

## **RESPIRATORY BLOCK**

**Physiology Team~ 430**

### **8<sup>th</sup> and 9<sup>th</sup> Lectures** **Alveolar-arterial Equilibration**

**Done By :**

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## For your information :

Sometime we use the term “**Alveolar-arterial gradient**” (**A-a gradient**) which is a measure of the difference between the alveolar concentration of oxygen and the arterial concentration of oxygen. Or (A-a gradient)

### ■ Used for what?

The A-a gradient is useful in determining the source of hypoxemia.

### ■ What is **hypoxemia**? ( **hypoxia** تختلف عن الـ )

Hypoxemia (or hypoxaemia) is generally defined as decreased partial pressure of oxygen in blood

Using A-a gradient diagnosing the cause of hypoxia (we will explain what hypoxia is).

## ● Hypoxia :

means **inadequate** غير كافية supply of  $O_2$  to the tissues, or inability of the cells to **utilize** الاستفادة  $O_2$  .

## ● Classified into groups:-

- Hypoxic or arterial hypoxia
- Anemic hypoxia
- Stagnant hypoxia
- Histotoxic hypoxia

- **Hypoxic or arterial hypoxia :**

**Reduced** oxygenation of blood in the lungs → **reduced** arterial oxygen  $PO_2$ .

- **It can occur in the following conditions:**

- Pulmonary edema
- Obstruction in the respiratory passages  
(أي عائق يمنع الممرات التنفسية من أخذ كمية كافية من الأوكسجين)
- Emphysema

(كما تعلمون ان Hb يحمل الـ  $O_2$  ، و أن هناك كمية من الهيموجلوبين سوف تتحول الى الهيموجلوبين المؤكسج Oxy-Hb في الدم ، لكن هذا النوع كمية قليلة من الـ Hb سوف يتحول، اذا الدم يوصل الى الانسجة حاملا معه كمية قليلة من الاوكسجين )

- **Causes of hypoxic :**

- Alveolar hypoventilation
- Diffusion abnormalities
- Right to left shunt
- Ventilation-perfusion imbalance

**Atmosphere**  
(Regions on the Earth's surface (or in its atmosphere) that are high above mean sea level)

طبقة أو غلاف من اغلفة الكرة الأرضية

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- 1- **Alveolar hypoventilation :**

For example:

- **Deficiency** of  $O_2$  in the atmosphere (**high altitude**)
- **Neuromuscular** disorders → paralysis of respiratory muscles
- **Bronchospasm** (constriction of the muscles in the walls of the bronchioles)
- ↓lung **compliance** الرئتين تقل في المطاوعة فيقل معدل التنفس فتقل كمية الاكسجين
- ↑airway **resistance**
- **Depressed** Respiratory Center

The **respiratory center (RC)** is located in the lowermost part of the brain stem. The RC receives controlling signals, and controls the respiratory movements of the respiratory muscles

## 2- Diffusion abnormalities:

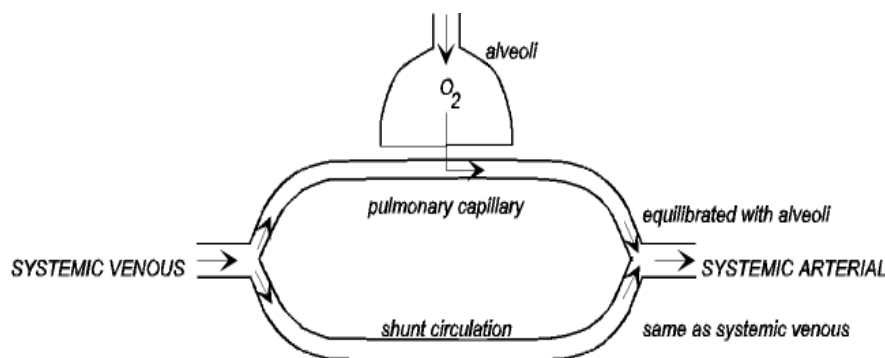
alveolar-capillary block (**improper or weak diffusion in the blood-gas barrier**)

## 3- Right to left shunt :

Right-to-left shunt is systemic venous blood that does not exchange with alveolar gas

Only **right-to-left shunts** cause hypoxia (but left-to-right shunts reduce systemic perfusion and increase cardiac work)

### “Venous-to-arterial shunts”



#### Note that:

The shunt will not be cancelled, while in other types  $PO_2$  in the arterial system will improve.

ولهذا سمينا النوع هذا من الهايپوكسيا بالـ **arterial hypoxia**

#### 4- Ventilation-perfusion imbalance :

علاقة التنفس بتدفق الدم ، يحدث فيها خلل نتيجة مرض.

(Including increased physiological dead space and physiological shunt).

