INTERNATIONAL MULTIDISCIPLINARY JOURNAL FOR RESEARCH & DEVELOPMENT
SJIF 2019: 5.222 2020: 5.552 2021: 5.637 2022:5.479 2023:6.563 2024: 7,805
eISSN :2394-6334 https://www.ijmrd.in/index.php/imjrd Volume 10, issue 12 (2023)

METHODOLOGICAL ISSUES CONCERNING THE EFFECT AND APPLICATION OF RADIATION ON MATERIALS IN MEDICAL PHYSICS

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Abstract: This article describes in detail the main types of radiation and their effects on substances. It presents the concepts of ionizing and non-ionizing radiation, discusses their properties in causing chemical and physical changes in substances. The article also pays special attention to the use of radiation in medicine in the diagnostic and therapeutic process. Among the medical methods, technologies such as radiography, computed tomography (CT), magnetic resonance imaging (MRT), nuclear medicine and radiotherapy are given as examples. The article also touches on the issues of sterilization and destruction of microorganisms using radiation. The negative effects of radiation, safety measures and the importance of using modern technologies are discussed.

Keywords: Integration, medical physics, medical technology, X-ray, CT, MRT, PET, NMRT, oncological disease, endoscopic diagnosis, sonoelastography,DNA molecule.

Introduction.

Physics is an extremely necessary science for a doctor or theoretical medicine. Realizing the incomparable role of physics in the current rapidly developing era, the issue of training physicist-medical specialists in our country can be called urgent.

The introduction of the achievements of physics into medical practice is putting on the agenda the need to create new equipment used in the diagnosis and treatment of diseases , as well as the training of qualified specialists to work with them . After all, the equipment used for treatment and diagnosis, which is becoming more complex and modern every day , cannot be managed by a doctor and a physicist who have received their primary specialty through the existing system of training medical physicists. Therefore, based on the achievements of scientific development of the 21st century, the deeper introduction of physics into medicine is required, which, in turn, will lead to an increase in the demand for medical physicists and a wide reliance on scientific achievements.

Based on the modern achievements of physics, it has become possible to direct CT and MRT methods to diagnostic purposes in medicine. The most modern equipment for diagnosis and treatment using ultrasound is entering medical practice. The achievements of physics - endoscopic diagnosis using fiber optics - are widely used in the treatment of gastrointestinal diseases, new equipment for endoscopic surgery has been created based on the achievements of physics (optics) and has begun to be used in clinical practice .

A medical physicist should actively participate in all stages related to the discovery, development and practical application of modern medical equipment. In recent years, the topic of conferences on medical physics has been supplemented by the direction "Application of nanotechnologies in medicine". The number of scientific reports in this direction is also increasing. Based on the experience of developed countries, it was found appropriate to carry out the training of medical physicists in three stages. According to it, at the first stage of training medical physicists, students acquire basic knowledge in physics , mathematics and other fundamental and humanitarian

sciences. At the second stage, medical physics is studied. At the third stage, students undergo practical training in leading medical and preventive institutions and laboratories .

The diagnostic methods used in medical practice for early diagnosis of oncological diseases are significantly lagging behind the requirements of the rapidly developing era. French writer Antoine de Saint-Exupéry - I believe that the day will come when patients with an unknown disease will surrender themselves to physicists. Physicists, without asking anything from the patient, will take his blood, find some constant value , multiply them by each other, then compare them with a table of logarithms and treat the patient with a single dose of medicine, he predicted the future prospects of physics in the 21st century [1-2].

It is clear that the solution to the problem cannot be solved within the framework of medical science alone, and the establishment of close cooperation with natural sciences, including physics, puts the issue of developing medical physics on the agenda. Medical physics is today increasingly playing a decisive role in the development of physical tools and physical-mathematical methods for studying humans and their diseases, as well as in the implementation of modern diagnostic and therapeutic effects in medical practice.

