PHYSIOLOGY TEAM 435

8

Hypoxia and Cyanosis

- Very important
- Extra information
- Terms

((إنما العلم علمان : علم الدين وعلم الدنيا. فالعلم الذي للدين هو الفقه والعلم الذي للدنيا هو **الطب**))

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Objectives

- Define hypoxia and list its various physiological and pathological causes
- Define hypo and hyper-ventilation in terms of arterial PCO2 and PO2 .
- Define cyanosis and its clinical presentation .
- Define ventilation/perfusion (V/Q) ratio and its normal values.

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Hypoxia

Definition : **Deficiency of oxygen in the tissue cells.**

It can be classified into the following groups "According to the causes":

1- Arterial hypoxia.
2- Anemic hypoxia.
3- Stagnant hypoxia.
4- histiotoxic hypoxia.

1- Hypoxic or Arterial Hypoxia

Caused by :**"Reduced arterial PO2"**

Due to :-

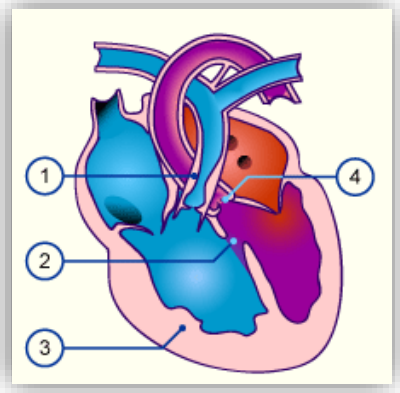
1- Alveolar hypoventilation – less breaths per min –

2- Diffusion abnormalities.–Problems in respiratory membrane-

3- Right to left shunt.

4- Ventilation-perfusion imbalance. – increased physiological dead space and physiological shunt –

Venous-to-arterial shunts ("right-to-left" cardiac shunts):
there is an opening or passage between the atria, ventricles, and/or great vessels. And, right heart pressure is higher than left heart pressure and/or the shunt has a **one-way valvular opening.**



② Right to left shunt

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Cont…

2- Anemic Hypoxia

Caused By: **Reduction in the oxygen carrying capacity of the blood.**

Due to :-

1- Anemia – Decreased amount of Hb –

2- Abnormal Hb – met Hb , carboxy Hb –

"PO2 and %Hb-O2 are Normal" →

- PO2 does not depend on The amount of Hb, "Hb-O2 form" .. It's depend on the "Dissolved form" .. That's why it's Normal.
- %Hb-O2 .. The binding between Hb and O2 is Normal.

➢ **BOYS NOTES**

- **Anemic hypoxia:** is oxygen deprivation in the tissues of the body caused by a decline in the blood's ability to carry oxygen. This can be caused by a number of factors including true anemia, where the number of red blood cells drops, making it harder for the blood to supply the body with the oxygen it needs. Patients with this condition may initially appear well, but start to develop fatigue, air hunger, and confusion as the limited oxygen supply persists and affects the brain.
- **When the iron in the heme group is in the Fe3+ (ferric) state, not the Fe2+ (ferrous) of normal hemoglobin.**
- **Carboxyhemoglobin:** that has carbon monoxide instead of the normal oxygen bound to it. Carbon monoxide has a much stronger binding to hemoglobin than oxygen.

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Cont…

3- Stagnant hypoxia

Caused By: **Reduced blood flow through the tissues.**

So 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.

Due to :-

1-General slowing of the circulation. (Heart failure and shock)

2-Local slowing of the circulation.(Vasoconstriction, Cold, Arterial wall spasm)

PO2 and Hb are normal , BUT the decreased circulation cause failure to provide adequate O2 to tissues.

Cont…

4- Histiotoxic hypoxia

Caused by : **Inability of the tissues to use oxygen.**

Due to :-

- Inhibition of the oxidative enzyme activity.

Oxidative enzyme : enzyme that catalyses oxidation reaction.

For Example:

Cyanide poisoning "تسمم الزرنيخ" causing blockade of the cytochrome oxidase activity.