May be caused by:

- Uneven **ventilation** (obstructive lung disease)
- Uneven **perfusion** (consolidation أو تماسك of the lung)

In general :

Arterial blood-gas composition is determined by **ventilation**, **pulmonary blood flow**, and by how ventilation is **matched** to blood flow in the lungs.

In healthy adults there are regional differences in both ventilation and blood flow in the lungs and the distribution of blood flow tends to parallel that of ventilation.

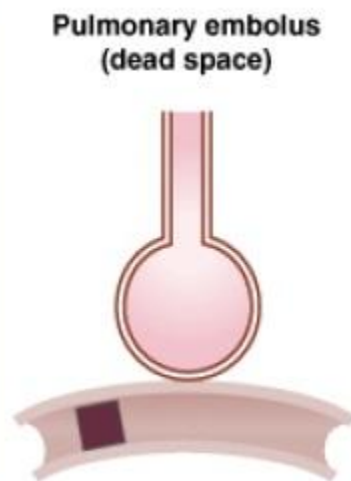
Ventilation and blood flow can become **mismatched** in a variety of disease processes that affect the lungs. Mismatching of ventilation and perfusion causes decreased  $PaO_2$ , may change  $Paco_2$ , and increases  $AaDO_2$  difference

**$PaO_2$** : partial pressure of oxygen in the blood.

**$Paco_2$** : partial pressure of carbon dioxide in the blood.

**$AaDO_2$** : alveolar-arterial oxygen tension difference

$\dot{V}/\dot{Q}$	$\infty$
$PAO_2$	150
$PACO_2$	0
$paO_2$	-
$Paco_2$	-

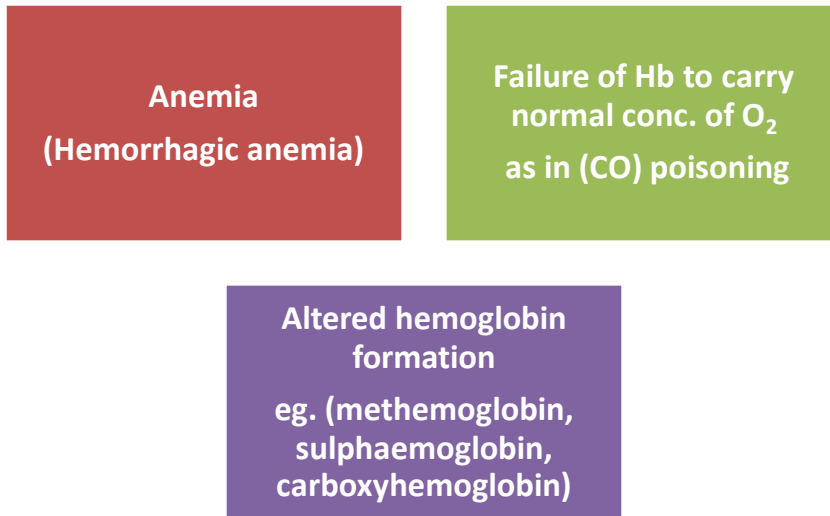


- **Anemic hypoxia :**

It is caused by **reduction in the oxygen carrying** capacity of the blood, due to **reduced Hb**, which is unable to carry oxygen . The PO<sub>2</sub> of oxygen and % Hb-O<sub>2</sub> is normal.

كما تعلمون أن الهيموجلوبين يحمل  
الأوكسجين وينقله للأنسجة ، وفي  
مرض الأنيميا يقل إنتاج الهيموجلوبين  
، إذا يقل معدل الأوكسجين في الأنسجة  
والدم

- **Causes of Anemic hypoxia :**



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- **Stagnant hypoxia : (Hypokinetic or Ischemic hypoxia)**

**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

- **Causes of Stagnant hypoxia :**

- **General slowing** of the circulation, as in heart failure and shock.
- **Local slowing** e.g. vasoconstriction, cold, arterial wall spasm .  
Or arteriosclerosis (a stiffening of arteries)

- **Histotoxic hypoxia:**

inability of the tissues to use oxygen – بالرغم من وجود كمية كافية من الأوكسجين

- **Causes of Histotoxic hypoxia**

Inhibition of the oxidative enzyme activity.

**The best example is:**

Cyanide poisoning causing blockade of the cytochrome oxidase activity.  
Or vitamin deficiency.

**More explanation:**

This is caused by inhibition of the tissue respiration electron transport chain

An **oxidative enzyme** is an enzyme that catalyses oxidation reaction.

**Cytochrome oxidase**

It is the last enzyme in the respiratory electron transport chain of mitochondria located in the mitochondrial membrane.

