MINISTRY OF HEALTH PROTECTION OF UKRAINE
ODESSA NATIONAL MEDICAL UNIVERSITY

Medical Faculty №2

Department of radiation diagnostics, therapy and radiation medicine and oncology

I APPROVE
Vice-rector for scientific and pedagogical work
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September 1, 2023

METHODOLOGICAL DEVELOPMENT TO THE LECTURES ON THE EDUCATIONAL DISCIPLINE

Faculty, MEDICAL course, 5th year

Educational discipline RADIATION MEDICINE

Odesa-2023

Approved:
Department meetingradiation diagnostics, therapy and radiation medicine and oncology
Odessa National Medical University

Protocol No. 1 dated 30.08. 2023

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Lecture No. 1

Topic: History of the development of radiation medicine

Relevance of the topic: In connection with the rapid development of atomic energy, the large-scale use of sources of ionizing radiation in industry, agriculture, as well as in medicine, the risk of radiation-related diseases is extremely high. Therefore, issues related to the peculiarities of the action of ionizing radiation on the human body, the principles of treatment of radiation injuries and prevention of the consequences of exposure to humans are particularly relevant.

Goal:

Educational: form ideas about the subject of radiation medicine, its connection with other disciplines, get acquainted with the historical path of development of radiation medicine, the structure of the nucleus; characteristics of types of ionizing radiation; learn questions related to dosimetric aspects of radiation action.

Basic concepts: the history of the development of radiation medicine, the discovery of X-ray radiation, the discovery of radioactivity, historical stages of the development of radiation medicine. `

Content of lecture material (lecture text)

Humanity first learned about the existence of the invisible world of high-energy radiation, got acquainted with its properties and features about 100 years ago. In December 1895, Würzburg University professor V.K. Roentgen informed the scientist world about the discovery of a new type of radiation, which he called X-rays (known today as X-rays). They possessed an amazing, mind-boggling ability: to penetrate through objects opaque to visible light - wood, fabrics, cardboard, the human body. The discovery of miracle rays instantly burst out of the pages of scientific physical magazines into the wide world of human passions, passions and delusions, became the first truly scientific sensation, the first step in the 20th century, in the era of the scientific and technological revolution.

The new rays attracted the close attention of scientists, and not only physicists. Biologists and doctors rightly saw them as a tool for studying living organisms, recognizing and treating human diseases. During the first year after Roentgen's discovery, more than 1,000 scientific articles and 49 books were devoted to the use of X-rays in medicine, and just six months later, the Russian scientist-physiologist, student of I.P. Pavlova - I.R. Tarkhanov published the first study on the effect of X-rays on the nervous system of animals.

X-rays were only the first of a whole cascade of brilliant achievements of scientific thought, which revealed to humanity the existence of the invisible world of elementary particles, the mysterious forces uniting these particles within the atomic nucleus. Then, at the dawn of the 20th century, even the greatest minds could not predict that the breakthrough of science into the microcosm would lead to the mastery of gigantic forces hidden in the atomic nucleus, to the creation of nuclear weapons and to the use of atomic energy for peaceful purposes, to atomic terrorism and the Chernobyl disaster.

The significance of new discoveries in physics and the history of human society in those years was understood by few. One of them is V.I. Vernadskyi, the first President of the Ukrainian Academy of Sciences. In 1911, he wrote without reason: "We are approaching a great upheaval in the life of mankind, which cannot be compared to anything that will ever be experienced by them. The time is not far when man will allow him to build his life as he wants. It can happen after a century, but it is clear that it will definitely happen. But will man be able to use this power, directing it for good, and not for self-destruction."

The newly opened holes never ceased to impress the imagination. Radiation of radioactive elements does not depend either on the composition of chemical compounds or on the pressure in the entire range of influence that science possessed. It became clear: radioactivity is based on deep physical laws that do not depend on the interaction of atoms and molecules, on the state of their electron shells. On the other hand, it turned out that the radiation of each radioactive element weakens over time according to a certain law characteristic of it. Some radioactive substances remain active quickly, others slowly, and in the process of radiation they themselves change their physical nature, disintegrate, turning into other substances. Their physical half-life - the time during which the intensity of radiation is halved - became a measure of the long-term existence of radioactive elements. Thus, the half-life of polonium is 13B days, radium - 1620 years, uranium - 4.5 billion years.

The source of energy emitted by radioactive substances remained a mystery for a long time. Back in 1933, P. Curie drew attention to that. that radium is not only a source of invisible radiation, but also heats up during this process. An attempt to calculate the amount of heat released during the radioactive decay of radium produced an unexpected and mind-blowing result. It turns out that one gram of radium, during its existence, releases 4000 times more energy than is produced by burning 1 ton of hard coal.

The study of radioactivity not only brings scientists closer to the knowledge of the fundamental laws of nature, but also opens the way to mastering the gigantic reserves of energy concentrated inside atoms. Penetration into the essence of the laws of the microcosm became the general direction of the development of science in the 20th century, and the prospect of using atomic energy was a mile-long path of research and development.

A BIT OF HISTORY

The emergence of radiation medicine owes to three great discoveries that crowned the end of the last century

1895 - discovery of X-rays by Wilhelm Konrad Röntgen.] 896 - discovery of the natural radioactivity of uranium by Henri Becquerel. 1898 - discovery of the radioactive properties of polonium and radium by Maria Skladovska-Curie and Pierre Curie.

Humanity has paid dearly for the discovery of the secret of nature. Almost all the first researchers died, many doctors. In the middle of the 20th century, the world witnessed the massive, one-time death of hundreds of thousands of people. Opposite the X-ray Institute in Hamburg, where T.E., one of the pioneers of medical radiology, worked for many years. Albres-Schonberg, who died from radiation cancer, on April 4, 1936, a monument erected by the German society of radiologists was unveiled. On its front side is an inscription: "The monument is opened to radiologists and radiologists of all nations, doctors, physicists, chemists, technicians, laboratory assistants and nurses who sacrificed their lives in the fight against the diseases of their loved ones. They heroically paved the way for the effective and safe use of X-rays. rays in medicine. Their glory is immortal." On the monument the names of 169 people who died by that time from unbearable radiation damage are engraved in alphabetical order. A year ago, their biographies and portraits were included in the "Book of Honor" specially published by Mayer. Later, the memorial was supplemented with two more monuments with the names of 17 victims, and in 1959, the second edition of the "Book of Honor" contained 360 more names. For the period from 1936 to 1959 when the development of nuclear research took on a gigantic scale, and many more people were drawn into the sphere of influence of ionizing radiation than before, the number of victims of science only doubled, with many of the victims dying from diseases that arose in the early years. The reason for such a happy dissonance between a sharp increase in human contact with ionizing radiation and an even more significant relative decrease in the frequency of radiation injuries is determined by the success of a new field of knowledge - radiation medicine. Paradoxically, the rapid development of radiation medicine was facilitated by the threat of a nuclear disaster. The inhuman experience of using a nuclear bomb in Japan, and later - a sharp increase in the radiation background of the Earth, put forward an urgent global task - the development of the problem against radiation protection, which requires a deep study of the mechanisms of the biological action of ionizing radiation. A new wave of interest in the problem was caused by the Chernobyl disaster in 1986. Thousands of scientists around the world contribute to the development of radiation medicine.

After such a cursory excursion, which showed what a high price humanity paid for mastering atomic energy, let's return to a sequential description of the main events, remembering their enormous importance for world progress. This is a clear example of the drama of facts and ideas, which are so rich in the history of mankind.

DISCOVERY OF X-RAYS AND RADIOACTIVITY.

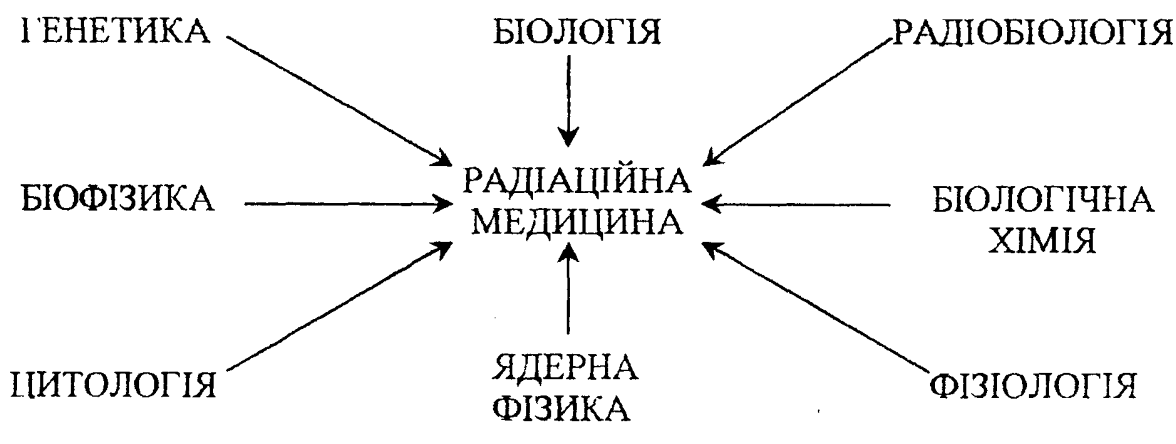
V.L. Roentgen was 50 years old at the time of his great discovery. At that time, he was in charge of the Institute of Physics and the Department of Physics of the University of Würzburg. On November 8, 1895, Röntgen finished his experiments in the laboratory late in the evening. Having extinguished the light in the room, he noticed in the darkness a greenish glow, which emitted crystals of plate-blue-red barium. It turned out that a Crooks tube was nearby, wrapped in black paper, and was under high voltage, which Roentgen had forgotten to turn off before leaving. The glow stopped immediately as soon as the current was turned off, and immediately resumed when it was turned on. Cathode and visible rays did not penetrate through the black paper, and the scientist was overcome by a brilliant guess that when a current passes through the tube, some unknown radiation appears in it, which he called X-rays. 50 days were absorbed by hard work. The crown of this self-sacrificing creation was the manuscript, containing 17 short pages sheet of paper, which Röntgen presented to the Chairman of the Würzburg Physico-Medical Society on December 28, 1895, together with the world's first X-ray image of his hand. In the early days of 1896 Röntgen's brochure is out of print, and in the coming weeks - translation into Russian, English, French, Italian.

The Russian translation, entitled "A New Kind of Rays, was released to the world in St. Petersburg and included photographs of the first radiograph of the hand, made in Russia on January 16, 1896. On January 6, 1896, the news of the discovery of all-penetrating rays by X-ray was transmitted by the London Telegraph to the whole world. All humanity accepted this news. as the biggest sensation. On January 23, 1896, Röntgen's triumphant speech took place at a meeting of the Society of Naturalists in Würzburg, where the scientist took a picture of the hand of the famous anatomist Kelliker to the applause of the audience. The respected scientist said that in 48 years of the work of the scientific society, he had never been present at such a He gave a three-fold "Hurray" in honor of Röntgen and proposed to name the new rays after him.

December 10, 1901 Röntgen was awarded the first Nobel Prize in Physics for his outstanding contribution to science. Volumes have been written about the significance of the discovery itself and the depth of Röntgen's experimental analysis of a new type of radiation. In the memoirs dedicated to the 50th anniversary of the discovery of X-rays, Academician A.F. Ioffe, who worked with Röntgen for about 20 years, wrote: "Not one word can be changed from what Röntgen published in the first three messages. Many thousands of researchers could not add a single note to what Röntgen himself did in the most elementary conditions with the help of the most elementary devices." The reaction of ordinary people and the press of those times to the sensational discovery is quite interesting. Some New York newspapers wrote that the new rays could photograph the souls of the dead. They reported that at the College of Surgeons, X-rays were used to project anatomical images directly into the brains of students, giving them only "stronger" knowledge than conventional teaching methods. On February 19, 1896, a bill was passed prohibiting the use of X-rays in theater binoculars for moral and ethical reasons. One of the newspapers of that time wrote: "We are tired of new rays. The best thing to do is to burn all the X-rays, execute all the researchers, sink the equipment of the whole world. Let the fish look at their bones, not us..." . The resulting newspaper uproar could not dampen curiosity about the biggest discovery. X-rays became not only the subject of deep study all over the world, but also quickly found practical application. In addition, they served as an impetus for the discovery of a new phenomenon - Natural Radioactivity - which stunned the world no less than six months after the discovery of X-rays. These were the first glimpses of the atomic dawn, invisible to the human eye. They appeared on the photographic film left on the table by Henri Becquerel, professor of physics at the Paris Museum of Natural History. He is a recognized authority in the field of luminescence - at that time, like many others, he was interested in the nature of all-penetrating X-rays. Investigating the sunlight-induced glow of various minerals. Becquerel discovered that it also occurs when uranium salts are illuminated. It turned out that if such a salt was placed on a photographic plate wrapped in black paper and exposed to the sun, when the plate was exposed, it lit up only in the place where the uranium salt lay. Becquerel decided to repeat this study, but the day turned out to be gloomy and the experiment had to be postponed, and the plate was in a dark desk drawer. Two days later - March 1, 1896, it was a sunny day again and it was possible to conduct research. Driven by intuition, the scientist decided to develop the plate without illuminating it with the sun's rays, and to his surprise, clear outlines of a cross appeared on the plate (it was in the shape of a cross that uranium salts lay). And so it was established that, regardless of sunlight, uranium emits "uranium rays" invisible to the eye. So, both great discoveries are largely due to chance. But let's remember the wise words of Louis Pasteur that "chance only helps minds prepared for discovery." Indeed, long before Röntgen and simultaneously with him, many researchers worked with cathode rays, observing even the glow of the screen, and therefore "saw" X-rays, but only V.K. X-ray: and because "...only those who deserve it come across a chance at great discoveries." After Röntgen's discovery, dozens of researchers were busy searching for new mysterious rays. But only the inquisitive and talented A. Becquerel managed to distinguish spontaneous emission of penetrating radiation by uranium from luminescence induced by sunlight.

