Hematology

Medical Committee
The University of Jorda

- Histology
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- lecture number : 4
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RBCs' TESTS AND LEUKOCYTES

✓ NOTE : I rearranged some pieces of information and added some for explanation , so don't be confused if you are listening to the record .

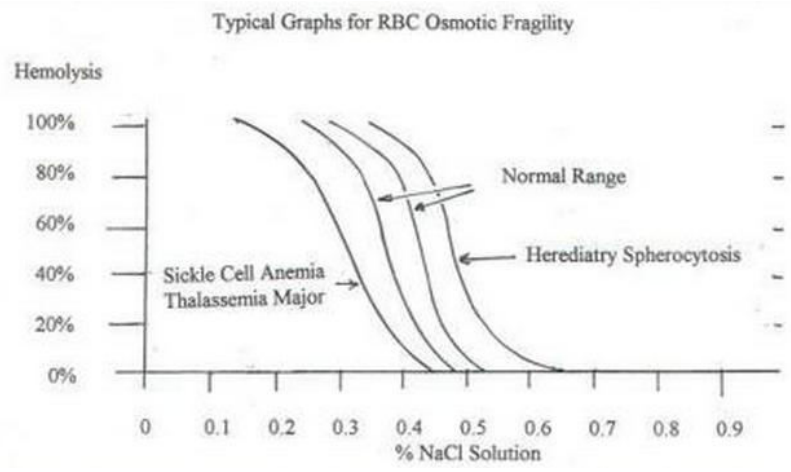
✓ Tests on the RBCs:

1 >> ESR (Erythrocyte Sedimentation Rate)

ESR indicates a presence of a disease, it's high in some diseases and low in others, but it doesn't indicate a specific disease.

2 >>Osmotic fragility test:

- This test is used to help in diagnosing different types of anemia, in which the physical properties of RBCs are changed.
- On the X – axis of the curve, the numbers (0.1-0.8) indicate different concentrations of NaCl.
  So we have tubes containing different concentrations of NaCl , then we add equal drops of blood to them and see what happened .
  NOTE: 0.9 NaCl conc. Is considered isotonic solution.



- So what we do actually is measuring the proportion of hemolysis in different hypotonic solutions.

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- To draw the curve , we measured the % of hemolysis in the tubes.
- normally, the RBCs begins to hemolyze either at 0.5 or 0.55 Nacl conc. and almost all cell become hemolyzed at 2.3.
- If RBCs begin to hemolyze in tubes with Nacl conc higher than 0.55 >>> the osmotic fragility test is **increased** . This happens in cases of : **hemolytic anemia and hereditary spherocytosis .**
- If the hemolysis begins at Nacl conc less than 0.5 >>> the osmotic fragility test is **decreased**. This happens in cases of : **sickle cell anemia , iron deficiency anemia, Thalassemia**
- The main factor which affects the Osmotic fragility test is : The shape of the RBCs , which in turn is dependent on : the volume , surface area and the functional state of the cells .
- The cause of abnormalities in hemolytic cells could be either in the cell itself such as deficiency of enzymes (like G6PD deficiency) , or some elements in the blood as in blood groups incompatibility , some drugs , and some infections like malaria .

** There are many other tests , but we talked about the most important two .

✓ Leukocytes (WBCs)

_ As we know , the normal range of WBCs is 4.000 – 11.000 cells/ µL . if the number exceeds 11.000 >>> Leukocytosis.

and if it is lower than 4.000 >>> Lukocytopenia .

_ Unlike the RBCs , there is no difference between males and females in the # of WBCs . But even in the same individual , the WBCs count changes from time to time , such as :

* it reaches its maximum in the evening , and the minimum in the morning .

Also , WBCs increase after having a meal , doing exercises and in pregnancy .

_ WBCs are 5 types , the usual (old) classification of the them is :

1) **Granulocytes** : Neutrophils , basophiles and eosinophils .

2) **Agranulocytes** : Lymphocytes and Monocytes.

NOTE : we said this classification is old because they found that there are some granules in the monocytes . Now we say : granulocytes , lymphocytes and monocytes .

_ WBCs contain nucleus , mitochondria and some other organelles .

_ Half life of WBCs differs depending on the type of the cell , ranging from hours in neutrophils (if they are intravascular) to days – months and sometimes years in monocytes . Also , the duration of action in the circulation is different from one cell to another.

_ All WBCs are produced from the bone marrow, "except for a type of lymphocytes which have another site of origin which is the lymphoid tissue". The doctor repeated this sentence twice; maybe he meant T-lymphocytes which become immunocompetent outside the bone marrow, in the thymus which is composed of lymphatic tissue.

