Hematology

Medical Committee
The University of Jorda

- Histology
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lecture number : 1

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PHYSIOLOGY OF THE BODY FLUIDS

-In the body there are 45 litres of fluid, 5 litres of these are blood.

-So, five litres of the body fluids are blood.

-The blood is composed of: 1-plasma 55% 2-blood cells 45%

If we take a tube full of uncoagulated blood (doesn't clot) and we centrifuge it for (5-10) minutes, we find that 45 percent is cells and 55 percent is plasma.

Blood cells are:

1-Erythrocytes (red blood cells-RBCs)

2-leukocytes (white blood cells-WBCs):

-neutrophils

-eosinophils

-basophils

-lymphocytes

-monocytes

3-Platelets

Normal red blood cell values are: (number of cells/ Volume unit)
-in males: 5 million cells per µl
-in females: 4 million cells per µl

Males have higher RBCs count than females because of some hormones like androgens (I.e.: testosterone) which stimulate RBC synthesis

Volume units we use when counting RBCs are:

1) Microlitre (µl) = Millimeter cubed (mm^3)

2) Millilitres (mL)

3) Litres (L)

Supposedly the RBC count was 5 million cells ($5x10^6$ cells) then:

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$5x\underline{10^6}$ (cells/ μl) = $5x\underline{10^6}$ (cells/ mm^3) = $5x\underline{10^9}$ (cells/mL)= $5x\underline{10^{12}}$ (cells/Litre)

Plasma pH ranges from 7.35 to 7.45

Normal average varies from one person to another but pH is within this range in most cases

Blood composition:

Water ranges from 90 to 92 percent, electrolytes (less than 1 percent), gases (very low), nutrients, waste products (billirubin, uric acid), and plasma proteins (albumins, fibronigens, globulins and prothrombins)

The pH of the gastric juice is less than that of lemon juice.

The highest pH (very basic) is for bleach and cleaners.

The pH scale of blood is different than that of water.

(meaning that, in water we refer to water as acidic when the pH is below 7, and basic when the pH is above 7, while in blood, it is considered acidic when it's below 7.35 and basic when it's above 7.45)

Water:

-acidic p H <7 -basic: pH>7

Blood:

-acidic pH<7.35 -basic: pH>7.45

The range of the normal pH of the blood is from 7.35—7.45

The change below is 6.8 or above 8 causes death.

How does the pH affect the human being?

-It can denature enzymes

- Affects CNS

-Affects Potassium pumps (because there is a close relationship between the hydrogen atoms and the potassium, they're always together), so entry and exit of Potassium is altered.

Functions of the blood:

1-Transport functions: transports carbon dioxide CO2 , O2, free nutrients, waste products, hormones (from endocrine cells), enzymes to various cells .

2-Regulates "body" pH through buffers and amino acids.

3-Plays a role in regulation body temperature, because it contains large volume of water.

4-Regulates cells water content, through dissolving sodium and chloride ions …the main electrolytes, which change the osmolarity of the blood.

5-Prevents body fluid loss through the clotting mechanisms

6-Protects against toxins and microbes, through special cells: white blood cells.

Plasma proteins:

Main plasma proteins are: 1) albumins 2) fibrinogens 3) globulins 4) prothrombins

There are over 1400 different plasma proteins but these are the most important ones.

-All plasma proteins are produced by the liver.

In liver diseases the concentration of plasma proteins decreases.

-Globulins have another source of production which is the lymphocytes.

Functions of plasma proteins:

1-Transport functions

2-Defence functions by the immunoglobulins

3-Reserving body proteins

4-Exchange of fluids between the by blood and tissues by the oncotic or colloidal pressure which is:

-produced mostly by albumins.

-Range from 25-28 millimeter mercury. (some books say it's 32)

The amino acids in proteins are either essential or non essential amino acids.

(Here's a quick review to refresh your memory)

-Essential amino acids:

Amino acids that are
required for life and growth but is not produced in the body, or is produc ed in insufficient amounts, and must be supplied by protein in the diet.

-Non essential amino acids:

Amino acids that are required for protein synthesis and can be synthesized by humans.

Now there are complete proteins and incomplete proteins

Complete proteins provide all essential amino acids in order to sustain normal growth.

The most important complete proteins are: eggs, chicken and fish

Incomplete proteins are provided by vegetables, so vegetarians usually have amino acid deficiency because incomplete proteins don't provide all essential amino acids.

Blood distribution:

The first thing that goes to the mind is the heart , but this is actually not accurate , the blood is mainly in the Veins (65-75%) , Arteries 10-15% Capillaries 5% ,heart 5% and it's just 5 ! lungs 10% .

There are physiological changes in the blood volume are due to:

1-gender; there is a difference between males and females (males have a higher blood volume)

2-pregnancy; pregnant woman have more plasma and blood volume.