It is appropriate to consider the emergence of methods such as non-linear ultrasound diagnostics and ultrasound Doppler tomography, which are widely used in medical practice, as an achievement of physical acoustics.

Today, electron and proton accelerators are widely used in the world to sterilize medical equipment and instruments, which is one of the most important practical and technical issues in medicine . Accelerators also charged particles synchrotron irradiation from the method high good quality X-ray transmission tomography in practice apply beginning X-ray computer tomography and simple transmission radiography accuracy level increase opportunity is giving . In Figure 1 below current at the time wide used methods cited .

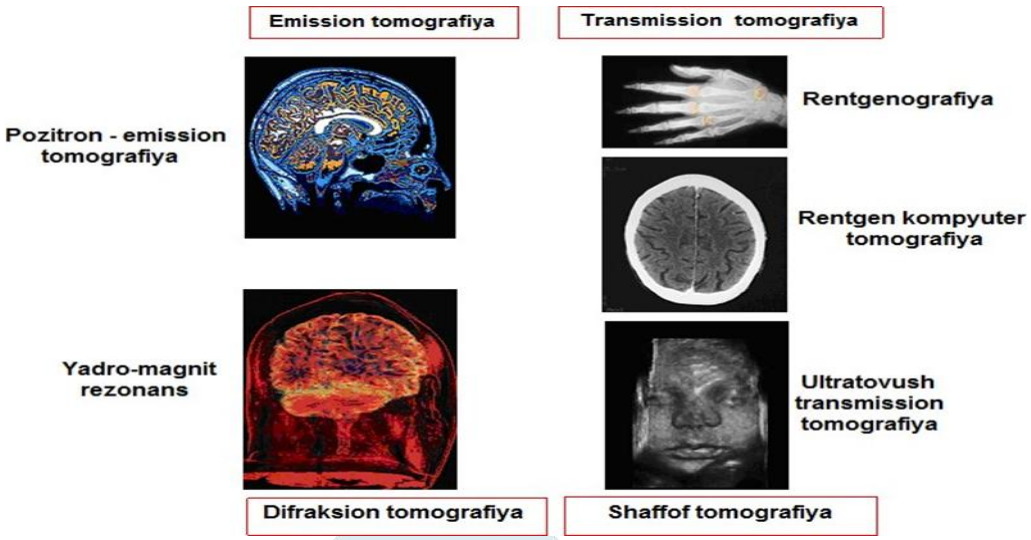

Figure 1. Human body using various methods of physical tomography organisms can be seen.

Let's take a look at the differences between computed tomography, magnetic

resonance imaging, and positron emission tomography. In the past luminous diagnostic main method radiography to be a patient (patient) she is or this part black white apparently the image to take opportunity gave was . Such in the picture of the bone skeleton good noticeable

was , light diagnostics according to expert – tape ‖ (image) studying, internal organism status about conclusion will release was.

Nowadays, various forms of tomography have emerged in addition to the classical X-ray method , which allow for layer-by-layer imaging of the human body[1-3].

So let's take a look at the differences between computed tomography (CT), magnetic resonance imaging (MRT), and positron emission tomography (PET).

Computed tomography. In the 1970s, scientists developed a technology for processing information from X-ray sensors that hit a patient's body part using a computer. As a result, the picture obtained during the examination became much clearer, and additional processing of the tomogram made it possible to see the patient's internal structure not only in a sectional (two-dimensional) view, but also in a volumetric (three-dimensional) view. Currently, CT has become the main method of radiological diagnostics. It is widely used in the diagnosis of trauma (wounds), joint diseases , and stroke.

