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# WATER-SALT HOMEOSTASIS OF THE HUMAN BODY AND ELECTROLYTIC COMPOSITION OF THE INTERNAL LIQUID ENVIRONMENT

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# ВОДНО-СОЛЕВОЙ ГОМЕОСТАЗ ЧЕЛОВЕЧЕСКОГО ОРГАНИЗМА И ЭЛЕКТРОЛИТНЫЙ СОСТАВ ВНУТРЕННЕЙ ЖИДКОСТНОЙ СРЕДЫ

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*Abstract.* Maintaining water and salt balance in the body is important for the basic functioning of cells. It reduces the water level by increasing the urine production of the kidneys. During excessive salt intake, the blood absorbs water from the tissues and edema occurs. To prevent this, the kidneys increase the amount of urine. Excess salt is excreted in the urine. Blood pressure regulation is one of the most complex aspects of homeostasis. The adrenal glands, spine, and sympathetic and parasympathetic nervous systems work together to balance blood pressure and keep it at a healthy level. Changes in blood pressure are detected by receptors and the information is sent to the brain for processing. Blood pressure either rises or falls with the help of nerve impulses and hormones to the heart.

*Аннотация.* Поддержание водно-солевого баланса в организме необходимо для нормального функционирования клеток. Это снижает уровень воды, увеличивая выработку мочи почками. При чрезмерном потреблении соли кровь поглощает воду из тканей и образуются отеки. Чтобы предотвратить это, почки увеличивают количество мочи. Избыток соли также выводится с мочой. Регулирование артериального давления является одним из наиболее сложных аспектов гомеостаза. Надпочечники, позвоночник, симпатическая и парасимпатическая нервные системы работают сообща, чтобы сбалансировать кровяное давление и поддерживать его на здоровом уровне. Изменения артериального давления регистрируются рецепторами, и информация отправляется в мозг для обработки. С помощью нервных импульсов и гормонов, которые поступают к сердцу, кровяное давление либо повышается, либо понижается.

*Keywords:* blood, homeostasis, buffer system, blood plasma.

*Ключевые слова:* кровь, гомеостаз, буферная система, плазма крови.

Studies have shown that the physico-chemical homeostasis of blood in the body is a complex physiological process, in its normal maintenance buffer systems, respiratory system and kidneys are involved in maintaining the concentration of $H^+$ and $HCO_3^-$ ions in all fluids of the body, especially in the extracellular fluid. Blood, like other fluids, has a certain active reaction. The reaction of the liquid is determined by the concentration of hydrogen ($H^+$) and hydroxyl ($OH^-$) ions. When hydrogen ions increase, the reaction of the liquid becomes acidic, and when hydroxyl ions increase, it becomes alkaline. When there is an equal balance between these ions, a neutral reaction is formed

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in the environment. The acidity and basicity of the environment is indicated by the pH of the solution (pH is the negative logarithm of the concentration of hydrogen ions in the solution). Since the pH of water is 7.0, its reaction is neutral. So, if the pH is greater than 7, the reaction is considered alkaline, and if it is less, it is considered an acidic environment. Keeping the active reaction of the blood stable is necessary for the normal functioning of the body. Although both alkaline and acidic nutrients and exchange products enter the blood intermittently from the tissues and digestive organs, its active reaction (pH) remains constant or temporarily changes only slightly in healthy individuals. The stability of the reaction of the blood depends on the complex physiological activity of the systems and organs contained in it. Carbonates, phosphates, hemoglobin and proteins in blood plasma have the ability to neutralize both hydrogen ions and hydroxyl ions. These substances are called buffers because they absorb the excess of acid and alkaline ions. 13% of the buffer volume of blood falls on bicarbonate substances, 76% on the hemoglobulin and oxyhemoglobulin buffer system, 10% on the protein buffer system and 1% on the phosphate buffer system. Buffer systems are also found in tissues. Therefore, the active reaction of the inter-tissue fluid is always kept constant, being relatively stable. Of the buffer systems in tissues, the most common occurrence is protein and phosphate buffer systems [1].