Occurs when a living organism is exposed to a compound that produces cyanide ions (CN^-) when dissolved in water-

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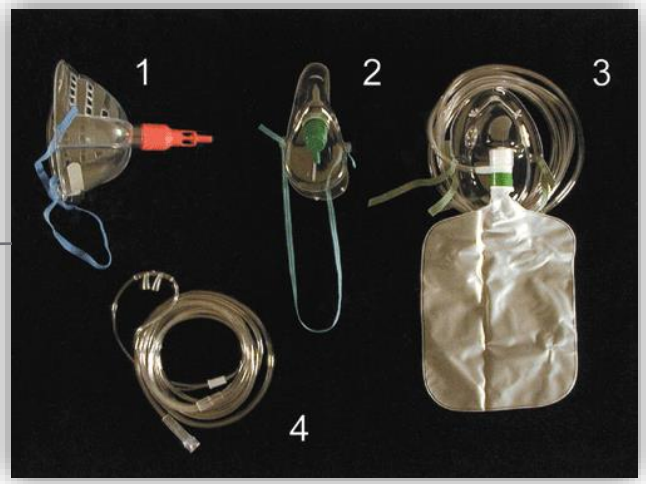
Effects of hypoxia

1. Impairment of judgment.
2. Inability to perform complex calculations.
3. Headache, nausea, irritability and dyspnea.
4. Increased heart rate.
5. Reduction in muscles working capacity.
6. Coma and death if severe.

Treatment

- By giving oxygen therapy in a tent or high oxygen tension mask.

Useful with	Less useful with	Unuseful with
Arterial hypoxia	Anemic and stagnant	Histiotoxic



Oxygen delivery devices.
1. Venturi mask. 2. Hudson mask. 3. Trauma mask. 4. Nasal cannulae.

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Hypercapnea

- Excess of CO2 in body fluids, it usually occurs with hypoxia,

PCO2 increases above 52mmhg it decreases the pH .

Features of hypercapnea :

1- Peripheral vasodilatation.

2- Sweating .

3- Warm extremities and bounding pulse.

4-Muscle twitching.

5- Headache, drowsiness and coma

6- Papilledema (swelling of optic disc)

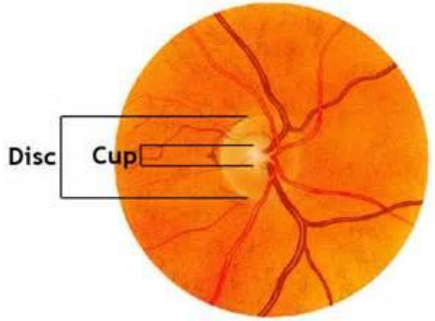
- Increase CO2 > Increase carbonic Acid > Increase H ions in Blood "Acidosis" > Leads to **Decrease PH.**

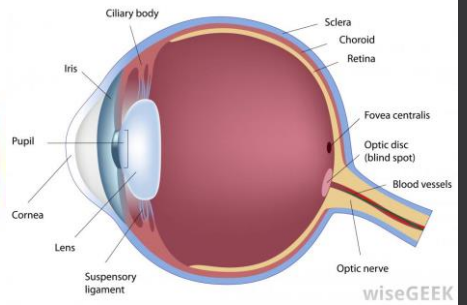
- **Bounding pulse :**

Is a medical sign characterized as a leaping and forceful pulse that quickly disappears.

- **The Optic disc:**

or optic nerve head is the point of exit for ganglion cell axons leaving the eye.





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Cyanosis

Cyanosis: Blue discoloration of the skin and mucus membrane due to more than 5 g/dl of reduced (deoxygenated) hemoglobin in blood.

A person with anemia almost never develop cyanosis.
WHY? There is not enough hemoglobin for 5 grams to be deoxygenated in 100 milliliters of arterial blood.

In warm places, Central Cyanosis.

Peripheral Cyanosis.

Ventilation-perfusion ratio (V/Q)

- It is the ratio of alveolar ventilation (amount of air getting to the alveoli) to pulmonary blood flow (amount of blood being sent to the lungs) per minute.