The study of this phenomenon became the subject of passionate searches, first by the great Polish scientist Maria Skłodowska-Curie, and soon by her fiancé - the no less brilliant French researcher Pierre Curie. 11 years of their love and joint creativity - one of the best pages in the history of science - was marked by the discovery and isolation of several radioactive elements, the main ones being polonium and radium (July and December 1898, respectively). in 1903, the Nobel Prize in Physics was awarded to Pierre and Marie Curie and A. Becquerel. In 1911, Marie Curie was awarded the second Nobel Prize for her work in the field of radiation chemistry - such an honor has not been awarded to more than one scientist to this day. In 1935, 32 years after her parents, their daughter Irene received the Nobel Prize - for the discovery of artificial radioactivity (together with her husband Frédéric Joliot-Curie). History knows no example of two married couples making such a contribution to world science in the next two generations as a family Curie. Devotion to science was such that their lives were literally sacrificed. Marie, Irene and Frédéric Joliot died of radiation sickness: and there is every reason to predict that only Pierre Curie's early death as a result of the disaster saved him from the same fate.

Radiation medicine is a complex scientific discipline, closely related to a number of theoretical and applied areas of knowledge (see Fig. 1), such as:



Мал. 1. Зв'язок радіаційної медицини з іншими дисциплінами.

Radiation medicine, its successes, are largely determined by the successes of related disciplines - radiobiology, which studies the biological effects of ionizing radiation. The study of the biological effect of ionizing radiation began at the time after the discovery of X-rays. Among the early works, the classic studies of the Russian scientist I.R. Tarkhanov, who in 1896 set up an experiment on frogs and insects reacting to radiation. Based on this, they suggested the possibility of therapeutic use of X-rays. Only a year after that, 49 books and more than 1,000 articles were published. They were devoted to the use of X-rays in medical practice.

In 1896, a report appeared in the press about skin lesions (dermatitis, erythema) in people who were affected by frequent and long-term effects of ionizing radiation. In 1902, Friben described the first case of radiation skin cancer. In 1914, about 115 cases of X-ray cancer, which were detected by medical and technical personnel, were described in the literature. As noted in 1933 by S.I. Nemenov - "at the convention of radiologists, you could meet veterans of radiology without fingers and even without an entire limb due to amputation due to cancer." Albers-Schonberg, Bergognier, Levy-Dory, Rosenblatt and others became victims of cancer. By 1959, 359 radiologists were known to have died from radiation skin cancer or leukemia The first information about radiation cancer comes from the 16th century. famous doctors of the Middle Ages (Paracelsus, Agricola and others) wrote about a mysterious lung disease in miners working in mines, where uranium and radium were later mined.

In 1879, long before the "era of radiation", Harting and Hesa recognized lung cancer in this disease.

From July 1901, A. Becquerel carried an ampoule with radium in his vest pocket for 6 hours and received skin burns. About this after 10 days, when erythema appeared. a long non-healing ulcer, the scientist told M. Curie: "I am happy to love, but angry with him."

These observations allowed P. Curie and Busharoyan Balthazar to come to the conclusion about the therapeutic effect of radium on lupus and some forms of cancer and served as the beginning of cure therapy.

The first attempt in the history of x-ray therapy for cancer was the work of doctor Jillmann from Chiko. He was approached by the physicist Grubbe about severe radiation burns on his hand. Gillmann was surprised by the effect of X-rays, and he sent a patient with breast cancer in an inoperable stage to Grubbe for irradiation. This treatment session was carried out on January 29, 1896, almost a week after Roentgen's triumphant message. The best effect was obtained, that is, Grubbe himself continued the practice of X-ray therapy (received some medical education). Later, he also became a victim of radiation cancer.

No one assumed that X-rays could affect internal organs, so for a long time the object of research was the skin. In 1903, Llbers-Schonberg discovered degenerative changes in the epithelium and azoospermia in guinea pigs and rabbits. In 1905, Halberstadter observed ovarian atrophy in irradiated females. Soon, Osgood and Brown discovered azoospermia, which turned out to be the cause of infertility in young workers at the X-ray tube factory who had worked at the company for a short period of about three years.

In 1903, under the influence of the works of E.S. of London, who discovered the lethal effect of radium rays on mice, H. Heinix used X-rays for this. He managed to cause the death of animals and he first described the typical changes in bone marrow cells and lymph nodes during histological examination.

In numerical experiments, E.S. London demonstrated the effect of radium radiation on body systems, in particular, on hematopoiesis.

In 1911, a monograph by E.S. of London "Radium in Medicine and Biology" - the first book on radiobiology and printed in German.

The given examples show the first stage of the development of radiobiology, as characterized by works of mainly descriptive nature.

But already in this period, two cardinal facts were established: radiation caused by ionization 1) inhibits cell fragmentation (Cornix, 1905) and 2) causes changes in different cells to radiation, varying in degree of their detectability (I. Bergognier, L. Tribondo). Spermatogonia were the most sensitive, and spermatozoa were the most resistant, the radiation of which did not cause morphological changes at all.

On the basis of these experiments, in 1906, provisions were formulated that went down in history under the name of the "Bergonnier-Tribondo law (rule): the more radiosensitive cells are, the more they have the ability to reproduce and the less differentiated they are. This rule has not lost its meaning to this day.

Thus, already in the earliest period of initial observations, the most important feature of ionizing radiation was noticed, namely: the selectivity of their action, which is determined by the properties of those cells on which the radiation acts.

Thanks to this, despite the completely identical radiation conditions of one and the same cell, tissue, organ, some cells are severely damaged and die, while others do not show any damage. For example, when the spleen or testicles were irradiated, the disappearance of all (or the total majority of) lymphoid elements was observed, while the fibrous elements and Sertoli cells (in the ovaries) were completely preserved.

Very early in 1903, the role of nuclear damage in cellular radioactivity was discovered. The conclusion about this was made by D. Bui.

Already in the first decade of the 20th century, the study of the effect of ionizing radiation on embryogenesis began. Although the early observations were of fundamental importance, they were still descriptive in nature. There was no theory explaining the mechanism of action of irradiation on a living object.

The second stage of the development of radiation medicine is connected with the formation of quantitative principles, which aims to relate the effect to the radiation dose.

This stage is characterized by mass experiments on different populations of cells and animals with quantitative display of results on "dose-effect" curves.

In 1922, F. Dessauer proposed the first theory that explained the radiobiological effect of radiation. These views were later reflected in the "principle of hits" and "theory of targets" in the works of I.V. Timofeev-Resovsky, K. Tsmmer, D.E. Lee et al., researcher-practitioners.

One of the epoch-making events of radiobiology revealed the effect of ionizing radiation on the genetic apparatus of the cell, which is accompanied by the hereditary transmission of newly acquired traits. For the first time, such studies were carried out by G.A. Knudson and G.F. Filippov in 1925 in surveys on yeast. This greatest discovery, unfortunately, did not receive the appropriate high attention at the time assessment and only after the work of H. Mellcher, who discovered the mutagenic effect of ionizing radiation in experiments on Drosophila, genetic research began to be conducted worldwide on a broad front. A powerful impetus to the rapid development of radiobiology was the success of nuclear physics, which marked the prospect of mastering the energy of the atomic nucleus. In the USA, in the early 1940s, special laboratories were created near large cities (Argonne, Bruchhevia, and others).

In the USSR, such centers were Moscow, Leningrad, Kyiv, Minsk, Sverdlovsk, Novosibirsk, Alma-Ata and other cities. Radiation medicine developed especially intensively after the barbaric atomic bombing of the Japanese cities of Hiroshima and Nagasaki.

The main task was the development of anti-radiation protection and treatment of radiation injuries, which, in turn, requires a detailed study of the mechanisms of the radiobiological effect and the pathogenesis of radiation sickness.

In the period from the 1940s to the 1950s, the largest research centers appeared in Europe and other continents. They are often organized at institutes and hospitals, usually oncological ones. We began intensively conducting research in Japan (Sugahara).

A broad international discussion of radiation medicine issues was held in 1955 at the Geneva Conference on the Peaceful Use of Atomic Energy. From that time, the third stage in the development of science began, which continues to this day,

Over the past 20 years (at least once a year), very representative international or national congresses, conferences, and symposia have been held on specific issues of radiation medicine. 1,200 scientists from 40 countries attended the Second International Congress on Radiation Research (England, 1962). V (USA 1974), VI (Argentina 1978) Koshresy were even more ostentatious.

At the United Nations in March 1910, the first radiological laboratory in Russia was created in a building designed by the prominent architect Baranov under the leadership of the corresponding member of the Academy of Sciences of Ukraine E.S. Burkser. Even today, his work on the determination of air radioactivity in medical areas on the coast of the Black and Azov seas has not lost its significance.

The accident at the Chernobyl nuclear power plant once again reminded us of the awesome power contained in an atom that has gone out of human control, and the danger posed by high doses of nuclear radiation. However, medical science was not caught off guard by this event. Our doctors were prepared to provide assistance to accident victims. Odesa scientists intensively deal with topical problems of medical radiology and problems related to the rehabilitation of victims of the Chernobyl disaster. The Research Institute was created under the leadership of Professor K.D. Babova Head of ODMU

Department of Spa Resorts, FUV Professor V.V. Kents and his colleagues developed methodological developments for the treatment of residents of the radionuclide-contaminated territory of Ukraine in sanatoriums in Odessa.

School of Prof. Savitskyi (Prof. Lytovchenko, Naphanuk, Rozanov, Mardashko, Lukyanchuk, Nagiyev) successfully developed the important field of radiation dysfermentoses.

GENERAL VALUES ABOUT RADIATION,its sources.

The word "radiation" often refers to what has a more specific name, "ionizing radiation." Radiation will be ionizing if it is able to break the chemical bonds of molecules that make up a living organism and thereby cause biological changes. Radio wave light, like natural solar heat, is a type of radiation. However, they do not cause damage by ionization, although, of course, they can show bioeffects if the intensity of their action is increased.

Ionizing radiation is of the following origin: first of all, these rays are X-rays and gamma rays. They represent energy transmitted in the form of waves without any movement of matter, just like light and heat from the sun, which pass through the vacuum of space until they reach the Earth. X-rays and gamma rays in their nature and properties do not differ from each other.

The only difference between them is in the means of formation, if X-rays are usually obtained with the help of an electronic device, similar to the one that can be seen in any dental clinic, then gamma rays are emitted by unstable or radioactive isotopes. Other types of ionizing radiation are represented by substances, fast-moving particles. Some of them carry an electric charge, and others are neutrons.

Neutrons are uncharged particles that are formed during each radioactive transformation. They are the most important type of ionizing radiation: they are usually associated with processes occurring in atomic bombs and nuclear reactors.

Neutron is an electroneutral particle whose mass is equal to the mass of an aproton, but unlike the latter, neutrons do not have an electric charge.

Due to the fact that these particles are electrically neutral, they penetrate deeply into all substances, including living tissues. When nuclei of heavy elements (uranium and others) split to form two lighter atoms, neutrons are emitted as a byproduct of the reaction. Neutrons can be obtained artificially in physical laboratories using powerful particle accelerators. Electrons are light negatively charged particles that exist in all stable atoms. They emit during radioactive decay of matter, and then they are called beta rays. These particles can also be obtained in laboratory conditions.

Protons are positively charged particles that are found in the nuclei of all atoms, their mass is approximately equal to the mass of a neutron and almost 2000 times the mass of an electron. Protons are not normally emitted by radioactive substances, but they have been found (in large numbers) in outer space, posing a possible hazard to research astronauts.

Alpha particles are the nuclei of helium atoms, but, in other words, helium atoms that are devoid of orbital electrons and consist of two protons and two neutrons joined together. They have a positive charge and are relatively heavy. Usually, alpha particles are emitted during the radioactive decay of isotopes (uranium and radium).

Heavy ions are the nuclei of other atoms, devoid of orbital electrons or moving at high speed. Ions of almost all known elements are present in space, which creates difficulties in ensuring the safety of space flight. But it is not possible to design a spacecraft that completely protects the crew from all kinds of heavy ions, which are carried at great speed and possess enormous energy.

Naturally, radioactive elements are contemporaneous with the birth of the Universe, a witness to the emergence of the Solar System, the formation of the Earth. During the billions of years of Earth's existence, the process of radio decay of unstable atomic nuclei took place. As a result, the total radioactivity of the Earth and rocks gradually decreased. Relatively short-lived isotopes decayed completely.

Mainly elements with a half-life comparable to the age of the Earth itself have been preserved.

Cosmic rays are a stream of elementary particles flying to the Earth's surface from outer space and increasing its natural radioactive background at sea level by an average of 25-30%. They are characterized by high penetrating ability.

The first cosmic rays are heterogeneous: a particle of solar origin, a particle of galactic origin, and a particle of intergalactic origin.

The penetrating ability of cosmic radiation is great. Spacecraft shells are not an obstacle for radiation particles. The half attenuation layer of cosmic radiation is 1 m of lead or 10 m of water.

The natural radiation background, as already mentioned, consists of naturally radioactive elements of rocks, as well as water, air, soil and cosmic radiation.

In most countries, the natural background slightly differs from the average value of 100 mrad (or 0.1 rad) per year. On the surface of the seas and oceans, the contribution of the Earth's radiation decreases by more than half, and the total amount of the background drops to 60-70 mrad per year. In the world we live in, the world is radioactive. This reality is not only present day. This has always been the case on Earth - since the birth of the solar system and the formation of our planet.

