State educational institution of higher professional education
"NORTH OSSETIAN STATE MEDICAL ACADEMY"
Federal Agency for Health and Social Development
Russian Federation
(FGBOU VO SOGMA)

DEPARTMENT OF
RADIATION DIAGNOSIS WITH RADIOTHERAPY AND ONCOLOGY

PHYSICAL FOUNDATIONS OF RADIOLOGY. RADIOACTIVITY, RADIOACTIVE RADIATION, THEIR CHARACTERISTICS. RADINUCLIDE DIAGNOSTICS

EDUCATIONAL AND METHODOLOGICAL DEVELOPMENT

General purpose of the lesson: To have an idea about radioactivity and radioactive emissions, their properties. The structure of the atom. Methods for recording radiation, the device of radio diagnostic equipment. Radionuclide diagnostics, its principles and diagnostic possibilities.

Specific objectives of the lesson:

Know:

1. The structure of the atom.
2. What is radioactivity, its qualitative and quantitative characteristics.
3. What is radiometry, radiography, gamma-topography, what are radioactive isotopes and their production.
4. Know the physiological basis of radionuclide diagnostics.
5. Requirements for radiopharmaceuticals used for diagnostic purposes.

Be able to:

1. Determine the activity of a radioactive substance according to the isotope passport.
2. Determine the indications for radionuclide research.
3. Assess the clinical significance of the conducted radionuclide study.

Base of holding and material equipment:

1. Study room.
2. Tables.
3. Detectors for registration of radiation.

Literature:

1. Lindenbraten L.D., Korolyuk I.P. Medical radiology and radiology. M.: Medicine, 1993.
2. Lindenbraten L.D., Korolyuk I.P. Medical radiology. M., 2000.
3. Lindenbraten L.D., Lyass F.M. "Medical Radiology".
4. Radiation diagnostics: Textbook for high schools. / Ed. prof. G.E. Trufanov. M.: GEOTAR-Media, 2007.

Information block:

Radioactivity is the ability of the nuclei of some chemical elements to spontaneously decay with the release of radiant energy in the form of alpha, beta and gamma rays. Natural radioactivity was discovered by the French physicist A. Becquerel in 1896, who discovered the emission of invisible rays from uranium salts, causing the photographic emulsion to blacken like X-rays. The studies of Marie and Pierre Curie, Rutherford / found that a beam of radioactive rays is inhomogeneous and breaks up into its component parts in a magnetic field: alpha rays deviated towards the negative pole and were positively charged particles, beta rays deviated towards the positive pole, and gamma rays the beams were not deflected at all and were electromagnetic waves, similar to X-rays. Later it was found that alpha rays are complex particles consisting of two protons and two neutrons, beta rays are a stream of electrons, or positrons, if the beta radiation is positive.

Radioactive rays have properties:

1. Penetrate through various media.
2. Ionize the environment through which they pass.
3. Cause the glow of certain substances - phosphors.
4. Cause blackening of the photographic emulsion.
5. They have a biological effect.

A deep study of the properties of radioactive elements led the English physicist Rutherford in 1911. to the creation of a planetary model of the structure of the atom. This model, improved by the Danish scientist Niels Bohr and the Russian scientist Ivanenko, is still in use today, because it helps to understand the phenomenon of radioactivity. All atoms are neutral and consist of a positively charged nucleus and negatively charged particles - electrons - rotating around it. According to the periodic table, you can represent the structure of the atom of any chemical element. The nucleus of an atom is made up of protons and neutrons. The number of protons is the charge of the nucleus - in the periodic table the serial number. The sum of protons and neutrons is the mass number, i.e. atomic weight. The number of protons in the nucleus corresponds to the number of electrons in the electronic levels, the number of the latter is determined by the period. The number of electrons in the outer electronic level is determined by the group, and chemically it is the valency. Protons and neutrons are held within the nucleus by forces called nuclear forces. Stable stable nuclei contain certain numbers of protons and neutrons. If the nucleus contains an excess of protons or neutrons, then it is unstable, radioactive. Spontaneously changing its composition, the nucleus eventually falls into a stable region.

1934 was marked by the discovery of the phenomenon of artificial radioactivity by the French scientists Frederic and Irene Joliot-Curie. This is how the well-known term "radioactive isotope" appeared. At present, by bombarding stable chemical elements with neutrons, it is possible to obtain a radioactive isotope of any chemical element, currently called radionuclides. That. the possibility of introducing radionuclides into the patient's body, to monitor their location with the help of radiodiagnostic equipment. The method is called radionuclide diagnostics, and the radionuclides introduced into the body are called radiopharmaceuticals (RP).

