hypercapnia

Air hunger Dyspnea (A PCO2 between 60-70 mmHg)

Headache, drowsiness and semicoma (PCO2 rises to 80 to 100 mm Hg)

Sweating

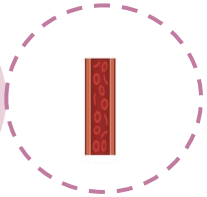


Papilledema (swelling of optic disc).

Anesthesia and death can result when the PCO2 rises to 120 to 150 mm Hg (due to depression of the respiratory center)

Muscle twitching

Peripheral vasodilatation



Warm extremities and bounding pulse

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

- **Blue** discoloration of the skin and mucous membrane due to more than 5 g/dl of **reduced** (deoxygenated) hemoglobin in the arterial blood.

Cyanosis seen in the thin places in the body

The Co2 binding to Hb normally is 23% and the hemoglobin in the body is 15 g/dl also normal
So,
15*23%=3.45g/dl of deoxygenated hemoglobin normally in our body so that why we don't show cyanosis .

- A person with anemia almost never develop cyanosis due to low amount of Hb for 5 grams to be deoxygenated /100ml blood.

the person with anemia the hemoglobin
Will be less than normal , let's say it 8
so 8*23%=1.84 g/dL of deoxygenated hemoglobin,that's why the person with anemia almost never develop cyanosis

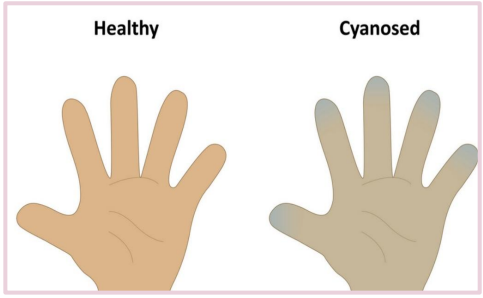
- In polycythemia, excess Hb that can become deoxygenated can cause cyanosis even under normal conditions. (explained by girls' Dr)

Polycythemia increase in RBCs content so The Hb will increase more than 15 let's say it 22
22*23%=5.06 g/dL so they will show cyanosis

(Mentioned by the females doctor)
Types of cyanosis:

1)central cyanosis : the cause that increase the deoxygenated Hb is systemic , so if I have problem in the circulation or ventilation the co2 will accumulate in the body so all of my body will be blue.(seen in nail beds and mucous membrane)

2)peripheral cyanosis : the cause that increase the deoxygenated Hb is local, if I have local vasoconstriction for any reason in my hand ,so only my hand will show cyanosis, (seen in nail beds).



Quiz

1.Which cause of hypoxia is corrected best with supplemental O2?
A. anemia
B. decreased cardiac output
C. high altitude
D. Toxicity in the tissue

2.Which of the following is not a cause of hypoxemia?

A. Alveolar hypoventilation
B. Right to left shunt
C. Diffusion abnormalities
D. Abnormal circulation

Q 3,4 and 5
A 65 years old patient suffering from pulmonary fibrosis.

3.The patient might develop which type of hypoxia?

A.stagnant hypoxia

B.anemic hypoxia

C.arterial hypoxia

D.histotoxic hypoxia

4.What happens to the A-a gradient?
(PA/Pa)

A.Decreases

B.Normal

C.Increases

D.Variable

5.Will the patient develop hypercapnia?
A.Yes
B.No

SAQs

1.Abdulsamad Jafar comes into the ER suffering with Hypoxia. His Alveolar PO_2 and Arterial PO_2 are normal. You can observe a bluish color on his extremities. Which type of Hypoxia is he most likely suffering from?

2.What are the main causes of stagnant hypoxia?

1.stagnant hypoxia

2.General slowing of circulation: Heart failure and shock
Local slowing: cold,vasoconstriction and arterial wall spasm

1.C 2.D 3.C 4.C 5.B

Physiology Respiratory Block ✔

We did it!!!

Special thanks to homoud Algadheb and Ghadah alouthman and Ibrahim altamimi For their efforts in this block.

Good luck!

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