Brachytherapy

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Introduction

Brachytherapy *(from the Greek brachys - close, close)* or also curitherapy means treatment with radiation at a short distance. It is one of the radiotherapeutic techniques used to treat oncological diseases. It is a type of radiotherapy in which the radiation source is placed close to the tumour site or directly into the affected tissue. The main purpose of this treatment is the possibility of increasing the radiation dose without much exposure of healthy tissues and organs. It is especially suitable for the treatment of small tumours (prostate cancer, breast cancer, skin cancer, etc.), because extensive applications are associated with the risk of necrosis. Brachytherapy is used alone or in combination with other treatment processes (chemotherapy , radiotherapy).

History

Brachytherapy techniques have been known for 100 years. The discovery of brachytherapy and its subsequent implementation brought a big change in the treatment of malignant (malignant) tumours. During its existence, there was a period when there was little interest in it and teleradiotherapy was preferred. The lack of interest in the 1950s was mainly due to the finding that radium, which was used in brachytherapy at the time, did not meet radio-hygienic requirements. At that time, brachytherapy posed a great threat not only to patients, but also to nursing staff. In recent years, brachytherapy has experienced a renaissance. New, more effective radionuclides have been discovered. Afterloading methods protect effective caregivers.

Afterloading means that the physician first inserts the non-radioactive carrier into the desired location, then checks its position, determines the distribution of the emitters, and only then introduces the active source. The radiation exposure of doctors is therefore smaller and the placement of emitters more efficient. Ideally, this operation is performed by automatic afterloading devices.

Comparison between brachytherapy and teleradiotherapy

Benefits of brachytherapy

- radiationApplication of a larger dose of radiation directly to the area affected by the tumour (irradiation - damage to the surrounding healthy tissues is therefore minimal),
- radiationapplications in a shorter time,
- radiationtreatment of small, precisely localised tumours.

Benefits of teleradiotherapy

- radiationIt can irradiate a larger area of diseased tissue,
- radiationsuitable for larger tumours where there is a risk of lymphatic spread.

Principle of brachytherapy

Brachytherapy uses ionising radiation for treatment, similarly to teletherapy . The biological effects of ionising radiation are important for treatment.

Knowledge about biological effects of ionising radiation

- Absorption in the cell results in the excitation and ionisation of atoms and molecules,
- when ions interact with molecules, radicals are formed,
- ions, radicals and excited atoms interact with cell molecules and cause DNA damage (breaks),
- changes in DNA cause changes in organs and the body (destruction of the tumour).

The biological effect of ionising radiation depends on chemical, biological and physical factors. By chemical factors influencing the biological effect of ionising radiation we mean primarily sufficient oxygen in the tissue affected by the tumour . More oxygen means more damage to the tumour. Cells with greater mitotic activity are more sensitive to ionising radiation and differentiated cells are not at great risk. Therefore, after the first irradiation can occur acute local changes in the skin (the cells of the skin are rapidly dividing), and only after a long time in some cases, the nervous form of acute radiation sickness (nerve cells have a low mitotic activity). Physical factors influencing the biological effect of radiation include radiation quality (type, energy and homogeneity of radiation), distribution over time and spatial distribution of ionising radiation over time.

Sources of ionising radiation

The source of ionising radiation for brachytherapy is characterised by the type of radiation, energy, activity, dimensions and filtration. We divide them into

- radiation*gamma emitters* ,
- radiation*beta emitters* ,
- radiation*neutron emitters* .
- radiation

Gamma emitters

The gamma radiation emitted by these sources is indirectly ionising electromagnetic radiation. It therefore has no charge and transmits energy indirectly through a secondarily charged particle, most often an electron. The transfer of energy takes place using the principle of ionisation or excitation.

Radium 226

The undeniable advantage of radium used in brachytherapy for decades is its long half-life (1620 years), so it was not necessary to look for alternative substitutes, which reduced operating costs. Radium decays into radon, which is an alpha emitter. Alpha decay is accompanied by weak gamma radiation. In medicine, the decay products of radium are most often used, most often radium type B and radium type C. The effective energy of the produced photon radiation is 0.83 MeV. It was used in the form of insoluble radium sulfate filling radiophores or emitters. It is a hollow metal cylinder, made of iridium and platinum alloys, less often also of silver, gold, copper, nickel, etc. We obtain alpha, beta and soft gamma radiation from it. We recognize 3 basic types: radioactive needles (10-60 mm), radioactive tubes (rounded ends, 12-40 mm, 1 cell with 5-20 mg Ra), radioactive cells. Today, radium is being replaced by other more effective radionuclides. The main disadvantage of Ra was the low degree of radiation protection given by the production of radon, mostly working with active sources, therefore not only the patient but also the medical staff was exposed to high radiation.

