

Human Physiology

Lecture 4 – Monday 22/2/2016

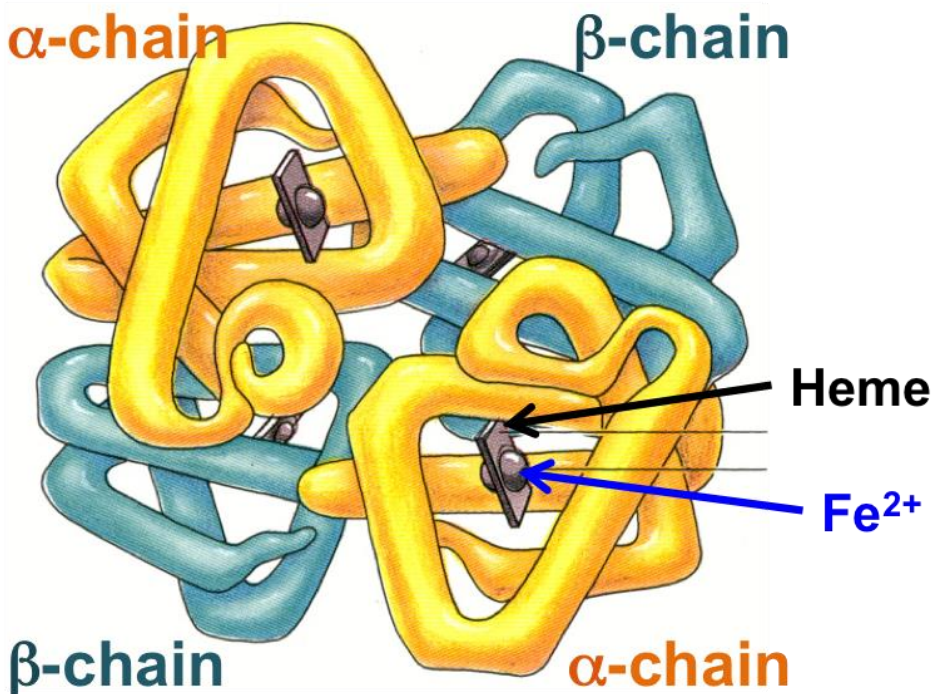
“Destruction of RBCs & Hemoglobin, and leukocytes”

with Dr. Khalid Talafih

By Haytham Otoom
PharmaGlory 15

Note: RBC= Red Blood Cell, WBC = White Blood Cell
[B] = from the book, not the lecture.

Reminder: **Hemoglobin** is made of two parts – the 4 **heme/haem** groups (the part that contains iron), and the **globin/protein** part.



- The globin part of hemoglobin is made of 4 polypeptide chains (2 alpha chains & 2 beta chains).

Each alpha chain is made of 141 amino acids and each beta chain is made of 146 amino acids.

Each chain has an iron atom attached to it, making each hemoglobin molecule = 4 iron atoms.

This describes the structure of normal hemoglobin, or “Hemoglobin A” (HbA).

When the sequence of amino acids in the polypeptide chains is changed, abnormal hemoglobin is formed.

Iron is very important in our body, as iron binds to O₂ in order to transport it in the blood.

- Iron is absorbed in the **duodenum** by complex processes.
Only 10% of the iron is absorbed in our body.
- Iron is important for the formation of:
 - Hemoglobin & Myoglobin.
Myoglobin is similar to hemoglobin but is found in our muscles.
 - Cytochromes (electron carriers in cell respiration)
 - Enzymes like catalase & peroxidase.
- The average human body contains 4 grams of Iron, and of these 4 grams:
 - 65-70% is located in Hemoglobin.
 - 15-30% is stored in the liver as **Ferritin**.
 - 4% in Myoglobin
 - 1% in other heme components & 0.1% as proteins
- Iron that is absorbed in the duodenum (only 10%) goes to the plasma as **transferrin**.
Then after it is absorbed, it will first be used to form Hemoglobin (then the formation of RBCs).
Iron that is not used, is stored in the **liver, spleen, bone marrow and muscles**.
- After 120 days, RBCs are destructed. This means that Hemoglobin is also destroyed. Which means we have continuous cycle for the need of Iron.

تدمير كريات الدم الحمراء يعني تدمير الهيموقلوبين، و هذا يحصل كل ١٢٠ يوم مما يسبب < احتياج متواصل للحديد في الجسم

Destruction of RBCs:

- The system in our body responsible for the destruction of RBCs is called the **Reticulo-Endothelial System (RES)**, found mostly in the spleen (طحال).

- Important Note:

Not only 120-day old RBCs are destroyed. Any RBC with a fragile membrane is destroyed by the RES.

This is because RBCs are always circulating through the body. Their diameter is about $8\mu\text{m}$. RBCs enter small blood vessels (like the ones in the brain, eyes, liver, and kidneys). These small blood vessels have a diameter less than the diameter of the RBC ($8\mu\text{m}$).