## • Effects of hypoxia :

According to the degree of hypoxia it could lead to :

- Impairment of judgment ⚠
- Inability to perform complex calculations ⚠
- Headache
- Nausea and Irritability
- Dyspnea
- Cyanosis (Deoxy-Hb) (لون الجلد و الدم مزرق)
- Tachypnea (سرعة في التنفس)
- Tachycardia
- Euphoria (النشوة)
- Reduction in muscle working capacity
- Even coma and death may result

⚠  
ضعف القدرة العقلية بسبب نقص  
الأكسجين في الدماغ حيث يؤدي نقص  
الأكسجين إلى اعتلال الخلايا العصبية و  
تلف الأغشية

## • Treatment of hypoxia :

- Oxygen therapy in a tent or high oxygen tension mask.
- Cardiovascular restoration
- Preventing pneumonia

**انتبه!!** Oxygen therapy in a tent or high oxygen tension mask

(This is **useful in hypoxic hypoxia**, but of less value in the other types of hypoxia, the least to benefit is histotoxic hypoxia because of the **damage of the oxidative enzymes** in the cells)

But prolonged breathing of 100% O<sub>2</sub> at 1 atmosphere may be harmful like:  
**Bronchopneumonia** and **decreased** blood flow to the brain.

In new born babies damage to the retina [Blindness] can occur with O<sub>2</sub> concentration over 40%.

Increased levels of O<sub>2</sub> free radicals [O<sub>2</sub>-] leads to Brain dysfunctions.



- **Cyanosis :**

- blue discoloration of the skin and mucus membrane when arterial blood contains more than 5 g/dl of deoxygenated hemoglobin in each 100ml of blood
- A person with anemia almost never develop cyanosis due to low amount of Hb for 5 grams to be deoxygenated /100ml blood.

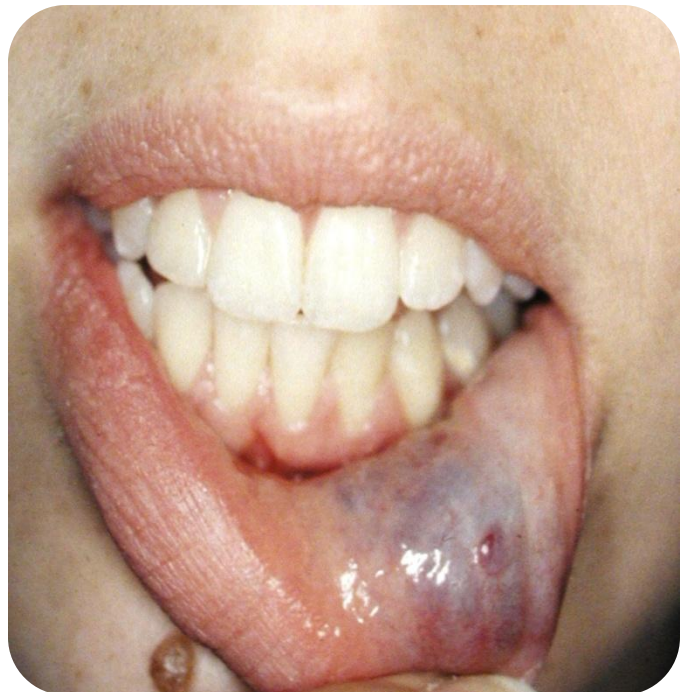
**For your information :**

- **Cyanosis is divided in to two main types:**

**1- Central :** Occur in the lips and tongue

**2- Peripheral :** Occur in the fingers, including underneath the fingernails

There is a common causes between the two types , And also each type has its own reasons



- **Hypercapnea (Hypercapnia) :**

excess of CO<sub>2</sub> in body fluids, it usually **occurs with hypoxia**, P<sub>CO<sub>2</sub></sub> increases above 52 mmHg, it decreases the PH

**For your information :**

**-- Hypercapnia occurs with two types of hypoxia :**

**1) Hypoxia caused by hypoventilation :** In hypoventilation, CO<sub>2</sub> and O<sub>2</sub> transfer between the alveoli and the atmosphere is affected . therefore , Hypercapnia occurs along with Hypoxia .

**2) Hypoxia caused by circulatory deficiency :** Diminished flow of blood decreases co2 removal tissue , resulting in tissue Hypercapnia in addition to tissue hypoxia .

