Effect of ionizing radiation on the organism

High-energy ionizing radiation is able to ionize the atoms of molecules that form the basis of all organisms. Ionization leads to the formation of aggressive radicals , which have a negative effect on biological structures. Ionizing radiation is mainly used **to treat malignant tumors** , because undifferentiated actively dividing cells in the body are most sensitive to it.

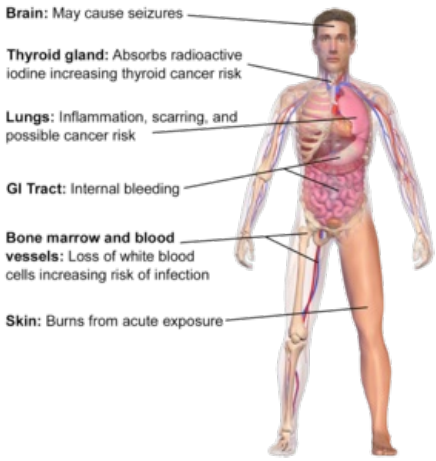
Biological effect of ionizing radiation

The effect of ionizing radiation on organisms lies in its interaction with the electron shell of the atoms that make up the organism. The result is their ionization. The whole mechanism can be described in several stages:

1. **The physical phase** , when the energy of incident radiation is absorbed by atoms and molecules. The duration of this phase is 10^{-13} s[1].
2. **Physico-chemical phase** , which consists of intermolecular interactions associated with the reception of radiation energy by molecules and atoms. The duration of this phase is 10^{-10} s.[2]
3. **Biochemical phase** , during which the formation of chemical radicals begins, which act on the nucleic acids and proteins of the organism's cells. This phase lasts about 10^{-6} s[3]
4. **The biological phase** includes a series of reactions of products created during previous phases with biological material at the level of its intracellular structures, cells, tissues, organs and the whole organism. The duration of this phase is significantly longer than the duration of the previous phases due to the complexity of the metabolic processes of the organism.

The biological effects of ionizing radiation are divided into **direct** and **indirect**.

- **Direct effects** include the absorption of radiation energy within the cell nucleus. They lead to changes in the chemical bonds of molecules, which are important for the metabolism and genetics of cells. They can also cause the disintegration of the affected molecules.
- **An indirect effect** includes the radiolysis of water, during which the free radicals H* and OH* occur. These radicals combine to form O_2 , H_2 and H_2O_2 , which interact with cellular structures, and also act on bonds in molecules and disrupt their spatial structure, which leads to damage to their biological function.



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Factors influencing the biological effect

The resulting effect of ionizing radiation is influenced by the following factors:

- **the amount of radiation** to which the organism is exposed - the greater the dose, the greater the extent of the biological effect;
- **method of radiation application** – cells are capable of partially correcting the effects of ionizing radiation, and therefore radiation applied in parts, or with less power, has a smaller effect on the organism than radiation applied once with greater power;
- **type of radiation used** – different types of ionizing radiation differ in their effect on the organism;
- **the state of the organism's metabolism** at the time of irradiation.

Use of ionizing radiation for treatment

Ionizing radiation is used for treatment because it is capable of causing cell death . At the same time, the sensitivity of cells to its action differs. In general, cells with a lower degree of differentiation and high mitotic activity are more sensitive to radiation than less dividing differentiated cells. An example of a cell structure that is highly sensitive to ionizing radiation is a malignant tumor that contains undifferentiated or poorly differentiated significantly proliferating cells. The main object of the action of ionizing radiation in the cell is DNA . The extent of its damage depends on the phase of the cell cycle in which the cell is located. The greatest damage occurs at the end of the G1 phase and during the mitotic phase.

The disadvantage of treatment with ionizing radiation is that, in addition to the desired effect on malignant tumors, it also affects the cells of normal, healthy tissue, which are mitotically active. These are, for example, cells of epithelial tissue or stem cells.

When using radiotherapy methods, it is therefore important to locate tumors as accurately as possible in order to minimize their adverse effect on healthy tissue.

Before their application, it is necessary to develop an irradiation plan , which includes 3 phases:

- **tumor localization** - with the help of computed tomography (CT) , ultrasonography , MRI , angiography and other diagnostic methods;
- **choice of radiation source** – the size, location and type of the tumor are decisive;
- **determination of irradiation conditions** - e.g. irradiation distance, irradiation time, amount of radiation dose.

Links

Related articles

- Ionizing radiation
- Gamma radiation
- Dosimetry
- Antitumor therapy

Reference

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