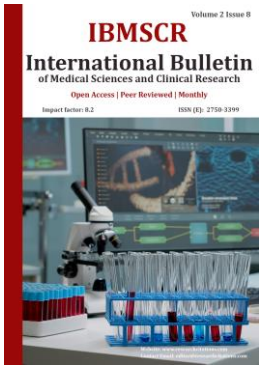

CHARACTERISTICS OF DIFFERENT FORMS OF RADIATION AND PATHOGENETIC ASPECTS OF ITS EFFECT ON THE HUMAN BODY

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Resume. It is known that ionizing types of radiation include short-wavelength electromagnetic vibrations, X-rays and γ-radiation, flow of α- and β-particles (electrons), flow of protons, positrons, neutrons and other charged particles. According to the absorption capacity of these particles during external radiation, it is not excluded that they penetrate into different layers of tissues, α-radiation and X-ray radiation have high absorption properties, and β-radiation has a lower absorption capacity. It has been determined that external ionizing radiation has a negative effect on the body only when it is present in the body during its exposure. Under the influence of ionizing radiation, various radioactive substances (radionuclides of sodium, phosphorus, etc.) occur in the body. Over a period of time, the victim's body becomes a carrier of these radionuclides, as a result of which internal radiation develops. Due to the instability of radioactive isotopes, the energy in the form of γ-radiation decays with the release of corpuscular particles in the form of α- and β-radiation.
Keywords: electromagnetic vibrations, X-rays and γ-rays, flow of α- and β-particles (electrons), protons, positrons, neutrons.

Radioactive substances can enter the body through intact skin, the gastrointestinal tract (GI) and the respiratory system. After entering the body, radioactive substances spread to organs and tissues through blood and lymph flow. The most dangerous isotopes are those characterized by a long decay period and, after entering the body, can be an internal source of radiation for the entire life of the victim.

Different forms of radiation are characterized by different levels of biological activity and danger. The initial stage of radiation exposure is ionization of atoms and molecules of cellular structures, which is accompanied by functional and organic disorders of organs and systems. The pathogenesis of radiation sickness is related to the complex combined effects of direct and indirect effects of ionizing radiation on the body. The direct effect of high-dose radiation on protein structures is accompanied by their denaturation and subsequent disintegration. In this case, the depolymerization of nucleic acids develops in the damaged cell with the disruption of physico-chemical processes, which leads to an increase in the permeability of the cell membrane. Cellular structures most sensitive to radiation include nuclear chromosomes and cell cytoplasm.

The indirect effect of radiation is associated with the occurrence of radiolysis of water, which makes up 75-80% of the mass of all organs and tissues of the body. In the process of water ionization, it has been proven that radicals with different oxidizing and alkaline properties are formed.

The greatest importance is given to the formation of atomic hydrogen, hydroperoxyl radicals and hydrogen peroxide during the irradiation process. Free oxidizing radicals undergo an enzymatic reaction in which active sulfhydryl groups are converted to inactive disulfide compounds. The emerging biochemical processes lead to a decrease in the catalytic activity of thiol enzyme systems, which leads to a significant decrease in DNA and RNA in cell nuclei, their renewal process is disturbed.

According to the radiation dose and its spread throughout the human or animal body, their death rate and causes vary. The bone-marrow form of acute radiation sickness (ARS) is the most common, in which death occurs in 7-30 days from the moment of exposure, depending on the type of mammal, and the causes of death are often hemorrhagic syndrome or infectious complications.

Changes in biochemical processes in cell nuclei are morphologically represented by various chromosomal diseases and disorders of the entire genetic system of the body. Radiotoxins accumulate in cell nuclei damaged by radiation for some time, disturbances in hormonal and neurohumoral processes develop, which in turn negatively affects metabolic processes. Toxic amino acids similar to histamine begin to be produced in the body. Tissue intoxication is manifested by clinical signs of nervous system dysfunction, changes in the functioning of internal organs.

Studies have shown that damage to the hematopoietic system is an important pathogenetic link in the development of light disease. It has been proven that the hematopoietic system of the body is most sensitive to the effects of radiation, especially bone marrow cells. Under the influence of radiation, bone marrow aplasia develops, mitotic processes slow down in hematopoietic organs, and lead to total death of poorly differentiated bone marrow cells. A significant decrease in blood formation occurs with the emergence of hemorrhagic syndrome.

Specific harmful effects of ionizing radiation on sensitive tissues and organs (stem cells of hematopoietic organs, testicular epithelium, small intestine and skin) and non-specific effects on nervous and endocrine systems play a leading role in the development of light disease. A certain importance is attached to disorders of the hypophysis, adrenal glands and thyroid gland. Elimination of radioactive elements occurs through OIT, kidneys and respiratory.

