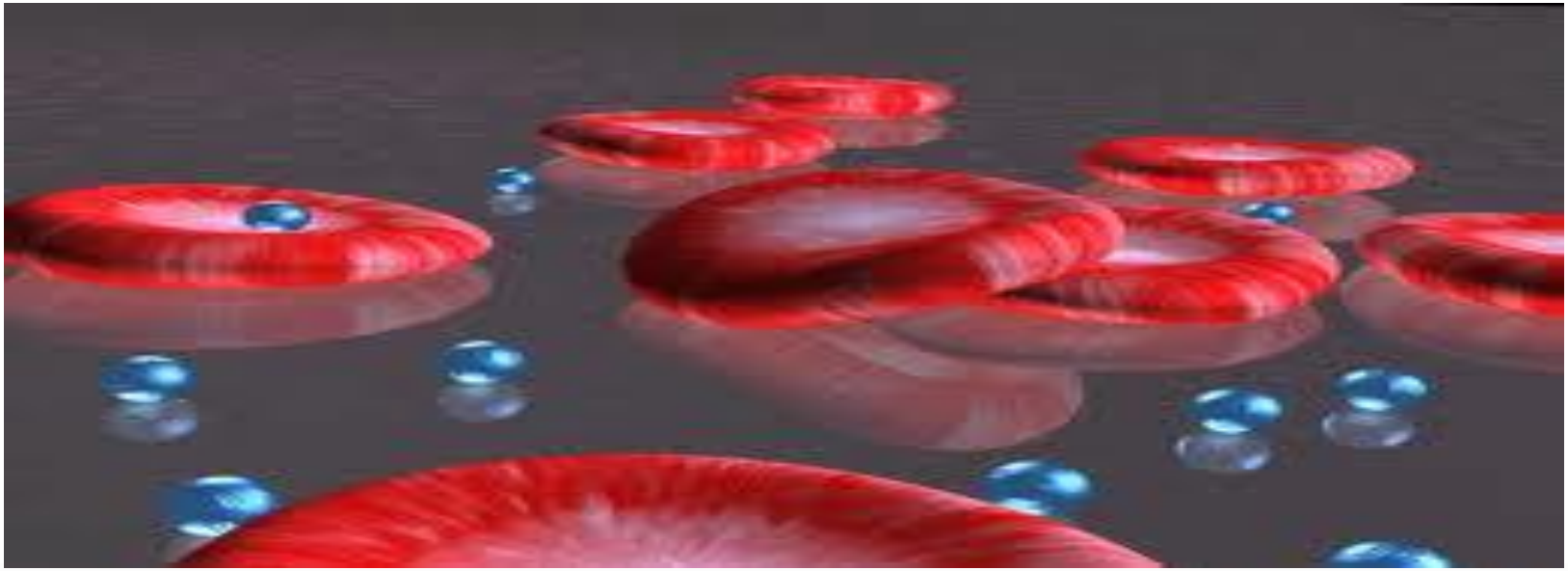
Federal state budgetary educational institution of higher education "Volgograd state medical University" of the Ministry of health of the Russian Federation

Department of clinical laboratory diagnostics

LECTURE №7
Acid-base balance.
Fluid and electrolyte balance.



Acid-base balance - constant concentration of hydrogen ions in the extracellular space and in the cells

Concentration H^+ mol/l	pH
$0{,}000000001 = 10^{-9}$	9
$0{,}00001 = 10^{-5}$	5
$0{,}1 = 10^{-1}$	1

- **The metabolic activity of the cells, the function of enzymes and stability of the membrane depends on the pH. Most of the enzymatic reactions in the body takes place in a narrow range of pH (7,30-7,50).**

- **In some cells, the pH can very significantly (4.5 in the prostate and 8.5 in osteoblasts).**

By metabolism in the body per day produced 15 billion nmol of hydrogen ions.

Whereas the concentration of hydrogen ions in the extracellular fluid OK - 100 nmol / l.

- **To maintain the pH of the blood, there are buffers:**
- **bicarbonate,**
- **phosphate,**
- **hemoglobin**
- **etc.**

The buffer system

It is a combination of a weak acid and salt of the acid.

When the buffer systems are replaced strong acid (or base) to the weak, the number of free ions [H +] decreases.

In plasma most significant bicarbonate and protein buffer systems, weak acid buffer which is in equilibrium mainly sodium salts of these acids.

Bicarbonate buffer system

- **Capacity is 53% of the buffer capacity of the blood (plasma bicarbonate - 35% bicarbonate, red blood cells - 18% of the buffer tank).**

Consists of:
H_2CO_3 / $NaHCO_3$ = 1/20

Bicarbonate buffer value due to the fact that CO_2 and H_2O with an excess of rapidly excreted by the kidneys and lungs, respectively.

