RESPIRATORY BLOCK

Physiology Team~ 430

6th Lecture

O_2 and Co_2 transport

Done By :

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• O_2 and Co_2 transport :

-- O_2 is mostly transported in blood bound to hemoglobin .. known as (oxyhemoglobin)
-- Co_2 is mostly transported in the blood as HCO3-

- IF the Po_2 increase the O_2 bind to Hb
- IF the Po_2 decrease the Hb release the O_2

Concept	Definition
O_2content	Amount of O_2 in ml per 100ml of blood, when blood is fully saturated with O_2 then its content is 20 ml, but when the blood is only saturated with 97% O_2 content is 19.4 ml
O_2 binding capacity	The maximum amount of O_2 bounded to Hb in 100ml of blood, it is measured by percent.

• Function of hemoglobin to transport oxygen in arterial blood :

- Oxygen content (20 ml O_2 /dl blood) each ml of Hb carry 1.34 ml O_2 (15 x 1.34=20)
- but when the blood is only 97% saturated with O_2 each 100 ml blood contain 19.4 ml O_2).

تركيز الاكسجين في الدم (الذي يرتبط بالهيموجلوبين) لا يصل إلى ١٠٠بل يكون ٩٧ وهذا التركيز أعلى ما يمكن وذلك لان الـ ٣ المتبقية من الاكسجين تذوب في البلازما

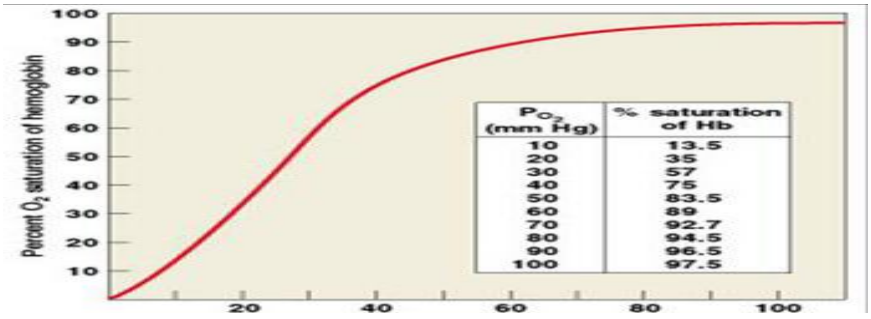
- Amount of oxygen released from the hemoglobin in the tissues (5ml O_2) is given to the tissues per each 100ml blood (19.4-5= 14.4 ml).

• Transport of oxygen during strenuous exercise:

- The oxygen uptake by the tissue increases 3 folds,
  So 15 ml O_2 is given /100 ml blood (19.4-15=4.4 ml O_2 /100ml blood).
- Tissues consume 250 ml O_2 /min at rest and produce 200ml CO_2

• Important notes :

1-the relation between PO_2 and Hb-O_2 is not linear. The curve is S-shaped or sigmoid



2- the presence of one molecule of oxygen on one hemegroup increases the affinity of the other oxygen binding sites to O_2.

عندما يرتبط جزئ اوكسجين بالهيموقلوبين يشجع جزئ الاكسجين الأخر بان يرتبط بالهيموقلوبين

Q : What is P50 ?

Is the PO_2 at which 50% of Hb is saturated with O_2 , normally P50:26.5

Q : But what if P50 showed decrease or increase in its value?

Abnormal values of P50	What does it mean?
P50↓	**1- high affinity between O_2 and Hb.** **2- low CO_2 and low H^+.** **3- high pH < alkalosis .** **4- low temperature.** **5- low 2,3- diphosphoglycerate (DPG).** **6- low CO.** **In this case the curve will shift to left.** **Oxygen is not loaded to tissues by Hb**
P50↑	**1- low affinity between O_2 and Hb.** **2- low pH < acidosis.** **3- high CO_2, CO** **4- high H^+** **5- high 2,3 DPG.** **6- high temperature.** **In this case curve will shift to right.** **Oxygen is bounded to Hb and loaded to tissues.**

Easy way :