NOC is a group of clinical syndromes that occur after short-term exposure to absorbed radiation from a few seconds to 3 days at doses exceeding 1 Gr (100 rad) allowed to the body. According to the total level, strength and distribution of the doses in the body parts, it affects the hematopoietic organs (1-10 Gr), intestines (10-20 Gr), general hemodynamic and toxemic symptoms (20-100 Gr) and disorders related to the brain (100 Gr). can pass with dominant damage.

The reason for the occurrence of nuclear explosion is γ-neutrons, X-rays and β-radiations caused by a nuclear explosion, mode change or violation of the rules of operation in stationary nuclear-energy facilities. As a result of the impact of ionizing radiation, simultaneous damage to all organs and systems occurs - acute damage to cellular structures, genetic apparatus, blood-forming structures of bone marrow, lymphatic system, OIT epithelium, skin, lungs and other organs.

The power of radioactive action is of great importance, because the same amount of energy absorbed by the cell damages more biological structures, the shorter the exposure time. A significant dose of radiation emitted over a longer period of time is much less harmful than a similar dose absorbed over a short period of time. Confirmation of ONC is based on the

indicators of individual and group dosimetric monitoring devices, anamnestic data and characteristic clinical signs.

Chronic radiation sickness (CNS) is a complex clinical syndrome that develops in case of long-term exposure to ionizing radiation at doses higher than the permissible dose. Characteristic signs of CNK are the duration and undulation of the course, the presence of signs of damage to the body as a result of radiation exposure in the clinical symptomatology, as well as the manifestation of recovery and adaptation reactions. Development periods of CNK: formation period; recovery period; period of consequences of radiation sickness.

In modern conditions, there is a risk of radiation for the population of many countries. The reason for this is, first of all, the existence of a developed industrial network engaged in the production of electricity and thermal energy by processing nuclear energy in more than 40 countries, nuclear facilities designed for energy production, and their accidental or intentional destruction leads to the formation of mass sanitary loss centers. A significant increase in the radiation load on the population is also associated with the wide use of ionizing radiation sources and radionuclides in various fields of production and science, especially in medicine. It has been proven that in developed countries, the number of people in professional contact with ionizing radiation is 8-9% of the population.

It is worth mentioning that, at the same time, work is being carried out to increase the military nuclear potential and large-scale modernization. There are about 19,000 nuclear weapons in the arsenals of nine nuclear-armed states. Other countries that have the potential to produce such weapons have or are capable of developing them. These situations do not ensure the maintenance of strategic stability and inevitably lead to the reduction of the "nuclear threshold", the possibility of using nuclear weapons in the initial stage of an armed conflict or local war. It is necessary to develop and improve measures to ensure the radiation safety of military personnel, including the field of immunoprophylaxis, taking into account the danger and threat of radiation factors for the health of the population, national security, and socio-economic development of countries.

The results of epidemiological studies of the last decade show an increased risk of diseases of the circulatory system, the basis of their development of which is atherosclerotic damage of blood vessels in the cohorts of people exposed to professional, man-made and medical radiation. The authors present the results of studies on the in vitro mechanism of atherosclerosis development in experimental animals and individuals exposed to radiation. Ionizing radiation has been shown to be one of the contributing factors to the development of atherosclerosis.

Kotenko K.V. based on a long-term study of hematopoiesis in 152 people who underwent ONK under the influence of γ-, γ-β- and γ-n-irradiation in a wide range of doses (1.2-9.8 Gr), transient cytopenic syndromes are more frequent in the long term observed in cases: thrombocytopenia in 26.9% of cases, leukopenia, neutropenia and lymphocytopenia in 13.1% of patients. In the long-term period, the number of multidirectional deviations compared to the norm (cytopenias and cytoses) increases with the increase in the severity of ONA, which indicates the relationship between the tension of the hemopoietic process and the absorbed dose of radiation exposure. The number of cytopenias increases with the addition of chronic persistent hepatitis, cirrhosis of the liver and evening radiation ulcers. Oncohematological diseases develop ten times more often in people who have undergone TNA than in people who have not been irradiated.

Individuals with cases of radiation sickness, which occupy an intermediate position between ONK and CNK and differ in their clinical presentation by acute subacute course, were analyzed. This variant of the course of the disease can develop as a result of fractionated or long-term radiation, which lasts from several days to several weeks. The appearance of a primary reaction occurs only in extreme cases, often ending in early death. Bone marrow syndrome after general radiation is characterized by a well-defined period of formation and recovery, the individual characteristics of its course are determined by the duration of radiation, the total dose and the power of radiation released from them. The most typical outcomes of the acute course of radiation sickness are death from infectious complications during the peak of the disease or the development of leukemia in the long term.

