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THE ROLE OF RADIOISOTOPE 131 I IN MEDICINE

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Abstract
The work examines the impact of radiation on human life. In nuclear medicine, doctors inject patients with a radioactive substance that accumulates in the part of the human body that is the target. When the radiation leaves the body, it is recorded, allowing doctors to draw conclusions about the physiological functions of an organ or tissue. It also shows the ways in which the artificial radioisotope 131 I is produced in a nuclear reactor.

Keywords: Radioisotope, radiation, artificial, reactor, iodine, symporter, pendrine.

Introduction

Radiation is all around us; living on this planet means being exposed to natural radiation. In the last century, artificial radiation has been successfully used for medical diagnosis and treatment of pathologies such as cancer. The IAEA supports Member States in developing safe and effective diagnostics and treatment of patients using radiation.

Radioactivity is not only present in space and the environment around us. Even the elements that make up our bodies exist in nature in different forms – isotopes – some of which are radioactive, such as the radioisotopes of potassium, cesium and radium.

Like visible light, radiation is electromagnetic in nature. When it is strong enough to break molecular bonds, thus ionizing matter (a process in which a neutral atom or molecule loses or gains electrons, forming ions), it is called "ionizing radiation." Molecular bonds can be present in all materials, even in the building blocks of life - DNA.

There is evidence that changes in DNA molecules caused by ionizing radiation can lead to mutations in biological cells. The vast majority of these mutations are not dangerous to human health, but there is a small chance that some mutations can cause cancer. Therefore, it is critical to understand how radiation interacts with biological matter.

Ionizing radiation can penetrate deeply into solids. This characteristic is the basis for X-ray diagnostics and radiation therapy. X-rays, a form of ionizing radiation, are emitted from an emitting device located on one side of an object. The radiation passing through the object is detected by appropriate sensors on the other side of the object. This process can be used to produce images showing the internal structures of the irradiated object without opening the object. When this process is applied in medicine, in a specialized area called diagnostic radiology, images of the internal structures of the human body are obtained with minimal intervention.

In nuclear medicine, doctors inject patients with a radioactive substance that accumulates in the part of the human body that is the target. As it leaves the body, the radiation is recorded,

allowing doctors to draw conclusions about the physiological functions of an organ or tissue. In radiation therapy, radiation is precisely penetrated into the human body to destroy a tumor. Approximately 80 percent of the average annual doses received by people worldwide come from natural sources. The largest artificial source of human exposure is medical radiation. Its contribution to the total average annual dose is approximately 20 percent. This is approximately half the contribution of the largest natural component of the average annual dose – radon inhalation in buildings.

It is therefore important to minimise unnecessary medical exposure when using ionising radiation. This is achieved by improving the processes of justification and optimisation of irradiation. Justification requires that a person should be exposed to radiation only when it brings him or her a clear net benefit. On the other hand, optimisation processes minimise the radiation dose used to achieve a given diagnostic or therapeutic result at the lowest achievable and justified dose level.

Fundamental research in nuclear physics in the 1920s–1940s laid the foundation for radiation and nuclear mathematic science. The birth of nuclear mathematic science lies between the discovery of artificial radioactivity in 1934 and the production of radionuclides by OakRidge National Laboratory , USA, in 1940 for their use in medicine. It took a lot of effort before the use of radioactivity became safe and effective.

One of the first artificially produced radioisotopes, used in medicine for the past 80 years, is the isotope ^{131}I. It is isolated in the form of sodium iodide (NaI) from the decay products of uranium or from the neutron bombardment of tellurium-130 in a nuclear reactor.

The isotope ^{131}I emits β- and γ-rays, the half-life is 8.02 days (Fig. 1).

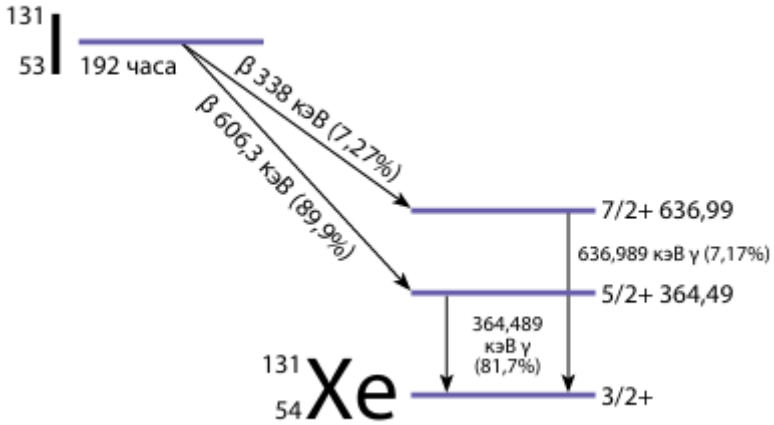

Figure - Decay scheme of ^{131}I. The isotope ^{131}I decays into stable ^{131}Xe (131-Xenon) in two stages, with γ-decay following immediately after β-decay. The main energy of γ-radiation is 364 keV (89.9%), β-radiation is 606 keV (81.7%). With a lower yield, γ-radiation with an energy of 637 keV (7.2%) and β-radiation with an energy of 338 keV (7.3%) are observed.

