Changes in the Chemical Composition of Blood

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The chemical composition of blood varies within rather narrow limit values. Relative constancy is more marked when certain components are concerned and less manifest when others are involved. Thus, mineral components allow narrower quantitative variation limits than organic substances concentration, more precisely than extractive substances, which may vary between wider limits. The variations of the formed elements/plasma ratio, which are common in pathological states, hinder the study of the chemical composition of blood, due to the fact that these oscillations are reflected in the overall chemical composition of blood. In most cases, chemical research needs to be conducted on blood serum and plasma, as they are more constant in their composition.

Keywords: changes, chemical composition, minerals, potassium, sodium, phosphorus, iron

Blood spreads throughout the body by thousands of channels and microscopic streams *-the capillaries-*. All the cells suck from it their *nutrient broth*, the food digested by the stomach and intestines, and release into it their superfluous substances and carbon dioxide. In addition to oxygen, blood also supplies many very varied substances: salts, acids, vitamins, enzymes, nutrient products and decomposition products.

Even when it is examined under a microscope, all that one sees in blood is a red opaque veil. However, when blood is diluted about 200 times and then a drop is examined under a microscope, it reveals a picture that filled the Dutch Leeuwenhoek with enthusiasm. He was the first to see it 200 years ago [1]. Here is what he saw: a multitude of pink-yellowish disks with convex edges and concave middle. They were the erythrocytes, the red blood cells [2]. They play a very important role on the life's stage: erythrocytes absorb oxygen in the lungs and supply it to consumers. On their way back, the microscopic *carts* are not empty, but carry carbon dioxide from the tissues to the lungs, which eliminate it. The most important role in the red cell is played by hemoglobin-complex protein, a molecule to which iron atoms are bound and to which the purple color of the blood is due [3].

Nutrients and intermediary metabolism products are continuously released in the blood [4]. As it passes through various organs, especially the lungs, gastrointestinal tract and kidneys, blood receives certain substances and releases other substances. The biochemical, physical, chemical and morphological properties of blood vary within narrow limit values. The relative constancy of blood composition is set due to the reflex activity of the nervous system which regulates the connections and correlations between organs.

Experimental part

Material and methods

The main physical and chemical properties of blood (acid-base balance, density, osmotic concentration, electrical conductivity, superficial tension, viscosity) are often changed in pathological conditions.

From 2014 to 2016, we have investigated 37 patients admitted to the Medical Clinic of *Sf. Apostol Andrei* Galati County Emergency Clinical Hospital, who showed changes in the physical and chemical properties of blood. Due to the emergency nature of hospital admission, our study group provided the opportunity to investigate a large number of diseases that affect the biochemical composition of blood.

Results and discussions

Blood density was decreased in 5 cases (13.51%). Blood density depends mainly on the number of erythrocytes, the amount of proteins and the concentration of sodium chloride. A decreased blood density was found after the dilution of blood. The cases indicated different forms of malnutrition.

Surface tension of blood and blood serum is subject to variation. As a result of asphyxia, surface tension decreased in 3 cases (8.10 %), when the amount of surfactants increased significantly.

Carbon dioxide is one of the essential components of blood and it has influenced the osmotic pressure. Respiratory disorders (4 cases - 10.8%) and circulatory disorders (3 cases - 8.10%) led to an increased osmotic concentration of blood.

The character of the diet is reflected on the blood viscosity [5]. The meat rich diet led to an increased viscosity (7 cases -18.91%), and the carbohydrate-rich diet caused a decreased blood viscosity (5 cases - 13.51%).

The rate at which hypotonic hemolysis occurs is determined by the osmotic resistance of erythrocytes. Certain forms of anemia are characterized by increased osmotic resistance and haemolytic anemia shows decreased osmotic resistance (4 cases - 10.8%). Large variations in resistance were found in 6 patients (16.21%) with kidney diseases, due to the accumulation of sodium chloride and disintegration products in blood, which influences the permeability of erythrocytes. The gradual decrease of the osmotic pressure of the environment causes haemolysis while preserving the integrity of the erythrocyte stroma. The rate of erythrocyte sedimentation is accelerated by the increase in plasma globulin and fibrinogen.