- **At rest:**

- The alveolar ventilation = 4.2 L/min.
- The pulmonary blood flow = right ventricular output per minute = 5 L/min. So:

V/Q ratio= 4.2/5 = 0.84 (≈ 0.8)

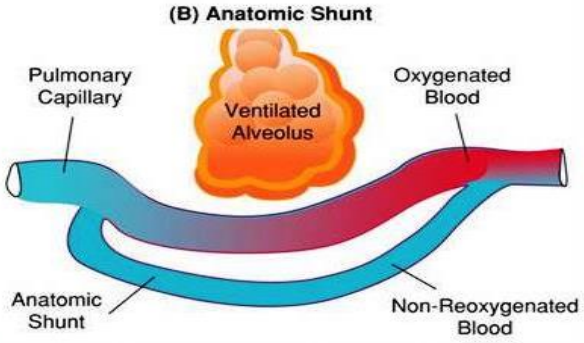
- So the average is 0.8 (which means the whole lungs have 4L of air, and 5L of blood each minute)
- **At the apex**: the ratio is 3 (this part of the lung is more ventilated and less perfused (lower blood supply) this makes the ratio greater. In another word, amount of air is high comparing to amount of blood reaching this specific area)
- **At the base:** the ratio is 0.6 (this part is less ventilated, and more perfused, so the ratio is lesser)

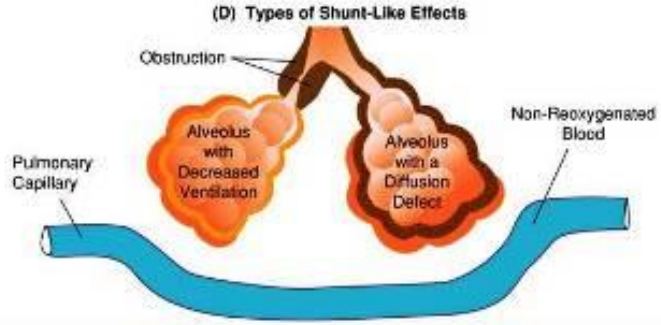
So, the apex is more ventilated than perfused, and the base is more perfused than ventilated.

During exercise, the ratio becomes more homogenous (متماثل) among different part of the lung (≈ 0.8)

Ventilation-perfusion ratio (V/Q)

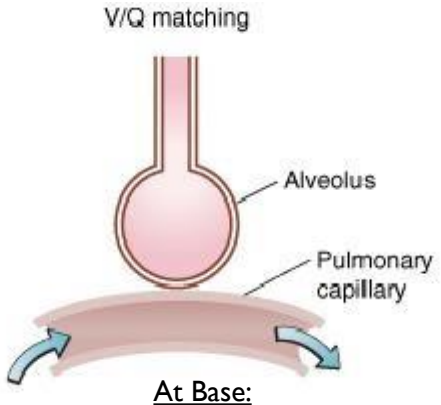
- The main function of this ratio is to determine the state of oxygenation in the body.
- Any mismatch in the ratio can result in hypoxia.
- If the V/Q ratio is less than normal (<0.8): this is called physiologic shunt. (a certain fraction of venous blood is passing through pulmonary capillaries without being oxygenated i.e. shunted blood) **EXTRA PICS:**





- If the V/Q ratio is more than normal (>0.8): this is called physiologic dead space (when the ventilation of some of the alveoli is great but the alveolar blood flow is low (hyperventilation but normal blood flow), ventilation of these alveoli is wasted)

Ventilation-perfusion ratio (V/Q)