A new medical paradigm, theranostics , uses a single multifunctional agent for therapy and diagnostics, achieving maximum personalized therapeutic response, as well as improving long-

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term prognosis and reducing dose-dependent toxicity. The term " theranostics " is formed by merging the words "therapy" and "diagnostics" [1] .

It was introduced in 2002 by American consultant John Funkhouser , chief executive officer of PharmaNetics. One of the first theranostic agents, radioactive iodine, was used for thyroid disease in the 1940s, and in 1950 by the American physician Benedict Cassen performed the first thyroid imaging using a rectilinear scanner after the introduction of radioactive iodine into the body.

The thyroid gland plays a major role in iodine metabolism in the body.

Iodine is an important microelement required for the synthesis of thyroid hormones, thyroxine (T4) and triiodine. ronin (T3).

Iodine makes up 65 and 59% of the mass of T4 and T3, respectively.

The production and secretion of thyroid hormones are regulated by the thyroid-stimulating hormone (TSH) of the anterior pituitary gland. The body of a healthy adult contains 15–20 mg of iodine, of which 70–80% is in the thyroid gland.

Iodine is mainly supplied to the body with food, with the most iodine-rich foods being iodized salt, dairy products, some types of bread, seaweed, and seafood. In chronic iodine deficiency, its content in the thyroid gland can decrease to less than 20 mcg. In areas with sufficient iodine intake, the thyroid gland of an adult takes up about 60 mcg of iodine per day to balance losses and maintain the synthesis of T4 and T3.

After absorption, iodine is excreted from the main blood flow mainly through the thyroid gland and kidneys. Iodine absorption by the thyroid gland is provided by the Na +/I–- symporter , described by S. Kaminsky et al . in 1993.

The Na +/I–- symporter is located on the basolateral membrane of thyroid cells. Iodide is transferred from the circulating blood into the thyrocyte along a concentration gradient formed by Na +/K +- ATPase and is approximately 30–50 times higher than the plasma concentration, ensuring the supply of sufficient iodine for the synthesis of thyroid hormones. TSH regulates iodine transport in the thyroid gland by stimulating the transcription of the Na +/I–- symporter and promoting its correct incorporation into the plasma membrane. With a low-iodine diet, TSH stimulates the expression of the Na +/I–- symporter and is responsible for changing its subcellular localization. There is a mechanism that ensures normal functioning of the thyroid gland with excess iodine.

When a large amount of iodine enters the body of a person with normal thyroid function, a transient decrease in the synthesis of thyroid hormones occurs for approximately 48 hours.

Excess iodine blocks its organification and formation of T3, T4. This process, described in 1948, is called the Wolff- Chaikoff effect. It is assumed that the Wolff- Chaikoff effect is associated with negative posttranslational regulation of the Na +/I– symporter by iodides [9]. In response to the introduction of large amounts of iodine, the release of thyroid hormones from the thyroid gland decreases with a compensatory increase in the TSH level. Over time, the synthesis of thyroid hormones is restored.

The phenomenon of "escape" from the Wolff- Chaikoff effect is an adaptation process, it does not depend on TSH and is associated with a decrease in the iodine content in the thyroid gland. The most likely mechanism for the development of this phenomenon is a decrease in the activity

of the Na +/I– symporter , leading to a decrease in the supply of the microelement to thyrocytes [2-14].

When the iodine level in the thyroid gland becomes lower than the values that support the Wolff- Chaikoff effect , the organification process is restored, and with it the thyroid function is normalized.

It was believed that iodide crosses the apical membrane under the influence of an electrochemical gradient, but studies have shown that TSH stimulates the transfer of iodide across the apical membrane by a specific transporter, pendrin .

Pendrin belongs to the SLC26A family and is encoded by the SLC26A4 gene. It is present in the apical membrane of follicular cells. In the lumen of the follicles, iodide is oxidized and incorporated into thyroglobulin (TG) by thyroid peroxidase , an enzyme localized in the microsomal fraction of follicular cells of the thyroid gland.

This process is called organification and results in the formation of 3-monoiodotyrosine and 3,5-diiodotyrosine. Afterwards, the tyrosol residues come closer to each other and condense. are converted to form iodothyronines , thyroid hormones.

Iodinated Tg is stored in the follicle lumen in a thick fluid called colloid and is excreted by endocytosis or micropinocytosis followed by proteolytic cleavage in lysosomes and release of T3 and T4 into the bloodstream.

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