ЛЕКЦІЯ

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RADIATION MEDICINE

The materials are intended for medical students studying radiation medicine.

Keywords: ionizing radiation, radiation medicine, background radiation, penetrating power.

In professional literature and medical practice term RADIATION MEDICINE used rarely, mainly as a synonym of radiation therapy in all its meanings and is absent in the most important terminological English dictionaries.

For the first time term RADIATION MEDICINE was used in 1955 in the USSR to denote scientific and practical problems of profilaxis, pathogenesis, diagnostics and treatment of radiation lesions.

Radiation medicine — is a science that studies the characteristics of the effects of ionizing radiation on the human body, the principles of treatment of radiation damage and the prevention of possible consequences of exposure to the population.

Radiation medicine is connecting with other medical disciplines **such as biophysics, radiobiology, genetics, nuclear physics, normal and pathological physiology, hematology, biochemistry**.

Ionizing radiation — is radiation, whose interaction with matter causes ionization of atoms and molecules.

X rays, gamma rays, alpha particles, and beta particles are ionizing radiation. Ionizing radiation has a lot of energy that gives it the ability to cause changes in atoms — a process called *ionization*. Radio and TV signals, microwaves, and laser light are nonionizing types of radiation. Nonionizing radiation has less energy than ionizing radiation. When nonionizing radiation interacts with atoms, it does not cause *ionization.*

There are two forms of Ionizing radiation: electromagnetic waves (gamma or X-rays) and particles (neutrons, beta or alpha).

ALPHA RADIATION

Alpha radiation occurs when an atom undergoes radioactive decay, giving off a particle (called an alpha particle) consisting of two protons and two neutrons (essentially the nucleus of a helium-4 atom), changing the originating atom to one of an element with an atomic number 2 less and atomic weight 4 less than it started with. Due to their charge and mass, alpha particles interact strongly with matter, and only travel a few centimeters in air. Alpha particles are unable to penetrate the outer layer of dead skin cells, but are capable, if an alpha emitting substance is ingested in food or air, of causing serious cell damage. Alexander Litvinenko is a famous example. He was poisoned by polonium-210, an alpha emitter, in his tea.

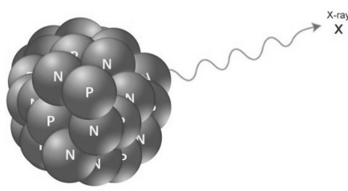
BETA RADIATION

Beta radiation takes the form of either an electron or a positron (a particle with the size and mass of an electron, but with a positive charge) being emitted from an atom. Due to the smaller mass, it is able to travel further in air, up to a few meters, and can be stopped by a thick piece of plastic, or even a stack of paper. It can penetrate skin a few centimeters, posing somewhat of an external health risk. However, the main threat is still primarily from internal emission from ingested material.

GAMMA RADIATION

Gamma radiation, unlike alpha or beta, does not consist of any particles, instead consisting of a photon of energy being emitted from an unstable nucleus. Having no mass or charge, gamma radiation can travel much farther through air than alpha or beta, losing (on average) half its energy for every 500 feet. Gamma waves can be stopped by a thick or dense enough layer material, with high atomic number materials such as lead being the most effective form of shielding.

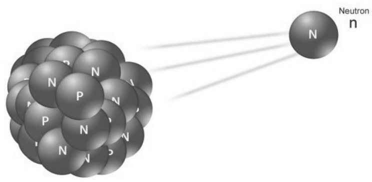
X-RAYS



X-Rays: The emission of a high energy wave from the electron cloud of an atom

X-rays are similar to gamma radiation, with the primary difference being that they originate from the electron cloud.

NEUTRON RADIATION



Neutron radiation: The emission of a neutron from the nucleus of an atom

Lastly, Neutron radiation consists of a free neutron, usually emitted as a result of spontaneous or induced nuclear fission. Able to travel hundreds or even thousands of meters in air, they are however able to be effectively stopped if blocked by a hydrogen-rich material, such as concrete or water. Not typically able to ionize an atom directly due to their lack of a charge, neutrons most commonly are indirectly ionizing, in that they are absorbed into a stable atom, thereby making it unstable and more likely to emit off ionizing radiation of another type. Neutrons are, in fact, the only type of radiation that is able to turn other materials radioactive.

In 1896 H. Becquerel discovered that uranium emits radiation similar to X-rays, which were discovered the year before by W. C. Roentgen. Maria Sklodowska-Curie investigated this phenomenon together with H. Becquerel and offered to call it radioactivity.

