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RADIATION THERAPY IN MEDICINE

1 Elmurotova Dilnoza Baxtiyorovna
2 Ibragimova Muyassar Nazarali qizi,
3 Bobajanov Bekzod Odilovich
Tashkent Medical Academy, Republic of Uzbekistan,
dilnoza_elmurodova@mail.ru

Abstract
The work examines all types of radiation therapy that are used in modern medicine. The purposes and medical purposes of all types of radiation therapy and ionizing devices are given.

Keywords: x-ray, proton, gamma, neutron, beam, therapy, electron.

Introduction

The broad indications for radiation therapy are explained by the possibility of its use in both operable and inoperable forms of the tumor, as well as the steadily increasing effectiveness of various methods of radiation therapy. The success of radiation therapy is associated with the development of diagnostic and therapeutic technology, with the advent of new device designs, with the development of clinical dosimetry, with numerous radiobiological studies that reveal the mechanism of tumor regression under the influence of radiation.
Radiation therapy is distinguished by the type of radiation:
- radiation therapy with high-energy X-rays;
- gamma therapy;
- irradiation with fast electrons;
- irradiation with protons;
- irradiation with neutrons;
- contact (radionuclide) RT [1]

Irradiation with high-energy X-rays: the most common method, where the sources are linear electron accelerators, in which electrons, accelerating to high energies, are decelerated to emit X-rays (Fig. 1).

Fig. 1. Installation for X-ray irradiation

The emitting head of the accelerator moves around the patient, due to which irradiation can be carried out at different angles and, as a result, the tumor receives a maximum dose with minimal radiation exposure to normal tissue [2-3]. This type of radiation therapy is used to irradiate deep-lying tumors (central nervous system, bladder, lung, etc.). One of the installations of this type is the CyberKnife robotic radiosurgical system (Fig. 2).

Rice. 2. Radiosurgical system “Cyber-Knife”

The term "radiosurgery" implies that high-power X-rays are collected into a narrow beam and used to destroy pathological tissue. In this case, the X-ray beam can be compared to a surgeon's scalpel, hence the name "Cyber Knife". This installation is used primarily for the treatment of the brain and spinal cord, and in some cases is even an alternative to surgery.

Gamma Therapy: This type of therapy uses a radionuclide as a source, which decays by emitting gamma radiation.

Fig. 3. Installation for gamma therapy

In gamma therapy, the source moves around the patient, similar to X-ray radiation therapy (Fig. 3). Gamma therapy is used to treat both tumors of internal organs and superficial tumors. Gamma therapy is also used to treat non-tumor diseases.

Electron irradiation: A linear electron accelerator or betatron is used as a source of electrons [4].

Fig. 4. Installation for irradiation with photons and electrons

As a rule, for medical purposes they use a linear electron accelerator, which operates in two modes: irradiation with photons or electrons (Fig. 4). This method is mainly used for repeated radiation therapy.

Proton irradiation: Protons are heavy charged particles that are accelerated using a synchrotron, phasotron or cyclotron. Proton irradiation has fundamental advantages over radiation therapy with electrons and photons. This is due to the property of protons to release most of the energy at the final point of their travel. In this case, it is possible to increase the dose to pathological tissues and reduce the dose to normal ones. Heavy ion irradiation is based on the same principle, which, together with proton irradiation, is included in the concept of "hadron therapy".

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Fig. 5. Installation for proton irradiation

Proton irradiation is used for radiation therapy of intracranial tumors of various sizes, as well as for the treatment of radioresistant tumors with a small diameter (Fig. 5).
Neutron irradiation: such irradiation is carried out in reactors and neutron generators (Fig. 6).

Fig. 6. Installation for irradiation with neutrons

When irradiated with neutrons, a double DNA break occurs in a cell, which leads to its death. Since not only tumor cells, but also healthy cells die, neutrons are characterized by a high percentage of radiation damage. Neutron irradiation is used for radiation therapy of radioresistant tumors, bone sarcomas, and soft tissues.

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Neutron capture therapy: In this treatment, malignant tumors are irradiated with a stream of low-energy neutrons from a nuclear reactor or neutron generator. For irradiation with a maximum effect in a tumor and a minimum in normal tissues, it is necessary to saturate the tumor with nuclides characterized by a large cross-section for the capture of slow neutrons [5].

Fig. 6. Research reactor

Such nuclides are boron (^{10}B) and lithium (^{6}Li). They slowly pass from the blood to the brain, and enter the tumor tissue much faster. It was found that 30 minutes after intravenous administration of boron compounds, its concentration in a brain tumor is 4–5 times higher than in normal tissue. And it is at this time that irradiation should be carried out. The concentration of boron and lithium in muscle tissue is very high, and therefore neutron capture therapy cannot be used for tumors of the trunk and extremities. This method is only applicable for brain tumors.

Conclusions: It has been shown that high-energy X-ray irradiation is used to irradiate deep-lying tumors, and the brain and spinal cords are treated in the CyberKnife installation. Gamma therapy is used to treat both tumors of internal organs and superficial tumors, a linear electron accelerator is used for repeated radiation therapy, and proton irradiation is used for intracranial tumors of various sizes, as well as for the treatment of radioresistant tumors with a small diameter. Neutron irradiation is used for radiation therapy of radioresistant tumors, bone sarcomas, soft tissues, and neutron capture therapy is used only for brain tumors.

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