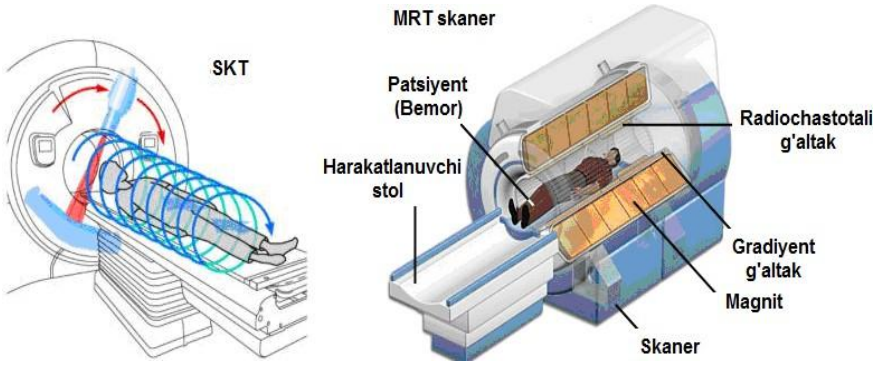

Figure 2. General view of magnetic resonance tomographing.

Magnetic resonance tomography (MRT). It began to be used in medical practice after CT , the revolutionary significance of this method is that it does not use X-rays. This type of tomography is based on nuclear magnetic resonance, which is the change in spatial orientation of protons in a hydrogen atom under the influence of a strong electromagnetic field. In other words, MRT can be performed very quickly, since it does not involve radiation. Since it is harmless, it can be used on children and pregnant women.

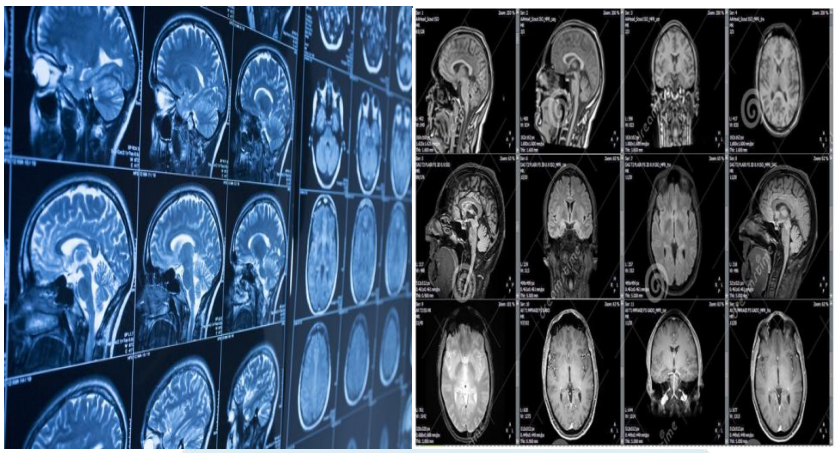

Figure 3. Taking image by magnetic resonance tomography.

To obtain and reconstruct a realistic image of internal organs, a computer and mathematics are needed. After the computer has finished collecting the materials , the signals are processed by algorithms and the relationship between the intensity of the signals measured at a certain frequency and the density of atoms at a certain point in the internal organ is determined. After that, an image of a certain part of the diseased organism appears on the computer screen. In order to diagnose a patient through an image, the doctor's knowledge in his field is not enough. Now he also needs physical knowledge.

Positron emission tomography (PET). It is considered the most promising method of modern radiology. It can be imagined as a "reverse X-ray". Instead of irradiating the patient from the outside, a radiopharmaceutical is injected into the patient's body, which accumulates in certain tissues for a short time. Due to this effect, in the tomography obtained, it is possible not only to see the part of the patient being examined, but also to detect the metabolism in the organs and the formation of new tissue.

This list can also include various radiation sources such as single-photon and positron emission tomography (PET), nuclear magnetic resonance tomography (NMRT), high-quality electroencephalography, lasers. In order to effectively work in the above and other areas of modern medicine, it is necessary to find solutions to a number of fundamental problems of medical physics.

