Physiology 4

From the previous lecture we have to remember that:

1) **MCV**: gives us an idea about the **size** of RBCs (normocytic or macrocytic or microcytic).
2) **MHC**: gives us an idea about **the amount of Hb in 1 RBC**.
3) **MCHC**: gives us an idea about the **amount of Hb in RBCs** (normal – normochromic – or abnormal –hypo or hyper chromic –).

4) The normal **RANGE** for each parameter :

MCV : (80-90) fL , MCH : (28-32) pg , MCHC : (32-36) g/dl .

**** Describe these cells: ****

Ex .1

MCV = 91 normocytic
MCH = 31
MCHC = 34 normochromic

> MCV is normal if its value within the range or a little bit above or below normal. **This is only** for MCV. MCHC has to be exactly in the range to be normal.

Ex .2

MCV = 67 microcytic
MCH = 22
MCHC = 33 normochromic

Ex .3

MCV = 67 microcytic
MCH = 20
MCHC = 30 hypochromic

Ex .4

MCV = 113 macrocytic
MCH = 38
MCHC = 33 normochromic

Ex .5

MCV = 90 normocytic
MCH = 26
MCHC = 29 hypoochromic

In general:

- ✓ Normally, we have 4*10^6 RBCs in female and 5*10^6 RBCs in male.
- ✓ Low count of RBCs: Anemia or Erythrocytopenia .
- ✓ High count of RBCs: erthrocytosis or polycythemia.

Anemia / Erythrocytopenia

- **Anemia:** group of disorders characterizes by quantitative or qualitative deficiency of the circulating RBCs.

Notice that: sometimes anemic pt has normal count of RBCs but with low Hb content.

- **What are the general causes of anemia?**

1) Deficiency in the production of RBCs.
2) Excessive loss.
3) Excessive destruction.

- **Classification of anemia** : (2 types, the doc said that we will take more in pathology)

1. Morphological :

Type:	**Problem:**
Normocytic Normochromic	Size and content normal, low count of RBCs
Normocytic Hypochromic	The size is normal but the content of Hb is low
Microcytic Hypochromic	The cells are small with low content of Hb
Macrocytic	Large cells with low count e.g. pernicious anemia
Microspherocytic	Abnormality in the shape (most probably there is hemolysis)

2. Etiological :

i. Increased blood loss :
   a. Hemorrhage.
   b. Hemolysis.

ii. Decreased blood production :
   a. Nutritional.
   b. Bone marrow failure.

- **The Effect of anemia on the body**

Blood viscosity in an anemic patient ***may fall*** to as low as (1.5) times the viscosity of water (because low count of RBCs), while it's normally 3 times that of water .As a result ***the resistance*** to blood flow in the peripheral blood vessels decreases, so blood flows easily, increasing the amount of blood returning to the heart and consequently increasing ***the workload on the heart***.

Remember: *viscosity* is maintained by RBCs count and plasma protein (mainly fibrinogen).

Notes:

- ✓ Heart rate increases usually in anemic patient because of the high amount of blood returning to the heart which increases the workload on the heart.
- ✓ So anemic patients have to avoid heavy exercises because they might have cardiac failure (because almost all of the oxygen is being utilized).

Erythrocytosis / polycythemia

An increase in the concentration of RBCs in the circulation. Usually, when we say erythrocytosis we mean physiological condition **while** in Polycythemia we may be referring to blood cancer.

- **Classification** :

1. **relative erythrocytosis :**

In dehydration (increased Hct with plasma loss).

2. **True erythrocytosis :**

**With high erythropoietin:*

a. hypoxia such as being at high altitude
b. drugs : cobalt

**With low or normal erythropoietin*: this is a cancerous case such as Polycythemia Vera.

- **The effects of erythrocytosis/polycythemia on the body**

A. ***Viscosity increases*** (more than 3X water viscosity), ***increasing the resistance***. The blood flow through the peripheral blood vessels is often ***very sluggish***. Increasing blood viscosity decreases the rate of venous return to the heart. ***However***, the blood volume is greatly increased at the same time, and that tends to increase venous return. At the end, ***the workload on the heart is increased*** by ***increasing the blood volume.*** (while in anemia, the increase in the workload on the heart is due to viscosity and the increased heart rate)

B. ***Cyanosis:*** some pts will have blue skin because some RBCs will not be oxygenated.

Tests on RBCs

Indicate the presence of diseases in the body or abnormalities in BBCs

- **Erythrocyte sedimentation rate (ESR)**: very important & common test .