Then, billions of years ago, the radioactivity of the Earth's substance was much higher than it is now. The following abyss of years completely absorbed the radiation of short-lived isotopes existing at that time. Only short-lived elements have survived to this day, if you do not count their daughter products of decay and constantly born radioactive products of the interplay of cosmic radiation and the atmosphere. But their number has significantly decreased compared to the original. Therefore, the entire history of the Earth (the year of our planet - let's recall - 5.3 billion years) took place under the conditions of a constant decrease in its radioactivity.

At this time, in the Odesa region, the power of the exposure dose of gamma radiation (11 μR/hour), caused by natural radioactivity.

According to these data, the total radioactivity of beta-irradiation of atmospheric aerosols of artificial origin (0.0026 ±0.0004*10"15 Ki/g).

The maximum value of total beta activity is 0.019 ±0.005*10"14 Ki/g (for cesium - 13) and 0.066±0.12*10"17 Ki/g (for strontium - 90). Excess temporary permissible level (TDR - 88) was not detected in food products.

A significant number of people are exposed to ionizing radiation in occupational settings.

Let's consider the main types of work and professional groups with different levels and types of radiation exposure.

X-RAY RESEARCH IN MEDICAL INSTITUTIONS.

The main radiation factor is the external irradiation of the tube in the transmittance mode, which is uneven in both localization and depth. According to the data of American researchers, at the age of 25-30 years, the total exposure doses reach 1000-2000 R for the entire working time. In recent years, only single cases of lesions have been described.

ANALYSIS.

The main radiation hazard is the possibility of local irradiation of the hands, eyes, and head from an intense working beam with relatively low radiation elements (10-40 kV). the power of the dose due to the small distance from the anticathode of the tube and weak filtering of rays can reach such a size that in a few seconds the irradiation will be sufficient for the development of acute radiation lesions of the skin.

RADIATION THERAPY.

The main radiation factor for personnel working on therapeutic properties is external gamma and X-ray radiation that penetrates into the room where medical personnel are located. Only if it is insufficiently isolated from the procedural one. The presence of radioactive substances in the body is possible only in the event of an accidental violation of the integrity of the shelter of sources (ampoules) or their loss and discovery by random people, which is extremely rare.

INDUSTRIAL GAMMA DEFECTOSCOPY AND GAMMAGRAPHY.

The main radiation factors are external general and local gamma irradiation of hands and individual parts of the body.

If the integrity of the ampoules is violated, it is possible for radon to enter the air, contaminate the skin, and supply the body with radioactive substances (b°Co, 137Cз, 738C), which is possible only in case of a serious violation of the rules for working with sources.

Violation of the rules of preservation of radiation sources. Accompanied by increased exposure of personnel and individuals who discovered the source, described in domestic and foreign literature. In such a situation, local radiation changes are most likely in the areas of direct contact with the source (the skin of the hands, the front surface of the thigh and chest when the source enters the pocket of pants or a jacket). Severe cases with fatal outcome are also described.

CHARGING AND ASSEMBLING GAMMAand X-ray sources.

If manual operations are maintained, there remains the possibility of local irradiation in increased doses with the development of clinical manifestations of local acute radiation lesions.

WORK ON NUCLEAR PARTICLE ACCELERATORS.

Persons engaged in the maintenance of accelerators are subject to combined general and local exposure to gamma and beta radiation and high-energy particles, including neutrons. Local lesions of the lens, radiation cataracts in persons who started working many years ago are described.

NUCLEAR REACTIONS FOR RESEARCH PURPOSES AND POWER PLANTS USING NUCLEAR FUEL.

The main radiation factor associated with the active zone of the reactor is the external gamma-neutron irradiation of the very uneven field created in its immediate vicinity. In addition, under certain special conditions, a planned or emergency violation of the integrity of technological communications and the reactor's operating mode, as well as in the case of experimental production of critical mass, it is possible to acquire external beta and X-ray radiation of significant importance, when radioactive aerosols and gases (argon, krypton)', xenon, iodine, etc.) enter the environment, as well as radioisotope contamination of premises, clothing and bodies of workers - when broken seals of the active zone. Experimental reactors and complexation of the critical mass in the event of an unpredictable change in the regime or in case of carelessness in the investigative development of acute radiation sickness in a person, as well as in case of severe local radiation injuries.

There is also a large group of people engaged in work in which there are open radioactive sources in the environment. One of the oldest and well-studied types of work of this kind is the permanent warehouse enterprise. The main radioactive factors in these very difficult conditions are:

- external gamma and beta radiation from luminescent substances, alpha and beta radiation of organs and tissues in case of inhalation. Through the digestive tract, radium and mesothorium, thorium, sirontium and others.
- gamma and beta irradiation of the skin, direct contact with radioactive substances.
- Irradiation of the respiratory organs from radon, thoron and tritium entering the body and exhaled.

RADON CONTROL IN MEDICAL INSTITUTIONS.

The main radiation factors for this group are: external gamma-onromineinya from bubblers, which contain the radiz-source of radon preparation; inhalation of radon, which is in some ratio with gamma -- and beta -- active substances of its decay in the form of highly dispersed aerosols. Due to good absorption of 222Ki along with changes in inhalation intake (upper respiratory tract

and lungs, which are irradiated primarily by radon decay products) it is possible to detect some clinical syndromes primarily in the blood system.

WORKING WITH URANIUM.

During the heat treatment of metallic uranium and the presence of personnel in the vicinity of non-refining large blocks, as well as during laboratory spider-research work with uranium salts, workers are subject to beta radiation, which in some cases exceeds that in the immediate vicinity. from the pranic level in 2-8 times. MINING EXPLORATION FORusing radioactive sources.

The principle of using radioactive sources is to compare the gamma radiation of natural elements, the content of ore with the exposure of standards. In addition, neutron sources are used to enter the well, the so-called neutron logging. All these types of work are accompanied by direct contact of personnel with gamma and neutron sources of various powers.

Irradiation becomes significant only when the rules of storage, transportation and operation of the sources are violated.

EXTRACTION OF RADIOACTIVE ORES.

An increase in the incidence of cancer is observed 10 years after the start of work with a 7-13-fold systematic increase in the accepted norms.

Numerous foreign publications about the working conditions and the state of health of this group of workers allows us to imagine that the most possible clinical effects having correlations with the effects of the radiation factor, which are slowly formed by changes in the epithelium of the respiratory tract, are signs of non-specific interstitial fibrosis and accelerates in a separate period of cancer cases lungs

LABORwith exposed artificial radioactive isotopes.

Some artificial radionuclides, which are produced by irradiation in reactors, have been widely used for a whole range of therapies, diagnostics and diverse scientific research.

The total number of these radionuclides in diagnostic and research laboratories is small with properly organized work, and significantly higher when radioactive substances are used for therapeutic purposes. In these cases, the possible exposure of personnel in the suspended dose is created only in case of violation of elementary work rules.

APPLICATION OF RADIATION SOURCESin the national economy and in scientific sources

Numerous forms of use of radionuclides in the national economy and scientific research, when used correctly, are only a source of external exposure to workers and do not lead to a significant entry into the human body. The level of external gamma radiation for the main professions is given in the table. 1.

Table 1

The level of external radiation with radiation sources in the national economy and science.		
Work process	Main professions	Dose of γ radiation per year, Mar
Assembly and attachment of radionuclide devices for control and regulation of production processes: thickness gauges, density gauges, moisture meters, balances, product counters, and others.	Mechanics, locksmiths, apparatchiks.	0.5-1.0
Storage and delivery of radioactive drugs at bases and warehouses.	Forwarders, dosimeters, selectors of radioactive packages.	1.0-2.0
The use of radionuclide devices for technological control of thickness gauges, density gauges, uniformity gauges, and others.	Mechanics, locksmiths, apparatchiks.	0.15-0.2
Study of heat-resistant products, materials, using a radioactive label (Cs51, Fem, Co60 and others) in machine building and metallurgy.	Forwarders, mechanics, apparatchiks.	0.4-0.7
Experimental radiological research in medical and biological laboratories	Laboratory assistants, mechanics, preparators, dosimeters.	0.2-0.5
Irradiation of farm animals using powerful gamma X-ray devices.	Operators and dosimeters.	0.15-0.2
Radiobiological research in agriculture (P32, 90Sg, 89Sg and others).	Laboratory assistants, preparators, dosimeters.	0.3-1.0

Cases of occupational radiation sickness in all the listed groups with casuistic rarity.

PROBLEMShygienic regulation of the radiation factor.

In the world of modern scientific ideas, the effects caused by the action of radiation are systematized into 3 groups:

-Somatic (CPC and CPC, local radiation damage - cataract, low-quality damage to the skin and others)

-Somatic-stochastic (reduction of longevity, leukemia, tumors of various tissues and organs)

-Genetic (dominant and recessive gene mutations, chromosomal aberrations, deletions and others)

Somatic effects develop in a person who was exposed to radiation, and genetic effects - in his descendants. The level of exposure at the enterprise is regulated by the amount of PDD, which is absorbed in the human body in the process of his professional activity. In the USSR, until 1950, a value equal to 5 ber/year was adopted as the traffic limit. It remains to this day in the domestic norms and rules in the recommendations of the ICRC and the IAEA.

Radiation safety standards are established separately (tab. 1) for workers (category A) and organic strata of the population (category B) taking into account the differences in the physical parameters of the active radiation, the age composition of the irradiated contingents. At the same time, single concepts are used to characterize the normative levels: PDD - the normative limit of occupational exposure and PD - the normative level of radiation effect on a limited segment of the population.

RADIATION SAFETY STANDARDS.

A group of critical organs	Critical organs	Traffic regulations for category A, March/year	PDC for category B, March/year
1(1)	Whole body, gonads, red THE BONE MARROW	5.0	0.5
2(11)	Muscles, thyroid, fat tissue, liver, spleen, organs of the gastrointestinal tract, lungs, lens	15.0	1.5
3(W)	leather cover, bone tissue, bone, forearm, ankle, feet, limbs	30.0	3.0

Conclusion

The use of radiation has become an integral part of modern life. From X-ray imaging of a broken joint to cancer treatment, the medical use of radiation is widely accepted, and X-ray equipment can be found in every clinic and hospital of any level.

Living organisms have always experienced the effects of certain amounts of radiation coming from natural sources, such as soil and food. And also from cosmic rays that come to us from space.

The effects caused by the action of ionizing radiation can be systematized into three groups: somatic, somato-scholastic and genetic.

In addition to exposure in professional conditions, the consequences of exposure as a result of the accident at the Chernobyl nuclear power plant are widely known, there is a large number of people exposed under other circumstances:

1. The precursor to Chernobyl is the accident at the radiochemical plant in Chelyabinsk-40, when a radioactive cloud covered 3 regions: Sverdlovsk, Chelyabinsk, and Tyumen.
2. The testing of nuclear weapons in the past in Semipalatinsk forces us to solve the problem of individual consequences for the population living near the nuclear test site. In Ukraine, we also have people who used to live in the Semipalatinsk region.
3. There is an unaccounted contingent of people who took part in military training with the use of nuclear weapons, the so-called Totsky scientists.
4. In the mass media, there was a report about the health of former soldiers who served in Kyiv in the internal troops, who on the first day of the accident at the Chayen nuclear power plant were brought in to establish order and peace without proper protective equipment, and were in the zone for 3-4 days.

Thus, the number of people who need the respect of radiation medicine specialists is listed in the millions. You already know that the use of radiation for medical and industrial purposes brings great benefits to society. But we also know that excessive doses of radiation can lead to disaster for our people.

Materials on the activation of students of higher education during the lecture: questions, situational tasks, etc*(if necessary)*.

General material and educational and methodological support of the lecture:

– educational premises;

- *equipment;*

- the equipment;
– slides, video films.

Questions for self-control:
a) on the topic of the lecture/literature, questions, assignments/;
b) on the topic of the next lecture/literature, list of main issues/.

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Main:
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Lecture No. 2

Topic: <u>Impact of ionizing radiation on the body. Acute and chronic effects of exposure</u>
Relevance of the topic: The biological action of ionizing radiation is determined by the energy they give to various tissues and organs, and in this connection, the radiation of the principles of diagnosis and treatment of radiation damage is particularly relevant.
Goal:
Educational: to form an idea of the principles of direct and indirect action of radiation, to have a general idea of the physical and biological factors that determine the radiation effect, as well as to classify the distant consequences of the action of ionizing radiation.
Basic concepts: Path of entry and distribution of radionuclides in the body, macrodistribution of radioactive substances in the body, microdistribution, distant

consequences of the action of ionizing radiation, general reactions of the body to ionizing radiation.

Content of lecture material (lecture text)

Effect of ionizing radiation on the body

After prof. Roentgen made a report about a new form of radiation, biology entered a period of rapid development. Becquerel's discovery of radioactivity in 1986 was an additional impetus to this development, although the connection between these two forms of radiation remained unclear. 4 months after Röntgen's report, Dantel described hair loss after radiography, and on August 12, 1896, the journal "published a description of severe skin damage in workers at an exhibition of X-ray equipment. At the same time, Lapp and Stevens investigated cases of dermatitis and hair loss after exposure. In 1987, Freund reported the successful removal of a mole covered with hair by X-rays, and Welsch described the symptoms of acute radiation sickness. Two years later, a report on the treatment of skin cancer with X-rays was published. In 1902, a case of cancer caused by exposure to radiation was reported. The first observation on the action of X-rays on the internal organs belongs, obviously, to Senna, who in 1903 described a case of a decrease in the size of the spleen after irradiation.

The twentieth century, which is more often called the atomic century, brought the expansion of contacts of humanity and all living things with ionizing radiation.

Impact of ionizing radiation exposure in professional conditions.

A significant number of people are exposed to ionizing radiation in occupational settings. Let's consider the main types of robots and professional groups with various levels of radiation exposure

X-ray research in medical institutions.