Characterization of radioactivity

Half-life is the time it takes for half of the atoms of a radioactive substance to decay.

The fraction of atoms decaying per unit time is the **decay constant.**

The activity of a radioactive substance is the number of atoms decaying per unit time.

Specific activity - the number of decaying atoms per unit time per unit mass of a substance.

Activity units

According to the SI system

Becquerel is one disintegration per second.

Derivatives:

Kilobecquerel - 1000 becquerels. Megabecquerel - 1,000,000 becquerels.

Off-system units.

Curie - 3.7×10^{10} disintegrations per second.

Derivatives:

Microcurie - 3.7×10^{7} disintegrations per second. Millicurie - 3.7×10^{4} disintegrations per second

Ionizing radiation is invisible, odorless, therefore, it is possible to measure them with the help of instruments that record the effect of radiation on physical, chemical and biological media. From here, physical, chemical, and other methods of recording radiation are distinguished. Physical methods are more often used: ionization and luminescent (scintillation) methods of registration of radiation. To perform radionuclide studies, a variety of diagnostic devices have been developed, which include a detector that converts ionizing radiation into electrical impulses, an electronic processing unit, and a data presentation unit. According to the type of the latter, they are distinguished: the method of radionuclide imaging, radiography, clinical and laboratory radiometry.

Radionuclide imaging is the acquisition of an image of the studied organ, part of the body or the entire body of the patient when radiopharmaceuticals are introduced into the body, using gamma scintigraphy. Options for gamma scintigraphy are single photon or two photon emission tomography. Sometimes a scanner is used for visualization, the study is called a scan.

To study the dynamics of the body's radioactivity, to study various physiological and biochemical processes in a number of installations, it is possible to register the results of the study in the form of numbers and conduct such a study at repeated time intervals and, based on the data obtained, judge the accumulation and excretion of radioactive material - this is radiometry. It is suitable for recording slow processes.

To study processes accompanied by a rapid change in the radiation intensity, continuous recording of pulses is required. In such cases, counting installations are used, in which the counting rate meter is connected to a recorder that draws a curve - a radiogram, and the recording method is called radiography. An example is the study of lung ventilation, hemodynamics, accumulation and excretion of radioactive substances by the liver, kidneys, etc.

To implement these methods, radionuclides (radioactive isotopes) or indicators labeled with them are used, which are called radiopharmaceuticals (RPMs).

Radiopharmaceutical is a chemical compound approved by the Pharmacopoeia Committee for administration to a person for diagnostic purposes, the molecule of which contains a radionuclide.

RFP must meet a number of requirements:

1. Be harmless.
2. The half-life must be sufficiently short, but must allow the necessary investigation to be carried out in time.
3. It is quickly excreted from the body.
4. Possess tropism for the studied organ or the studied metabolism.
5. Must have a certain emission spectrum.

6. Use in small (indicator) doses. An important minimum radiation exposure, for which the concepts are used.

The physical half-life is the decay time of half of the atoms of a radionuclide. The time during which the activity of the drug introduced into the body is reduced by half due to its excretion is called **the biological half-life.** The time during which the activity of the radiopharmaceutical introduced into the body is reduced by half due to physical decay and excretion is called **effective?" half-life.**

In some cases, a radionuclide study can be carried out without the introduction of radiopharmaceuticals into the body - in vitro , i.e. All studies are carried out in test tubes. It makes it possible to detect in biological fluids (blood, urine) hormones, enzymes, medicinal and other substances in negligible concentrations. The principle of this method, called radioimmunoassay, consists in the competitive binding of the desired stable and similar labeled substances with a specific receiving system.

Radionuclide analysis in vitro has come to be called radioimmunoassay because it is based on the use of immunological antigen-antibody reactions. However, in the future, other types of research were created, similar in goals and methodology, but differing in details . vitro . So if an antibody is used as a labeled substance, and not an antigen, the analysis is called **immunoradiometric,** but if tissue receptors are taken as a binding system, they talk about **radioreceptor analysis.**

TEST QUESTIONS

1. What is radioactivity? Radioactive radiation and their characteristics.
2. The structure of the atom and the relationship of the structure of the atom with the table of chemical elements of Mendeleev.
3. What is artificial radioactivity? Obtaining radioactive isotopes.
4. What are radiopharmaceuticals and what are the requirements for them.
5. What is the difference between the distribution of radioactive isotopes in the body and the distribution of stable ones.
6. Methods for registration of radiation.
7. The device of radiodiagnostic equipment.
8. Principles and possibilities of radionuclide research.
9. What are the requirements for radiopharmaceuticals used for diagnostic purposes.