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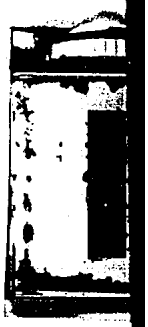

APPLICATION OF RADIOACTIVE SUBSTANCES IN MEDICINE IN THE USSR

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Radiant energy was originally applied for therapeutic purposes at the time of the discovery of X-rays and rays emitted by radium in the last decade of the 19th century.

As technology and physics developed, an increasing number of sources of radiation was found and used. In addition to the natural radioactive elements, radium and mesothorium, artificial radioactive substances, particularly the radioactive isotopes of cobalt, gold, phosphorus, iodine, sodium, etc., have been applied during recent years. Radium and mesothorium belong to the group of metals. These elements emit a mixed alpha, beta, and gamma radiation. Only the hardest gamma rays emitted by these sources of radiation are used for therapeutic purposes.

To obtain hard gamma radiation, it is necessary to filter out the soft alpha rays and beta rays. This is achieved by using filters made of gold and platinum. Notwithstanding the filtration, the radiation of each of the radioactive metals mentioned is characterized by an inhomogeniety, i.e., by the fact that every photon does not have the same energy, a condition which is responsible for some peculiarities as far as the biological action exerted by the radiation is concerned.

The inhomogeniety of the radiation is particularly characteristic for mesothorium. As far as the artificial radioactive isotope cobalt 60 is concerned (the half-life of this element amounts of 5.3 years), it yields gamma radiation which has an almost homogeneous energy of photons equal to 1.1-1.3 Me V. The beta particles emitted by cobalt 60 have an energy which is so small that the beta rays are completely absorbed by filters made of metals which have a medium atomic weight, for instance, nickel.

Thus, as far as the possibility of obtaining homogeneous gamma radiation for therapeutic purposes is concerned, radioactive cobalt compares favorably with natural radioactive substances.

The homogeneity of the radiation emitted by radioactive substances is particularly significant in the treatment of various pathological processes, especially of malignant tumors. When pathological formations which are located deeply in the body are irradiated, the soft components of the radiation are absorbed by tissues which lie in the path of the ray bundle, primarily by the skin and the subcutaneous cellular tissue. This brings about an undesireable reaction which is occasionally quite acute, so that severe injuries may result. When the hard homogeneous radiation emitted by radioactive cobalt is used, the reaction of the surrounding tissues will be considerably less pronounced than in the case of radium or mesothorium although the biological action on the tumor remains the same. Another advantage of radioactive cobalt is that it can be obtained in any desired quantity needed for therapeutic purposes. Radioactive cobalt is cheap, simple in use, and does not require expensive filters made of gold or platinum.

In addition to solid radioactive cobalt, colloidal solutions of radioactive gold and solutions of salts containing radioactive phosphorus are used for therapeutic purposes. Gold and phosphorus belong to the so-called short-lived radioactive elements, i.e., they have a short half-life (2.73 days in the case of gold and 14.3 days in the case of phosphorus). Gold yields gamma radiation and beta radiation while phosphorus emits only beta rays.

All radioactive substances, both natural and artificial, may be used in the most diverse diseases and applied by the most diverse methods. The diseases that can be treated with radioactive substances comprise blood diseases such as erythremia, leukoses, and myeloses; skin diseases such as eczemas, neurodermites, and psoriasis; and pre-cancer conditions of the skin and of the mucous membrances, i. e., Bowens disease, leukoplakia, hyperkeratosis, etc. Radioactive substances are widely used in the therapy of various inflamation processes and particularly in the treatment of malignant and benignant tumors located in various parts of the body, beginning with superficial tumors (cancer of the skin) and ending with tumors which are located deeply in the body (cancer of the lungs or cancer of the esophogus).

At the Scientific Institute of Roentgenology and Radiology imeni V. Molotov, several methods of radium therapy are being developed and widely applied. Pathological processes, primarily malignant tumors, are being subjected to teleradium therapy; to carry out this therapy, substances which emit hard gamma rays, namely radium, mesothorium, and cobalt, can be used. Cobalt is used almost exclusively for this purpose at present.

Teleradium therapy is carried out by means of special equipment manufactured at present by the USSR industry. This equipment consists of the so-called teleradium installations or gamma installations, i.e., GUT-CO-20 and GUT-CO-400 [gamma ray teleradium installations containing quantities of radioactive cobalt equivalent to 20 g and 400 g of radium, respectively]. The plant designations correspond to the size of the charge of radioactive substance used in the installation. The equipment in question is colloquially referred to as radium cannons. At present, all oncological institutions in the USSR have the possibility of using this equipment. The use of the powerful teleradium apparatus GUT-CO-400 makes it possible to exert an action on the focus of an affliction which may be located at a depth of 10-15 cm from the surface of the skin. Depending on the depth of the location of the tumor, various focal distances are used, i.e., the distance from the center of radiation to the surface of the body of the patient is varied appropriately. With the aid of apparatus GUT-CO-400, patients suffering from tumors of the lungs, of the mediastinum, and of the esophogus are treated. By means of the same apparatus, deeply located sarcomas of soft tissues and of the bones and cancers of the female genital organs can be subjected to therapy.

The apparatus GUT-CO-20 contains a smaller charge and correspondingly is used for the treatment of tumors located near the surface of the skin, for instance cancer of the jaw or of the throat and metastases in the lymph nodes of the neck, the arm pit, and the groin. The therapy of conditions susceptible to treatment with the GUT-CO-20 model can also be carried out with the aid of the model GUT-CO-400.