The main radiation factor is external irradiation of the tube in the transillumination mode, which is uneven both in localization (mainly head, chest, hands) and in depth. According to American studies, with 25-30 years of experience, total exposure doses reached 1,000-2,000 rubles for the entire period of work. In recent years, only single cases of lesions have been described.

X-ray structural analysis.

The main radiation hazard is the possibility of local irradiation of the hands. eyes, head from an intense working beam with relatively small irradiation energies (10-40 kV). Due to the small distance from the anticathode of the tube and the weak filtering of the rays, the dose power can reach such a size that in a few seconds of irradiation it becomes sufficient for the development of acute radiation lesions of the skin.

Radiation therapy.

The main radiation factor for personnel working at therapeutic facilities is external gamma and X-ray radiation, which penetrates into the room where the medical personnel is located, only if it is not sufficiently insulated from the procedure room. The entry of radioactive substances into the body is possible only in the event of an accidental violation of the integrity of the source shelter (ampoules) or their loss and discovery by random people.

Industrial gamma defectoscopy and gammagraphy

The main radiation factors are external general and local gamma irradiation of hands and individual parts of the body. If the integrity of the ampoules is violated, radon may enter the air. Contamination of the skin and entry into the body of radioactive substances (So, C$. 5s. Ry) are possible only in gross violation of the rules for working with sources.

Violation of the rules of storage of radiation sources, which is accompanied by excess exposure of personnel and individuals who found the source, described in domestic and foreign literature. In this situation, local radiation changes are most possible in the areas of direct contact with the source (skin of the hands, front surface of the thigh or chest when the source is in a jacket or jacket pocket). Severe cases with a fatal outcome have been described.

Charging and assembly of gamma and X-ray sources.

When maintaining manual operations, there remains the possibility of local irradiation in increased doses with the development of clinical manifestations of acute local radiation lesions

Work on nuclear particle accelerators.

Persons engaged in the maintenance of accelerators are exposed to the combined general and local effects of gamma and beta radiation and high-energy particles. including neutrons. Local lesions of the lenses, radiation cataracts in persons who started working many years ago are described.

Research nuclear reactions and power plants using nuclear fuel.

The main radiation factor associated with the active zone of the reactor is external gamma - neutron irradiation, which creates a non-uniform dose field in its immediate vicinity. In particular, under certain special conditions, planned or emergency violations of the integrity of technological communications and work routinesof the reactor, as well as during the experimental assembly of the critical mass, external beta and X-ray irradiation, the ingress of radioactive aerosols and gases (argon, krypton, iodine) into the environment, as well as the contamination of the premises, clothing and bodies of workers with radioisotopes in the event of a violation of the hermeticity of the active zone are of great importance. Experimental reactors and assembly of critical mass in the case of an unforeseen change of regime or more often in the case of carelessness of the service personnel are a source of powerful gamma neutron irradiation, causing the development of acute radiation sickness in humans, as well as local radiation lesions.

There is also a large group of persons who are engaged in work in which there are open radioactive sources in the environment. One of the oldest and well-known types of robots is the production of constant action world assemblies. The main radioactive factors in these difficult conditions are:

- external gamma and beta radiation from luminescent substances;
- alpha and beta - irradiation of organs and tissues in case of inhalation of radium and mesothorium, thorium, strontium in the body through the digestive tract;
- gamma and beta irradiation of skin directly in contact with radioactive substances;
- radiation of respiratory organs from radon, thoron. tritium, which are supplied and inspired.

Working with radon in medical institutions.

The main radiation factors for this group are: external gamma irradiation from bubblers, which contain radium - the source of radon production; breathing radon, which is in relation to gamma - and beta - active products of its decay in the form of highly dispersed aerosols.

In connection with good absorption of 222Cl along with changes in the main critical organ upon inhalation exposure (upper respiratory tract and lungs, which are irradiated primarily by radon decay products), it is possible to detect some clinical syndromes, primarily in the blood system.

Work with uranium and its compounds.

During the heat treatment of metallic uranium and the presence of personnel in the vicinity of crude large blocks, as well as during laboratory scientific and research work with uranium salts, workers are exposed to beta radiation, which in some cases exceeds the threshold levels in the immediate vicinity of the ingot by 2-8 times.

Mineral exploration using radioactive sources.

It is easy to observe an increase in cancer diseases 10 years after the start of work with a 7-13-fold systematic excess of the accepted norms.

Numerous foreign publications about the working conditions and state of health of this group of workers allow us to imagine that the most possible clinical effects, which have a correlation with the action of the radiation factor, are slowly forming changes in the epithelium of the respiratory tract, signs of non-specific interstitial fibrosis and acceleration in certain periods cases of lung cancer.

Works with discovered artificial radioactive isotopes (I131, P32, Ai198, CO60, Ts)

Some artificial radionuclides, created by irradiation in reactors, have been widely used for the purposes of therapy, diagnostics and various scientific experiments. The total number of these radionuclides in diagnostic and research laboratories - with properly organized work - is small, much higher - when using radioactive substances for therapeutic purposes. In these cases, the possibility of exposing personnel to an increased dose is created only when basic work rules are violated.

The use of radiation sources in the national economy and scientific experiments.

Numerous forms of use of radionuclides in the national economy and scientific experiments, when used correctly, are only sources of external exposure to workers and do not lead to a significant entry of radioactive substances into the human body.

The level of external gamma radiation for the main professions is given in Table 1.

Cases of occupational radiation sickness in all the listed groups are a rare case.

Work process	Main professions	Dose of gamma radiation per year, ber.
Assembly and adjustment of radionuclide devices for control and regulation of production processes (thickness gauges, hydrometers, moisture meters, level meters, product counters, etc.)	Mechanics, locksmiths and hardware workers.	0.5-1.0.
Storage and delivery of radioactive drugs at bases and warehouses	Selectors of radioactive packages, forwarders, dosimeters.	1.0-2.0.
The use of radionuclide technological control devices (thickness meters, hydrometers, blood meters, etc.)	Mechanics, locksmiths and hardware workers.	0.15-0.2.
Study of wear-resistant products, materials and coatings using a radioactive label in mechanical engineering	Experimenters, mechanics, apparatus technicians.	0.4 - 0.7.
Experimental radiological experiments in medical and biological laboratories.	Laboratory assistants, preparators, dosimeters.	0.2-0.5.
Irradiation of farm animals using powerful gamma and X-ray devices.	Operators, dosimeters.	0.15-0.2.
Radiobiological experiments in agriculture.	Laboratory assistants, preparers	0.3-1.0.

Expanding the contacts of humanity and all living things by ionizing radiation made the study of their biological action especially relevant for all medical workers, regardless of their narrow professional specialization.

Ignorance of the biological effects of ionizing radiation can lead to fatal consequences. Yes, in January 1988 a case that happened in Brazil was published. . The managers of the radiology center, while moving the clinic to a new building, decided to throw old medical devices in the old building. Including a device with a "cesium cannon", where a capsule with cesium-137 was located. The device was unattended for a year. Then he caught the eye of an unemployed person who handed the capsule in for scrap. The owner of the reception point of waste raw materials noticed that the capsule glowed at night, broke it and began to distribute the "wonderful thing" to his friends, who rubbed the glowing powder before performing at the carnival. Cesium, which was partially scattered at the landfill, spread in other ways - on the soles of shoes, in the folds of clothes, on car tires.

With these doses of energy, immediate direct disturbances in the chemical bonds of biomolecules are very small, and the decisive role in the damage is played by the processes in which the primary effect is amplified, which develops already after the action of ionizing radiation.

A long dispute!, which developed over many years on the topic: is the biological effect caused by the direct action of particles and electrons on chemical bonds in the molecules of biochemically important components of the cell, or is it caused by an indirect way, has already lost its sharpness after numerous studies, as a result of which it was established that the aqueous phase of cells and tissues of organisms plays a major role in the action of ionizing radiation.

Currently, there is no doubt that in the development of radiation damage in biological objects, the primary activation occurs with the help of radicals that are formed during the radiolysis of water in the aqueous phases of colloids of cells and tissues. The importance of such activation is explained by the fact that the act of splitting water into radicals requires relatively little energy, and the resulting radicals have very high chemical activity.

When radiation passes through the water phase of the cell, water is ionized. At radiation doses that are harmful to organisms, the number of radicals created in the aqueous phase increases linearly with increasing dose.

Aqueous phases are located directly near the surfaces of biomolecules that have a large number of active reactive groups. The hydrogen bridges that separate these molecules do not exceed 3-4 molecular radii, not to mention that there are soluble chemically active organic compounds in the aqueous phase. Under these conditions, the formed radicals have the opportunity to directly react with biomolecules, and recombination processes are reduced to a minimum.

The radicals H, OH, HO formed during the radiolysis of water oxidize and reduce various organic compounds. However, it can be considered established that at the primary stage of radiation damage the leading role belongs to oxidation reactions and the biological effect is connected with biological radicals OH and HO.

Some scientists have established that not all the energy of ionizing radiation absorbed by the tissues of organisms causes a biological effect. The probability of a successful interaction of energy quanta of ionizing radiation with the biosubstrate, that is, that the ionization act will cause reactions in cells, is very small, approximately 0.01 - 0.0001. When explaining this phenomenon, two positions were formed:

the principle of hitting. This principle characterizes the features of the active agent -

discrete energy absorption;

the principle of the target - takes into account the peculiarities of the studied object of the cell, its height
heterogeneity in physical and functional terms, and accordingly, the difference in
responses to the same hit.

For the first time, the theory of the target was formulated by Dessauer in the early 20s. The principle of hitting and the theory of the target based on it were developed in the works of Kruozer, Timofeev-Ressovsky, Zimmer, Lee and others.

The use of the basic provisions of the principle of hit and target is limited to a strictly defined area - the analysis of the most primary elementary actions. But attempts to adapt the theory of the target directly to the understanding of the nature and stages of the formation of the final radiation reactions of cells, and even more so of organisms, are pointless, since the formation of the very concepts of "hit" or "target" does not imply any specific physicochemical or biochemical processes that take place in a micro volume.

The initial hypotheses of the interaction of ionizing radiation with the biosubstrate were based on simplified ideas about the mechanism of primary radiobiological processes based on purely physical, and later - radiation-chemical laws, established during the irradiation of simple systems, without taking into account the specificity of biological macromolecules, which greatly complicate the very first stages of the radiation reaction. A more advanced hypothesis is the stochastic hypothesis, which takes into account both physiological and radiation-induced processes.

The stochastic hypothesis considers any biological object, including a cell, as a labile dynamic system that is constantly in a state of transition from one state to another. Due to the extreme complexity of the system, any such transition is accompanied and connected with a large number of complex and elementary interconnected reactions of individual cell organelles and macromolecules. It is natural that in the process of life, due to the influence of various factors, there is a probability of "failures" in elementary links, and as a result of this, or regardless of this, the "collapse" of the entire system. According to the stochastic hypothesis, under the influence of radiation, the probability of spontaneous violations of cell homeostasis, which is supported by numerous regulatory mechanisms, increases, and the primary radiation physicochemical changes are only a trigger for such multicomponent processes that lead to this effect.

Neither classical models based on the principle of hitting nor the concept of biological stochasticity are able to explain the entire set of experimental data obtained. Added the principle of hitting with a proposal about the likely nature of the manifestation of lesions, Kapultsevich Yu.G. proposed a model of radiation damage to the cell, which he called probable. The main difference between the probable model and the classical model is that, according to the latter, the radiosensitivity of the cell is determined only by the volume of the target and the critical number of hits. From the point of view of the probable model, the problem of radiosensitivity appears to be more complicated. Yu.G. Kapultsevich proposes to formally divide the process of radiation cell damage into three stages.

The first stage is the implementation of hitting actions, as a result of which primary potential lesions are formed.The second stage - radiation damage - realization of potential damage.

The third stage is noticeable secondary violations of the normal course of intracellular processes caused by the realization of damage.

The hypotheses of the interaction of ionizing radiation with the biosubstrate that we considered do not allow us to reveal the nature of the affected cells during irradiation, as well as to explain the main radiobiological paradox of inappropriate small amounts of absorbed energy with pronounced biological biological effects. The explanation of this phenomenon is given from the standpoint of qualitative hypotheses. A characteristic feature of qualitative hypotheses is that they attach significant importance in the primary processes of radiation damage to various highly reactive products - radiotoxins, formed in the biosubstrate following the absorption of radiation energy, which initiates multiple reactions of the affected type.

Back in the 50s, A.S. Mochalinoy, Yu.B. Kudryashov in Harusov's laboratory found that water-salt extracts from the livers of irradiated animals can imitate the biological effect of ionizing radiation. A group of substances was isolated in the irradiated body, receiving the general name "radiotoxins". According to current ideas, radiotoxins are assigned a certain role in the development of radiation damage to the body along with the recognition of other numerous mechanisms of damage, and therefore between radiation damage and the radiation toxic effect, an equal sign cannot be put. On the basis of the hypothesis, which was actively developed by A.M. Kuzyn from 1965, there is an idea that not only purely radiation-chemical processes develop in the cell under the action of ionizing radiation. According to the structural-metabolic hypothesis advocated by the author, the leading role in the primary processes of radiation damage to the cell belongs to the violation of its structural organization and strict orderliness in each of its chains.

It is no accident that scientists paid so much attention to the primary processes of radiation damage. After all, without understanding the mechanisms of radiation cell death, it is impossible to protect the body from the impressive effects of radiation, as well as the current diagnosis and teaching of radiation sickness. Lymphoid tissue is the most sensitive in the body of animals and humans. Mass death of lymphoid cells occurs already in the first hours after irradiation. Meanwhile, these cells, or lymphocytes, play a primary role in regulating the body's immunity against various infections. For many years, the high radiosensitivity of lymphocytes remained a mystery. After all, cells that reproduce and divide are usually more radiosensitive. This property of theirs has long been used in radiation irradiation of malignant neoplasms. Lymphocytes, on the other hand, are cells that do not divide, and thus their death is in no way connected with division.