The pH of the blood depends on pCO_2 - respiratory component of ABB.

With an excess of a shift to the right, forms carbonic acid and H^+ and acidosis.

The shortage of CO_2 is a shift to the left and alkalosis.

Hemoglobin buffer system

- **Form in the tissues carbon dioxide enters the red blood cells and is converted into carbonic acid (H_2CO_3). Under the influence of the enzyme carbonic anhydrase erythrocytes H_2CO_3 dissociates into H^+ ion and anion HCO_3^-.**
- **Hydrogen ion binds to hemoglobin and phosphates. Bicarbonate anion returns to the blood plasma. Electro-neutrality is maintained by moving the red blood cells of chloride ions. In erythrocyte anion chlorine binds to potassium cations.**

Hemoglobin buffer system

- **In the lungs, resulting oxyhemoglobin binds much of potassium, resulting in anion chloride is displaced beyond the red blood cells and binds to the sodium cation, which was released in removing carbon dioxide.**
- **As a result, there is an active education and the delay in the body of the anion HCO_3^-(base) and the removal of carbon dioxide.**

The phosphate buffer system

- **Is greatest in the renal tissue and the regulation of ABB.**
- **The blood in the main role is to maintain the continuity and reproduction bicarbonate buffer.**
- **Represented one-based phosphate NaH_2PO_4 (weak acid) and dibasic Na_2HPO_4 (weak base).**

Functional systems of the body involved in the regulation of ABB are:

- **Respirtory,**
- **Urinary,**
- **Digestive system,**
- **Biliary bypass**
- **Skin**

Respiratory System

- **With the increased formation of hydrogen ions bicarbonate system associates with hydrogen ions to form water and carbon dioxide, which is excreted in expired air.**
  $H^+ + HCO_3\text{-} = H_2CO_3 = H_2O + CO_2$

Adequate ventilation changes are regulated by the respiratory center, which is sensitive to carbon dioxide and hydrogen ions.

Pulmonary mechanisms provide temporary compensation, since this reduces the oxygen capacity of arterial blood.

Urine system

- **The kidneys excrete ions [H +] (acidogenesis, ammonium genesis), are reabsorbed and syntesied HCO3-. Carbon dioxide from the blood plasma and urine with carbonic anhydrase converts:**

$H_2O + CO_2 = H_2CO_3 = H^+ + HCO_3^-$

The resulting ion [H +] is secreted into the lumen of the tubules, which is neutralized by buffer systems glomerular ultrafiltrate.

LIVER

- The regulation occurs through
- the oxidation of organic acids produced in the Krebs cycle,
- oxidation of lactic acid (45% metabolized)
- Formation of urea [CO(NH2)2] from ammonia,
- secretion in the bile of sodium bicarbonate,
- excretion through the bile into the intestine shunted metabolic products.

Digestive tract

- **Maintaining ABB provided by regulating the quantity and quality of absorbed and excreted electrolytes and water.**
- **In the stomach, secreted iones [H^+] and Cl^-.**
- **Normally, this phenomenon is quickly corrected by bicarbonate secretion into the lumen of the intestine and reabsorption of chloride ions.**

Key indicators of ABB blood

Key	Norma
pH blood	7,40
pCO_2	40± 5 mm Hg
AB	19-25 mmol/l
SB	20-26 mmol/l

- - PH - the level of hydrogen ion plasma.

- PCO_2 - an indicator of partial tension of CO_2 in the blood. Reflects the functional state of the respiratory system.

- AB (astua1 bicarbonate) - true plasma bicarbonate, HCO_3^- in the blood.

- SB (standart bicarbonate) - standard bicarbonate plasma. Bicarbonate content in standard conditions ($rS0_2$ = 40 mm Hg, NO_2 = 100%, to = 37°C).

Key indicators of ABB blood

Key	Norma
BB	44-52 mmol/l
BE	±2.3 mmol/l

- BB (buffer base) - base buffer plasma, the sum of all major components of bicarbonate, phosphate, protein, hemoglobin systems.
- BE (base excess) - shift buffer bases reflects the changes in the content of blood buffer bases.

Acidosis and alkalosis

- **Acidosis - change of ABB, in which the blood appears absolute or relative excess acids.**
- **Alkalosis - change ABB characterized by absolute or relative increase in blood basic valences.**

On the degree of compensation, all the states can be divided into:

- **Compensated - pH = 7,40 ±, 04**

- **Subcompensated**
  acidosis - pH 7,35-7,31
  alkalosis - pH 7,45-7,49

  Decompensated
  acidosis - pH <7.30
  alkalosis - pH> 7.50

Metabolic acidosis

Develops when tissue metabolism disorders with excessive formation and accumulation of non-volatile acids or loss of bases.