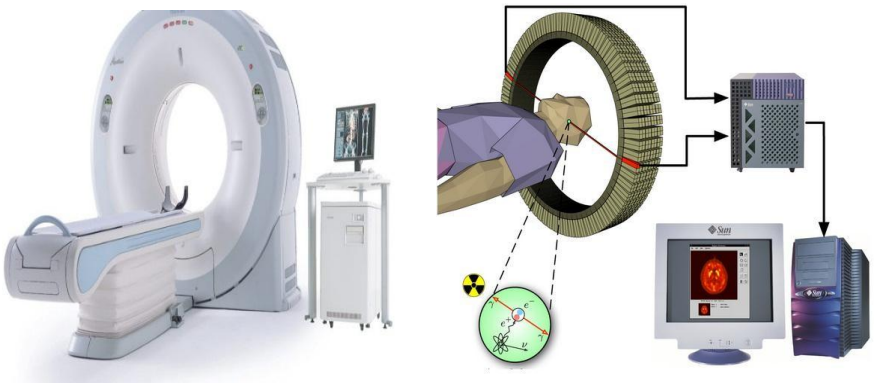

Figure 4. General view of positron emission tomography.

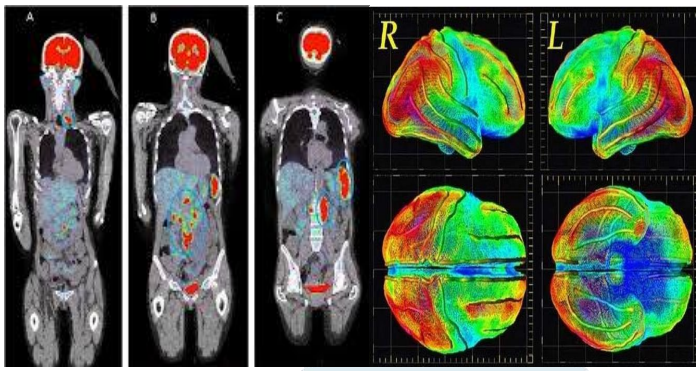

Figure 5. Images obtained using positron emission tomography .

Such fundamental problems of medical physics include, first of all, physical research aimed at creating physical and mathematical models of various organs and systems of the human body, working in collaboration with medical workers and physicists to study the nature of existing fields , environments and biophysical, biochemical, pathological and regulatory physiological

processes in the human body, and a comprehensive study of the interaction of the human body with physical radiation. In recent years, fundamental physical research in medical physics, a detailed study of the mechanism of the actin-myosin complex in muscle vessels, has made it possible to create a physical and mathematical model of the complete mechanochemical cycle of muscle cells [3].

Scientific research in medical physics has resulted in a number of achievements in the development of hybrid methods for diagnosing malignant tumors (cancer), which are considered extremely relevant worldwide, including for our Republic, within the last 5-6 years.

To understand the essence of the hybrid diagnostic method, the use of sonoelastography in ultrasound diagnostics made it possible to detect malignant tumors that have developed in the soft tissues of the body (at the cellular level) based on the study of their elastic properties. Sonoelastography provides information about the development of malignant tumors in soft tissues, depending on the size of the deformation area. (Figure 5)

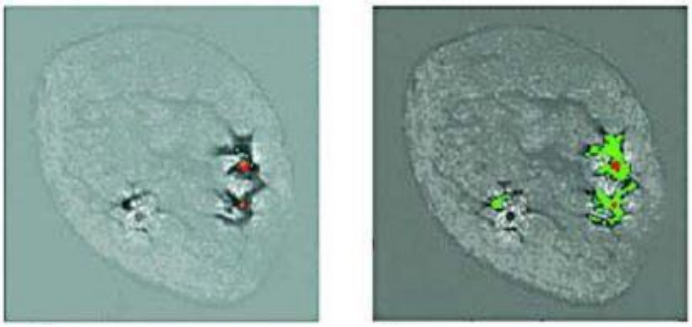

Figure 5. A real cross-section of soft tissues and their synthesized image are depicted, showing the state of the tumor (in red) and the perspective of its development (in green).