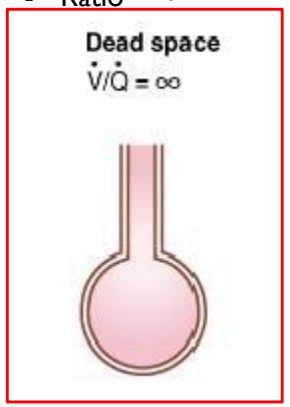
- V = Wasted
- Q = 0
- Ratio = ∞

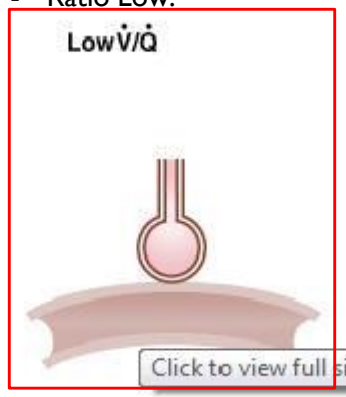
<u>At Apex :</u>

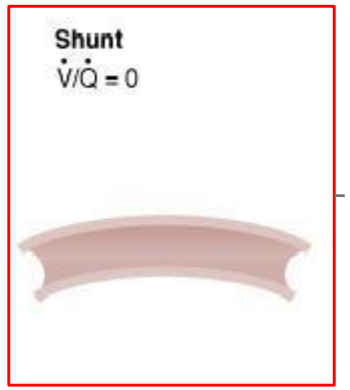
- Q Low.
- Ratio High.

<u>At Base:</u>

- Q High.
- Ratio Low.







<u>A pulmonary shunt:</u>

The blood entering the arterial system without passing through ventilated areas of lung causing the PO2 of arterial blood to be less than that of alveolar PO2.

is a physiological condition which results when the alveoli of the lungs are perfused with blood as normal, but ventilation (the supply of air) fails to supply the perfused region. In other words,

the ventilation/perfusion ratio (the ratio of air reaching the alveoli to blood perfusing them) is zero.

- A pulmonary shunt often occurs when the alveoli fill with fluid, causing parts of the lung to be unventilated although they are still perfused.

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Ventilation-perfusion ratio (V/Q) Summary

➢ BOYS NOTES

Concept of "Physiologic Shunt" (When A/ Is Below Normal)

Whenever A/ is below normal, there is inadequate ventilation to provide the oxygen needed to fully oxygenate the blood flowing through the alveolar capillaries. Therefore, a certain fraction of the venous blood passing through the pulmonary capillaries does not become oxygenated. This fraction is called shunted blood. Also, some additional blood flows through bronchial vessels rather than through alveolar capillaries, normally about 2 percent of the cardiac output; this, too, is unoxygenated, shunted blood.

Concept of "Physiologic Dead Space" (When A/ Is Greater than Normal)

When ventilation of some of the alveoli is great but alveolar blood flow is low, there is far more available oxygen in the alveoli than can be transported away from the alveoli by the flowing blood. Thus, the ventilation of these alveoli is said to be wasted. The ventilation of the anatomical dead space areas of the respiratory passageways is also wasted. The sum of these two types of wasted ventilation is called the physiologic dead space.