In order to find ways to help the irradiated organism, it was necessary to understand the reasons for the greater radiosensitivity of lymphoid cells. As a result of the conducted experiments, it was found that the effect of radiation on lymphocytes leads to rapid changes in the properties and functions of biological membranes, the activity of a number of key enzymes regulating metabolism, in the energy state of cells and their ion balance.

In a healthy, non-irradiated lymphocyte, there are effective systems for controlling the activity of enzymes. The action of radiation disrupts them, the "uncontrolled" nuclease acts on the DNA molecule, which leads to its disintegration and, as a result, to the death of the cell. It is significant that the cell's loss of control functions does not occur immediately after irradiation, but after some time. It was possible to follow the stages of this process. It turned out that specific protein factors appear in irradiated lymphocytes. Eyewitnesses, it is precisely under their influence that nuclease splits DNA. Scientists came to the fundamentally important conclusion that the death of irradiated lymphocytes ultimately occurs when specific biochemical reactions are activated. The process of death is controlled. For example, some

Antibiotics inhibit protein synthesis and can prevent protein (DNA) degradation in irradiated lymphocytes, protecting them from death.

The most universal response of a cell to radiation is a partial delay (inhibition) of cell division, often referred to in the literature as radiation blocking of mitoses.

A decrease in the number of dividing cells after irradiation was noticed already after the discovery of X-rays and served as the basis for their use with the aim of suppressing tumor growth.

The results of the absolute majority of numerous experiments provided convincing evidence of the incomparably greater radiosensitivity of the nucleus and the decisive role of its damage at the end of cell irradiation. It turned out, for example, that the entry of only one α-particle into the nucleus of a cell causes its death, which, in the case of irradiation of the cell cytoplasm, is registered after the passage of 15 ml of particles.

Such changes in hereditary information can have far-reaching consequences, when the cell does not die, but takes on new properties that were not there before, or loses old properties.

A change in the properties of a cell (organism) enshrined in heredity is called a mutation, a changed organism is a mutant, and an external agent causing a mutation is a mutagen. The natural radiation background, UV radiation from the Sun, some chemical substances, as well as temperature fluctuations - these are the mutagenic factors of the environment that caused changes in the heredity of organisms throughout the history of life on Earth, the emergence of new life forms-mutant individuals.

But the acquisition of a new trait or the loss of an old one can be beneficial or harmful for the body, or it may have no effect. The criterion for the benefit of mutations is the living condition of an organism, a group of organisms (population), a species as a whole. It is in real life conditions that it becomes clear whether a new sign will give advantages to its owners, or, on the contrary, puts it at a disadvantage compared to its relatives. The organism - the carrier of a useful trait - other things being equal, has more chances to survive and leave offspring so that over time a useful mutation becomes the property of the entire old species or contributes to its formation in the bowels of a new one. A harmful mutation, on the contrary, reduces the chance of its carrier to survive in the competition, its offspring becomes less numerous, or death occurs before the appearance of offspring. Therefore, a harmful mutation more or less quickly disappears along with its carriers.

It is another thing when it comes to the fate of an individual organism, for example, an individual person. Positive mutations in humans are very rare. Most of them are harmful or do not affect the body in any way, some cause hereditary or congenital diseases. Ionizing radiation, including natural radiation, makes some contribution to this process.

The radiosensitivity of the tissue is proportional to the proliferative activity and inversely proportional to the degree of differentiation of its component cells. This regularity was formulated by I. Bergognier and L. Tribondo back in 1906, at the very beginning of the study of the biological effect of ionizing radiation. This rule has not lost its role even today, despite some exceptions to it.

For resistant, slow-renewable tissues (bone, muscle, nerve), the radiation effect does not remain without a trace. In the laboratory of H.S. Strelin, it was established that the poorly regenerated tissue "remembers" the radiation effect and therefore becomes functionally inferior. As a result of such hidden disorders that occur in the cells of any low-renewable tissues, cystitis, rectitis, damage to the kidneys, heart, liver, and possibly malignant tumors.

Changes that occur at the level of the cell population can be associated with the onset of acute radiation damage after total radiation exposure. The general response after irradiation is revealed by four cardinal parameters of cell populations:!) the relative size of the stem cell pool. 2) radiosensitivity of cells and the ability to restore them. 3) cell proliferation. 4) speed of disposal of mature elements.

The biological effectiveness of external radiation is somewhat dependent on the dose, its strength, the frequency of exposure, the type of ionizing radiation, etc. The lighter the particles and the greater their energy, the greater their penetrating ability. Weakly penetrating through the skin beta particles and alpha particles absorbed by the epidermis cause damage limited to the place of their application, while the flow of gamma quanta, protons and electrons penetrates through the entire thickness of the animal and human body. The higher the specific ionization, the greater the biological efficiency.

The biological efficiency of X-ray irradiation of 180-300 kV is taken as a unit. For other types of exposure, a coefficient of relative biological efficiency (RBE) has been introduced. Table 3 shows the BBE values of different types of exposure.

Table 3.

VBE of various types of exposure

Type of exposure	VBE
X-rays, gamma rays, electrons, beta radiation.	1
Fast neurons and protons up to 10 MeV	3-Yu
Alpha particles are naturally radioactiveisotopes	10

Heavy recoil cores	20

The degree of severity of radioactive damage is directly dependent on the radiation dose and its strength (Table 4)

Table 4. The effect of the dose strength during continuous irradiation on the mortality of rats.

Dose strength, r/min		Dose strength, r/min	LOzoIzov
0.10	2100	71.0	
0.33	1500	80.0	917
2.0	1150	82.0	930
6.0	920	150.0	870
60.0	920	212.0	715

The larger the single dose, the faster the effect appears. When exposed to doses higher than 5,000-10,000 R (life expectancy of approximately 2 days), direct action on the central nervous system is decisive in pathogenesis. At doses of 15,000 R and above, death occurs "under the beam" or a few hours after exposure. In the range of doses of 1200-5000 P (life expectancy of about 7 days), in the clinic of the disease and the mechanism of development of death, damage to the gastrointestinal tract prevails. In the pathogenesis of which disorders of hematopoietic organs, hemorrhagic and infectious complications are acquired (Table 5).Table 5. Life expectancy of people exposed to lethal and sublethal doses.

Irradiation dose, p.	Lifetime	The leading system (organ) in th pathogenesis of the lesion
15,000 and above	Death "under the beam" orsevera hours after exposure	central nervous system
5000-10000	About 2 days	central nervous system
1200-5000	About 7 days	gastrointestinal tract
300-1000	Typical acute radiation sickness Fatal cases are possible dependin on the radiation dose an efficiencytreatment.	

Restorative processes in radiation damage.

However, the decrease in biological activity during long-term fractional irradiation shows that the body has the ability to restore the main part of the affected tissues. The general theory of damage and restoration was proposed in his time (1952) by Blair.

The phase of imaginary cellular well-being

After 2-4 days, the symptoms of the initial reaction disappear, and the patient's well-being improves or even normalizes. The disease enters the second phase, we call it the hidden or latent stage of radiation damage with - in the absence of clinically visible signs of the disease.
The duration of the latent phase depends on the severity of the lesion and ranges from 14 to 32 days in humans. In very severe forms of damage (at doses more than IOGr.), it is absent at all.
Among the clinical signs during the latent phase, there is hair loss (if the dose exceeds the epilation dose) and neurological symptoms, which gradually smooth out.
Imaginary or, as they say, illusory well-being can be easily detected. When examining the blood, it is easy to find lymphopenia, as well as a decrease in the number of neutrophils, and later - platelets and reticulocytes, in the bone marrow already in the first days, clearly expressed aplasia, and from 2 to 3 weeks, signs of regeneration are visible. During this period, there is atrophy of the ovaries and suppression of the early stages of spermatogenesis.

The phase of pronounced clinical manifestations.

At the end of the latent period, the patient's well-being deteriorates sharply again, weakness increases, the temperature rises, and the ESR increases. A picture of a severe disease is developing, which is why this phase is called the height of the disease. The so-called hemorrhagic syndrome occurs — bleeding into the skin, mucous membranes, digestive system, brain, heart, lungs.
The danger of hemorrhages in vital organs, supported by thrombocytopenia, and the occurrence of infectious complications is the main threat to the life of patients during this period.

The morphological composition of the blood is represented almost exclusively by lymphocytes, since all the last elements of white blood are counted as single cells or disappear altogether, which leads to relative lymphocytosis. At the end of the phase (and with higher doses and pronounced hemorrhagic syndrome earlier), anemia is detected and begins to progress. At this time, the bone marrow and lymph nodes clearly show signs of regeneration, with the exception of extremely severe degrees of damage, which early lead to fatal cases in cases of complete aplasia.

Early recovery phase.

A sharp decrease in body weight is a reflection of metabolic disorders and dyspeptic disorders (loss of appetite and diarrhea). In treatable patients, the third phase of the disease lasts from one to three weeks, and then in cases with a favorable result, it passes into the fourth phase - recovery.

The beginning of the recovery phase is characterized by normalization of temperature, improvement of well-being, appearance of appetite, restoration of sleep. Bleeding stops, dyspeptic symptoms disappear or weaken. As a rule, patients rapidly increase their body weight. There is a gradual restoration of blood parameters, which in surviving patients begins even at the height of the disease as a result of bone marrow regeneration. Even then, early forms of cells appear in the peripheral blood — reticulocytes and younger leukocytes, regenerative forms of platelets, but anemia increases and reaches a maximum by week 5-6, then the number of erythrocytes beginsincrease and after 2-3 months reaches the initial level.

The normalization of the morphological composition of the blood is a reflection of the regenerative processes in the hematopoietic system, which is easily confirmed by bone marrow puncture and dynamic analysis of myelograms. Biochemical indicators of blood and urine also normalize during this period. The duration of recovery phases is 2 - 2.5 months. At the end of the 3rd month from the onset of the disease, the feeling of well-being usually becomes complete satisfactory, although individual manifestations still occur, for example,baldness continues (hair growth resumes only around the 4th month), reproductive properties normalize only after 4-6 months. The phase of early reproduction is characterized by the completion of the main processes of direct recovery. The considered variant of typical acute radiation sickness with general, relatively uniform external irradiation is rare. It can be reproduced in experiments on mice (small laboratory animals), when special conditions are created (a powerful source, a large room, multi-sided irradiation) and on large animals. In humans, this kind of damage occurred only as a result of atomic bomb explosions and in isolated accidents.

Experimental data can be given to illustrate the recovery process. One group of mice is irradiated once at a dose of 1000 g. By the 20th day, all mice die from radiation sickness. Another group of mice was irradiated fractionally in a dose of 50 R for 20 days. The total dose is also equal to 1000 rubles, but the mortality in these conditions is only 35%.

On the basis of numerous experiments, it was concluded that the net damage (without recovery) significantly decreases with an increase in the time during which the body can be exposed to radiation.

The speed of recovery processes in the body after radiation is not always constant. It is most pronounced in the range of doses that cause mild radiation damage. On either side of this dose level, the rate after radiation recovery slows down. This is due to the fact that with exposure in smaller doses, the number of changes occurring in the body, which are the driving reason for the development of restorative processes, decreases. With large doses, on the contrary, biological mechanisms are already disturbed, with the help of which post-radiation recovery is carried out. In addition, the speed of recovery processes depends on the dose rate (irradiation intensity).

Now we will move on to the direct manifestation of the radiation effect on the body, namely: acute radiation sickness, CLB, as well as remote effects of exposure.

Clinic of acute radiation sickness.

In the course of acute radiation sickness, three periods are distinguished: the period of formation, recovery, and results and consequences. The period of GPC formation, in turn, can be clearly divided into 4 phases:

1. Phase of the primary general reaction.
2. Phase of imaginary clinical well-being (hidden, lethal phase).
3. The phase of pronounced clinical manifestations (phase of the outbreak of the disease)
4. Early recovery phase.

Phase of the primary general clinic.

The primary reaction of the human body occurs quickly (in the first minutes, hours) and is manifested in all cases of irradiation at doses exceeding 2 Gy. Nausea, dryness and bitterness in the mouth appear. Victims feel heaviness in the head, headache, general weakness, drowsiness. The duration of phase 1 is 3 days.

The most diagnostic, and in some cases, prognostic value is the time of onset of nausea, vomiting, as well as the duration of the dyspeptic syndrome. In persons who suffered the most during the explosion of the atomic bomb, the initial reaction occurred after 0.5 - 3 hours and continued for several (3-4) days.

Unfavorable from a prognostic point of view, the signs that determine a very severe course of the disease (namely, those that indicate the total dose of radiation IOGr.) are the development of a shock-like state with a decrease in blood pressure, short-term loss of consciousness, subfibrous temperature, diarrhea.

Transient hyperemia in the form of a tan occurs on skin areas that were exposed to radiation in doses of 6-10 Gy.

In the peripheral blood on the first day after irradiation, neutrophilic leukocytosis with a shift to the left, as well as absolute and relative lymphopenia, is observed.

In the bone marrow of a person, with the usual hematolytic analysis of a punctate, it is possible to find more or less clear changes, which are most noticeable on the 2-3rd day: a decrease in the total number of myelokaryocytes, a decrease in the mitotic index, and the disappearance of young cell forms. But with a special cytological examination of the human bone marrow, sharp degenerative changes can be found already in the first hours after exposure.

Biochemical changes in blood and urine can be noted at doses of 3-4 Gy. an increase in the level of sugar in the blood and a decrease in chlorides, as well as aminoacidiuria (probably due to increased protein breakdown of dead cells).