Currently, NMRT-tomography methods are also used in elastographic examinations. Therefore, the idea of hybrid diagnostics, such as recording electrical impedance using ultrasonic excitation - magnetic resonance imaging (MRT), is being implemented. This method allows combining the excitation arising in soft tissues under the influence of a focused acoustic wave train and the electromagnetic radiation of electric microcurrents developed in them with the process of recording using MRT. Electric microcurrents arise as a result of the Hall effect occurring in the blood, which is considered the internal fluid environment of the body - electrolyte. Such blood - electrolyte saturates soft tissues in which malignant tumors grow.

From a physics perspective, this method directly generates electrical currents in the tissues. The inherent uncertainty of electrical impedance tomography, such as measurement, is replaced by the precise recording of electromagnetic radiation generated by the focal acoustic beam. As a result, the accuracy of tumor localization increases.

This effect was discovered in 1879 by the American physicist Edwin Hall. Its brief essence is that if we send a current through a certain metal plate, for example, in the X-direction, and a magnetic field perpendicular to it in the U-direction acts on it, a potential difference will appear in the Z-direction. It will be possible to transfer a certain signal to another state through the magnetic field.

Thus, obtaining a synthetic image of the characteristic features of three different physical methods, including electrical impedance tomography, ultrasound transmission tomography, etc., allows for visual control of low-grade tumors. It is impossible to obtain such information when using these

methods separately. Today, the hypothesis that the development of a number of neurodegenerative diseases, including Alzheimer's disease, Parkinson's, Huntington's, type II diabetes , rheumatoid arthritis, acellular encephalopathy, etc. is associated with the misalignment of fibrous protein aggregates called amyloids, has many supporters. Such misalignment of protein filaments, which perform regulatory functions and underlie the occurrence and development of the above-mentioned diseases, is considered one of the promising and extremely important areas of nanomedicine in the field of diagnosis and treatment. In this regard, the development of nanotechnology in the last decades and the discovery of the technology of encapsulating pharmacological drugs with nanocarrier liposomes, using the incredibly wide possibilities of nanostructured molecular systems, have initiated revolutionary changes in medicine. The fact is that the use of free forms of pharmacological drugs actually causes their various side effects. Because such free drugs disrupt the natural state of proteins and nucleic acids. They also reduce the level of effect of such drugs on tumors. In addition, a number of drugs used against tumors have a high toxic effect on the body. Therefore, today, intensive scientific research is being conducted worldwide to create a capsule form of cytostatic drugs coated with liposomes and to increase their therapeutic index. By coating the capsule shell and surface with semi-synthetic nanocoatings, it is possible to control the dosage of antitumor drugs and antibiotics with various properties to pre-defined pathological zones.

Research Methodology.

Radiation is energy that propagates in the form of electromagnetic waves or streams of particles, which, when interacting with matter, cause various changes. Radiation is divided into the following main types:

1. Ionizing radiation: X-rays, gamma rays, alpha and beta particles. These radiations ionize atoms and molecules in matter, that is, they remove electrons from them.

2. Non-ionizing radiation: Infrared, ultraviolet, radio waves. They produce heat or other physical changes in substances.

The effects of radiation on matter depend on its energy, frequency, and ability to be absorbed by the matter. Ionizing radiation causes changes in the chemical structure of matter, for example, gaps or mutations in the DNA molecule. These properties are used in medicine to diagnose and treat diseases [4,5].

1. Radiation is widely used in medicine for diagnosis. The most commonly used methods are:

- Radiography: X-rays are used to examine bones and internal organs. They are based on the difference in density of substances.

- Computed tomography (CT): Uses X-rays to create three-dimensional images of the body. This method provides more accurate diagnostic information.

- Magnetic resonance imaging (MRT): This method is based on non-ionizing radiation – a magnetic field and radio waves. It is used to examine the condition of soft tissues.