The character trait of the buffer system of blood is that its reaction can move more easily towards alkalinity than towards acidity. So, in order for the blood reaction to move towards alkalinity, it is necessary to add 40-70 times more sodium base than water, and in order for it to move towards acidity, it is necessary to add 327 times more hydrochloric acid than water. This has been called acid-alkaline homeostasis, as the constant certain acid and alkali equivalence in the blood is constant. Experiments conducted on heated animals show that the non-life-threatening size of the active reaction of the blood is between 7.0 and 7.8. In elderly people, the concentration of hydrogen ions is 7.35-7.43, and the reaction of the blood is weakly alkaline. If these parameters of pH deviate, drastic changes in the body and even death can occur. A slight change in the active reaction of the blood is observed during heavy muscle work, frequent breathing, intake of a lot of sour food and some diseases. Due to the large amount of lactic acid entering the blood during heavy physical work, the reaction changes towards acidity. Over a long period of time, the change of the blood reaction even by 0.1-0.2 compared to the norm is considered dangerous for life [2].

*Discussion and conclusions of the study*

Water is the main component of living organisms. The water (H2O) molecule is an ideal fluid for physiological reactions. Water is a substance in a polar state (dipole moment) because the $O_2$ atom in the $H_2O$ molecule slightly repels the electrons in the H atom. At the same time, $H_2O$ molecules are connected to each other by dynamic hydrogen bonds. Due to the above reasons, some properties specific to water appear: 1. High surface tension; 2. High evaporation capacity and heat capacity; 3. High dielectric constant [3].

The role of physico-chemical properties of water in carrying the perfect biological fluid function is great. In the process of evolution of multicellular organisms, a closed blood circulation is formed. In organisms with closed blood circulation, the intercellular fluid environment (ECF) is an essential condition for cell survival. Intercellular fluid medium (ECF) includes extracellular fluid, circulating blood plasma and lymph fluid between them, and transcellular fluid. This environment covers all the cells in the body, all the substances necessary for the cell's survival are delivered to the cell through this environment, and the exchange products of the cell are also secreted into this environment. All indicators of this environment are within clear and strict parameters, which is called homeostasis. Homeostasis is the stable maintenance of the internal

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environment of the body with the help of various functional systems for the continuation of life. The body's need for water is met by intake from the outside and as a result of internal physiological processes. In middle-aged people, the amount of exogenous water required is about 2 liters per day (30 ml/kg). 500-1000 ml of exogenous water is taken as liquid, and 800-1200 ml as solid food. The required amount of water is 180 ml/kg for newborns, 125 ml/kg for 6 months, and 100 ml/kg for one year old. Half of the total water is in the muscles, 1/8 in the skeleton, 1/16 in the skin, and 1/20 in the blood Table 1.

Table 1

THE AMOUNT OF WATER IN THE BODY IN % DEPENDING ON AGE

| *Age* | *Amount in % by body weight* |
|---|---|
| 6 week old embryo | 97,5 |
| In newborn children | 80 |
| 3 months | 70 |
| 6 months | 60 |
| 1-2 years old | 59 |
| 11-16 years old | 58 |
| Old person | 58-60 |
| In a fat person (fat) | 40-50 |
| In a thin person | 70-75 |

Water in the body has various functions: a) Mechanical function: transport (transportation of various substances), protective (spinal fluid), prevents friction (pleura, pericardium and joints); b) Chemical function: Hydrolysis, hydration, oxidation-reduction processes, etc. in the organism; c) Physical function: maintenance of acid-base balance, filtration, secretion, reabsorption processes, as a solvent, etc. [4] (Table 2).

Table 2

THE BALANCE OF WATER ENTERING AND LOSING THE BODY
IS STRICTLY MAINTAINED BY THE BODY

| *Indicator* | *Inclusion* | *Disposal* | *Minimal inclusion to maintain balance* |
|---|---|---|---|
| Water, ml | 1000with solid food;<br>1300 in liquid form;<br>Oxidation water 300 | 1600 with urine;<br>Lungs and skin 900;<br>Intestinal contents 100 | 1700 |
| Cəmi: | 2600 | 2600 | |

Water exists in different forms in the body:

1. Free water is the basis of intracellular and extracellular fluid environment. It is very mobile. It is a universal solvent for solid, liquid and gaseous substances. It participates in biochemical processes in the body's internal environment.

2. Constitutional water — water formed as a result of the metabolism of proteins, fats and carbohydrates. 0.41 ml of water is formed during the oxidation of 1 g of protein, 1.07 ml during the oxidation of 1 g of fat, and 0.61 ml during the oxidation of 1 g of carbohydrates. The amount of endogenous water is 300 ml/day. The amount of endogenous water varies depending on the intensity of metabolic processes, type of food and age.

