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RADIATION AND NUCLEAR MEDICINE

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Resume. *This article highlights modern nuclear physics, instruments used in nuclear medicine, nuclear reactions by multiply charged ions, dosimetry, nuclear physics and measurement methods, radiopharmaceutical-based diagnostic methods in the diagnosis of radionuclides, cancer and its treatment options, radioactivity with substances such as nuclear reactors, gamma-ray detectors, radioisotope thermoelectric generators, Parkinson's and Alzheimer's diseases, the consequences of heart attacks, the condition of transplanted organs.*

Key words: *radiation, nuclear reactors, gamma detectors, radioisotope, thermoelectric generator, gamma rays or X-rays, photoelectrons, Compton electrons and electron-positrons, nuclear medicine.*

I. INTRODUCTION

The rapid changes taking place in the life of our society, the bold entry of our independent Republic into the international arena and the pursuit of economic prosperity impose a number of serious tasks on the employees of the education system. The development of scientific fields, the increase in new methods and approaches to research from year to year lead to a continuous increase in information. In such conditions, in order to raise the level of education and upbringing, it is necessary to find new methods and techniques for students to acquire knowledge, to create new educational literature. For this reason, we would like to draw attention to the importance of physics in the field of medicine. The study of nuclear medicine is gaining importance in modern medicine.

Radiation (Latin: radiatio - radiation) - electromagnetic and corpuscular radiation, solar radiation, cosmic rays, which arise as a result of nuclear changes. The effect of radiation on a living organism is determined by the radiation dose. It is measured in roentgen (r). The amount of radiation depends on the damaging effects of absorbed radiation and other radioactive radiation. Up to 20 R of radiation per day is considered a safe dose for the human body. More than this amount of radiation damages tissues in the body and causes radiation sickness. The radiation dose is measured using dosimetric instruments. A set of measures has been developed to reduce the harmful dose to a safe radiation dose when working with radioactive substances (rays, neutrons, etc.) and other ionizing radiation sources (X-ray devices).

Radioactive substances are not released into the environment from sealed radiation sources (hermetic radiation sources, X-ray devices, accelerators, etc.). When working with such sources, only external radiation affects the body. To reduce the dose of external radiation, it is necessary to minimize the time spent working in the radiation field, stay away, and shield the source or object.

When working with open radiation sources, radioactive substances can enter the body through the respiratory tract, stomach, intestines, or skin, and the body can be irradiated from within. To reduce the internal radiation dose, it is necessary to seal technological equipment and the workplace, install filters in ventilation systems, use personal protective equipment, and follow radiation hygiene rules.

Radiation safety service conducts radiation control at all enterprises working with radioactive substances and other sources of ionizing radiation.

Radiation protection, radiation safety - a set of measures to ensure safety when working with radioactive substances and other sources of ionizing radiation. It is based on the achievements of radiobiology, nuclear physics, space biology, space medicine and other sciences. The main goal of radiation protection is to prevent contamination of the biosphere with radioactive substances, to protect the human and animal body from harmful radiation, for example, in space conditions, etc. Information about the biological effects of harmful radiation on the body serves as the basis for the development of radiation protection or radiation safety standards. Ensuring safe conditions when working with radioactive substances or using them is, first of all, to reliably protect employees from exposure to sources of dangerous radiation (nuclear reactors, gamma defectoscopes, radioisotope thermoelectric generators, etc.). This is achieved by shielding (barring) devices, creating labyrinthine (detour) routes to enter the workroom, limiting the time of work with these sources, timely removal of radioactive waste and appropriate processing, use of individual protective equipment and other measures.

II. LITERATURE REVIEW

To ensure regulatory radiation protection, radiation safety standards were developed based on the materials of the International Commission on Radiation Protection (1976). This document sets out the basic principles of radiation protection. These standards establish the permissible values and control levels of radiation exposure to radioactive rays, radiation dose limits, and quality coefficients of various radiations. These standards are mandatory for all persons working with radioactive substances. If it is determined that the radiation protection limit standards have been violated, measures are taken in accordance with the basic sanitary rules for working with radioactive substances and other ionizing radiation.