Proteins are the essential component of the internal environment of the body. A decrease in the blood concentrations of proteins (*hypoproteinemia*) is connected to severe metabolism disorders, such as, disorders caused by prolonged starvation, cachexia, hepatic and renal lesions, hemorrhage, abundant transudates and exudates. One of the manifestations of these disorders is hydremia

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(blood dilution) and colloid osmotic pressure decrease in the plasma, which is especially maintained by albumins [6].

Blood enrichment using proteins may be relative and is determined further to blood viscosity increase (anhydremia), as a result of severe diarrhea, burns, persistent or incoercible vomiting or in other states accompanied by dehydration.

The changes in the relations between different forms of proteins are extremely important. Fibrinogen makes up 0.25% (3.2% of the total amount of proteins), globulin 2.5% (32.3%) and albumin 5% (74.5%) of the total amount of blood proteins (7.75%). Variations in the protein composition of blood are possible not only in different individuals, but in the same individual at various times of the day. The increase in the amount of fibrinogen (hyperinosis) (sometimes up to 1.5%) is rather common in different infections (tuberculosis, pneumonia), and especially in nephrosis. The reduction of the amount of fibrinogen (hypinosis) is uncommon, occurring only after severe liver lesions, which are the main source of fibrinogen.

Under normal circumstances, the serum albumins/ globulins ratio is 1.5/2.3, by somehow diminishing the quantity of albumin, whereas the quantity of globulin increases, as an expression of the variations in the immunological reactivity of the body in its daily existence.

In pathological conditions, the changes in the quantity of serum proteins are found mainly in globulins. The albumins/globulins ratio changes are very high in acute and chronic infectious diseases, when antibodies accumulate in the blood as globulins, according to their chemical structure. This ratio is also upset in hepatic diseases, in cardiovascular system function disorders, in cachexia and in disorders of the function of the central nervous system, which regulates the metabolic processes.

Globulins are divided into two fractions: *pseudoglobulins* and *euglobulins*. Globulins are involved in immunological reactions, in which they are thought to play a vital role. Albumins carry water, salts, bilirubin and urobilin. This explains the higher blood albumin concentration during jaundice.

Among the protein metabolism products, there are substances that make up the *non-protein nitrogen* group. Non-protein nitrogen designates nitrogen-containing substances which remain in the solution after blood protein precipitation. This group includes urea, uric acid, creatinine, purinic substances, substances of the adenilic complex, carbaminic and hipuric acid, as well as amino acids and intermediate purine degradation products.

Depending on the individual properties of the body, the amount of non-protein nitrogen in the blood ranges from 20 and 40 mg %. Functional kidney failure and certain liver function disorders often cause protein decrease and hydremia phenomena associated with non-protein nitrogen level increase in the blood (*azotemia*). A nonprotein nitrogen level increase in the blood occurs due to cachexia of different origins, for instance due to blastomatous increase, pernicious anemia, etc.

Nitrogen metabolism products may also accumulate in the tissues, and this often materializes in the increase of the amount of non-protein nitrogen in the blood. The amount of *urea* often increases, which, in normal conditions, makes up 35-50 % of the whole non-protein nitrogen. Any increase in the amount of urea over 40mg% exceeds the normal variation limits (25-35mg %). The ingestion of a large amount of nitrogen-containing food may increase the amount of urea in the blood.

Starvation and pregnancy cause the decrease in the amount of urea due to nitrogen substance degradation diminution. A significant decrease in the amount of urea in blood is usually detected in patients with liver conditions (when urea synthesis is low) or with tissue acidosis, when the ammonia is used for acid neutralization and it is no longer turned into urea.