3. Constitutional water — water formed as a result of the exchange of proteins, fats and carbohydrates. 0.41 ml of water is formed during the oxidation of 1 g of protein, 1.07 ml during the

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oxidation of 1 g of fat, and 0.61 ml during the oxidation of 1 g of carbohydrates. The amount of endogenous water is 300 ml/day. The amount of endogenous water varies depending on the intensity of metabolic processes, type of food and age.

4. Water in the form of compounds. It is included in the composition of colloids, affects their structure and biological properties. This water makes up about 10% of body weight.

Water accounts for 60% (42 liters) of the body weight of the average adult. The aquatic environment in the body is conditionally divided into 2 parts: intracellular (intracellular) and extracellular (extracellular). 28 liters of water in the body are inside 75 trillion cells, which is an intracellular fluid, and 14 liters are extracellular fluid. More than half of the intracellular fluid is contained in myocytes, which is taken as a benchmark. The extracellular environment includes intercellular fluid (interstitial) and lymph (15%), intravascular fluid (Plasma) (5%). Some transcellular fluids also belong to the intercellular fluid: Fluids of serous spaces, synovial fluid, fluid of the anterior chamber of the eye, spinal cord fluid, first urine in the kidneys, tears, secretions of the gastrointestinal tract (0.5-1% of the body). 40% of the water in the body is functional less active liquid in cartilage, bone, and fascia. The remaining 60% is a functionally active liquid that can easily change places. The intercellular environment is continuously filled with products of cellular metabolism, and its composition changes accordingly. Practically, they consider the composition of intravascular and intercellular fluid to be the same. However, it should be taken into account that in the intravascular fluid there are more proteins, more $Na^+$ ions, and less $Cl^-$ ions [4, 5].

Circulating blood and lymph are part of the extracellular fluid environment and have very important functions: transporting oxygen, nutrients, water and electrolytes to cells, and removing waste products. There is ionic asymmetry between intracellular and intercellular fluids. Inside the cell, the $K^+$ ion is 23 times more than outside the cell, and the $Na^+$ ion is 9.4 times less (Table 3).

Table 3

BALANCE OF ANIONS AND CATIONS

| *Mühitlər* | $Na^+$ | $K^+$ | $Ca^{2+}$ | $Mg^{2+}$ | $Cl^-$ | $PO_4^{3-}$ | $HCO_3^-$ |
|---|---|---|---|---|---|---|---|
| Intravascular (plasma) | 142-151 | 4-5 | 5-5,4 | 1,1-3,2 | 103-109,7 | 2-2,1 | 27-28,7 |
| Interstitial | 144-145 | 4-4,4 | 2,5 | 1,5 | 114-117 | 2-2,3 | 27-30 |
| Intracellular (striated muscle cell) | 10-12 | 150-160 | – | 35 | 2 | 140 | 8 |
| Gastric juice | 60 | 7 | | | 100 | – | – |
| Pancreas juice | 148 | 7 | 3 | 0,3 | 80 | – | 80 |
| Sweat | 75 (18-97) | 5 | 5 | – | 75 | – | – |
| Bile | 145 | 5,2 | – | – | 100 | – | – |
| Milk | 14 | 16 | 17 | 3 | 11 | 6 | – |
| Cerebrospinal fluid | 142 | 3 | 2,5 | 2 | 124 | – | 21 |

This difference is an important condition for keeping cell membrane permeability stable. Up to 30% of the basic exchange energy is spent on keeping this conductivity constant. The extracellular fluid environment covers all the cells in the body in the form of a thin layer and takes part in the delivery of necessary substances to the cells — transport, removal of intracellular exchange products from the cell, important exchange processes — intermediate exchange. Electrolytes make up 90% of the total amount of dissolved substances in the body. Electrolyte composition of the body's main fluid environments. The percentage of water in children is greater than that of adults. For example, 75-77% of a normal weight child consists of water. The

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extracellular part of this water is equal to 42-50%. That is, extracellular water is 2 times more than in adults. The average amount of extracellular fluid is 376 ml/kg. Interstitial fluid is 3 times more than in adults. This means that the cells of a newborn child are surrounded by a larger amount of fluid. Children need 2-3 times more water than adults (according to ml/kg). Such a large demand for water is due to the speed of exchange processes, low concentration capacity of the kidneys and rapid growth. The amount of circulating blood per kilogram of body weight is greater in newborns than in adults (90 ml/kg). After the birth of the child, a large amount of water in the plasma is excreted from the body within 1-2 hours. The main cations of the fluid environment in the body are $Na^+$, $K^+$, $Ca^+$, $Mg^+$, and the anions are $Cl^-$, $HCO_3^-$, $SO4^{2-}$, $PO_4^{2-}$, etc. Anions and cations are in equilibrium with small differences (Table 4).