Dosimetry (from Greek dosis - share, piece and meterio - measure) is a branch of applied nuclear physics; it deals with the study of physical quantities that express the effect of ionizing radiation on living and inanimate objects of nature, in particular, determining the dose (standard) of radiation, and creating methods and instruments for measuring these quantities. Radioactive radiation is emitted in natural and artificial radioactive decay, in charged particle accelerators (betatron, cyclotron, etc.), in atomic reactors, and in X-ray machines. After the discovery of radium, it was established that the rays of radioactive substances affect living objects in the same way as X-rays. When working with radioactive substances, there is a risk of these rays entering the body. The main purpose of measuring the dose of radiation is to ensure the safety of personnel working with these devices and substances. The effect of radioactive rays on various objects (physical, chemical and biological effects) is determined by the amount and nature of the rays absorbed by these objects. The absorbed dose is measured in rads. Various physical phenomena occur when radioactive radiation hits objects. For example, photoelectrons, Compton electrons, and electron-positron pairs are formed as a result of the absorption of gamma rays or X-rays. An ionization chamber, a "Cactus" X-ray meter, and universal dosimeters are used to measure the dose of X-rays, gamma rays, beta radiation, and neutrons. A Geiger-Muller counter is used to measure the dose of low-intensity radiation, and a scintillation counter is used in the laboratory. There is also a photographic method of dosimetry. It is based on the darkening of photographic film under the influence of rays. Chemical dosimeters based on oxidation or reduction reactions, ferrous sulfate and cesium sulfate dosimeters, are also used. The thermal effect of radiation on objects is measured by the calorimetric method.

Nuclear medicine is a specialized field of radiology that uses very small amounts of radioactive materials, or radiopharmaceuticals, to study the function and structure of organs. Nuclear medicine imaging is a combination of many different disciplines. These include chemistry, physics, mathematics, computer science, and medicine. This branch of radiology is often used to diagnose and treat abnormalities early in a disease, such as thyroid cancer. Because X-rays pass through soft tissues such as the intestines, muscles, and blood vessels, these tissues are difficult to see on a standard X-ray when contrast media is used. This allows the tissues to be seen more clearly. Nuclear imaging allows the structure and function of organs and tissues to be visualized. The degree to which a radiopharmaceutical is absorbed or "taken up" by a particular organ or tissue can indicate the level of function of the organ or tissue being examined. Therefore, diagnostic X-rays are primarily used to study anatomy. Nuclear imaging is used to study the function of organs and tissues.

III. RESULTS

During the procedure, a small amount of radioactive material is used to aid in the investigation. The radioactive material, called a radionuclide (radiopharmaceutical or radioactive tracer), is absorbed into body tissues. There are different types of radionuclides. These include forms of the elements technetium, thallium, gallium, iodine, and xenon. The type of radionuclide used depends on the type of examination and the part of the body being examined.

After the radionuclide is injected and accumulates in the body tissues being examined, radiation is released. This radiation is recorded by a radiation detector. The most common type of detector is a gamma camera. Digital signals are generated and stored by a computer when the gamma camera detects the radiation.

By measuring the movement of the radionuclide in the body during a nuclear scan, a doctor can evaluate and diagnose a variety of conditions, such as tumors, infections, hematomas, enlarged organs, or cysts. Nuclear scans can also be used to assess organ function and blood flow.

Areas where radionuclides accumulate in large amounts are called "hot spots." Areas that do not absorb the radionuclide and appear brighter in the scanned image are called "cold spots."

In planar imaging, the gamma camera remains stationary. The images obtained are two-dimensional (2D). Single-photon emission computed tomography (SPECT) produces axial "slices" of the organ being examined as the gamma camera rotates around the patient. These slices are similar to those in computed tomography. In certain cases, e.g. PET scans, SPECT data can be used to create three-dimensional (3D) images.

Nuclear medicine is a branch of medical radiology that uses radionuclides and ionizing radiation to study the functional and morphological state of the body, as well as to treat human diseases.

Currently, various radioactive isotopes and sources of ionizing radiation are used in medical practice to diagnose and treat various diseases. Purpose-designed X-ray machines, powerful gamma-therapeutic devices, electron, proton and other elementary particle accelerators, radioactive isotopes - sources of ionizing radiation of various types, radionuclides for medical purposes and substances labeled with them are radiopharmaceuticals.

Nuclear Medicine: How Does the Atom Help Treat Cancer?

Nuclear medicine is one of the most innovative and rapidly developing areas of modern medicine. Nuclear medicine techniques help doctors detect dangerous cancer cells at an early stage of the disease, which allows for treatment with almost 100% certainty.

Nuclear medicine is the diagnosis and treatment of diseases using pharmaceuticals containing radioactive isotopes, called radiopharmaceuticals. Radiopharmaceuticals are widely used to diagnose and treat cancer in various organs. Among the advantages of treatment with radiopharmaceuticals is its local effect, which, unlike chemotherapy, does not affect the entire body.

The need to quantitatively assess the effects of ionizing radiation on various substances in animate and inanimate nature led to the emergence of dosimetry. Dosimetry is a branch of nuclear physics and measurement techniques that studies the quantities, measurement methods and instruments that characterize the effects of ionizing radiation on matter. The initial impetus for the development of dosimetry was the consideration of the effects of X-rays on humans. The chapter also included cosine rays and elementary particles as phenomena and concepts related to ionizing radiation.