↓P50 : Decrease all Factors Except affinity and pH

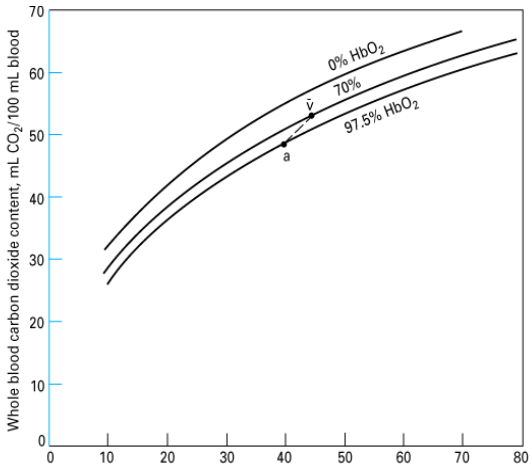
↑P50 : increase all Factors Except affinity and pH

- **Some points:-**
  - 2,3 DPG likes to bind to deoxygenated Hb, therefore it reduces O_2 binding to Hb. In healthy amounts it controls O_2 diffusion to tissue to prevent excessive O_2 uptake by tissues where in high amounts of 2,3DPG , few O_2 will diffuse to tissues leading to hypoxia or anemia.
  - fetal hemoglobin (Hb F) is made of two α chains and 2 γ chains → α2γ2
  - fetal Hb has higher affinity to O_2, it's P50=20 (the lower the number ,the higher the affinity).
  - Hb F is Facilitates O_2 movement from the mother to the fetus.
  - When the baby is first born , he has Hbf for the first 6 months then after that HbF is replaced with hemoglobin A

- **Myoglobin :**
  - it's a heme protein.
  - occurs in muscle cells.
  - consists of a single polypeptide chain attached to a heme group .
  - it can combine chemically to a single oxygen molecule
    (it is like a single subunit of the hemoglobin).

- **Carbon dioxide in blood :**
  - Normally 4 ml of CO_2 is transported from the tissues to the lungs in each 100 ml blood
  - CO combines with Hb at the same point on the Hb molecule as does oxygen,
  - CO binds with Hb about 250 times as much as O_2
  - ↑ affinity of CO to Hb than O_2 to Hb

- **The CO_2 dissociation curve:**
  1-the curve is curvi-linear
  2-there is a greater change
  in the CO_2 content per mm Hg
  in PCO_2 than the O_2 content per mm Hg in PO_2



- **Transport of carbon dioxide in the blood :**
  - **Carbon dioxide is carried in the blood by three forms :**

1- Dissolved in plasma (7%):

Therefore, only about 0.3 ml CO_2/100 ml blood is transported in the form of dissolved carbon dioxide.

2- Carbaminohemoglobin (23%):

CO_2 combines reversibly with an amino acid in hemoglobin (and to a much lesser extent other plasma proteins to form carbamino proteins).

3- Bicarbonate ions (70%):

CO_2 combines with water in RBCs to form carbonic acid (H_2CO_3)

ثم سيحصل تفكك لهذا الحمض إلى ايونات هيدروجين وايونات بايكربونيت
* ايونات البايكربونيت هي التي ستخرج من كريات الدم الحمراء لتنقل الكربون في جميع الجسم ويحل محلها ايونات كلور

Note: Only a small amount of carbon dioxide stays as dissolved CO_2 in the plasma. The bulk of the carbon dioxide diffuses into the red cell, where it forms either carbonic acid (H_2CO_3) or carbaminohemoglobin

- **The Chloride Shift :**
  - **The chloride movement from the plasma into the RBCs in exchange for HCO^-_3 is known as the chloride shift and is facilitated by the bicarbonate-chloride carrier protein (anion exchanger) in the RBC membrane.**

- **HCO^-_3 leaves the RBCs giving it a net positive charge, and this attracts chloride ions (Cl^-) which diffuses into the RBC from the plasma maintaining the electrical neutrality**

- **Formation of HCO^-_3 &Chloride shift inside RBC :**
  - **Carbaminohemoglobin is formed in RBCs from the reaction of CO_2 with free amine groups (NH_2) on the hemoglobin molecule (deoxygenated hemoglobin can bind much more CO_2 in this way than oxygenated hemoglobin).**

$$Hb + CO_2 \rightarrow Hb\text{-}CO_2 \ (carbaminoheamoglobin)$$

  - **Bicarbonate: In the RBC, the carbonic acid is formed in the following manner:**

$$CO_2 + H_2O \rightarrow H_2CO_3$$

  - **Carbonic acid dissociates in RBCs to bicarbonate (HCO_3) and H+:**

$$H_2CO_3 \rightarrow H^+ + HCO^-_3$$

  - **Haldane effect:**
    O_2 + hemoglobin :
    1-CO_2 is released
    2- hemoglobin becomes stronger acid

Good Luck