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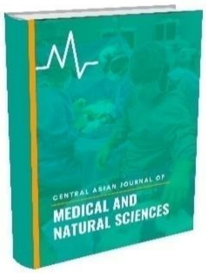

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Radiation Protection. Dosimetry

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Abstract: In the article, dosimetry of ionizing radiation considers the properties of ionizing radiation, physical quantities describing the field of radiation or the interaction of radiation with substances, as well as the principles and methods of their determination.

Dosimetry deals with the physical quantities associated with expected radiation exposure. These quantities are usually called dosimetric. The established relationship between the measured physical quantity and the expected radiation effect is the most important feature of dosimetric quantities. Without this connection, dosimetric measurements lose their meaning.

Key words: Ionizing radiation, radiation effect, dosimetry, nuclide activity in a radioactive source, exposure dose rate.

Introduction

The main cause of radiation exposure is the absorption of ionizing radiation energy by the irradiated object, and the dose as a measure of absorbed energy is the main dosimetric quantity.

Quantification of the radiation dose affecting a living organism is necessary, first of all, for the identification, assessment and prevention of possible radiation hazards for humans. If hygienists and radiobiologists need to answer the question of what are the maximum permissible levels of radiation from the point of view of biological risk, dosimeters must ensure the correct measurement (determination) of these levels.

The development of dosimetry was initially fully determined by the need to protect people from the harmful effects of ionizing radiation. Soon after the discovery of X-rays (1895), its harmful effects on humans were discovered, and the need to quantify the level of radiation danger arose. Photographic effect, fluorescence, thermal effect, as well as chemical methods for measuring the intensity of X-rays.

Later, the measurement of physical quantities characterizing X-ray radiation and its interaction with the sphere became an independent field - X-ray measurement, which is now an integral part of ionizing radiation dosimetry. The main quantities measured in radiometry were determined and almost all methods of modern dosimetry were formed

Two main types of measurements of great practical importance can be made using dosimetric instruments. The first type includes the measurement of the total dose (or amount) of radiation received during the entire period of exposure and expressed in X-rays.

Examples of personal dosimeters include ion chambers, photographic flat film dosimeters, and telescopic devices operating on the principle of silver phosphate scintillation. The second type includes the measurement of radiation intensity, expressed in x-rays (or its fractions) per hour. Dosimeters used to determine radiation intensity include ion chambers, Geiger-Muller counters, or scintillation counters combined with appropriate electronic and electrical measuring devices.

Literature Analysis And Methodology.

The development of dosimetry was initially determined by the need to protect people from ionizing radiation. Soon after the discovery of X-rays, the biological effects of human exposure were noticed. It became necessary to quantitatively assess the level of radiation danger. The main quantitative criterion was the exposure dose measured by X-ray and determined by the magnitude of air ionization.

With the discovery of radium, it was discovered that exposure to radioactive substances can produce biological effects similar to those of X-rays. In the process of extraction, processing and use of radioactive preparations, there is a risk of radioactive substances entering the body. Methods for measuring the activity of radioactive sources (the number of decays per second) have been developed, which is the basis of radiometry.

The activity of a radioactive substance is a characteristic of the amount of a radioactive substance (the number of decays per unit of time). The systematic unit of activity is the Becquerel (Bq) - the activity of a radioactive source in which 1 decay occurs in 1 second (1 Bq = 1 decay/s). An arbitrary unit - Curie (Ci) - is the activity of a radioactive source, in which 3.7×10^{10} decays occur in 1 second.

Table 1

Basic radiation quantities and their units

Physical quantity	Unit, its name, name (international, Russian)		Ratio between units
	out of the system	SI	

Nuclide activity in a radioactive source	Curie (Ci, Ki)	becquerel (Bq, Bq)	1 Bq = 2.7×10 $^{-11}$ Ci 1 Ci = 3.7×10 ^{10} Bq
Radiation exposure dose	X-rays (R, R)	Coulombs per kg (C/kg, C/kg)	1 K/kg = 3876 R 1 P=2.58×10 ^{4} C/kg
Exposure dose rate	x-rays per second (R/s, R/s)	Ampere/kg (A/kg, A/kg) Ampere/kg (A/kg, A/kg) Ampere/kg (A/kg, A/kg) Ampere/kg (A/kg, A/kg)	A/kg = 3876 R/s 1 R/s = 2.58×10 $^{-4}$ A/kg 1 A/kg = 3876 R/s 1 R/s = 2.58×10 $^{-4}$ A/kg
Absorbed radiation dose	Happy (ref, happy)	Gray (Gy, Gr)	1Gy = 100 rad 1 rad = 0.01 Gy
Absorbed dose rate	rad per second (rad/s, rad/s)	Gray/second (Gy/s, Gy/s)	1 Gy/s = 100 rad/s 1 rad/s = 0.01 Gy/s
Integral radiation dose	rad·gram (rad·g, rad·g)	Joule (J,J)	1 J = 10 5 rad·g 1 rad·g = 10 -5 J

Equivalent radiation dose	Rem (rem,rem)	Sievert (Sv, Sv)	1 Sv = 100 rem 1 rem = 0.01 Sv
Dose equivalent level	Rem/second (rem/s, rem/s)	sievert per second (Sv/s, Sv/s)	1 Sv/s = 100 rem/s 1 rem/s = 0.01 Sv/s

* Since 1 Gy is, by definition, 1 Joule per kilogram, the SI unit of integral dose is converted to the Gray·kilogram Joule.