The causes of metabolic acidosis:

- ***hypoxia (hypoxic, circulatory, hemic, tissue);***
- ***uncompensated diabetes mellitus,***
- ***prolonged fasting;***
- ***prolonged fever,***
- ***infectious and inflammatory processes.***

Laboratory indicators of metabolic acidosis

- **Compensated acidosis: bicarbonate ions and the partial pressure of carbon dioxide in the blood is reduced, but the ratio is not changed.**

- **Decompensated acidosis: blood pH, pCO_2, AB, SB, BB are lowered.**

Carbon dioxide acidosis

Respiratory acidosis is characterized by an increased concentration of hydrogen ions in the blood due to a delay in the body of carbon dioxide.

- **Causes of respiratory acidosis:**
- ***disorders of the central regulation of breathing in trauma and tumors of the brain, bleeding in the brain;***
- ***poisoning by morphine, barbiturates, alcohol;***
- ***hypoventilation resulting from obstructive changes in the lungs***
- ***incorrectly selected mode ventilation;***
- ***arteriovenous shunting in the lungs for respiratory distress syndrome, extensive atelectasis and severe pneumonia.***

Clinical manifestations of respiratory acidosis

- **Against the background of hypercapnia develops paralytic vasodilatation of the brain, increases the production of cerebrospinal fluid, increased intracranial pressure. Severe violations of possible generalized CNS depression. <u>Hypercapnia and hypoxia call:</u>**
- ***Giperkateholaminemia.***
- ***Stimulates the vasomotor center. Enhanced cardiac function (heart rate, IOC, SV), the tone of the arterioles, develops hypertension or a tendency to it.***
- ***With continued respiratory acidosis increases tissue hypoxia, Arrhythmias reduced sensitivity to adrenergic catecholamines.***
- ***Advanced heart failure, hypotension, disorders of the gastrointestinal tract, pulmonary hypertension.***

Laboratory indicators of respiratory acidosis:

- **pH of the blood is reduced;**
- **pCO2, AB, SB and BB increased;**
- **BE - a moderate shift in the positive direction;**
- **Chloropenia as a result of the enhanced urinary excretion;**
- **Hyperkalemia in the initial stages of acidosis, replaced later hypokalemia (within 5-6 days).**

Metabolic alkalosis

Characterized by a deficiency of the ions [H +] in the blood in combination with an excess of bicarbonate ions.

Causes of metabolic alkalosis:

loss of acidic ions in anacatharsis acute liver failure; hypovolemia (uncontrollable vomiting, diabetes insipidus, acute blood loss, osmotic diuresis with hyperglycemia, diuretics); transfusion of massive doses of bicarbonate in the correction of acidosis, or sodium citrate (with massive transfusion);

Laboratory indicators of metabolic alkalosis:

- **pH, AB, SB, BB increased;**
- **BE strongly positive;**
- **pCO2 moderately elevated;**

Respiratory alkalosis

Is the result of hyperventilation, there is a rapid elimination from the blood and reducing carbon dioxide pCO2 below 35 mm Hg.

- **The causes of respiratory alkalosis:** ***stimulation of the respiratory center in pathological processes in the central nervous system (trauma, tumor process); high fever (especially in children), pyrexia; hyperventilation during mechanical ventilation; salicylates poisoning, carbon monoxide.***
- **Laboratory indicators of respiratory alkalosis:**
- **pH of the blood and urine pH increased;**
- **sharp decline in pCO2;**
- **AB, SB, BB lowered;**
- **BE moderately negative;**
- **hypocalcemia;**

LEVEL SHIFT ABB

- **If different in character shifts ABB blood pH remained within normal limits, such changes can be considered compensated;**
- **If the pH is out of the norm, then the violation of ABB may be either partially compensated or uncompensated (depending on the degree of deviation of the pH).**

Compensation mechanisms disorders of acid-base balance

Types of violations	compensation mechanisms
Respiratory Acidosis	PH reduction offset by increased bicarbonate reabsorption by the kidney and back into the blood Arterial gipoksiemiya offset by increased red blood cell count
Respiratory alkalosis	Compensation by buffer systems: Kidneys - increased excretion of bicarbonate in the urine due to decreased reabsorption in the kidney
Metabolic acidosis	Due to respiratory mechanisms: Decrease in the partial pressure of carbon dioxide
Metabolic alkalosis	Due to respiratory mechanisms: By withdrawing from the lungs of CO2

Water-salt metabolism

Water-salt exchange is a set of processes of water and salt consumption(electrolytes), their absorption, distribution in internal media and excretion from the body.