_**75%** of the cells in the bone marrow belong to the WBCs and 25% to the RBCs although the number of RBCs in the body is much more than WBCs. The doctor said that this most probably due to the short half-life of WBCs.

_ As we took before , the RBCs are circulating and functioning in the circulation and don't leave it , however , the WBCs use the circulation as a vehicle to reach the tissues (ex : to the site of infection) .

_ The measured count of WBC is 50% of the actual number of WBCs because the other 50% of WBC are adhering to the inner walls of blood vessels and this

adhered part is called **Marginal pool ,** these cells are released in some conditions such as in hemorrhage (mainly) and hemolysis .

Usually , neutrophils have higher count than the others , but in rare cases the lymphocytes might have a count equal to that of neutrophils or even more !

_ The % of the different types from the total WBCs (Differential leukocyte count) and the main characteristic feature of each of them under the microscope :

1) **Neutrophils** : **60%** ,the main feature >> **lobes of the nucleus** (3-5)

2) **Eosinophils** : **4%** , the main feature >> **orange color** (in normal stain)

3) **Basophils** : less than **1%** , the main feature >> **the nucleus is covered** by the large granules

4) **Lymphocytes** : **30%** , the main feature >> **large nucleus** that occupies most of the cytoplasm , and if there is a small apparent part of the cytoplasm , it appears blue.

5) **Monocytes**: **5%** , the main feature >> **gray color** of the cytoplasm , and sometimes the horse -shoe shaped nucleus .

__ All WBCs are increased in infections (bacterial, viral …) , but there are some specializations :

1) **Neutrophils** increase mainly in **bacterial** infections.

2) **Lymphocytes** increase mainly in **viral** infections.

3) **Monocytes** increase mainly in **parasitic** infections.

4) **Eosinophils** increase during **allergy** >> so , if a patient come to you and you suspect that he has allergy , the first test you will ask for is eosinophils ' count.

5) **Basophils** also increase in **allergic reactions** but less than eosinophils do increase. And in cases of inflammation and bacterial infection.

_ Anyway , there are common features between all these cells such as :

1>> They are able to pass through the walls of the capillaries to enter the tissues , this process is called **Diapedesis .**

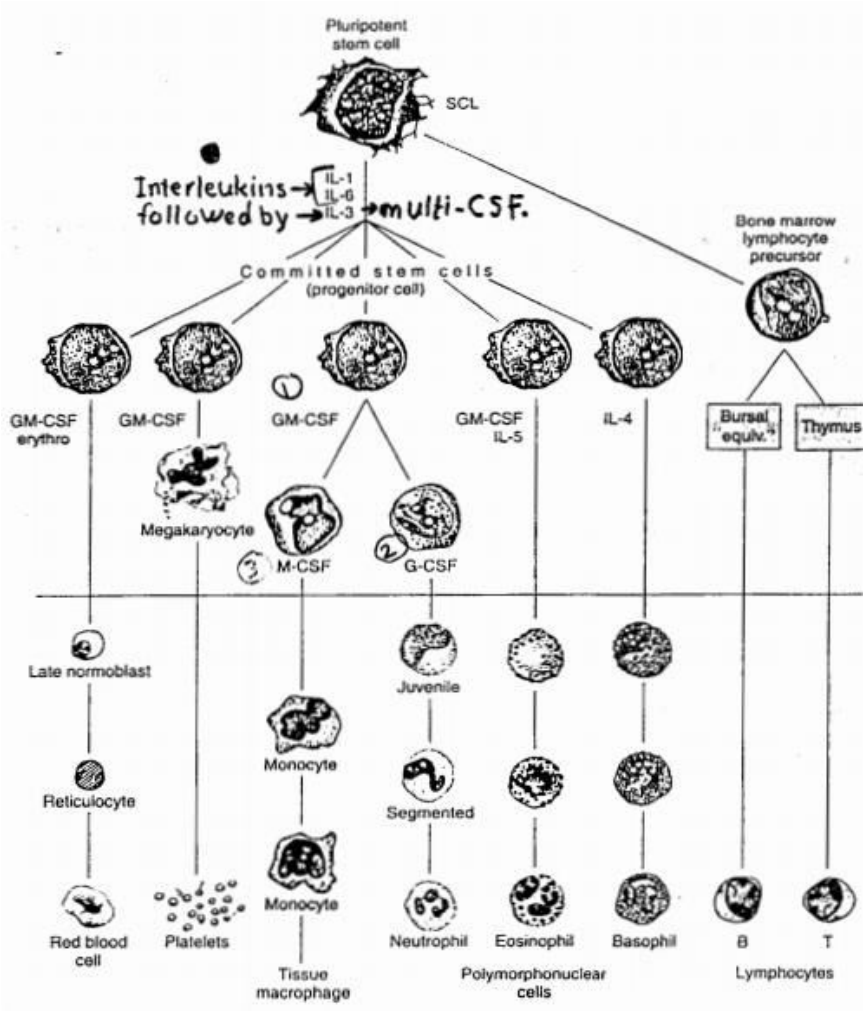
2>> They move between the blood vessels (from one to another) in the circulation and also in the tissues, this is called **Amoeboid motion.**

3>> They are attracted to the site of infection by certain chemicals, this is Known as **Chemotaxis.**

4>> They have the ability to engulf and digest bacteria and dead cells **(phagocytosis) .**

NOTE : Wiki says that the professional phagocytic cells are : neutrophils , monocytes.