Clinical manifestations of the first phase of GPC are a consequence not only of cell division of radiosensitive systems (lymphopenia, delay of cell division, decrease in the number or disappearance of young forms of cells), but also clearly indicate transient, but clearly early violations of neuroregulatory and humoral relationships.

uneven exposure of a person, there are certain types of uneven exposure, depending on the radiation situation, first of all, on the irradiated volume and the penetrating properties of the radiation:

1. General uneven exposure;
2. Local (local) irradiation.

In the first of them, the unevenness of the absorbed dose is formed as a result of the weakening of the penetrating radiation in depth, and in the second - as a result of shielding (accidental or special) of the last parts of the body or as a result of targeted radiation action.

Between these extreme samples there are various intermediate options and their combinations. Accordingly, the variety of clinical forms of emerging lesions should be expected.

The systematization of ideas about the main variants of radiation damage to the body that occur in case of uneven exposure is very important for the development of new methods of better treatment of malignant neoplasms, in large-field exposure, as well as for prognostic assessment of the consequences of accidents occurring in industrial conditions and as a result of possible exposure of astronauts during solar radiation flares .

The only correct approach to the study of various forms of acute lesions in case of uneven irradiation is the self-justified concept of a critical organ linking the object under consideration with the absorbed radiation dose in the irradiated volume. "Critical organ" is an organ, tissue or system responsible for the outcome of the disease arising from this form of radiation damage. That is why, with sufficiently large doses (more than 10 Gy.), not only hematopoietic organs can be critical, as in general radiation, but also other organs and systems of the body. For example, when exposed to weakly penetrating radiation (b-particles, low-energy X-rays), the critical organ is the skin, the area and degree of burns of which primarily determine both local and general damage to the body.

In the literature, there are many examples of human damage due to strong uneven, mainly local irradiation, in various, sometimes very large doses of 930Gy. — 5 kGy.), when various organs and tissues are critical: individual loops of intestines, soft tissues, nerve tissue (nerve bundle of the heart), skin, etc. The fatal outcome in these cases developed, respectively, from peritonitis, sepsis, severe hemodynamic disorder, etc., and death occurred either earlier, than hematopoietic damage occurred, or regardless of it. Therefore, the more carefully the geometry of the position of the affected person in relation to the radiation source is analyzed, taking into account the quantitative and temporal characteristics of the manifestation of the lesion in certain organs and tissues (and their significance for the outcome of the expected disease), the more correctly its form can be predicted, the more accurate it will be a possible prognosis and defined therapy tactics. To illustrate what has been said, we will cite a case described by A.K. Guskova and G.D. Baisogolov, in which the unevenness of irradiation affected significant segments of the body.

In the course of less than 1 second, the victim K. was exposed to extremely uneven gamma-neutron irradiation with an average dose of 5.8 Sv (gamma rays 1.1 Gy, neutrons - 4.7 Sv), average tissue dosefor the left half of the body reached 10 Sv, and in the surface (up to 5 cm) layer 16-20 Sv, for the right half of the body - 2.8 Sv.

The primary reaction developed in the first two hours after exposure; after 5-10 minutes. There was a feeling of "distension" in the whole body, and then nausea, frequent vomiting, weakness and numbness of the skin of the left half of the body.

From the end of the first day and for 25 days, a high temperature (+ 38° C) was maintained, at the same time symptoms of damage to the skin of the face, mucous membranes of the oral cavity, nose, and later - the gastrointestinal tract and extremities appeared and increased. From the 10th to the 20th day, the picture of damage to the skin and mucous membranes was the most severe: there were numerous blisters, erosions, dot hemorrhages, very painful inflammation of the eyelids and hair removal, a sharp loss of body weight - 8 kg in 2 days.

From the 24th day, the temperature dropped to normal, the state of health began to improve rapidly, epithelization of erosion in the oral cavity and healing of skin lesions began, and hair growth resumed on the 3rd month. At the same time, the formation of hydration edema of the affected tissues of the entire left half of the body began. Soon the victim was discharged from the hospital with unpleasant sensations (dryness) in the oral cavity, tightening pains in the left half of the chest, as well as a feeling of weight in the left half of the head. As the edema disappeared, deep atrophy of the subcutaneous fat tissue and baldness began to appear in the affected areas, and hair growth in the left temporal region was not restored for 10 years. In the patient's peripheral blood already 4 hours after irradiation, neutrophilic (93.5%) leukocytosis (14,900 in 1 mm) and deep lymphopenia (2.5%) were detected. On the 4th day, the number of leukocytes began to decrease and by the 7th day it was 375 cells in 1 mm3. Despite such an early and rapid decrease, the number of leukocytes in the following period not only did not decrease, but gradually increased and reached the initial level - 400 in 1 mm3 by 20 - 27 days. Other indicators of peripheral blood suffered a similar clinical course (large and early drop) followed by rapid recovery. Analyzing this observation, the author notes that the atypical course and outcome of the disease were due to the extreme unevenness of the irradiation, in which the early decrease of Fermi elements of the blood is due to the rapid devastation of larger volumes of bone marrow irradiated in doses of 10 - 20 Sv, temporarily excluded from the hematopoietic system. Along with this, the presence of less damaged areas of hematopoiesis exposed to a small amount of radiation contributed first to the maintenance (stabilization) of the number of formed elements at a reduced level, and then, from the 3rd week, to its rapid recovery, i.e. by this time, regeneration had begun in the more affected areas

Chronic radiation sickness.

Chronic radiation sickness is an independent nosological form of radiation damage that develops during long-term exposure of the body in small doses.

A pronounced syndrome of chronic radiation sickness develops with total doses of 0.7-1 Gy. and radiation intensity of 0.001-0.005 Gy/day.

There are three degrees of chronic radiation sickness: mild, moderate, and severe. The first usually begins imperceptibly for the patient. Very often, the disease is detected only during periodic medical care. The first symptoms of a mild degree of GPH are expressed in the appearance of weakness, increased fatigue, lethargy, headache, loss of appetite, drowsiness. At first, the indicated symptoms make themselves known only until the end of Sunday, and after a one-day rest, the state of health improves. As a result, there is an increase in symptoms and longer rest is needed to restore health.

The symptoms listed above can also be observed in other diseases. With radiation sickness, the composition of the blood also changes. At the first stage of HCC, a slight increase in the number of leukocytes is first detected in the blood, and then their number decreases to 2,000-4,000 in 1 mm3. The number of erythrocytes decreases less (up to 3,500,000 in 1 mm3), and the number of platelets remains normal.
Thus, the mild form of GPC is characterized by the fact that not all organs are affected by ionizing radiation, and most importantly, they have not lost the ability to compensate for the bad effects of radiation. Elimination of radiation helps to stop the development of the disease and complete recovery. To do this, it is enough to switch to a job not related to radiation.
Wave-like flow is characteristic for the second degree of CPH. Happens
Alternation of improvement and deterioration of the patient's condition. Work capacity is sharply reduced. A debilitating headache cannot be treated with medication. Patients can't tolerate loud music, light, even spoken language very badly. They become irritable and lose their memory to a great extent. There is a decrease in blood pressure and normal digestion is disturbed. Gastritis develops, which is accompanied by a lack of appetite, frequent vomiting. Progressive anemia is observed in patients. The ability of blood to clot decreases. Further deterioration of blood composition occurs. The number of leukocytes is below 2 thousand, and sometimes decreases to 900 in 1 mm. The number of erythrocytes is at the lower limit of normal, and the number of platelets is below normal.
Timely detection of CPH of the second degree under the influence of medical measures can be stopped, but the full recovery of the patient's health occurs slowly and not in all cases.
People who suffer from a chronic disease of the third degree are seriously ill, requiring bed rest. The signs of damage to the body are the same as in the second degree of the disease, but they become more pronounced. Diseases and the process, as a rule, are irreversible. A sharp change in the blood is observed. The number of leukocytes decreases to hundreds and even tens per 1 mm, the number of erythrocytes to 1.5-2 mDN in 1 mm, and platelets to several thousand. Death occurs with the catastrophic destruction of blood-forming organs, as well as as a result of sepsis, which is caused by the loss of immunity.
Hands, namely hands and fingers, are exposed to the most intensive exposure of professionals. Over-irradiation of the skin can cause chronic inflammation and local atrophy, which lead to chronic damage to the skin of the hands. The first signs of this disease appear in redness of the skin and some swelling of the hands. Later, there is a violation of blood circulation, the skin thins, becomes fragile and cracks appear on it. Longitudinal markings are observed on the nails, they become brittle and lose their natural shine. The skin on the ends of the fingers becomes dry, loses sensitivity. Treatment of chronic damage to the skin of the hands begins with the removal of a person from work with radioactive drugs.

Materials on the activation of students of higher education during the lecture: questions, situational tasks, etc*(if necessary)*.

General material and educational and methodological support of the lecture:
– educational premises;
- *equipment;*
- the equipment;
– slides, video films.

Questions for self-control:
a) on the topic of the lecture/literature, questions, assignments/;
b on the topic of the next lecture/literature, list of main issues/.

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Lecture No. 3

Topic: **Medical consequences of a large-scale nuclear accident**
Relevance of the topic: The applicant must familiarize himself with the main types of accidents in nuclear production, must have a general idea of the predicted medical consequences of radiation disasters, must learn the main stages of providing medical aid to victims of an accident.
Goal:
Educational: to form an idea of the main types of accidents in nuclear production; have a general idea of the predicted medical consequences of radiation disasters; learn the main stages of providing medical assistance to victims of an accident.
Basic concepts: Types of possible radiation accidents; medical and tactical characteristics of the radiation situation that developed after the disaster at the Chernobyl nuclear power plant; acute effects of irradiation; distant consequences of the accident at the Chernobyl nuclear power plant.

Content of lecture material (lecture text)

Introduction

With the development of humanity, its need for energy is constantly growing. It is believed that in the conditions of depleting reserves of natural fuel, nuclear energy is a significant source, which is at the appropriate stage of development, which is able to solve the problem of contradictions between the required and produced amount of energy.

At present, there are about 400 power units operating in the developed countries of the world as part of more than 200 nuclear power plants (NPP), nuclear thermal power plants (APEC), and nuclear power plants. The share of nuclear generators in different countries is from 30% to 70% of all electricity produced in these countries.

Despite the enormous resources invested in ensuring the safety of nuclear power plants, it is impossible to completely exclude emergency situations. For 35 years (from 1954 to 1988), 152 accidents involving the release of radioactive substances outside the reactor were registered in the world.

Radiation accidents occur constantly in Ukraine, for example, in 1992 there were 20 radiation accidents in Ukraine, including in Vinnytsia, Luhansk, Donetsk, Zaporizhzhya, Ternopil, Kharkiv, and Chernihiv regions.

In 1991, 91 radioactive sources were stolen. Currently, 73 sources are being sought (in particular, a plutonium source was lost in Zaporozhye, the Pavlogradska mine in Dnipropetrovsk region was contaminated with radionuclides, wagons with uranium were overturned in Chernihiv region. A 137-caesium capsule with markings was found in a non-residential building in Cherkasy region 134-cesium.

Unaccounted for radioactive sources are detected during dosimetric control of the area. Radioactive sources continue to be imported from abroad without the sanction of the Ministry of Defense. On the territory of the Kharkiv oncological dispensary, radio needles were found that had not been used in practice for a long time and were not in the records of the dispensary. But the greatest danger associated with the possibility of mass radiation damage is represented by accidents at nuclear reactors (nuclear power plants, etc.) with their depressurization.

General ideas about possible radioactive accidents at nuclear power plants

In a broad sense, it is customary to call radiation accidents: events associated with the loss of control over a source of ionizing radiation, as a result of which radioactive products escape protective barriers in an amount that exceeds the established standards, which can lead to exposure of personnel, and when certain situations and part of the population.

If the events are related to the damage of the heat-emitting elements of the nuclear reactor, are caused, for example, by a violation of the control and management of the distribution chain reaction in the reactor core or heat removal from the heat-emitting elements, and are accompanied by emergency exposure of people, they are usually called nuclear accidents.

Thus, the term "nuclear accident" is narrower than "radiation accident" and is used to refer to the loss of control only over fissile materials, not over any source of ionizing radiation. Radiation accidents can occur as a result of unexpected technical malfunctions of equipment.

As a result of the most severe radiation accidents, radioactive materials are released into the environment from a damaged NPP in the form of gases and aerosols, which form a radioactive cloud. This cloud, moving in the atmosphere in the direction of the wind, causes radioactive pollution of the area and atmosphere along the path of its movement. The area contaminated as a result of RR falling from the cloud is called the cloud trail.

Medico-tactical characteristics of radioactive contamination zones during accidents at nuclear power plants

According to the extent of spread of released radioactive substances and the radiation consequences of the accident, they are divided into three types:

1. Local accident- this is an accident, the radiation consequences of which are limited to one building or building, and in which there is a possibility of exposure of personnel and contamination of buildings located on the territory of the station, above the levels established for normal operation.

2. Local accident- radioactive consequences are limited to buildings and the territory of the nuclear power plant, with possible exposure of personnel and contamination of buildings and structures, which

are on the territory of the station, above the levels established for normal operation.

3. General accident- radiation effects spread beyond the territory of the NPP and lead to exposure of the population and environmental pollution of the above levels.

Characteristics of radioactive contamination zones

According to different levels of radioactive contamination and the degree of danger to the population, zones of moderate (A), strong (B), dangerous (U), extremely dangerous (G) contamination, as well as zone (M) - (zone of radiation danger) are distinguished.

