**Lecture topic is…**

**(Slide 1) Lecture 4**

**Physiology of the blood system**

**(Slide 2)** Lecture plan:

1. Blood system concept.
2. Functions of the blood.
3. Cell Composition of blood.

**(Slide 3) The blood system** is a combination of hematopoietic organs, peripheral blood, blood destruction organs and neurohumoral regulation apparatus. The term "blood system" was proposed by Georgy Fedorovich Lang in 1939.

Blood differs significantly from other tissues in a number of specific properties:

1. Blood is liquid, tissue moving through the vessels

2. Organs of production (red bone marrow, spleen, lymph nodes and organs of destruction - liver, spleen), as well as the apparatus of neurohumoral regulation are located separately from the liquid part of the blood itself circulating through the vessels.

**(Slide 4) Blood has three main functions:**

1. Transport.

2. Protective.

3. Homeostatic.

In turn, respiratory, nutritional, excretory, regulatory and thermoregulatory functions are also secreted in the transport function of blood.

**(Slide 5) Respiratory function of blood (Video).** Blood absorbs oxygen from air in the lungs. It transports the oxygen to cells throughout the body, and it removes waste carbon dioxide from the cells. In the lungs, the carbon dioxide moves from the blood to the air and is exhaled.

**(Slide 6) Video.** Observe how a red blood cell travels from the heart to the lungs.

**(Slide 7) Nutritional function of blood.** Digested nutrients are absorbed into the bloodstream through capillaries in the villi that line the small intestine. These nutrients include glucose, amino acids, vitamins, minerals, and fatty acids.

**(Slide 8) Excretory function of blood.** Blood transports waste substances to the organs that remove and process them for elimination. Blood flows into the kidneys through the renal arteries and out through the renal veins. The kidneys filter substances such as urea, uric acid, and creatinine out of the blood plasma and into the ureters. The liver also removes toxins from blood. During digestion, it cleans blood that has been enriched with vitamins before sending it back out to the rest of the body.

**(Slide 9) Regulatory function of blood.** The regulatory function of blood is the transfer of hormones produced by the endocrine glands and other biologically active substances, with the help of which the functions of individual tissue cells are regulated, as well as the removal of these substances and their metabolites after their physiological role has been fulfilled.

**(Slide 10) Thermoregulatory function of blood**. Blood absorbs and distributes heat throughout the body. It helps to maintain homeostasis through the release or conservation of warmth. Blood vessels expand and contract when they react to outside organisms, such as bacteria, and to internal hormone and chemical changes. These actions move blood and heat closer to or farther from the skin surface, where heat is lost.

**(Slide 11) Protective function of blood.** The protective function is carried out by substances that provide humoral protection of the body against infection and toxins entering the bloodstream, as well as by lymphocytes participating in the formation of antibodies. Cellular protection is carried out by leukocytes, which are carried by the blood stream to the site of infection, to the site of its penetration and, together with other tissue substances, provides the formation of a protective barrier. The blood stream removes and neutralizes the products of their destructuring formed in the event of tissue damage. The protective function of blood includes its ability to clot, form a blood clot and stop bleeding. Platelets are involved in this process. With a significant decrease in the number of platelets, slow blood coagulation is observed.

**(Slide 12) Homeostatic function of blood** − reaching the space of the internal environment of the body due to the movement of blood, washing all tissues with it, with the intercellular fluid of which its composition is balanced.

**(Slide 13)** Composition of blood. Blood is classified as a connective tissue and consists of two main components:

1. Plasma, which is a clear extracellular fluid

2. Formed elements, which are made up of the blood cells and platelets

The formed elements are so named because they are enclosed in a plasma membrane and have a definite structure and shape. All formed elements are cells except for the platelets, which are tiny fragments of bone marrow cells.

**(Slide 14)** Formed elements are:

1. Erythrocytes, also known as red blood cells (RBCs)

2. Leukocytes, also known as white blood cells (WBCs)

3. Platelets

In turn, all leukocytes are divided into neutrophils, eosinophils, basophils, monocytes and lymphocytes.

**(Slide 15)** The blood that runs through the veins, arteries, and capillaries is known as whole blood, a mixture of about 55 percent plasma and 45 percent blood cells. About 5 to 9 percent of your total body weight is blood. An average-sized man has about 6 liters of blood in his body, and an average-sized woman has about 5 liters. When a sample of blood is spun in a centrifuge, the cells and cell fragments are separated from the liquid intercellular matrix. Because the formed elements are heavier than the liquid matrix, they are packed in the bottom of the tube by the centrifugal force. The light yellow colored liquid on the top is the plasma, which accounts for about 55 percent of the blood volume and red blood cells is called the hematocrit,or packed cell volume (PCV). The white blood cells and platelets form a thin white layer, called the "buffy coat", between plasma and red blood cells.