Leukopoiesis (the production of WBCs)



_ Leukpoiesis is a very complicated process because of the following points :

A) The stem cell is affected by many factors (IL-1 , IL-6, then IL-3, GM-CSF, Granulocyte-CSF and stem cell factor) , if any of these is deleted or became not functioning , the production of WBCs will be affected .
NOTE: CSFs are so called because in vitro, if we use any of them on one cell in a culture, this cell will produce a colony of cells.

B) Each one of these factors is produced by many cells or tissues.

C) Of course , there are many steps in leukopoiesis and in each step , there are many factors affect each step and the production of the cells .

D) Sometimes one factor affects many steps, and there is overlap between ILs and CSF .

_ The duration of leukopoiesis is similar to the duration of erythropoiesis which is about 6 days , but WBCs remain in the bone marrow for another 6 days , so they remain in the bone marrow about 12 days.

_ During the production of WBCs , other cells (RBCs and platelet) are also affected , and remember that in pernicious anemia even neutrophils are affected , so >> there is a relation between the production of WBCs and RBCs.

_ When leukocytosis occurs, if the cause is eliminated, the number of WBCs will return back to normal . But if there is a great uncontrolled increase in the # of WBCs, this is called leukemia .

Leukemia

- It is the malignant proliferation of WBCs precursor cells , and this happens at the expense of the production of RBCs and platelets , so anemia and thrombocytopenia occur .

- **Causes of leukemia** :

1) **Genetic causes** (some families have high % of cases of leukemia)
2) **Environment** (the % of cases of leukemia is high in certain areas)
3) **Radiation** (such as what happened in Nagasaki in Japan)
4) **Chronic exposure to some chemicals and some viruses**

- Usually , leukemia affects all types of WBCs , but sometimes it doesn't affect the 5 types , so it might be neutrophilic leukemia , eosinophilic leukemia , basophilic leukemia , monocytic leukemia or lymphatic leukemia .

- There are 2 types of leukemia :

1) **Acute leukemia** : appears mostly in children , the onset is stormy (suddenly, the patient experience flu-like symptoms (from wiki: feeling sick, having fevers, chills, feeling fatigued), bone pain, the patient suffers from anemia , tendency to bleeding and frequent infections) .

2) **Chronic leukemia** : appears mostly in old ages (above 45 y) , develops slowly , the symptoms are less severe.

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- In general , leukemias are divided into 2 types according to the origin :

1- ***Lymphocytic leukemias***

2. ***Myelocytic leukemias***

- The leukemia cells are bizarre (unusual in appearance) and undifferentiated and not identical with any of the normal white blood cells, Usually the more undifferentiated the cells, the more acute the leukemia is . Leukemic cells especially the very undifferentiated are nonfunctional , and because of that , the patient suffers from frequent infections .
And with some of the more differentiated cells , the process will be quite chronic .

Effects of leukemia on the body :

1) Metastatic growth of leukemic cells in abnormal areas of the body. Because of that , if the disease is discovered early , it can be cured . but if it is discovered in late stages there will be no hope of curing !

2) The leukemia cells of the bone marrow invade the surrounding bone, almost all leukemias spread to the spleen, the lymph nodes, the liver and vascular regions.

3) In each of these areas, the rapidly growing cells invade the surrounding tissues, utilizing the metabolic elements of these tissues and consequently causing tissue destruction.

4) Frequent infections , severe anemia and bleeding tendency caused by thrombocytopenia.

5) The most important effect of leukemia on the body is the excessive use of metabolic substrates by the growing cancerous cells.

6) Tremendous demands are made on the body for foodstuffs, especially the amino acids and vitamins. Consequently, the energy of the patient is greatly depleted, rapid deterioration of the normal protein tissues of the body.

NOTE: Sometimes , because the # of WBCs is very high (above 100.000) , we use the methods of RBCs' counting to count them .

*** SORRY FOR ANY MISTAKES

***** This sheet is dedicated to my life's everything, MY MOTHER**
And to the best friends ever : Ala'a Al qhaiwi , Arwa AlNsairat***