- Nuclear medicine: Uses radioactive isotopes to monitor organ function, such as positron emission tomography (PET) and stationary gamma camera scans.

2. Use of radiation in treatment

The properties of ionizing radiation on biological tissues are effectively used in the treatment of:

- Radiotherapy: Used to treat cancer. Ionizing radiation damages the DNA of cancer cells, stopping them from multiplying.
- Photodynamic therapy: Based on targeting tumor cells using special photosensitizers and light beams.
- Nuclear therapy: Treatment by injecting radioactive substances directly into the affected tissue.

3. Use of radiation in sterilization.

Ionizing radiation is used to sterilize medical equipment and drugs. For example, gamma radiation destroys microorganisms and disinfects surgical instruments.

Long-term and high-dose radiation exposure can lead to negative consequences:

• Harm from ionizing radiation: DNA damage, cell death, or mutations.

• Non-ionizing radiation: Can cause overheating or heat damage. The following measures are taken to reduce negative effects:

1. Dose control: Individual radiation doses are calculated for each patient.

2. Use of protective equipment: Reduce radiation exposure using lead coatings and special screens.

3. Improving technologies: Accurately targeting the desired area with the help of modern equipment and avoiding excessive radiation. Students studying in higher educational institutions in the field of "Medical Physics" will be trained in the formation of skills and qualifications in the use of medical devices that operate based on the laws of physics, and Taking into account the high level of development of professional orientation, an innovative integrated educational program of the educational process in Medical Physics and Medical Sciences has been developed. When developing this program, we relied on the basic principles of higher education pedagogy (Figure 6). From some of the diagnostic methods presented above, it becomes clear that improving the treatment and diagnostic process of common serious diseases, including oncological and diabetes mellitus, cannot be achieved without the development and application of modern medical physical methods, as well as specialists who are able to think in a completely new way and who have acquired modern knowledge and are able to harmoniously apply the achievements of such disciplines as physics, medicine, and biology, who are able to work with high-tech medical equipment.

A medical physicist is a highly talented specialist who has fundamental knowledge in physics, mathematics, biology, and medicine, and who can propose new ideas in response to contemporary demands.