Afterwards other natural radioactive chemical elements were discovered, abd in 1934 M. Sklodowska-Curie's daughter Irene Joliot-Curie together with her husband F Joliot-Curie discovered that it was possible to create radioactive elements artificially by means of the phenomenon which was called artificial radioactivity.

Although I want to mention that

In 1898, Ernest Rutherford discovered α rays and β rays.

Then Paul Ulrich Villard discovered γ rays slightly after that, and neutrons were first discovered quite a bit later in 1932, by an English scientist named James Chadwick.

Next

What radiation measurement units do we use?

Exposure dose

Absorbed dose

Dose equivalent

Effective dose

collective effective dose

To quantify the dose was originally used in medicine value erythema dose — exposure could cause a primary inflammatory reaction of the skin. By 20 years of the last century, when the practice came ionization chambers for quantifying dose began to use the exposure dose (X).

Radiation dose from photon radiation measured in the air of the ionizing chamber is called EXPOSURE DOSE.

The system unit (SI) of exposure dose is one coulomb per kilogram (C / kg). Common Units is roentgen (R).

ABSORBED RADIATION DOSE

The effect of radiation depends on the amount you have received. Therefore, amounts of radiation received are referred to as doses, and the measurement of such doses is known as dosimetry.

The unit of ABSORBED DOSE is specified in terms of the amount of energy deposited by radiation in 1 kg of material. This unit is the gray, abbreviated Gy.

An absorbed radiation dose of 1 GRAY corresponds to the deposition of 1 joule of energy in 1 kg of material.

The gray is a measure of energy absorbed by 1 kg of any material, be it air, water, tissue or whatever. A person who has absorbed a whole body dose of 1 Gy has absorbed one joule of energy in each kg of body tissue.

Studies have shown that alpha and neutron radiation cause greater biological damage for a given energy deposition per kg of tissue than gamma radiation does. In other words, equal doses of, say, alpha and gamma radiation produce unequal biological effects.

The absorbed radiation dose, when multiplied by the radiation weighting factor (Q), will give us a measure of the biological effect of the dose. This is known as the EQUIVALENT DOSE. Equivalent dose is given the symbol H. The unit of H is the sievert (Sv).

EFFECTIVE DOSE

Radiation exposures to the human body, whether from external or internal sources, can involve all or a portion of the body. The health effects of one unit of dose to the entire body are more harmful than the same dose to only a portion of the body, for example the hand or the foot. To enable radiation protection specialists to express partial-body exposures (and the accompanying doses) to portions of the body in terms of an equal dose to the whole body, the concept of effective dose was developed. Effective dose, then, is the dose to the whole body that carries with it the same risk as a higher dose to a portion of the body. As an example, 80 mSv to the lungs is roughly the same potential detriment as 10 mSv to the whole body based on this idea.

The tissue weighting factors are needed because different organs have different levels of sensitivity to radiation, even if the equivalent dose is the same.

System units for equivalent and effective dose is the sievert (Sv) Nonsystem unit — ber (the biological equivalent of rem). 1 Sv = 100 rem.

COLLECTIVE EFFECTIVE DOSE

The concept of collective effective dose (E_p) has been introduced for estimation of negative value of radiation exposure of the whole population, which is determined as the sum of all effective doses obtained by irradiated persons in the population.

NATURAL BACKGROUND RADIATION

During the entire history of its formation and existence every living creature on the Earth is exposed to constant irradiation from natural IR sourses: Cosmic rays, radiation from the Earth's crust and natural radionuclides contained in organisms. In general this omnipresent and pervasive IR flux Is called NATURAL BACKGROUND RADIATION

COSMIC RAYS

Cosmic rays are extremely high-energy particles (largely protons) originating from our sun and other stars. They collide with atoms in the earth's outer atmosphere to produce showers of lowerenergy particles. Most of these lower-energy particles are absorbed by the kilometres of air between the earth's outer atmosphere and its surface. This means that the higher the elevation above sea level, the greater is the dose rate received from cosmic rays.

RADIOACTIVITY IN THE EARTH'S CRUST

When the earth was formed, a relatively large number of its isotopes must have been radioactive. In the four billion years or so since then, all the shorter-lived isotopes have decayed. The radionuclides that now remain are those that are long-lived (with half-lives of 100 million years or more), and those that are formed from the decay of these long-lived radionuclides.

Three very important naturally occurring radionuclides are U-238, U-235 and thorium-232. As they decay, not only do they emit radiation, but they also produce other radionuclides with shorter half-lives. These three families of radioactive heavy elements are all found in the earth's crust and account for much of the radioactivity to which man is exposed.

These naturally occurring radionuclides in the ground lead to two different types of radiationexposure: internal exposure from radon and its daughters, and external gamma exposure.