Fresh anti-coagulated blood is placed in a graduated cylinder, kept in lab conditions (normal temperature & humidity) for 1 hour, afterwards the free plasma on the top is measured (the height) which indicates the ESR.
In which RBCs precipitate without any effect (only) the time and some other factors.

Normally, free plasma distance usually reaches from (0-5 OR 1-5) mm in males and it reaches up to 15 mm in females if we're using the ***Wintrobe method***.

There are 4 methods to measure ESR (Wintrobe, Landau, Cultur & Westergen – Sedimentation Rate Tubes) vary according to:

A. Range of graduation.
B. Height of blood column.
C. Length of tube.
D. Internal diameter of tube.
E. The amount of blood.

NOTEs:

- ✓ Each method has its own normal range for men or women
- ✓ During sedimentation cells form rouleaux (similar to a cylindrical packet of coins)

*****Factors affect the ESR :*****

1. erythrocytes
2. plasma composition
3. mechanical & technical factors (errors)

1- Erythrocytes:

- ✓ Size: the larger the cells the faster the sedimentation rate.
- ✓ Shape: any alteration in the shape such as: sickle cell anemia or micro spherocytic anemia will decrease ESR because cells will NOT be able to form rouleaux easily.
- ✓ Cell count: **in Anemia** the ESR is relatively **high** but it is **normal** in **polycythemia.**

Why ESR is high in anemia?

Normally RBCs have a negative charge on their surface, so there is repulsion between cells (cells remain suspended) ***while*** in anemia the repulsion decreases leading to easily sedimentation (because of the less count).

2- Plasma composition:

Is the single most important factor determining the ESR, rouleaux of RBCs are affected mainly by the levels of plasma protein, levels of fibrinogen and globulins increase ESR.

3- Mechanical & technical factors (errors):

- ✓ Temperature: the ESR increases with large change in temperature.
- ✓ Humidity.
- ✓ Tubes should stay 100% vertical in the racks. A tilt of 3° can cause errors up to 30%.

ESR is a non-specific test (not a diagnostic test); it indicates the presence of a disease (x-disease) but doesn't specify it. So we need further investigation.

ESR increases in:

- ✓ All infections (acute or chronic)
- ✓ Connective tissue destructive diseases

ESR is high in: Rheumatoid arthritis, Tuberculosis (very high it can reach up to 50 mm) & in Acute hepatitis.

So we conclude that the age plays a role in ESR test , ESR is **low in young people** and **high in elderly** (both males and females), That's because most old people suffer from connective tissue destructive diseases.

- **Osmotic fragility test:**

✓ Indicates the presence of an abnormality in RBCs not in the whole body (in general).
✓ The numbers on the x axis indicate different NaCl concentrations in different test tubes (0.1 in the first tube, 0.8 or 0.9 in the last one).
✓ Equal drops of blood are added to each tube then they're incubated for an hour.

We notice the following:

1. **Normally**, the blood **begins** to hemolyze in the test tube **from 0.5-0.55 of NaCl concentration** and **it is completed at 0.3** (all RBC's are hemolyzed at 0.3) and this is the normal case (curve).

2. If RBCs begin to hemolyze in tubes that contain NaCl concentration **higher than 0.55**, the **osmotic fragility is increased** which means that RBCs are **fragile**, aren't intact and there is something wrong either in the medium or in the cell itself. **Occurs in**: Hemolytic anemia, Hereditary spherocytosis.

3. If RBCs begin to hemolyze at NaCl concentration **below 0.5**, the **osmotic fragility is decreased**, **such as**: in sickle cell anemia, iron deficiency anemia, thalassemia. So the problem is in the small size of RBCs (microcytic) & their shape, the surface area exposed to NaCl is decreased.

4. The main factors which affect the osmotic fragility test are: the shape of RBCs, which in turn is dependent on the volume, surface area, and the functional state of the RBCs.

The cause of abnormal osmotic fragility tests can be:

A. **Corpuscular**: (genetic)
✓ G6PD deficiency.
✓ Pyruvate kinase deficiency.

B. **Extra corpuscular**: such as in
✓ ABO incompatibility.
✓ Some drugs sometimes cause hemolysis, such as Penicillin,
✓ Diseases.

Please refer to the slides
SORRY for any MISTAKE …..