The problem of reducing the radiosensitivity of biological objects, including people, is one of the central problems of radiobiology. Modern researchers have discovered the radioprotective effect of many chemical compounds, which their introduction into the body increases radioresistance and alleviates the course of radiation sickness. Basically, these are radioprotectors, which are used immediately before radiation in sufficiently large doses.

Prophylactic radiation agents include substances that increase the body's resistance to radiation in "sublethal" doses, causing the bone marrow form of radiation sickness of varying severity. These are immunomodulators, hormonal preparations, vitamins, adaptogens of plant raw materials, bee products, antioxidants. The author has shown that the use of zootoxins as radioresistance stimulators is a sufficiently promising direction in radiobiology today.

The clinical and hematological materials of 114 patients who underwent advanced NSC as a result of γ- and β-irradiation in the late period (from 1.5 years to more than 20 years after the radiation accident) are presented. In the period of the late effects of NK, the average values of peripheral blood are within the limits of physiological norms, in some patients cases of transient non-profound cytopenia are detected (thrombocytopenia 22.7%, leukopenia 12.2%, neutropenia 13.1%, lymphocytopenia 10.5%). In the dynamics, it became known that in the late period of TNA (1.5-20 years after radiation), the average level of erythrocytes, leukocytes, neutrophils and lymphocytes in the blood is within normal limits. But in the individual analysis of the functional state of hemopoiesis, transient and long-term cytopenias were observed in some patients.

It has been determined that the subacute course of radiation sickness can be observed when receiving radiation in the range of 0.1-0.3 Gr per day. The initial symptoms of the disease in the form of signs of a primary reaction were not observed at all. The first complaints appear at least a month after the start of work in unfavorable conditions, on average after 6 months. Pancytopenia in the blood during the formation period is characteristic, and the duration of this period is also determined. After the cessation of radiation exposure, hematopoietic recovery is slow and may not be complete, and hemoblastoses are more likely to develop.

Zolotareva S.N., Logacheva V.V. [2018] studied the modifying effects of hypoxic gas mixture and electromagnetic radiation on the effect of γ-irradiation on the ratio of the gastric mucosa to the main morphological criteria in 4-month-old white male rats. The authors considered the priority of using modifiers based on morphofunctional changes in the ileal mucosa, mathematical prediction and correlation adaptometry. According to the results of the study, morphological signs of the development of compensatory-adaptive reactions involving fat and mitotic cells of the mucous membrane of the ileum under the conditions of using a hypoxic gas mixture and electromagnetic radiation, respectively. In the complex application of factors, a

modifying effect contributing to the increase of radioresistance and the development of the general adaptation syndrome is concentrated.

The authors found that fractionated radiation has a lower biological effect than single radiation at comparable doses. This phenomenon is explained by the development of the most intensive recovery processes that occur in the body during breaks between radiations.

Pathological processes that occur in the body in response to the effects of radiation involve various human systems and organs in an indirect process through the immune system, which has high radiosensitivity. A characteristic feature of ionizing radiation is the long-term preservation of defects in individual joints of the immune system and the emergence of complications as a result. It is known that the regular dependence of the effect on the size of the radiation dose occurs in the dose range of 1-7 Gr.

To date, a mathematical model has been developed to calculate the distribution of absorbed energy around γ-radiation sources in internal organs, both in experiments and in humans. In recent years, a number of scientific studies aimed at assessing the risk of the effects of radiation at different doses have been conducted.

The study of the effects of ionizing radiation on the body is closely related to the assessment of the activity of regulatory networks that coordinate systemic responses to radiation exposure, one of the main of which is apoptosis, which dominates the population of immunocompetent cells in lymphoid organs, which makes the study of disorders of the immune system at the level of functional characteristics of immunocompetent cells an urgent issue.

After irradiation, the barrier-fixing function of the epithelial cover decreases due to the damage of all its antimicrobial components. The bactericidal activity of the serum begins to decrease when exposed to sublethal doses of radiation due to the decrease in the amount of lysozyme and properdin in it. At the level of lethal doses of radiation, the decrease in bactericidal activity is caused by antibodies, transferrins, interferons, β-lysins, fibronectin and complement is maximally expressed due to the additional decrease in its content.

In addition, blocking cell proliferation by ionizing radiation leads to a decrease in the number of macrophages and natural killers (NK). All this destroys the innate immune mechanisms that ensure resistance to infection of the irradiated organism. The authors concluded that radiation of mammals impairs the innate immune system and immune defense against indigenous and transient microorganisms. This condition is described as total secondary (post-irradiation) immunodeficiency.