The zone of radiation danger (denoted by the index M) is a section of the contaminated area, within which the radiation dose in the open area will be from 0.05 to 0.5 Gy. in a year. The zone of moderate radioactive contamination (denoted by the index A) is a section of the contaminated area, within which the annual radiation dose can range from 0.5 to 5 Gy. In the zone of strong radioactive contamination (marked by the index B), radiation doses in the area range from 5 Gy. up to 15 Gr. in a year. The zone of dangerous radioactive contamination (zone B) is characterized by a dose of 15 to 50 Gy per year, in the zone of extremely dangerous radioactive contamination (marked by the index G) radiation doses will be more than 50 Gy. in a year.

As a result of general radiation accidents, as was the case at the Chornobyl NPP, radioactive materials are released into the environment in the form of heated gases and aerosols (xenon, krypton - these noble gases quickly disperse in the atmosphere, are chemically inert, do not accumulate in the human body and have a harmful effect) they don't). Most of the others (zirconium, molybdenum, ruthenium, cadmium, tellurium, barium, cerium) with a half-life of 3 to 300 days are insoluble in water and body fluids, are not absorbed into the blood from the gastrointestinal tract and the surface of the skin, and only when inhaled air is partially retained in the body. Radioactive aerosols emitting beta particles irritate the mucous membranes of the respiratory tract, oral cavity, conjunctiva of the eye, skin, causing people to feel dryness, sore throat, catarrhal phenomena, metallic taste in the mouth, tingling of the skin. However, these isotopes in quantities insufficient for intensive external irradiation do not pose a serious danger to human life and health.

The real danger is the entry into the body of certain radioactive isotopes that, due to their solubility in water and body fluids, are able to enter the body's tissues, and then selectively accumulate in them and cause local internal irradiation until their complete or disintegration removal from the body . Such isotopes include radioactive iodine-131, strontium-90, and cesium-137.

Iodine-131 has a half-life of 8.08 days, that is, it decays relatively quickly. However, in the initial period after a radiation accident, it accounts for a significant part - up to 40-50% of the total radioactivity. Because of this, as well as due to accumulation in the body, it represents an important source of potential radiation danger. In the human body, up to 43% of the received iodine-131 accumulates in the thyroid gland. Here, iodine is included in the structure of thyroid hormones - thyroxine and triiodothyronine, and circulates in the blood as part of them. Accumulating in the thyroid gland, iodine-131 creates a local high dose in it.

Two other radionuclides, strontium-90 and cesium-137, are distinguished by a significantly longer life span: their half-life periods are 28 and 30 years, respectively, they enter the human and animal bodies, advancing along characteristic food pathways.

Strontium is very close to calcium in terms of its qualities. Following calcium, it comes from the soil to plants, then to animals, and accumulates in the bones of people, especially children aged one to two years. Strontium, which has settled in the skeleton, is excreted with difficulty and slowly. With very high local accumulation of strontium in cysts, long-term local radiation can be created, which poses a potential danger in relation to the formation of osteosarcoma after many years.

Cesium-137, chemically similar to potassium. Entering the body of animals and humans with plant food, it, like potassium, is evenly distributed in soft tissues: liver muscles, the nervous system, and is present in every living cell. Sources of cesium for humans can be vegetable (bread, vegetables, fruits) and animal products (meat, fish, milk).

In peacetime, radioactive contamination of the area is possible in case of failure of automatic safety systems as a result of inadvertent oversights on the part of operators servicing nuclear power plants of NPPs.

During the existence of atomic energy, there were three major accidents at nuclear reactors of various types. In England at the Windscale station (an accident that was hidden for decades), at STTTA at the Three Mile Island NPP and in the Soviet Union at Chernobyl.

In addition to the well-known accident at the Chernobyl NPP, there were two consecutive accidents at the Leningrad NPP back in 1974 and 1975. All this with over-radiation and emissions. In 1982, the engine room burned down at the Armenian NPP. On Balashovska Street - 14 people died during commissioning works. In 1984, there were fires at the Zaporizhskaya, Kalininskaya, and Yuzhnoukrainskyi stations. In 1986-1987, there were accidents of steam generators at the Zelandsko-Voroneza and Zaporizhzhya NPPs.

There are estimated data on the possible radioactive contamination of the area in the Odesa region in the event of an accident at the South Ukrainian NPP. According to the calculations, contamination is possible within a 50 km zone with a total area of 0.05 thousand km2 with a number of workers and their family members of 11 thousand people. Oriented levels of radiation are from 0.05 to 0.5 r/h

The main causes of disasters at nuclear power plants.

Imperfection of the design of nuclear reactors	Lack of control over the work of NPP builders and operators
Low quality of components	Narrow departmental position of the NPP
Insufficient reliability of control equipment	Bad choice of the city of construction of stations
Discipline. Morality of performers	A large number of agreements. Fear of taking responsibility
Knowledge of professional duties	The lateness of the information and its low probability
According to mass media	

It should be borne in mind that in Ukraine the moratorium on the construction of nuclear power units has been lifted and the powerful (third largest in the world) nuclear power unit at the Zaporizhzhya NPP has recently been put into operation.

Characteristics of the radiation situation that developed after the disaster at Chernobyl Nuclear Power Plant

The biggest radio-ecological disaster of our time took place in Ukraine. Already in the first ten days after the accident, the direction of the wind changed by 360 degrees, actually describing a full circle. This caused the contamination of large areas with radionuclides. Where it rained at that time, "spots" of radioactive contamination formed.

The formation of the main part of the radioactive fallout ended in the first 4-5 days. However, the full formation of the radioactive "trace" and "spots" continued throughout May 1986.

The generalized (by many surveys) gamma radiation dose power map became the basis for making many decisions - it was based on it that the evacuation isolines of the population were finally determined: exclusion zone - (20 mr/h), resettlement zone (more than 5 mr/h) and the control zone (3-5 mr/h) with temporary resettlement of part of the population (pregnant women, children).

Exclusion zonehas an area of 982 km2, on its territory are located the NPP, the city of Pryynati, 15 settlements, 4697 yards and 4 collective farms, 9 industrial enterprises, 11 educational institutions. 62,852 people lived there.

Settlement zone(evacuations) has an area of 3,300 km2, 23 settlements, 9,000 yards, 5 collective farms, 8 industrial enterprises, 27 educational institutions were located on it. The population was 93,000.

Zone of hard controlhas an area of 1,500 km2, on which 96 settlements, 3,000 yards, 22 collective farms, 16 industrial enterprises, and 40 educational institutions are located. The population in this zone was more than 46 thousand people.

Fallout of radioactive products was detected in many areas of the western part of the European territory of the USSR. Were air pollution with iodine-131 detected before May 2, 1986 in Ukraine - in Kyiv, Vinnytsia, Ivano-Frankivsk, Rivne; in Belarus - in Minsk, Brest, Mogilev; in the Baltic States - in Klaipeda, Riga and many other cities and towns. Noticeable falls of radioactivity with rain reached Austria, Germany, Italy, Norway, Sweden, Poland, Romania, Finland.

During the accident at the Chornobyl NPP, conditions arose when radioactive products could also enter water bodies as a result of direct deposition on water

surface, as well as through runoff from the contaminated area, as well as through migration with groundwater. In the first weeks and months of the accident, the most important thing was to find out the degree of pollution of the Pryynati River and the Kyiv Reservoir - the source of Kyiv's water consumption.

Acute effects of exposure. Medical consequences

237 people from among the personnel who were in the area of the emergency unit were hospitalized with a diagnosis of "acute radiation sickness" of various degrees of severity. Subsequently, this diagnosis was not confirmed in 92 of them. Out of 145 people with a diagnosis, IV degree of acute radiation sickness was noted in 21 people (20 of them died, one is alive), III degree - in 21 people (7 died, 14 alive), P degree - in 53 people (one died, 52 are alive), I degree - in 50 people (all alive). Among the population of the 3-kilometer zone and other regions, there were no cases of OPH.

Employees who were at the industrial site in the immediate vicinity of the NPP accident zone and auxiliary personnel were exposed to the combined effect of a number of radiation factors:

1. short-term external gamma and beta radiation of the gas cloud of the emission for faces that were in the emergency zone at the time of the explosion;
2. external gamma and beta radiation decreasing in power from fragments scattered on the industrial site, the damaged active zone of the reactor;
3. inhalation of gases and aerosol dust particles containing a mixture of radionuclides;

4 their application on the skin and mucous membranes at the time of intense vaporization and dusting of wetting of clothes (blowing from contaminated products)

At the same time, the general external relatively uniform gamma irradiation of the whole body, beta irradiation of large body surfaces with practically insignificant (except for 2 cases) significance of inhalation of a mixture of radionuclides with a determining contribution to the dose of iodine and cesium appeared as the leading ones. The main clinical form, thus, was a peculiar variant of OPH from uneven combined gamma and beta irradiation of the whole body and large areas of the skin.

The initial diagnosis of OPH was carried out in the MSCH (medical and sanitary unit) serving the NPP. Information about the accident at the station was received after 10-15 minutes. The first aid to the victims was provided at the NPP by the average medical staff and ambulance crews, starting from the first 30-40 minutes to 3-4 hours. The first aid consisted in the conclusion of the victims from the industrial site, the simplest sanitary treatment, giving antiemetics and symptomatic agents, and transporting persons with a pronounced primary reaction to the hospital. Persons with a satisfactory state of health were actively called for service in the ICU in the first 12-24 hours after the accident, a total of 132 persons were hospitalized in the ICU in the first 12 hours. The victim with severe burns died in the first 12 hours and 1 person from the reactor staff was not found: his workplace was in the zone of blockage and high radioactivity.

After 12 hours, a specialized emergency team arrived and began work. In 6 hours, the brigade, together with the staff of the Ministry of Health, cared for more than 350 people, performed about 1,000 blood tests (2-3 tests for each person).

In the first 3 days, 299 people were sent to a special hospital in Moscow and a hospital in Kyiv, and with the assumption of the presence of OPH, in the next term, about 200 more people were sent for examination.

The main criteria for establishing a diagnosis and determining the order of hospitalization were the presence of: the time of onset and intensity of nausea and vomiting, primary erythema of the skin and mucous membranes, and a decrease in the number of peripheral blood lymphocytes below 1-10% on the 1st day after exposure.

In the following, the diagnosis of OPH was confirmed in 99 out of 129 who entered the special hospital in Moscow in the first two days (firemen, operators of the fourth block, on-duty and auxiliary personnel of the turbine hall) and in 6 out of 74 victims hospitalized during the next three days. This indicates the high specificity of the used screening methods for OPC. Another 10 cases of mild OPH were diagnosed among the persons who were at the time of the accident at the industrial site, due to a number of circumstances, who were admitted to the hospital later. In the reception room of a specialized hospital, repeated control of pollution and, if necessary, sanitation was carried out (washing under the shower with ordinary soap and changing underwear). Blood and urine samples were taken for rapid assessment of radionuclide incorporation, and the content of radioactive iodine in the thyroid gland was measured (the study was repeated 4-6 more times during the first 6-10 days). To measure the activity of radionuclides in the entire human body, counters based on scintillation and semiconductor detection units were used.

Acute effects of radiation at the Chernobyl nuclear power plant

In the early days, the main diagnostic task was to assess the degree of severity of KMS based on the dose of external total radiation. This was possible at this time on the basis of previously developed methods for measuring the number of lymphocytes and chromosomal aberrations in the culture of peripheral lymphocytes or blood based on the number of aberrations in bone marrow preparations.
which made it possible to divide the victims into a number of groups according to the predicted weight of KMS: mild (1-2 Gy.), medium (2-4 Gy.), severe (4-6 Gy.) and extremely severe (6 Gy. and more) , as well as separate the victims whose radiation dose was less than IGy.

In the first days, special attention was paid to identifying faces with extremely severe (irreversible) degree of myelodepression, which required an urgent decision on bone marrow transplantation. Additional signs that made it possible to specify belonging to this group were the appearance of vomiting in the first half hour and diarrhea in the first 1-2 hours after the start of irradiation, and the increase of the parotid glands in the first 24-36 hours. The main manifestations of CMS were fever, infectious complications and hemorrhages on the skin and mucous membranes of the mouth.

Treatmentwas based on the principles of anti-infective and supportive therapy (isolation, systemic antibiotics and replacement transfusions of cellular blood components), and in the case of prognosis of irreversible myelodepression, transplantation of allogeneic bone marrow and human embryonic liver cells was used.

All patients with CMS of the 1st degree and more pronounced were placed one by one in ordinary hospital wards, adapted to ensure aseptic management of patients: sterilization of the air with ultraviolet lamps, strict observance by the staff of hand treatment when entering and leaving the ward, mandatory use of individual or disposable gowns , masks, caps, treating shoes with antiseptics, changing patients' underwear at least once a day, washing the walls, floor of the ward with antiseptics and waste objects treated with antiseptics in the wards, food was ordinary, raw vegetables and fruits and canned foods were excluded.

Prevention of endogenous infections was carried out with biseptol and nystatin - inside 6 tablets and 5,000,000 units per day, respectively. At the onset of fever, 2 or 3 antibiotics of a broad antibacterial spectrum were prescribed intravenously - one at a time (gentamicin or ampicillin) - all in maximum doses. As a result, no less than

the fever stopped in half of the patients. In the absence of an effect within 24-48 hours, gamma globulin was used.

For the first time, acyclovir was used with good effect for the treatment of patients with herpes simplex infection, which was affected by at least 1/3 of patients with class III and IV type of cystic fibrosis. Prophylactic acyclovir was not prescribed, experience has shown that it should be done in case of general exposure in high doses. An ointment containing acyclovir gave a good effect in the treatment of herpetic skin lesions.

The indicated regimen of empiric anti-infective treatment proved to be highly effective: there were practically no deaths due to infection in patients with bone marrow, even severe and extremely severe forms of APC, not complicated by burns, radiation enteritis or acute secondary disease (ABD) as a result of bone marrow transplantation. In addition, in the autopsy of patients who died from non-bone marrow lesions, no unmistakable macroscopic signs of bacterial and mycotic infections (septiconecrotic foci) were found.