**-- Hypercapnia is not concomitant of other types of hypoxia**  
( likes : little oxygen and little Hemoglobin )

- **Features of hypercapnea :**

- Peripheral vasodilatation
- Sweating
- Warm extremities and bounding pulse
- Muscle twitching
- Headache, drowsiness and com
- Papilledema ( swelling of optic disc)

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- Ventilation –perfusion ratio (V/Q) :**

- It is the ratio of alveolar ventilation to pulmonary blood flow per minute.
- The alveolar ventilation at rest ( 4.2 L/min)
- The pulmonary blood flow is equal to right ventricular ( 5L/min) output per minute

$$\text{The } \dot{V}/\dot{Q} \text{ ratio} = \frac{4.2}{5} = 0.84$$

Alveolar ventilation= respiratory rate x ( tidal volume-dead space air)

$\dot{V}/\dot{Q}$ DISTRIBUTION IN THE LUNG					
	Blood Flow ( $\dot{Q}$ )	Alveolar Ventilation ( $\dot{V}$ )	$\frac{\dot{V}}{\dot{Q}}$	PaO <sub>2</sub>	Paco <sub>2</sub>
Apex					
Zone 1	Lowest	Lower	Highest (3.0)	Highest (130 mm Hg)	Lower (28 mm Hg)
Zone 2	–	–	–	–	–
Zone 3	Highest	Higher	Lowest (0.6)	Lowest (89 mm Hg)	Higher (42 mm Hg)
Base					

- Blood Flow , Alveolar ventilation and Pa co2 are high in the Base
- (V/Q) and PaO<sub>2</sub> are high in the Apex

- Average V/Q ratio across the lung is 0.8
- At the apex V/Q ratio=3
- At the base V/Q ratio=0.6
- So, the apex is more ventilated than perfused and
- The base is more perfused than ventilated.
- During exercise, the V/Q ratio becomes more homogenous among different parts of the lung

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- **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.

-- When the V/Q ratio is less than normal this is called physiologic shunt (a certain fraction of the venous blood is passing through the pulmonary capillaries without being oxygenated i.e. shunted blood ).

-- When V/Q ratio is more than normal this is called Physiologic dead space (when the ventilation of some of the alveoli is great but the alveolar blood flow is low , ventilation of these alveoli is wasted).

## V/Q mismatch

### $\dot{V}/\dot{Q}$ DEFECTS

Normal

Airway obstruction (shunt)

Pulmonary embolus (dead space)

$\dot{V}/\dot{Q}$

0.8

0

$\infty$

$PAO_2$

100

—

150

$PACO_2$

40

—

0

$PaO_2$

100

40

—

$PaCO_2$

40

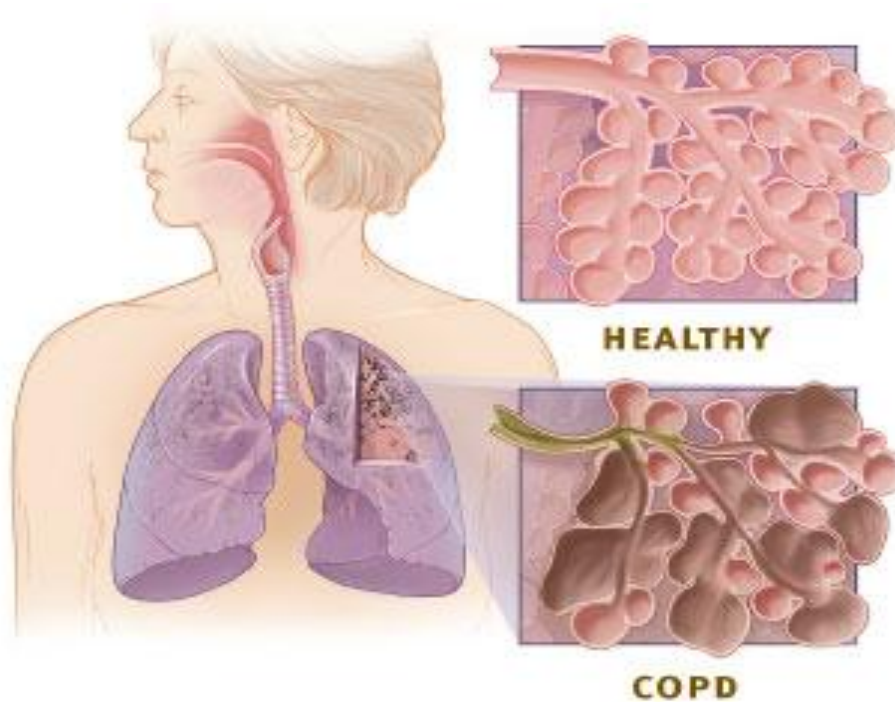
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- **Abnormalities of the V/Q ratio :**

- **In Chronic Obstructive Lung disease COPD :**

- Because of bronchial obstruction in some areas and because of destruction of the alveolar septa in other areas with patent alveoli those people with COPD has some areas of the lung exhibit serious physiologic shunt and other areas serious physiologic dead space.
  - COPD is the most prevalent cause of pulmonary disability today, lung effectiveness as a gas exchange organ may decrease to 10%



**Good Luck**