Cesium 137

The half-life is 30 years, the radiation energy is 0.66 MeV. It has often been used for gynecological applications in the form of tubes enclosed in platiniridium cells. The dimensions of Cs needles can be compared with needles and radio tubes. In some modern afterloading devices we can find cesium pellets arranged in chains (train of sources) as radiation sources.

Iridium 192

Iridium sources for manual afterloading are most often produced in the form of wires made of an alloy of 25% iridium and 75% platinum. On the surface, they are coated with a pure platinum shell that absorbs beta radiation. Larger diameter wires are produced in the form of hair pins (40-60 mm) and single pins. Iridium can also be obtained in the form of grains wrapped in a steel shell, the length of the grains being 3-6 mm and the diameter 0,5 mm. The sources are placed in nylon fibers at regular intervals.

Tantalum 182

Uncommon use, used more for interstitial brachytherapy, as well as iridium.

Cobalt 60

Its physical half-life is 5.29 years and the mean energy reaches 1.25 MeV. It is used in the form of a point source for automatic afterloading devices with high power consumption. Cobalt has too penetrating radiation for brachytherapy.

Subtypes for short half - life radioisotopes

They are most often used in the treatment of brain tumors and prostate tumors in permanent applications, they are stored as active sources in the tissue, where they soon disintegrate.

Gold 198

Used in the form of platinum-coated grains (2.5 x 0.8 mm or 5 x 0.95 mm). The half-life is 2.7 days. They are usually inserted into the tissues with an application gun.

Iodine 125

The half-life is 60 days. Again prepared in the form of grains (0.8 mm in diameter, length 4.5 mm). It is absorbed on a silver rod. Sometimes it is also used for temporary applications.

New artificial radioisotopes

Radioisotopes with improved parameters for brachytherapy, ie: have higher activity, more suitable energy and more favorable half-life. Examples are ***145 samarium*** or ***103 palladium*** , which gradually replace I 125 in the treatment of brain tumors and prostate tumors.

Beta emitters

Beta radiation is directly ionizing radiation, corpuscular, meaning that the energy of the emitters is transmitted directly to the tissue. Beta emitters include ***90 strontium*** , from which ***90 yttrium*** is emitted . These sources are used in the form of flat or curved surface applicators. They are most often used in the treatment of non-cancerous superficial injuries of the eye, in which deeper structures must not be disturbed.

Neutron emitters

Neutron radiation reacts with the nucleus of the atom and releases photons, protons.

Californ

An artificial radioisotope emitting neutrons, ie radiation with a high LET. The advantage is a higher effect on hypoxic tumors. Problems of protection against neutron radiation cause this radioisotope to be used only in a few workplaces in the world, one of which is the Masaryk Institute in Brno.

Application of brachytherapy

Before applying the source of ionising radiation, it is necessary to accurately locate the tumour, determine the target volume and calculate the dose distribution in the plane and in space, create an isodosis plan.

Forms of application according to the location of the source

- radiation*Intracavitary* - the radiation source is implanted in body cavities (vagina, uterus , trachea , rectum, esophagus), for example in the form of radioactive grains,
- radiation*interstitial* - a source in the form of special wires or tubes inserted directly into the affected area of the tissue,
- radiation*mulching technique* - a radiation source placed on the surface of the body in special applicators.

Forms of application in terms of time

- radiation*Permanent* - resources are left in the target tissue permanently, they are used in brain and prostate tumours,
- radiation*fractionated* - may take the form of *single irradiation* (skin tumours), *daily irradiation* (conventional fractionation), *hyperfractionation* (more than once a day - lower single but higher total daily dose) and *hypofractionalization* (less than 5 fractions per week).

Brachytherapy is used in the treatment of small, precisely localised tumours, or as a secondary radial treatment for teleradiotherapy. It also alleviates the problems associated with cancer (palliative care).

Types of brachytherapy

From the radiobiological point of view, brachytherapy is differentiated according to the dose rate

- radiation***LDR brachytherapy*** *(Low dose rate)*

It is a brachytherapy with a low dose rate (0.2−2 Gy / h). As the dose rate increases, the biological effectiveness of the total dose increases and therefore the physical dose must be corrected. In this form of brachytherapy, small hollow catheters are temporarily inserted directly into the tumour tissue. Irradiation lasts for tens of hours, usually a day or two. LDR radioactive grains are the only ones used for permanent application. Their activity gradually decreases until it becomes unmeasurable. LDR is commonly used to treat oral cancer , nasopharynx , sarcoma, and prostate cancer .

- radiation***HDR brachytherapy*** *(High dose rate)*

It is a brachytherapy with a high dose rate (12 Gy / ha or more). It has a higher effect on the tumour and even higher on late-reacting tissues. Irradiation lasts only tens of minutes here. Most HDR treatments are used on an outpatient basis. The most common use of HDR brachytherapy in the treatment of tumours: the neck of the uterus , esophagus , lung, breast and prostate .

Links

Related articles

- Ionizující záření

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