**(Slide 16)** Plasma is made up of 90% water, 7-8% soluble proteins (albumin maintains bloods osmotic integrity, others clot, etc), 1% carbon-dioxide, and 1% elements in transit. One percent of the plasma is salt, which helps with the pH of the blood. The largest group of solutes in plasma contains three important proteins to be discussed. There are: albumins, globulins, and clotting proteins.

**(Slide 17)** Albumins are the most common group of proteins in plasma and consist of nearly two-thirds of them (60-80%). They are produced in the liver. The main function of albumins is to maintain the osmotic balance between the blood and tissue fluids and is called colloid osmotic pressure. In addition, albumins assist in transport of different materials, such as vitamins and certain molecules and drugs (e.g. bilirubin, fatty acids, and penicillin).

Globulins are a diverse group of proteins, designated into three groups: gamma, alpha, and beta. Their main function is to transport various substances in the blood. Gamma globulins assist the body's immune system in defense against infections and illness.

Clotting proteins are mainly produced in the liver as well. There are at least 12 substances, known as "clotting factors" that participate in the clotting process. One important clotting protein that is part of this group is fibrinogen, one of the main components in the formation of blood clots. In response to tissue damage, fibrinogen makes fibrin threads, which serve as adhesive in binding platelets, red blood cells, and other molecules together, to stop the blood flow.

**(Slide 18)** Main Functions of Plasma Proteins:

**Protein Nutrition:** Plasma proteins perform as the main source by providing a course, whenever the require arises.

**Osmotic Pressure and water balance:** Plasma proteins apply an osmotic pressure of about 25 mm of Hg and therefore play a significant part in balancing a proper water percentage in between the tissues and home-blood. Plasma albumin is mostly accountable for this function because of its low molecular weight and the quantitative amount over other proteins. However, during the situation of protein loss from the human body as be found in kidney diseases, a huge percentage of water moves to the tissues as a result edema may cause.

**Buffering action:** Plasma proteins play an important role in maintaining the pH of the body, i.e. seven, by performing asampholytes process.

**Transport of Lipids:** One of the most crucial works of plasma proteins is to deliver lipids and lipid soluble substances in the whole human body. Fatty acids and bilirubin are carried mainly by albumin, while on the other side cholesterol and phospholipids are transferred by the lipoproteins exist in β-globulins also transport fat-soluble vitamins.

**Transport of other complexes salts:** If we considering to lipids, plasma proteins also helping in transporting various metals and other substances, i.e. thyroxine etc.

**Blood Coagulation:** Prothrombin that present in α2-globulin fraction and fibrinogen, take part in the blood clotting.

**(Slide 19)** The density and viscosity of blood depend mainly on the number of formed elements and normally fluctuate within narrow limits. In humans, the density of whole blood is 1.05–1.06 g / cm3 (grams per cubic centimeters), plasma is 1.02–1.03 g / cm3, and that of cells is 1.09 g / cm3. The difference in density allows whole blood to be separated into plasma and blood cells, which is easily achieved by centrifugation. Erythrocytes make up 44%, leukocytes and platelets - 1% of the total blood volume.

**(Slide 20)** The osmotic pressure of blood, at 37 ° C equal to 7.63 atm. Is determined by its osmotic concentration, i.e. the sum of all particles − molecules, ions, colloidal particles, located in a unit of volume, mainly electrolytes that are part of it; in plasma − with sodium and chlorine ions, in erythrocytes − potassium and chlorine, as well as proteins present in the blood. This value is maintained by physiological mechanisms with very great constancy. In medical research, the value of osmotic pressure is rarely investigated, much more often they use the equivalent concept of osmotic concentration, which is determined by the magnitude of the depression (lowering) of the freezing point of the liquid under study in comparison with water. Normally, this value is 0.55-0.56, which corresponds to 0.27-0.31 mol / l or 270-310 mmol / l.

The primary force driving fluid transport between the capillaries and tissues is hydrostatic pressure, which can be defined as the pressure of any fluid enclosed in a space. Blood hydrostatic pressure is the force exerted by the blood confined within blood vessels or heart chambers. Even more specifically, the pressure exerted by blood against the wall of a capillary is called capillary hydrostatic pressure (CHP), and is the same as capillary blood pressure. CHP is the force that drives fluid out of capillaries and into the tissues.

**(Slide 21)** Oncotic pressure, or colloid osmotic-pressure, is a form of osmotic pressure induced by the proteins, notably albumin, in a blood vessel's plasma (blood/liquid) that displaces water molecules, thus creating a relative water molecule deficit with water molecules moving back into the circulatory system within the lower venous pressure end of capillaries. It has the opposing effect of both hydrostatic blood pressure pushing water and small molecules out of the blood into the interstitial spaces within the arterial end of capillaries and interstitial colloidal osmotic pressure. These interacting factors determine the partition balancing of total body extracellular water between the blood plasma and the larger extracellular water volume outside the blood stream.