One of the main successes in the treatment of CMS in this group of patients with APC was the rational use of fresh donor platelets for the prevention and treatment of bleeding

For 1 transfusion, platelets obtained from 1 donor (in the amount of 200-250 mol of blood plasma) were used. Transfusions were started when the level of platelets in the blood dropped below 20-10 /l or even lower, only with the appearance of signs of bleeding, repeating the administration in 1-3 days. Platelet mass, like all other blood components, must be irradiated at a dose of 15 Gy before infusion in order to inactivate immunocompetent cells of donor origin for the prevention of OVB.

The specified regimen of platelet transfusion ensured the absence of not only life-threatening bleeding, even in patients with long-term (more than 2-4 weeks) and deep thrombocytopenia, but also of any signs of bleeding in most patients.

In the actual situation, cryopreserved allogeneic and, most importantly, autologous platelet mass were successfully used. The latter was given to patients with CMS of 11-111 degrees of severity of CMO in the first days after irradiation (1-2 sessions), which did not affect the regular post-radiation dynamics of the number of platelets in them, and was used with high efficiency in the development of critical thrombocytopenia.

Leukocyte mass was not used for the prevention and treatment of agranulocyte infections. The need for erythrocyte mass turned out to be much higher than expected.

The indication for transplantation of allogeneic bone marrow cells and human embryonic liver cells was a dose of total gamma radiation, estimated by the number of peripheral blood lymphocytes and chromosomal aberrations, of the order of 6 Gy. and above According to the ideas that existed, irreversible or extremely long-lasting deep myelodepression was predicted at this dose of radiation. Transplantation of allogeneic bone marrow cells was performed.

In the period from the 2nd to the 19th day after transplantation (from the 15th to the 25th day after irradiation), 7 patients died from acute radiation injuries incompatible with life, skin, intestines and lungs. Of the patients who did not have life-threatening skin and intestinal lesions, and the radiation doses were estimated at 4.3-10.7 Gy. 2 people survived (gamma radiation dose 5, 8 and 9 Gy.).

Non-bone marrow syndromes of radiation damage and their therapy.

Widespread radiation damage to the skin, caused by exposure to beta radiation, was a distinctive feature of the defeat of people in this emergency situation.

Radiation burns of the skin in firefighters and victims of station personnel were observed only in combination with radiation damage to hematopoiesis and were, thus, a component of the general clinical syndrome of OPH.

Skin lesions were observed in half of all patients with OPH, and in cases of III and IV severity of KMS - in almost all patients.

The aggravating contribution of radiation damage to the skin in the overall clinical syndrome of OPH was determined not only by the prevalence of the process, but also by the degree of expressiveness of the pathological changes, as well as the duration of the course with peculiar relapses of the pathological process.

One person, as a rule, had burns localized on different parts of the body. In the early period, the most frequent localization was the hands, face, neck, feet, later lesions appeared on the chest, back, then on the lower legs, thighs, and buttocks. In some cases, this sequence was violated.

Diffuse hyperemia of the 1st day (primary erythema) was replaced by a latent period up to 3-4 days. Secondary erythema in the most severe cases appeared from the 5th day, and in most patients - from the 8th to the 21st day. Depending on the degree of damage, it ended with dry epidermis (I degree of radiation burn) or wet with the formation of bubbles (II degree) or bullous-ulcerative and ulcerative-necrotic dermatitis (111-1V degree). Epithelialization of erosive surfaces continued for 2-3 weeks from the moment of appearance of visible skin changes.

Burns in OPH patients covered from 1 to 100% of the body surface. At the same time, it can be noted that if there were relatively early (from 5-6 days) burns of the 11th-111th degree, at least on the area of 30-40%, with the subsequent spread of hyperemia, then they were incompatible with life. No less than 19 out of 56 patients with burns, the latter, undoubtedly, were fatal. Naturally, with the appearance of early secondary erythema on more than 40% of the body area, patients first developed a febrile-toxic syndrome, then renal-hepatic failure and encephalopathic coma with cerebral edema, which led to death within 14-18 days after exposure .

Intestinal syndrome

Intestinal syndrome was one of the most threatening manifestations of PCOS. The onset of the syndrome from the 4th to the 8th day, noted in 10 patients, indicated a short-term total gamma irradiation in the order of 10 Gy. and more (all these patients died in the first 3 weeks after exposure), the appearance of diarrhea after 8 days (in 7 people) - with a lower degree of defeat. With intensive water-electrolyte protein maintenance therapy, the presence of such radiation enteritis, which lasted from 10 to 18-25 days, could not be the only or the main reason for the fatal outcome.

Oropharyngeal syndrome

(OFS) - acute radiation mucositis of the mouth and pharynx - is observed in only 80 patients. Its mildest manifestations (1-11 degrees of severity) were characterized by swelling of the mucous membrane in the area of the cheeks, tongue and loose gums and were observed from 8-9 to 20-25 days. The main symptoms of more severe OFS (grade 1-1U) were erosions and ulcers on the mucous membrane of the mouth, sharp pain, a large amount of rubbery mucus, sometimes clogging the vestibule of the larynx and disturbing breathing. In a significant number of cases, radiation mucositis was complicated by secondary microbial and viral infection, which delayed its treatment. The primary early (on 3-4 day) manifestation of similar herpetic rashes forming massive crusts on the lips and facial skin was characteristic, which was observed in almost 30% of patients with severe CMS.

In the patients of this group, mainly with IV degree OCD, pronounced radiation parotitis was also observed with impaired salivation and a significant increase in the level of amylase in the blood from the 1st to the 4th day. The parotid glands decreased without special treatment, but the secretion of the salivary glands recovered more slowly.

Acute radiation pneumonitis

Acute radiation pneumonitis, described in recent years during total gamma therapeutic irradiation of patients with leukemia, was observed in this situation in 7 patients with OPC 111-1V severity level. Its characteristic features were rapidly increasing shortness of breath, when auscultated - "humming" like an "iron roof in the wind", wheezing in the lungs, which progressed for 2-3 days, ventilation failure, lethal exits from hypoxemic coma followed. Pneumonia developed, as a rule, a few days before death, combined with extremely severe lesions of the skin and intestines. Time of death - 14-30 days after exposure. Apparently, the radiation pneumonitis was complicated by a secondary, hard-to-recognize viral infection.

Bleedingonly in one case it reached a certain pathogenetic significance (hemothorax provoked by mechanical trauma during manipulation - catheterization of a vein).

In almost all cases, on the eve of the fatal outcome, there were pronounced manifestations of severe endogenous intoxication in connection with extensive radiation destruction of tissues, increased by infectious and septic complications. This was expressed in the insufficiency of the function of the liver, kidneys, signs of discirculatory toxic encephalopathy in combination with respiratory and vascular insufficiency.

The organ of vision

The dynamics of changes in the organ of vision had certain regularities. The lesion was characterized by early and consistent involvement of all tissues of the eye in the pathological process. At a dose not exceeding 1 Gy. no changes were noted. Among patients with OPHI, the degree of change was noted only in the front part of the eye: appearance in the first 2-4 days in some patients of light erythema of the skin of the eyelids and increased vascular pattern of the conjunctiva of the eyelids and the eyeball. Changes in the conjunctiva of the eyelids and the eyeball were noted with the same frequency as skin changes in the corresponding dose range.

Topical eye treatment consisted of applying ointments to the surface of the flaking skin of the eyelids.

The fight against the painful syndrome, as always with radiation damage, was quite difficult and ineffective. Undoubtedly, there are currently not enough effective local anesthetics in the arsenal of medical science.

In patients with severe radiation stomatitis and enteritis, a positive effect was noted from the use of total parenteral nutrition (based on a hydrolyzate of alvesin or an amino acid mixture - aminon and 40% glucose solution as energy material.

The phase of clinical recovery in the majority of patients with OPC of severity 1-11 was completed by the 3-4th month. In longer treatment, patients with severe radiation burns and the consequences of KMS Sh-1U degree suffered.

Starting 4 months after radiation, patients periodically came to the specialized hospital in connection with changes in the skin (areas of dystrophy and ulcers, with edema of the plantar tissue, mainly on the lower legs and feet), they were treated with de-aggregants and means that improve local blood circulation and tissue trophic. 5 patients with deep, large ulcers on the hands and other parts of the body underwent repeated plastic surgeries, some of whom needed longer treatment.

Several patients who survived severe and extremely severe CMS have laboratory signs of immunodeficiency status, but they did not have any severe and life-threatening infections during this time. In some of these cases, an attempt at immunocorrective therapy with T-B-activin has been started.

Demographic indicators after the accident at the Chernobyl nuclear power plant.

The employees of the National Center for the Study of Human Resources have discovered the impact of exposure and radioactive fallout from Chernobyl on the main demographic indicators. Thus, a close correlation was found between:

- A sharp decrease in the birth rate in 1987 in controlled areas and radiation. A decrease in the birth rate begins with exposure to doses of 30 Gr or more.
- A decrease in the birth rate in areas with soil contamination with strontium radioisotopes.
- A decrease in the birth rate depending on the doses of internal radiation and an increase in the proportion of boys in the ratio of sexes born on soils contaminated with cesium and strontium
- An increase in the level of child mortality in controlled areas in 1987 with radiation doses.

Analysis of population dynamics revealed a significant decrease in Zhytomyr and Chernihiv regions, with the opposite trend in Poltava region. For the areas of control and observation, the average annual rate of decrease is 3.5 thousand people and 2.8 thousand people, which led to a decrease in its number by 15-20%

This is due to both a decrease in natural growth and a preference for outflow over inflow in mechanical migration. At the same time, there are significant changes in the age structure of the population, its type is changing. All this has a profound effect on the process of reproduction of the population. One of the reasons for the decline in the birth rate in controlled areas is a 2.5-fold increase in the level of involuntary abortions.

Significant increase in total mortality in Zhytomyr region. There is an increase in mortality from neoplasms, diseases of the endocrine system, blood and hematopoietic organs.

Consequences of the Chernobyl disaster for public health.

As a result of the Chernobyl disaster, about 3 million people were affected in Ukraine (excluding the city of Kyiv), among them 5,237 people who lost their ability to work, 187 people who were sick with chronic obstructive pulmonary disease, and 30,000 people whose illnesses are related to the consequences of the Chernobyl disaster.

155,000 people who took part in the liquidation of the accident, 130,000 evacuees and displaced persons will require the greatest medical attention. This group includes liquidators from 1986-1987, with radiation doses of about 250 mSv. and more.

Among the population, children and elderly people are the most radio-sensitive.More than 300,000 children who suffered from the Chernobyl accident live in Ukraine.

In the structure of diseases of the adult population, diseases of the respiratory organs and the nervous system are on the first plan, and diseases of the respiratory organs, digestion, and the nervous system of the children's population, the specific weight of diseases of the digestive organs, iron deficiency anemia, adenoids, congenital anomalies of the heart, circulatory

system, etc. is also increasing. Attention is drawn to the increase in spontaneous abortions, bleeding, and other complications of pregnancy in women.
Among the population, a decrease in indicators of cellular and humoral immunity, an increase in cytogenetic effects with an increase in specific radium markersthis influence. An increase in the incidence of thyroid cancer in children has been noted.
In a practical sense, the assessment of non-neoplastic pathology with long-term external and internal radiation in a small dose is of great importance. Such exposuremay be exposed to the population living in the territory contaminated by radioactive products as a result of accidents at nuclear power plants.
In the conditions of long-term irradiation with a dose of low power, the slow development of pathological processes is noted, because the protective and adaptive mechanisms ensure the normal vital activity of the organism for a long time.
As already mentioned, the critical group consists of children, pregnant women and mothers-are blowing Thus, in children, due to the small mass of the thyroid gland, its radiation dose is 2-10 times higher than in adults, in pregnant women, a significant amount of iodine isotopes passes through the placenta into the body of the fetus, in nursing mothers, iodine isotopes are well excreted with milk and enter the child's body.
Damage to the thyroid gland is accompanied by involvement in pathological process of other endocrine organs, which leads to a violation of neuroendocrine regulation. These processes may result in changes in the cardiovascular and other systems.
Changes in the cardiovascular system can be manifested by neurocirculatory dystonia. Predominant is a violation of blood circulation in the skin, brain, limbs (ostealgia).
Atrophic and hypoplastic conditions, a decrease in the protective and adaptive (adaptive) capabilities of the body can be manifested by the growth of various diseases. It should be borne in mind that the growth of these diseases can be caused by non-radiation factors, therefore it is necessary to keep track of the real radiation doses of a certain contingent of the population. All sick people or those who are considered "sick from Chernobyl" should be classified as victims of the disaster, at the same time, the contribution of each of its pathogenic factors should be sensitively

As a result of the implementation of the national program of immediate measures to eliminate the consequences of the accident at the Chernobyl nuclear power plant, the formation of a new socio-ecological community characterized by a high level of public anxiety and passive adaptation processes was revealed.
I can compare the psychological state of professionals - workers of the nuclear industry and the described psychological state of "Chernobyl residents". Professionals differ rather bravado in relation to the influence of radiation: "We are with radiation on you." Obviously, the stated anxiety of the population is caused by the lack of accurate data on radiation and the stressful impact of the disaster situation.

Materials on the activation of students of higher education during the lecture: questions, situational tasks, etc*(if necessary)*.

General material and educational and methodological support of the lecture:
– educational premises;
- *equipment;*
- the equipment;
– slides, video films.

Questions for self-control:
a) on the topic of the lecture/literature, questions, assignments/;

b on the topic of the next lecture/literature, list of main issues/.

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