This causes a change in the membrane of the RBC. Healthy RBCs have a smooth membrane... however, any RBC with a fragile membrane is destroyed by the RES.

تدمير كريات الدم الحمراء لا يعتمد على عمر الخلية فقط. الخلايا المتخصصة في الطحال تدمر < أي خلية بغشاء ضعيف. أغشية كريات الدم الحمراء تضعف بسبب دخولها أوعية دموية صغيرة (أصغر من حجم كريات الدم، و هذا يجبر الخلية على التغيير في الغشاء) >

What happens to the components of the RBC/Hemoglobin?

- The proteins of the RBCs & Hemoglobin are broken down into amino acids, and these amino acids are stored in the general amino acid pool (مخزن الاحماض الامينية) of the body.
- The iron from the heme group is removed and stored in the body as **Ferritin**.

So the amino acids & iron of Hemoglobin are stored and can be re-used later to make other Hemoglobin molecules.

- The rest of the heme/haem molecule is converted into a yellow pigment called **Bilirubin** & a green pigment called **Biliverdin**.

Bilirubin and Biliverdin are waste products, and must be removed from our bodies.

An increase in the amount of Bilirubin in the blood causes damage to the brain.

- Almost all of the waste products in our body are removed by the kidneys, except Bilirubin (only a very small amount of Bilirubin is removed by the kidneys, and this small amount is what causes the yellow color of our urine).
- The process of removing Bilirubin from our body:
 - (1) Bilirubin passes through the blood to the liver.
 - (2) From the liver cells, to the bile duct.
 - (3) They then enter the duodenum, then they go to the GIT system (small and large intestine) and then they leave the body as feces.
- Any blockage of the Bilirubin pathway in our body (especially in the bile duct) causes an accumulation of Bilirubin in the blood. This accumulation of Bilirubin raises the Bilirubin level in the blood, which causes the color of the blood to turn yellow. This is known as **Jaundice**. There are many factors that contribute to Jaundice:
 - (1) Stones in the bile duct (القناة الصفراء)
 - (2) Cancer
 - (3) Overload/too much destruction of RBCs.
 - (4) Other diseases like Malaria

Jaundice is normal in new born babies, as the RBC count for them is high. This causes a lot of destruction in RBCs & contributes to Jaundice.

What happens when the hematocrit (percentage of RBCs) decreases or increases?

- **Polycythemia** is an increase in hematocrit or RBC level in the blood. Polycythemia increases the work load on the heart, and people with polycythemia frequently have headaches. The overload on the heart causes rupturing in the blood vessels.

There are two types of polycythemia...

- **Polycythemia Vera or Primary Polycythemia:** this type is caused by unknown disease in the bone marrow.
- **Secondary polycythemia** (can be treated):
 - 1) Decrease in O₂, as a result of
 - High altitudes
 - Heart diseases
 - 2) Losses of fluids (like diarrhea).
- **Anemia** is a decrease in hematocrit or RBC count.
- [B]: There are many types of anemia (Dr. Khalid said that we should know every type of anemia)
 - **Nutritional anemia** (فقر دم ناتج من التغذية): occurs when one of the factors of erythropoiesis (production of RBCs) is missing or deficient.
 - **Iron deficiency anemia** occurs when there is not enough iron available to make hemoglobin.
 - **Pernicious anemia** (فقر الدم الوبيل): occurs when the body is unable to absorb enough vitamin B12, caused by a deficiency of an intrinsic factor.
 - **Aplastic anemia** (فقر الدم اللاتنسجي): occurs when the bone marrow fails to produce enough RBCs, even when all the factors needed

are present. It can be caused by toxic chemicals (like benzene), heavy exposure to radiation (الإشعاع), or cancer.

- **Renal anemia:** occurs as a result of kidney disease (erythropoietin, the hormone responsible for RBC production, is released by the kidney)
- **Hemorrhagic anemia (فقر الدم النزفي):** occurs as a result of losing a lot of blood.
- **Hemolytic anemia (فقر الدم الانحلالي):** when too many of the RBCs are destroyed (probably by a disease like malaria).
- Anemia takes 3 or more years to recover as only 10% of iron is absorbed, making it difficult to return to the original level of iron in the body.

WBCs or leukocytes:

- They are not actually white, they are transparent (they can only be seen when they are stained).
- They have a nucleus unlike RBCs and have no hemoglobin.
- The range of WBCs is 4500 to 11000 cells, with an average of 7000 cells
- Their major function is combat inflammation and destroy any toxic agents (like viruses or bacteria) that enter our body.

There are 5 types of leukocytes (the percentages are very important):

- Neutrophils (60-70%, with range of 3000-6000)
- Eosinophils (2-4%, with range of 150-300)
- Basophils (0.5-1%, with range of 0-100)
- Lymphocytes (20-25%, with range of 1500-3500)
- Monocytes (3-8%, with range of 300-600)

Note: The information here is from the lecture, slides, and the book (pages 321 to 322).