Lebedev S.M., Fedorova I.V. [2020] believe that by affecting the immune system, radiation causes changes in the regulation of the immune response and the death of immunocompetent cells. The response of the immune system to the effects of radiation depends on its dose, exposure, power and type of radiation. The authors suggest that cells of the immune system differ in their radiosensitivity. T-lymphocytes (T-helpers and T-suppressors), V-lymphocytes and thymocytes of the thymus have the greatest sensitivity. The death of these cells occurs after exposure to radiation, in which the radiosensitivity of V-lymphocytes is higher than that of T-lymphocytes. Memory T-cells retain their functional activity after radiation at a dose of 6-10 Gr.

Jetpisbaeva H.S. [2014] proved that in the initial period of the general adaptation syndrome, the mass of the thymus decreases and the number of lymphoid cells increases, and in the later stage, the mass of the thymus increases and the number of lymphoid cells normalizes. Proved

that the proliferation of lymphoid cells occurs in the bone marrow at all stages of the adaptation syndrome.

Solovev V. Yu. [2011] analyzed the hematological parameters of victims of the 1986 Chernobyl NPP accident. The correlation between the relatively uniform external radiation dose and certain hematological criteria was evaluated: "the concentration of lymphocytes in the blood on days 2, 3 and 4", as well as their "average value on days 3-7" and "500 neutrophils per day". For each tested test, its statistical error was estimated over the entire dose range. As a result, it was concluded that the "average number of lymphocytes on days 3-7" has the greatest informative value, and in the late periods (8-21 days) "500 neutrophils per day" test. The prognostic value of hematological criteria and the dose of human β-uniform radiation were evaluated to assess the severity of radiation damage as a result of the work.

Antonishkis Yu.A. [2013] studied the role of hematological indicators, the effect of low doses of ionizing radiation and a number of physical factors of a non-radiation nature in the system of early diagnosis of acute radiation syndrome. The characteristics of the effect of different options of radiation exposure on hematological indicators are given. Possibilities of using television microscopy and spectrophotometry stations to record informationally important changes in erythron under the influence of adverse environmental factors are shown. Methods of early hematological diagnosis of the severity of acute radiation sickness, pre-nosology conditions are highlighted.

It is known that chronic exposure to low doses of ionizing radiation primarily affects the T-system of the immune system, which causes the development of autoimmune processes. The results of the analysis of the suppressive effect of radiation on the immune system showed that immunodepression is determined by the disruption of cell functions. Studying the nature of immune disorders under the influence of different levels and types of radiation allows the results to be used to predict the consequences of long-term radiation [Uzbekov D.E., 2016].

Vlasenko A.N. According to [2019], radiation damage from internal radiation occurs in various situations in the conditions of professional activity. Radiation sickness caused by internal radiation is a collective concept and depends on the properties of incorporated radionuclides. In an isolated form, ONK rarely develops from internal radiation, more often SNK occurs. The main condition for the successful treatment of radiation sickness caused by internal radiation is to limit the victim's work with the source of ionizing radiation. Further treatment is carried out according to the same principles as the treatment of radiation sickness caused by external radiation - it should be complex, individual and correspond to the severity of the disease. Medicines used in the case of radioactive substances entering the gastrointestinal tract include gastric lavage, cleansing enemas, laxatives, diuresis enhancement, and mucolytics and expectorants are used in case of inhalation.

The clinical and hematological materials of 114 patients who underwent advanced NSC as a result of γ- and β-irradiation in the late period (from 1.5 years to more than 20 years after the radiation accident) are presented. In the period of the late effects of NK, the average values of peripheral blood are within the limits of physiological norms. However, transient non-profound cytopenic states are detected in some (thrombocytopenia 22.7%, leukopenia 12.2%, neutropenia 13.1%, lymphocytopenia 10.5%). During the dynamic study, it was found that in the late period of NK (1.5-20 years after radiation), the average level of group erythrocytes, leukocytes, neutrophils and lymphocytes in the blood were within physiological limits. But in

the individual analysis of the functional state of hemopoiesis, transient and long-term (for many years) cytopenias were observed in some patients.

It is known that radiation damage to the gastrointestinal tract is one of the serious problems of gastroenterology. The most frequently manifested form is the intestinal form of ANC, a violation of the functional activity of the stomach. These symptoms are divided into periods that reflect different degrees of damage to the digestive organs. All this begins with damage to the DNA apparatus of epitheliocytes, and then the functioning of cells and organs is disturbed. Today, there are many approaches to the treatment of OIT. The authors recommended the use of a special diet with a high content of protein, fat, carbohydrates, vitamins, glucocorticosteroids, 5-aminosalicylic acid, and enzyme preparations, and the use of enzyme agents as a substitute treatment. According to them, timely detection and treatment of radiation damage of OIT can alleviate the condition of patients [Erstenyuk Yu.N., Tsvetkova D.A., 2018].

Thus, the obtained data indicate that some work has been done on the effects of radiation on the human body. However, there was a need to study materials on the effect of different forms of radiation on body organs and tissues.

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