Diagnosis in the early stages of any disease is important. In cancer, this plays a very important role. Nuclear medicine methods allow for the diagnosis of cancer in the early stages. The use of a minimum amount of drugs in combination with the latest equipment and highly qualified personnel provides convenient, fast and accurate examination [3]. The uniqueness of nuclear medicine methods allows us to detect abnormalities in the vital functions of organs in the early stages of the disease, that is, when a person does not notice any symptoms of the disease. This allows us to quickly identify and treat various diseases, and also helps to save on treatment costs. For example, studies conducted in the USA, Japan, Western Europe and Australia show that, compared with the healthcare systems of these countries, 1 US dollar spent on nuclear medicine saves 1.5 to 2.5 US dollars in other healthcare costs, i.e. surgical procedures, hospital treatment, etc.

Currently, nuclear medicine methods in Uzbekistan are used in the Department of Nuclear Medicine of the Republican Specialized Scientific and Practical Center of Endocrinology named after Academician Ya. Kholmatov and in the Department of Radioisotope Diagnostics Laboratory of the Republican Specialized Surgical Center named after Academician V. Vokhidov. This department uses the iodine-131 radioisotope to diagnose and treat thyroid diseases, as well as thyroid cancer. In recent years, more than 850 patients have undergone iodine-131 radiotherapy. Also, the IAI of Endocrinology and the V. Vokhidov State Research Institute of Radiology have introduced the use of the samarium-153 oxabifor radiopharmaceutical and a technetium generator.

The more difficult-to-name drug samarium-153 oxabifor is used to relieve and treat pain in bone metastases. At the V. Vokhidov RIJM, up to 2,000 diagnostic studies are performed annually using technetium-99 (a radiopharmaceutical used in the diagnosis of cancer, cardiovascular diseases, brain, kidney, liver and other diseases) and up to 300 bone metastases are treated with radiotherapy using the drug samarium-153 oxabifor. The drug samarium-153 is injected into the blood vessels, the drug accumulates in bone tissue and mainly in cancer metastases. One dose of the drug provides pain relief for 6 months and keeps cancer tumors in remission (cancer development has stopped) and replaces daily strong painkillers, such as morphine. Also, the amount of radiation in the drugs is small enough to irradiate the entire body, but sufficient to destroy cancer cells in a specific area.

Radionuclide diagnostics is a type of radiation diagnostics based on external radiometry of radiation emitted by organs and tissues after the introduction of radiopharmaceuticals directly into the patient's body. This is a functional imaging method that allows you to qualitatively and quantitatively assess the presence of functioning tissues in the organ under study. The features of nuclear medicine technologies are to recognize the pathological process at the molecular level, in some cases at the preclinical stage. Radionuclide diagnostic technologies have functional and physiological properties, that is, they do not affect the normal or pathological process of the vital activity of the organ and system they reflect (Fig. 1).

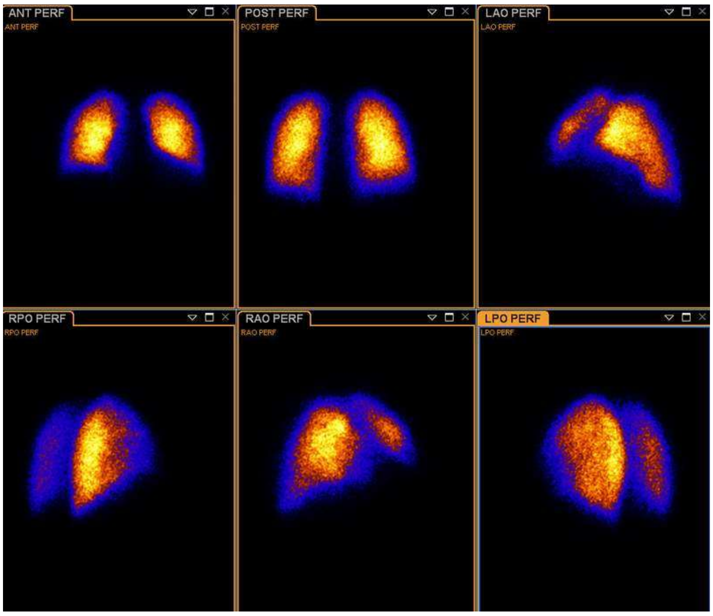

Fig. 1. Radionuclide examination of the lungs

Radionuclide diagnostics is based on remote radiometry and the use of radiopharmaceuticals, the distinctive feature of which is the ability to accumulate and spread in the organ under study, depending on the presence of functioning tissues and reflecting the dynamics of processes occurring in the body. When a radioactive isotope is introduced into the human body, a counter can be used to measure the radiation generated and determine the localization, amount and distribution of the introduced isotope.