**(Slide 22) Video. Capillary exchange.**

**(Slide 23)** Proper physiological functioning depends on a very tight balance between the concentrations of acids and bases in the blood. Acid-balance balance is measured using the pH scale, as shown in Figure 26.4.1. A variety of buffering systems permits blood and other bodily fluids to maintain a narrow pH range, even in the face of perturbations. A buffer is a chemical system that prevents a radical change in fluid pH by dampening the change in hydrogen ion concentrations in the case of excess acid or base. Most commonly, the substance that absorbs the ions is either a weak acid, which takes up hydroxyl ions, or a weak base, which takes up hydrogen ions.

**(Slide 24)** The buffer systems in the human body are extremely efficient, and different systems work at different rates. It takes only seconds for the chemical buffers in the blood to make adjustments to pH. The respiratory tract can adjust the blood pH upward in minutes by exhaling carbon dioxide from the body. The renal system can also adjust blood pH through the excretion of hydrogen ions (H+) and the conservation of bicarbonate, but this process takes hours to days to have an effect.

The buffer systems functioning in blood plasma include plasma proteins, phosphate, and bicarbonate and carbonic acid buffers. The kidneys help control acid-base balance by excreting hydrogen ions and generating bicarbonate that helps maintain blood plasma pH within a normal range. Protein buffer systems work predominantly inside cells.

**(Slide 25) Protein Buffers in Blood Plasma and Cells**

Nearly all proteins can function as buffers. Proteins are made up of amino acids, which contain positively charged amino groups and negatively charged carboxyl groups. The charged regions of these molecules can bind hydrogen and hydroxyl ions, and thus function as buffers. Buffering by proteins accounts for two-thirds of the buffering power of the blood and most of the buffering within cells.

**(Slide 26) Hemoglobin as a Buffer**

Hemoglobin is the principal protein inside of red blood cells and accounts for one-third of the mass of the cell. During the conversion of CO2 into bicarbonate, hydrogen ions liberated in the reaction are buffered by hemoglobin, which is reduced by the dissociation of oxygen. This buffering helps maintain normal pH. The process is reversed in the pulmonary capillaries to re-form CO2, which then can diffuse into the air sacs to be exhaled into the atmosphere. This process is discussed in detail in the chapter on the respiratory system.

**(Slide 27) Phosphate Buffer**

Phosphates are found in the blood in two forms: sodium dihydrogen phosphate (Na2H2PO4−), which is a weak acid, and sodium monohydrogen phosphate (Na2HPO42-), which is a weak base. When Na2HPO42- comes into contact with a strong acid, such as HCl, the base picks up a second hydrogen ion to form the weak acid Na2H2PO4− and sodium chloride, NaCl. When Na2HPO42− (the weak acid) comes into contact with a strong base, such as sodium hydroxide (NaOH), the weak acid reverts back to the weak base and produces water. Acids and bases are still present, but they hold onto the ions.

HCl + Na2HPO4→NaH2PO4 + NaCl

(strong acid) + (weak base) → (weak acid) + (salt)

NaOH + NaH2PO4→Na2HPO4 + H2O

(strong base) + (weak acid) → (weak base) + (water)

**(Slide 28) Bicarbonate-Carbonic Acid Buffer**

The bicarbonate-carbonic acid buffer works in a fashion similar to phosphate buffers. The bicarbonate is regulated in the blood by sodium, as are the phosphate ions. When sodium bicarbonate (NaHCO3), comes into contact with a strong acid, such as HCl, carbonic acid (H2CO3), which is a weak acid, and NaCl are formed. When carbonic acid comes into contact with a strong base, such as NaOH, bicarbonate and water are formed.

NaHCO3 + HCl → H2CO3+NaCl

(sodium bicarbonate) + (strong acid) → (weak acid) + (salt)

H2CO3 + NaOH→HCO3- + H2O

(weak acid) + (strong base)→(bicarbonate) + (water)

As with the phosphate buffer, a weak acid or weak base captures the free ions, and a significant change in pH is prevented. Bicarbonate ions and carbonic acid are present in the blood in a 20:1 ratio if the blood pH is within the normal range. With 20 times more bicarbonate than carbonic acid, this capture system is most efficient at buffering changes that would make the blood more acidic. This is useful because most of the body’s metabolic wastes, such as lactic acid and ketones, are acids. Carbonic acid levels in the blood are controlled by the expiration of CO2 through the lungs. In red blood cells, carbonic anhydrase forces the dissociation of the acid, rendering the blood less acidic. Because of this acid dissociation, CO2 is exhaled (see equations above). The level of bicarbonate in the blood is controlled through the renal system, where bicarbonate ions in the renal filtrate are conserved and passed back into the blood. However, the bicarbonate buffer is the primary buffering system of the IF surrounding the cells in tissues throughout the body.

CO2 + H2O ↔ H2CO3 ↔ H+ + HCO3–

**(Slide 29) Video. The Blood Buffer System.**

Finish for today

The full lecture is at the indicated website.

**Thank you for attention**