NATURAL RADIOACTIVITY IN YOUR BODY

Traces of radioactive materials are normally present in your body. They come from radioactivity present in tiny concentrations in our food supplies. The only radionuclide that contributes significantly to human exposure from ingestion is the K-40 isotope of potassium. A 70-kg man contains about 140 g of potassium; most of that is located in muscle. About 0.01 % of the potassium is K-40, and this isotope delivers about 200 μSv a year. There is another 10 μSv from C-14

According to the estimations of the United Nations Scientific Committee on the Effects of Atomic Radiation, components of NATURAL RADIATION BACKGROUND, dose variation, and mean doses of irradiation of the world's population from them are the following

Source	Worldwide average annual effective dose (mSv/yr)	Typical annual effective dose range (mSv/yr)
External exposure		
Cosmic rays	0.4	0.3–1.0
Terrestrial radiation (outdoors and indoors)	0.5	0.3–0.6
Internal exposure		
Inhalation (mainly radon)	1.2	0.2–10.0
Ingestion (food and drinking-water)	0.3	0.2–0.8
Total	2.4	1–13

MAN-MADE SOURCES OF RADIATION

These include medical uses of radiation, fall-out from weapons testing, and radiation sources leading to occupational exposure.

We'll briefly discuss the highlights.

MEDICAL USES OF RADIATION

After natural sources, the largest source of radiation dose is the diagnostic use of X-rays in medicine, and the medical use of radioactive materials.

DIAGNOSTIC X-RAYS

Diagnostic X-ray exams account for about 90 % of the radiation dose the population receives from medical sources. Chest X-rays are the most common (25 % of all X-ray exams), followed by X-rays of the shoulder, pelvis and limbs (another 25 %) and dental X-rays (10 %). Recent measurements show that the average dose from a diagnostic chest X-ray or a mammogram is about 70 μSv, and about 20 μSv from a dental X-ray. Much larger doses are given in examinations of the digestive and urinary tracts. Doses received by patients in these exams may be as high as 1 mSv. In computer-aided tomography (CAT) an X-ray source rotates around the patient, and the X-rays that pass through the patient's body are measured by a row of detectors. Many measurements are made, and the results are fed to a computer that reconstructs an image of a cross-section of the patient. A CAT scan therefore gives an image of adjacent slices of the patient's body. Doses can be quite high; as much as 40 mSv per scan.

NUCLEAR MEDICINE

In diagnostic nuclear medicine, the patient receives a drug containing a gamma-emitting radionuclide. The drug chosen is one that is taken up by a particular organ or tissue whose functioning is to be assessed. A gamma camera is then used to follow the distribution of the drug in the patient. Sometimes the radioactive drug can be used in the treatment itself: an example is the treatment of thyroid disease with I-131.

Nuclear medicine procedures are much rarer than Xray exams, and contribute about 5 μSv a year to the medical dose of the average Canadian. The dose from diagnostic procedures (X-rays and nuclear medicine) done in Canada is about 0.6 mSv a year when averaged over the whole population.

RADIOTHERAPY

Radiotherapy is the treatment of cancer by killing tumour cells using beams of high-energy gamma rays from cobalt-60 or from accelerators. The aim of the treatment is to deliver a very high dose to the tumour, but as little dose as possible to the surrounding healthy tissue. A large source, providing a narrow beam of gamma radiation, is rotated around the patient. The hospital physicist carefully works out the pattern and properties of the beam to maximise destruction of the tumour and minimise irradiation of healthy tissue. The treatment is drastic and accompanied by unpleasant side effects. Doses to the tumour are typically around 100 to 200 Sv per treatment. Very heavy stuff.

Here are some approximate comparisons of background radiation and effective radiation dose in adults for several radiology procedures.

All protection factors can be divided into three categories:

• Protection by time — is achieved by regimenting the time spent by personnel in the presence of radiation.

• Protection by distance — is provided by optimum placement of personnel workspaces and movement paths at a maximum possible distance from the radiation source.

• Protection by shielding — is construction og various stationary and movable barriers composed of materials effectively absorbing ionizing radiation.

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РАДІАЦІЙНА МЕДИЦИНА

Матеріали призначені для студентів медичних факультетів, що вивчають радіаційну медицину.

Ключові слова: іонізуюче випромінювання, радіаційна медицина, фонове випромінювання, проникаюча сила.

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РАДИАЦИОННАЯ МЕДИЦИНА

Материалы предназначены для студентов медицинских факультетов, изучающих радиационную медицину.

Ключевые слова: ионизирующее излучение, радиационная медицина, фоновое излучение, проникающая способность.

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