- **Daily human consumption of water is about 2.5 liters, of which about 1 liter it gets from food.**
- **In humans, two-thirds of all water is contained in the intracellular fluid, and one-third in the extracellular fluid.**

CLINICAL MANIFESTATIONS? VIOLATIONS

- **Excess water and electrolytes in the body clinically manifested as edema syndrome (*nephrotic syndrome, kidney disease, heart failure in cardiovascular disease, cirrhosis of the liver, etc.*).**
- **The patient can observe weight gain, nausea, vomiting does not bring relief. Skin and mucous membranes moist, body temperature often decreases.**
- **Defined peripheral edema, fluid in the abdominal and thoracic cavity. Urine output is reduced.**

CLINICAL MANIFESTATIONS? VIOLATIONS

- **Causes of loss of liquids *(hyperthermia syndrome, kidney disease, with polyuria, diabetes insipidus and PTH hypersecretion, uncontrollable vomiting, diareeya, etc.) with irrational and uncontrolled use of powerful loop diuretics***

Negative fluid and electrolyte balance clinically loss of more than 1/3 of the extracellular water.

Manifested as severe headache, fall in body weight, thirst, dryness and decreased elasticity of the skin and mucous membranes, respiratory rhythm irregularities and heart rate, drop in blood pressure, dizziness, seizures, an increase in hematocrit.

Types of violations of water-electrolyte balance

1. **Hypoosmotic dehydration. The intake of water (without electrolytes) exceeds its allocation.**
2. **Hyperosmolar dehydration. With the simultaneous introduction into the large amount of water and electrolytes.**
3. **Hypoosmotic hypohydration. With the loss of water and electrolytes, but filling by introducing water without salt.**
4. **Hyperosmolar hypohydration. The loss of water exceeds its introduction into the body and endogenous formation.**

Edema

Called edema with accumulation in the body cavities and intercellular spaces of water and electrolytes.

Having an excess of sodium in the intravascular and interstitial spaces, often with kidney disease, chronic liver failure, increased permeability of the vascular walls.

Anasarca - is accumulation of fluid and electrolytes into the subcutaneous tissue. Hydrothorax - a fluid in the chest cavity, hydropericardium - in the pericardial sac, ascites - in the abdominal cavity.

Causes edema

Heart failure, and the venous pressure increases, increased filtration in the capillaries.

This decreases the release of salt and water by the kidney and, in turn, increases the amount of blood and leads to a further increase in hydrostatic pressure in the capillaries, further contributing to the development of edema.

Thus, if no action is taken for the treatment of heart failure, the totality of all these factors lead to the development of generalized extracellular edema.

Causes edema

- **Edema caused by decreasing allocation of water and salt by the kidneys. Is an increase in extracellular fluid volume (extracellular edema), an increase in pressure due to the increased blood volume.**
- **Edema, caused by a lower protein content in the plasma. In various diseases of the kidneys are damaged glomeruli, and their membranes become permeable to plasma proteins**
- **This leads to a decrease in oncotic pressure, which, in turn, increases fluid filtration in the capillaries, leading to extracellular edema.**
- **Significant generalized edema were observed at concentrations of the protein in plasma below 25 g / l.**

Regulation of water-salt metabolism

In human plasma ion concentration ismaintained with a high degree of permanence and is (in mmol / l):

- ***Sodium - 136-145,***
- ***Potassium - 3,5-5,1,***
- ***Calcium - 2,3-2,75 (including ionized not bound to proteins - 1,12-1,32).***

Cells are characterized by a higher content of potassium ions than in the blood plasma and interstitial fluid and a low concentration of sodium ions.

Regulation of water-salt metabolism

- **Water-salt metabolism is regulated by antidiuretic and antinatriuretic systems.**
- **Osmolality and volume receptors placed in the atrium, pulmonary veins, and the mouths of some arteries.**
- **The central authorities of regulation are neurosecretory supraoptic and paraventricular nucleus of the hypothalamus that control the synthesis of anti-diuretic hormone (vasopressin).**

Methods of indications of mineral metabolism

- **The concentration of electrolytes in the blood plasma is the result of a dynamic equilibrium between them, to the intracellular content and clearance from the body.**

- **Knowledge of pathological processes that lead to a change in the ionic composition of the blood plasma or the concentration of the individual ions in it, it is important for the differential diagnosis of various diseases.**

Methods of indications of mineral metabolism

- **Currently, there are a few basic methods of analysis - and ionometry, flame photometry, and for total calcium - atomic absorption spectrophotometry.**

Methods of indications of mineral metabolism

- **In recent decades, there were ion-selective analyzers. For the determination of inorganic phosphorus using colorimetric methods.**

- **At present study acid-base balance of blood is carried by gas analyzers, which, given the temperature and blood pressure directly determine the concentration of H+ions (pH) and the index pCO2 (the amount of CO2).**

Thanks for your attention