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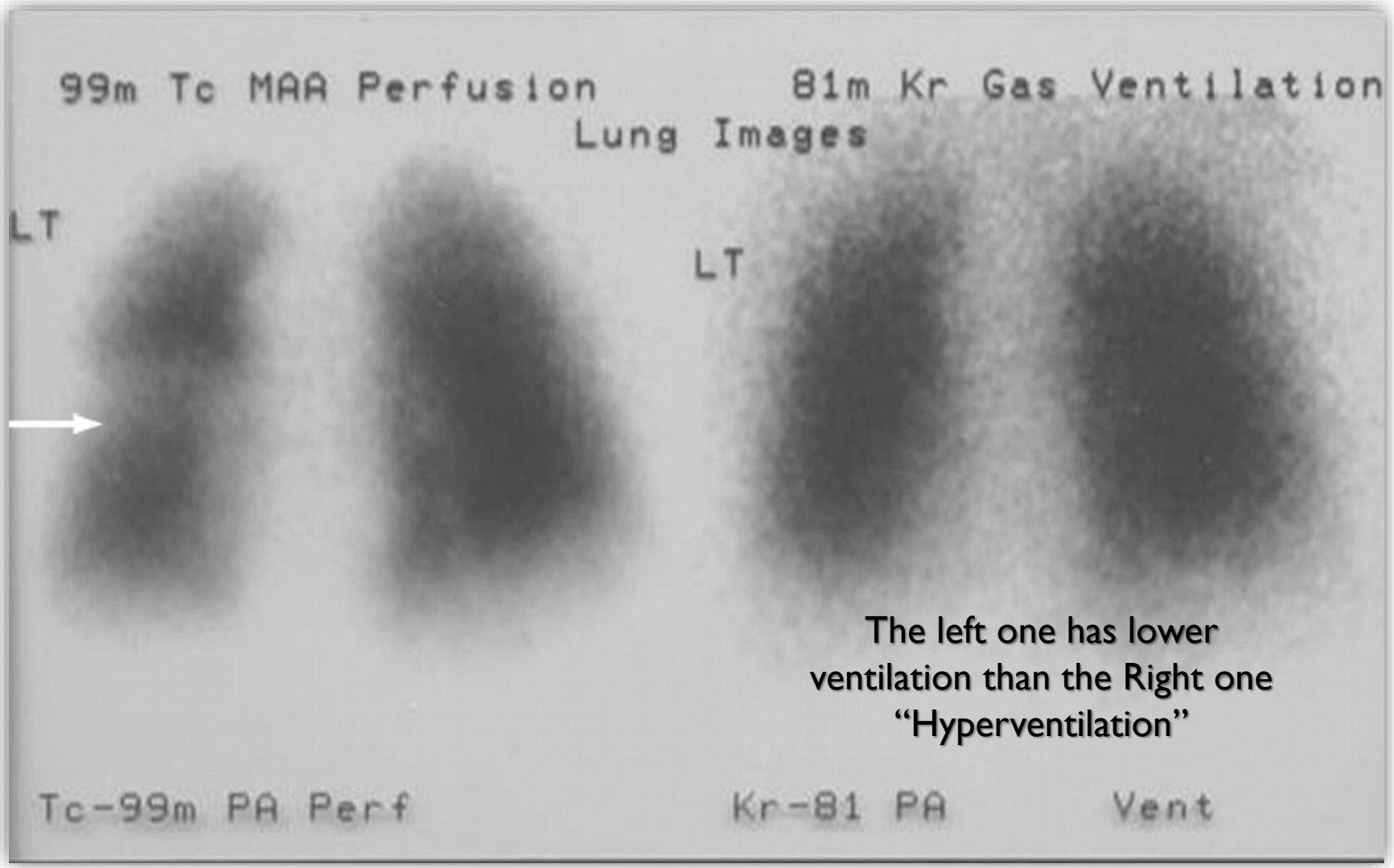
Ventilation-perfusion lung scan

White area in the image means hypoventilation



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Abnormalities of the V/Q ratio

- In the upper and lower regions of the normal lung
  Apex V/Q ratio = 3 (moderate degree of physiologic dead space)
  Base V/Q ratio = 0.6 (represent a physiologic shunt)

- **In Chronic Obstructive Lung Diseases (COPD)**

Because of bronchial obstruction in some areas and destruction of the alveolar septa in other areas with patent alveoli , those people has some areas of the lung exhibit serious physiologic shunt and other areas serious physiologic dead space. (values are changed in COPD, either greater or lesser values)

"COPD is the most prevalent cause of pulmonary disability today, lung effectiveness as a gas exchange organ may decrease"

Abnormalities of the V/Q ratio

➢ **BOYS NOTES**

Abnormalities Chronic Obstructive Lung Disease.

Most people who smoke for many years develop various degrees of bronchial obstruction; in a large share of these persons, this condition eventually becomes so severe that they develop serious alveolar air trapping and resultant emphysema.

The emphysema in turn causes many of the alveolar walls to be destroyed. Thus, two abnormalities occur in smokers to cause :

- **First,** because many of the small bronchioles are obstructed, the alveoli beyond the obstructions are unventilated, causing a A/ that approaches zero.
- **Second,** in those areas of the lung where the alveolar walls have been mainly destroyed but there is still alveolar ventilation, most of the ventilation is wasted because of inadequate blood flow to transport the blood gases. Thus, in chronic obstructive lung disease, some areas of the lung exhibit serious physiologic shunt, and other areas exhibit serious physiologic dead space.

*Both conditions tremendously decrease the effectiveness of the lungs as gas exchange organs, sometimes reducing their effectiveness to as little as one-tenth normal.

*In fact, this is the most prevalent cause of pulmonary disability today.

Quiz

https://www.onlineexambuilder.com/lec.10/exam-58740

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- Abdulrahman Albarakah
- Abdullah Aljaafar
- Adel Alshihri
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- Khalil Alduraibi
- Hassan Albeladi
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