The extensive application of teleradium therapy at our institute has made it possible at present to treat successfully patients with tumors of a type for which no effective therapy existed previously. Two case histories follow:

Patient B with a neglected cancer of the upper jaw was admitted for treatment at the institute. He had been subjected to surgery at other medical institutions, after which a rapid recurrence of the original condition. A huge tumor covered the whole right side of the face. This tumor closed one

eye, and obstructed the nasal passages, thus interfering with respiration through the nose. Another surgical operation was out of the question. The patient was subjected to teleradium therapy. As a result, the tumor regressed; vision of the eye and respiration were restored. The patient regained ability to work. There was no recurrence of the condition during a year and a half.

A fluorographic investigation disclosed that Patient T had a neglected case of lung cancer. Surgical interference was impossible in this case for technical reasons. Application of teleradium therapy resulted in a regression of the tumor, and the patient regained ability to work. After the treatment, Patient T was under observation for 2 years. No recurrence of the condition was observed.

In addition to teleradium therapy, we use the surface application method. This method is used in the treatment of tumors which are located either on the surface of the body or at shallow depths in the subcutaneous cellular tissue. By this method, cancer of the skin, melanomas, angiomas, recurrences of cancer of the lactic gland in the scar after the removal of the cancer, cancer of the lips, and metastases located superficially (in the skin and in the lymph nodes) can be treated.

In the surface application method, preparations of radium, mesothorium, or cobalt are used. During recent years, cobalt has been used more extensively than any other element for this purpose. The preparations are sealed in small tubes made of platinum, gold, or nickel. The tubes which contain the radioactive substance are inserted in a definite order into the applicator (i.e., a molding which conforms to the contours of the tumor) made of a plastic mass. This mass consists of a mixture of wax and paraffin wax to which sawdust has been added. The dose of radiation, the intensity of the radiation, and the time during which the molding is applied to the patient are determined by means of tables which were drawn up at the institute in 1948.

Phosphorus in the form of sodium phosphate can also be used in the surface application method. However, phosphorus is used only for the treatment of processes of an inflammatory or tumor type which occur at the very surface. In other words, capillary angiomas of the skin, eczemas, neurodermites, psoriasis, and similar conditions are treated.

The procedures of using phosphorus in the surface application method of therapy have been developed at our institute by Prof. A. V. Kozlova, who reported on the results of applying this method at the International Congress of Radiologists in Rome which was held in April 1954. In this type of application, the calculation of the dose and of the intensity of the radiation is done according to a special formula developed by our institute in cooperation with the Leningrad Institute of Roentgenology and Radiology.

The intratissue method of radiotherapy is carried out by inserting radioactive needles directly into the tissue of the tumor to the required depth. The needles are placed at definite distances from each other. The needles used are filled either with radium, mesothorium, or cobalt. This method is of considerable advantage as compared with the methods of external irradiation, because it enables us to exert action directly on the tumor while it subjects the surrounding normal tissue to the least possible damage.

The intratissue method is particularly effective when it is used in combination with surgery. When it is not possible to remove the tumor by surgical means or when the tumor has not been removed completely by surgery, the tumor or its site can be treated by inserting radioactive needles along the periphery. The intracavity method differs from the intratissue method in that the radioactive needles are introduced into the natural cavities formed by such organs as the uterus, esophagus, urethra, mouth, etc. This method is usually supplemented

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by external irradiation. The intratumor method is distinguished by the fact that there are introduced into the tumor solutions of radioactive substances which decay rapidly. The substances used may be a colloidal solution of gold or a suspension of the chromate of radioactive phosphorus [sic]. These solutions, on infiltrating the tumor, remain there until the radioactive elements have decayed completely. During this time, they destroy the afflicted tissues.

A considerable group of so-called radium-resistant tumors has existed; i.e., tumors which are not very sensitive to the action of radiant energy applied in the doses available at present and by the methods now at our disposal. It is apparent that these radium-resistant tumors can be subjected to destruction under the action of higher doses of radiation, which in direct treatment of the tumor by radioactive substances may reach an intensity of one million roentgens.

In the application of radiant energy for therapeutic purposes it must be remembered that the greatest obstacle has been the action of the radiation not only on the tumor but also on the normal tissues surrounding it. Tissues were damaged to such a considerable extent that irreversible changes occasionally occurred in them as a result of the treatment. All this resulted in great harm to the patients and led to functional disturbances in some organs. For instance, pneumosclerosis occurred after irradiation of tumors of the chest; also scarification of various tissues as well as atrophy of the skin and of the mucous membranes. Furthermore ulcers, that did not heal occasionally resulted. Injuries to normal tissues brought about in the process of therapy often formed an obstacle to the completion of therapy by radiation.

For many years, work has been carried out at the Institute [by Prof A. V. Kozlova] of measures which would prevent injury to normal tissues in connection with radiation therapy. Thus, when the method of external radiation is used, a number of auxiliary measures are applied which contribute to an increase in the ratio between the sensitivity of normal tissues to radiant energy and the sensitivity of tumor tissues to this energy. Among these measures are the novocain block, the tying up of blood vessels which nourish the area of the tumor, local application of various drugs, etc. Application of these measures, although it has yielded definite results, did not solve the problem completely. Only by using the intratumor introduction of radioactive substances in the form of solutions from which the dissolved substances combine directly with the tissues of the tumor so that they act solely upon them, can this problem be resolved in a satisfactory manner.

The personnel of our institute is occupied in work on the development of such methods. At the same time, we are continuing to perfect the methods of the application of radiant energy that have already been developed and are being used in the therapy of various diseases. We also seek new ways of using this energy not only for therapeutic purposes, but also for diagnosing correctly various diseases and investigating complicated processes of metabolism that occur in the human body.

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