Table 4

EQUILIBRIUM TABLE OF CATIONS AND ANIONS IN BLOOD PLASMA

| *Cations – 154 mekv/l (+)* | *Anions – 154 mekv/l (-)* |
|---|---|
| Na=142 K=4 | Cl=103 $HCO_3$=27 |
| Ca=5 Mg=3 | Protein=16 Inorganic =3 Organic =5 |
| | BB (basic buffer) =39 *(deduction)* |

Osmotic pressure is one of the most important parameters of the body's internal environment. Osmosis refers to the diffusion of water from a higher density part to a lower density part. The main reason for the distribution and movement of water entering the body between different fluid environments is the concentration of osmotic active substances in it. Effective osmotic pressure is the main factor affecting fluid movement in cellular and intercellular environments. The main difference between blood plasma and intercellular fluid is that proteins do not pass through the capillary wall into the interstitial environment. As a result, the amount of proteins in the plasma increases [6]. The daily requirement of electrolytes of an elderly person is: $Na^+$ 215, $K^+$ 75, $Ca^{2+}$ 60, $Mg^{2+}$ 35, $Cl^-$ 215, $PO3^{2-}$ 105 meq/l. These substances enter through the digestive system, some of them are temporarily stored in the liver. The excess is eliminated through the kidneys, lungs, intestines and skin. Along with electrolytes, non-electrolytes also participate in the regulation of plasma homeostasis (Table 5).

Table 5

AMOUNT OF MAJOR NON-ELECTROLYTES IN PLASMA, mq/dl

| *Fosfo-lipidlər* | *Xolesterol* | *Yağlar* | *Qlükoza* | *Sidik cövhəri* | *Süd turşusu* | *Kreatinin* | *Bilirubin* |
|---|---|---|---|---|---|---|---|
| 280 | 150 | 125 | 100 | 15 | 10 | 1,5 | 0,5 |

Water passes through the cell membrane by free diffusion as a result of osmotic pressure. When plasma osmolarity is high, free water moves from the intercellular medium into the plasma. Electrolytes $Na^+$, $Cl^-$, $HCO3^-$ are mainly involved in the creation of osmolarity. These electrolytes make up 85% of the total osmotic pressure. The passage of ions through the cell membrane occurs as a result of both active and passive diffusion. Active diffusion occurs mainly through the "Na pump" and this process consumes a lot of energy. The "Na-pump" is involved in the removal of $Na^+$ ions out of the cell (10-15 meq/l $Na^+$, 70-150 meq/l $K^+$). As a result of active diffusion, $2K^+$ and $1H^+$ ions move into the cell, and instead, $3Na^+$ ions are taken out of the cell. As other osmotically active substances (glucose, urea) can easily pass through the cell membrane, they can participate in the regulation of osmotic pressure both inside and outside the cell. An increase in the osmotic pressure outside the cell causes the fluid inside the cell to move into the interstitial environment [5].

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*Results*

As a result of studies carried out in connection with the change in the homeostasis of blood in the body depending on age, the following have been identified.

1. The interaction of [$H^+$] — hydrogen and [$OH^-$] — hydroxyl ions in the blood depends on the activity of enzymes, the intensity of oxidation-reduction reactions, the process of decomposition and synthesis of proteins, the oxidation of carbohydrates and lipids, the sensitivity of cell receptors to mediators and hormones, membrane permeability, physico-chemical properties of colloidal systems of cellular and intercellular structures.

2. Of the $CO_2$ produced in tissues, 27% accumulates in erythrocytes in the form of $HCO_3^-$, 11% in the form of carbohemoglobin combined with hemoglobin, 12% in the form of physically dissolved or dissociated carbonic acid, and the remaining 50% in the form $HCO_3^-$ in plasma.

3. The stability of the concentration of $H^+$ ions in the body's fluids is regulated by three main mechanisms, the acid-base buffer system, the respiratory system and the kidneys.

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