(1 Gy·kg = 1 (J/kg)·kg = 1 J).

Discussion and Results.

A prerequisite for radiation safety in radiation therapy is an accurate quantitative calculation of radiation energy absorbed by personnel and patients exposed to radiation.

To determine the amount of AI, the concept of "dose" is used. AI dose is the ratio of radiation energy to the mass or volume of the irradiated substance. The following concepts are used in clinical dosimetry:

Radiation exposure dose - radiation dose measured in dry (free) air in the absence of scattering bodies. It mainly describes the source of radiation (its power, constancy of its parameters, etc.). Exposure dose applies only to ionizing radiation with an energy not exceeding 3 MeV.

Non-systemic unit of exposure dose Roentgen is a dose of X-ray or □ radiation, which creates a charge equal to 1 e in 1 cm 3 of air under normal conditions (0 0 C and pressure 1 atmosphere). With. e) static electricity (2.08 x 10 9 pairs of ions of each character).

The SI unit of exposure dose is the coulomb per kg - the dose of X-ray or □ radiation produced under normal conditions by a charge equal to 1 coulomb in 1 kg of air.

The same dose can be given at different intervals. Therefore, the concept of dose rate is introduced - the calculated dose per unit of time. The biological effect of ionizing radiation depends on both the dose and its strength.

Absorbed radiation dose is the main quantitative indicator of the effect of ionizing radiation on irradiated tissues. It is determined by the amount of energy corresponding to the mass unit of the irradiated substance during the radiation process.

Absorbed dose applies to any type of ionizing radiation. The SI unit of absorbed dose is J/kg. This value is called " Gray " (Gr). 1 Gy is the dose of ionizing radiation, in which 1 kg of irradiated substance absorbs energy equal to 1 J. The unit of the absorbed dose outside the system is rad. 1 rad is a radiation dose in which 1 g of irradiated substance absorbs energy equal to 100 erg.

When irradiating biological objects, there is a concept of "equivalent radiation dose" because different ionizing radiations have different biological effects at the same absorbed dose. The biological effects caused by certain types of radiation are compared to the effect caused by photon radiation with an energy of 200 keV.

The coefficient (200 keV at the same absorbed dose) is called the quality factor, which indicates how many times the radiation risk for a certain type of radiation is higher than that of photon radiation during chronic human exposure (at low doses). (QC). KK 200 keV for photon radiation = 1. KK = 20 for α-particles, KK = 10 for protons and fast neutrons, KK = 2.5-3 for thermal neutrons. The value of QC depends on the LET of a given type of radiation.The higher the LET, the greater the damage to the cell and the lower the ability to recover. Thus, at the same absorbed dose, the harmful (or therapeutic) effect of radiation with protons is 10 times greater than that of photon radiation.

The dose received by a living object, taking into account the QC of this radiation, is called the equivalent dose. The equivalent dose takes into account the absorbed dose and the biological effect of the AI. The concept of "equivalent dose" is used only to assess radiation risk.Currently, it is recommended to use physical quantities expressed in SI units in all cases.

Dosimetry methods of ionizing radiation.

AI has no sense of smell, taste, or other characteristics that would allow a human to register them. To measure the quantitative and qualitative properties of AI, various methods are used based on the registration of the effects of the interaction of radiation with matter.

Dosimeters are instruments designed to measure AI dose or dose rate. These devices are based on recording and quantifying ionization, scintillation, photographic, chemical and other effects resulting from the interaction of AI with matter.

The main groups of dosimeters:

Clinical - to measure AI in the working light. It is used in preparation for radiation therapy and in the radiation process.

Dosimeters for protective control - for measuring the dose rate of radiation distributed in workplaces (in the radiation safety system). These dosimeters must be read directly.

Dosimeters are instruments designed to measure AI dose or dose rate. These devices are based on recording and quantifying ionization, scintillation, photographic, chemical and other effects resulting from the interaction of AI with matter.

Dosimetry methods:

Biological - based on the assessment of the reactions that occur when the tissues are irradiated with a certain dose of II (erythemal dose, epilation dose, lethal dose). They are indicative and mainly used in experimental radiobiology.

Chemical - consists of recording irreversible chemical reactions that occur in certain substances under the influence of radiation (radiochemical method, photographic method).

The radiochemical method is based on trivalent oxidation of black iron under the influence of II (Fe^{2+} Fe^{3+}), which leads to a change in color (transparency). Ferrous sulfate dosimeters are used.

Since the range of these dosimeters is very large (from 20 to 400 Gy), they are used only in emergency situations.

Photographic method - under the influence of IR, darkening of the X-ray film occurs, the degree of which is proportional to the absorbed energy of the rays. The density of the black color can be used to determine the radiation dose. The disadvantage of this method is that the dosimeter readings depend on the quality of the radiation. The accuracy of dose determination is low. With the help of film dosimeters, it is convenient to determine the correspondence between light and radiation fields in radiation therapy devices.

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