Such data are invaluable for diagnosing a number of medical diseases. Due to the high sensitivity of radiation detectors, very small amounts of radioactive substances are introduced into the human body. Therefore, such examinations are performed at very low doses of tissue irradiation, which means that it is necessary to introduce a very small mass of the radiopharmaceutical. In many processes in the body, especially when interacting with hormones or vitamins, it is easy to disrupt the normal balance of substances. Radioactive testing rarely requires the administration of more than 1 microgram (one millionth of a gram) of a substance, and its path through the body must be monitored, without disrupting the normal balance above. This is a valuable quality of the radioisotope method used in medical and biological research.

Radionuclide diagnostics is a diagnostic method based on the administration of a radiopharmaceutical (Rf) to a patient, which has the following properties:

1. Tropism (proximity) to the organ or tissue under study (for example, participation in the metabolism of the tissue under study).

2. The presence of a radioactive label that allows you to determine the dynamics and amount of accumulated radiopharmaceuticals using an external sensor.

A radiopharmaceutical is a chemical compound intended for administration to a person for diagnostic or therapeutic purposes and containing a specific radioactive nuclide in its molecule. It is introduced into the body by injection, ingestion or inhalation along with pharmaceuticals. It is not safe, and the effect is phenomenal: weak radio emission from the body provides the most accurate information about various organs and pathological conditions; obtaining such information by other means requires complex research and surgical intervention. The peculiarity of the method is that the radio emission comes from inside the organ and is not transmitted from the outside, as is the case with X-rays, computed tomography or magnetic resonance imaging (radioelectron radiation tomography, not an external device emitter). The so-called radioisotope - a radioactive part of the drug introduced into the body). This allows you to study the organ of interest at a high level. The resulting image, as in the above cases, shows not only anatomical anomalies, but also biological processes [6]. Nuclear medicine uses gamma rays, similar to X-rays used in fluoroscopy. The weak radiation coming from the organ under study is recorded by a special camera installed a few centimeters from the patient's body. This takes several minutes, the cameras work without changing the object, and the data obtained can be indispensable in a number of cases: when studying the work of the heart and blood circulation in the brain, when studying brain cells, when studying the sufficiency of the kidneys, lungs and stomach, when studying the absorption of vitamins and bone density. Nuclear medicine allows us to detect small bone fractures before they are visible on X-rays. It can also detect cancer and its treatment options, detect epileptic seizures, Parkinson's and Alzheimer's diseases, the effects of heart attacks, and the condition of transplanted organs. Labeled compounds were first used in clinical practice in the late 1920s. Then, in 1927, Blumgart and Weiss published scientific studies on the use of radon gas to determine hemodynamics in patients with heart failure. The advent of radioactively labeled atoms at the disposal of doctors opened up a whole field known as radioisotope medicine, and we see it now as a legitimate new specialty.

IV. DISCUSSION

Use of radioactive isotopes. A new field of medicine is based on the use of radioactive isotopes. The chemical properties of an isotope are the same as those of the normal corresponding element. Some isotopes, having too many or too few neutrons in the nucleus, are radioactive, that is, they emit radiation that can be detected by a sensitive instrument such as a Geiger counter or scintillation counter. The radiation can consist of alpha or gamma rays, or both. There are certain isotopes used in radioisotope medicine. The choice of a radioactive nuclide is made with the following requirements in mind: low radiotoxicity, an acceptable half-life (from a few minutes to a few hours), and a gamma radiation that is convenient for recording [9]. The radioactive nuclide, incorporated in one way or another into the composition of the drug, acts as its marker. The radiation of the radionuclide becomes a carrier of information from the patient under study to the information-measuring complex. The physical properties of the radionuclide radiation predetermine the size and depth of the body area to be detected. In this case, the radioactive radiation emitted by the patient's body indirectly provides information about the functional state of various physiological mechanisms and the structural and topographic features of various organs and systems. By observing the distribution characteristics of a radioactive drug over time in a selected volume of the body (organ) or throughout the body as a whole (distribution dynamics), we can assess the functional state of organs and systems.

V. CONCLUSION

By studying the nature of the phase distribution, we can obtain information about the structural and topographic features of a particular part of the body, organ or system. Therefore, according to their functional properties, RFs can be divided into physiologically tropic and inert. It follows that the first is the best tool for conducting structural and topographic studies, each of which is carried out from the moment when a more or less stable distribution of radiopharmaceuticals in the studied organ or system is established. The latter, often called "transit" indicators, are mainly used to study gamma chronography.

Thus, the rate of accumulation of the drug in the thyroid gland is determined empirically. If the accumulation occurs faster, we are dealing with hyperfunction of the thyroid gland, and if the accumulation is slower than normal, then with hypofunction, we use a radioactive tracer for clinical purposes. This example clearly demonstrates the essence and capabilities of radionuclide diagnostics.

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