Uric acid accumulates in the blood (*hyperuricemia*) in patients with purinic metabolism disorders, for instance, gout. In normal conditions, the amount of uric acid in the blood is about 3-4 mg %. An increase in the amount of uric acid in the blood occurs before gout attacks (when it reaches 6-8 mg % or even more), in patients with leukemia, due to the disintegration of the cell elements, or in certain metabolic disorders caused by kidney diseases and liver failure.

The detection of a high amount of *ammonia* may be an indication of a pathogenic condition of certain organs, like the liver and kidneys, involved in amino acid deamination and urea forming processes.

Creatinine and *creatine* occur in blood plasma in very small amounts: 1-2 mg% creatinine and 1-1.5 mg% creatine.

Creatinine accumulates in the blood (hypercreatinemia) in functional hepatic and renal disorders (where creatine is turned into creatinine). The accumulation of these substances occurs due to muscle metabolism disorders and muscle tissue disintegration in which creatinic metabolism plays an important role.

The amount of substances in the adenylic complex, adenosine triphosphoric acid, decreases due to various muscle metabolism disorders. Their amount may increase due to glycolytic process intensification (during inflammation).

Amino acids, intermediate protein metabolism products, occur in the blood as a result of their resorption in the intestine and of the protein metabolism processes which occur in the tissues. They have very high levels in blood in acute yellow atrophy of the liver, when the amount of nitrogen in amino acids may reach 25mg % or even more, instead of 5-8mg %.

The increase of bile pigments, especially bilirubin (hyperbilirubinemia) in the blood serum is specific to liver conditions, especially in jaundice. In certain forms of jaundice, the amount of bilirubin reaches 30-40 mg % (instead of 0.5-1mg% in normal conditions). In such cases, the blood plasma or serum becomes first yellow and then black-brownish [8].

A special reaction allows the detection in the serum even of bilirubin traces. Bilirubin accumulation in the blood may also be detected in experimental conditions, when it causes hemolysis and liver lesions in animals due to phenylhydrazine intoxication.

The increase in the amount of bile pigments in blood occurs in pernicious and hemolytic anemia, when the destruction of the red blood cells and the turning of the hemoglobin released by erythrocytes into bilirubin are detected. This transformation occurs in the reticuloendothelial elements.

Blood serum color may also depend on red blood cell hemolysis, i.e. on hemoglobin leaving the cells; the blood plasma, the blood serum may also contain hemoglobin derivatives which are formed further to the accumulation in the blood and in the hematopoietic organs of toxic substances and different metabolic products.

Hemolysis, which occurs under the influence of nitrites, potassium permanganate $(KMnO_4)$, KCL_3 , causes *methemoglobin*, which contains an amount of oxygen

twice smaller than oxyhemoglobin, oxygen being in a nondissociated form [7]. Methemoglobin also emerges in the blood in anaerobic septicemia, in pregnancy toxicoses and in certain forms of autointoxication (for instance, due to intestinal inflammatory processes accompanied by intestine nitrite resorption).

Carbon oxide intoxication causes *carboxyhemoglobin* formation, which dissociates much harder than oxyhemoglobin and usually causes hypoxia phenomena. In addition, carbon oxide blocks the respiratory ferment, which contains a heme complex.

One of the hemoglobin derivatives is *hematoporphyrin*, whose presence in blood is accompanied by the increase of *porphyrin* release: *porphyrinuria*. It occurs in intoxications.

The blood and plasma undergo changes in what concerns their ferment content: diastasis, maltase, lipase, nuclease, peroxidase and catalase.

Parenteral heterogeneous protein administration intensifies especially the proteolytic activity of blood. Blood ferment activity changes in case of malignant tumors, leukemia, anemia and pregnancy.

The catalase content changes in many diseases, for instance in infectious diseases and especially in nutrition disorders, in vitamin deficiency and in lesions of the various areas of the central nervous system. In the latter cases, cholinesterase activity changes are marked, as it is involved in nervous impulse transmission. The quantities of substances inhibiting enzyme reactions (antiferments) also change.