3-muscular exercise; increases blood volume.

4-posture, in standing position there is a reduction in blood volume of about 15%.

5-blood pressure; rising blood pressure lowers blood volume

6-Altitude; increases blood volume

7-excitement; because of adrenaline release.

8-contraction of spleen, as it contains blood.

Erythrocytes

-are enucleated, biconcave disk shaped cells

-They change their shape; so they're able to pass through small blood vessels

Note that they don't LEAVE the blood vessel, if they do; it means there's a problem either in the blood vessel or in the blood cells themselves.

The dimensions are:

1-Mean corpuscular volume (MCV) is the average volume of red cells.

Ranges from 80-90 fL (ml^3)

2-Surface area is (135±16 μm2) .

3. diameter (7.82± 0.5 μm)

When these dimensions change, the thickness also changes!

When we say the number regardless of what the gender is, we just say 5 million

But when we're specific, we say 5 million for males and 4 million for females

Here's what we see in a tube full of anti- coagulated and centrifuged blood:

_45% RBCs and 55% plasma

_2% of blood cells trapped in plasma (because RBC shape is not uniform); this plasma is called trapped plasma.

_Hematocrit or packed cell volume; which is the ratio of the volume of red blood cells to the total volume of blood.

_Less than 1% Buffy coats leukocytes & platelets.

The parameters of the blood :

- Haemoglobin
- Volume of hematocrit
- Volume of packed Red blood cells

In the new born all these parameters are high: haemoglobin is high, the number of cells of (RBCs count) is high, and the hematocrit is high ---- why is that? Because of the oxygenation through the placenta.

- At the beginning (first month) just RBCs are produced (primitive erythrocyte). After one month megakaryocytes are produced then granulocyte then lymphocyte and at the beginning of the 5th month monocytes are produced.

After birth within three months the parameters are normalized with little variation because now we have normal oxygenation through the lungs and now the fetal haemoglobin is gradually replaced by the adult haemoglobin

Hematopoiesis (blood cell production)

-During fetal life blood cell production erythrocytes production mainly occur in the liver, little in the spleen.

-in the first three months from the yolk sac.

-at the beginning of the fourth month in the bone marrow and also the lymph nodes (but with little role)

After birth: Just bone marrow continues to produce but not in all bones, in specific bones. In some kinds of anemia the liver and spleen regain the ability for hematopoiesis.

Before the age of 18 or 20 the marrow of all bones produces blood cells but after that blood production is confined to some bone marrows like: vertebrae, pelvis, sternum, ribs, in the proximal ends of the long bones, the skull, and the scapula.

In children—all bones

In adults--- in some bones

Now talking about the successive appearance of the cells

First erythrocytes…the fetus needs oxygen very logic :p

Second the stem cells of platelets.. So they don't coagulate

Third granulocytes ya3ne mainly neutrophils

Fourth lymphocytes

Finally monocytes

Regulation of erythropoiesis

All these factors keep the number of the red blood cells in the circulation relatively constant meaning that they keep Number of RBCs produced= number of RBCs destroyed

.and they all work in a synergistic manner/pattern.

Number of RBCs produced= number of RBCs destroyed

The effect of tissue oxygenation on the production of erythropoietin on the cells

In hypoxia erythropoiesis increases . While in hyperoxia erythropoiesis decreases (such as in people live around Dead Sea level) .

Oxygen supply either decrease or increase the tissue oxygenation;

Here we see the reduction of tissue oxygenation in one of these conditions: low blood volume, anemia, low hemglobin, poor blood flow, other diseases

Now there are cells in the kidney that are sensitive to the tissue oxygenation, these cells they produce a hormone called erythropoietin, which affects the hematopoietic stem cells to increase the erythroblastic cells

90% of erythropoietin comes from the kidney and 10% from the liver, sometimes they write spleen among the liver but now they don't write it.

Glycoprotein (erythropoietin) increases by hypoxia and decreases by hyperoxia

Erythropoietic activity durarion in the bone marrow is 3 to seven days as short as three as long as seven days

The last stage of erythropoiesis is … reticulocytes

Reticulocytes don't contain a proper nucleus only the remnant of the nucleus but they still produce hemoglobin

The number of reticulocytes in the bone marrow = the number of other cells (cells that contain nuclei)

The reticulocytes remain in the bone marrow for two to three days then they're released into the circulation

The percentage of reticulocytes in the circulation is about 1-2%

The number of reticulocytes in the circulation is less than the number of reticulocytes in the marrow

65% of hemoglobin synthesis occurs in the erythroblast stage, and 35% is synthesized in the reticulocyte stage.

Mature RBCs don't synthesize hemoglobin

Dedication:

Sewar bishara, abdalla awwad, rami affifi, yousef abdeh, dina mijali, aseel al-saud, aseel khatib, louai smeirat.