The discovery of specific *antitoxin*, *hemolysin*, *cytotoxin* etc. is characteristic to immunity reactions. In most cases, these substances are easily precipitated together with globulins.

The *mineral* components of blood are characterized by better constancy than the organic components. The mineral parts occur in the blood in an ionized state, as nondissociated molecules, as well as in combination with colloidal substances, especially with proteins. Even if calcium, phosphorus, potassium, sodium, chloride, magnesium, and iron collectively represent 3.2%–3.3% of a normal adult body weight, they are essential for body physiology [9]. Calcium and magnesium are considered major minerals [10].

In normal conditions, the potassium/calcium ratio in blood plasma and serum shows better constancy and ensures the physical-chemical status required by proteins and lipoids: serum calcium (9-11mg %) and serum potassium (13-23mg %). The increase of the amount of calcium in the serum or in the plasma is rather rare. The higher the hydrogen ion content of the blood, the higher the amount of active dissociated calcium in the blood.

The decrease of the total and ionized calcium content is usually connected to the hypofunction of epithelial corpuscles; in such cases, the potassium content is high; in rickets, the K/Ca coefficient changes in the opposite direction. The change of this coefficient often depends on the vegetative nervous system activity disorders; calcium is connected to the function of the sympathetic nervous system, and potassium with the activity of the parasympathetic nervous system.

By determining the overall amount of calcium and potassium in the serum, plasma or blood, one cannot have a precise image on the actual K/Ca coefficient, since calcium may occur in the blood in different states: as ions or as molecular and colloidal compounds.

Sodium occurs in the blood as sodium chloride (450-500mg % in total blood and 570-720 mg% in plasma). Due to the uneven distribution of chlorides among the blood cells and plasma, the pathological states accompanied by the diminution of the number of erythrocytes (for instance, in anemia) are characterized by a relatively high concentration of chlorides in total blood, whereas in polycythemia their concentration is lower. Therefore, in clinical conditions, it is more correct to determine chlorides in the plasma.

The sodium content of blood (as sodium chloride) usually decreases during fever; its blood concentration decreases in anemia and other blood conditions.

The chloride content of blood also varies; it may increase in hydremia and in infectious diseases and decrease in intestinal occlusion; chloride content decrease is also detected in certain kidney diseases, due to chloride retention in tissues or to kidney chloride release disorders, as well as in vomiting, when the body loses a big quantity of hydrochloric acid. In edemas, the sodium chloride content varies within wide limits.

Inorganic *phosphorus* occurs in more or less constant amounts in the plasma (2.8mg%). An insignificant plasma phosphate content decrease was detected in pregnancy and it is probably related to the fetus bone development processes. The amount of phosphates is lowered in the blood in rickets; therefore, the Ca/P coefficient remains high in rickets.

Phosphate increases in the blood during muscle activity, as well as under the influence of vitamin D, in uremia and in other pathological processes.

Iodine, fluoride, copper, zinc, manganese, chromium, molybdenum, selenium are considered trace minerals. Arsenic, boron, bromine, cadmium, lead, lithium, nickel, silicon, and vanadium are ultratrace elements [10].

There have been attempts of establishing a connection between blood iodine concentration changes and alterations of the thyroid gland function, between fluoride and the thymus and thyroid function and between bromine and the hypophysis and diencephalon function [11].

Iron exists in the structure of hemoglobin. Iron ingested from food has either a ferric or a ferrous oxidation state. Most of the food iron is in the ferric form. In vitamin A deficient individuals, liver and spleen stores of iron cannot be used for producing hemoglobin [12].

Conclusions

The investigation of changes in the chemical composition of blood is a useful diagnostic tool. It can also provide prophylaxis for various diseases, through recommending changes in diet or the avoidance of exposure to air and water pollution. Therefore, blood testing procedures, which are the most common medical tests, help healthcare workers to initiate therapy in the early stages of disease.

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