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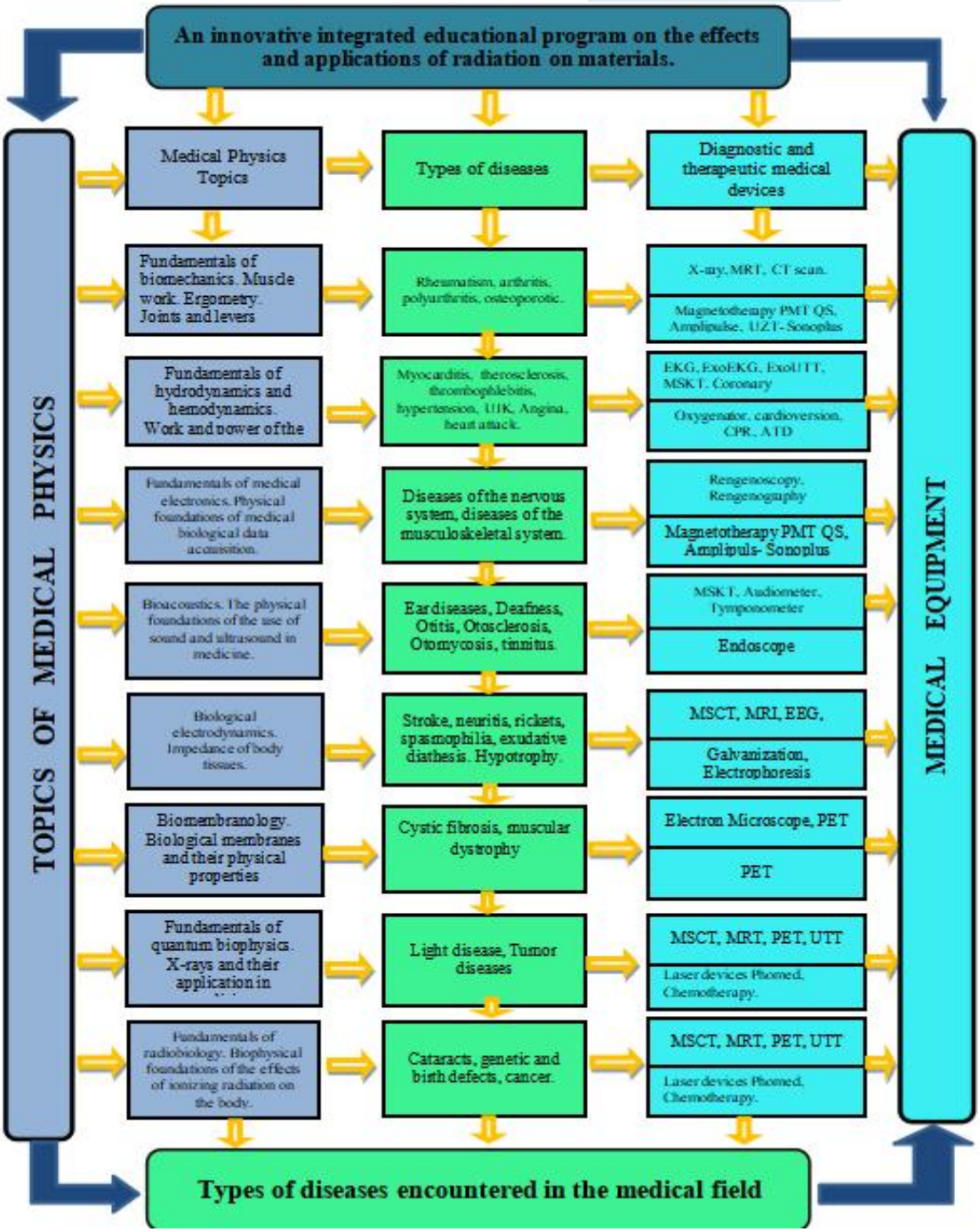

6 - Fig. Innovative integrated educational program

Medical physicists, who possess such comprehensive knowledge, contribute their knowledge to various areas of social life, including:

In treatment and prevention institutions;

In medical research institutes;

In physics research institutes and universities;

The manufacturer works in large companies, discovering and applying high-tech diagnostic and treatment methods, improving existing ones on a physical basis. Direct participation in the production process of high-tech medical diagnostic and treatment equipment, world-famous companies (in the USA, Europe and Eastern countries)They will have the opportunity to actively work in production processes that require extremely high skills, such as working in collaboration with. However, Training expert medical physicists armed with such extensive knowledge is no easy task.

Analysis and results. The scientific novelty of the results in these processes is that we have applied this generalized model to increase the effectiveness of the independent learning process of students of the professional education system, in order to form the competencies of students in teaching Medical Physics through the "Innovative Integrated Educational Program of Medical Physics and Medical Sciences" for students of the Tashkent Medical Academy, Faculty of "Management, Medical Biology, Biomedical Engineering and Higher Education Nurse", Department of "Biomedical Engineering, Informatics and Biophysics" in groups 21-101 A, 21-101B of the 1st stage of the educational direction 60711800-"Biomedical Engineering" and groups 21-101A, 21-102A of the 1st stage of the educational direction 6041120-" Management: Health Care Management". The students in the group were randomly divided into two groups: the first experimental group (25 students) received instruction using electronic learning resources and interactive methods , and the second control group (24 students) received traditional classroom instruction [3].

Conclusion/Recommendations. In conclusion, it can be said that in the field of medical physics, the effects of radiation on matter create new opportunities in medical diagnosis and treatment. Although their proper use serves to improve human health, caution and safety measures are necessary. Scientific research in the field of radiation creates the basis for the development of more effective and safe technologies in the future.

This article is based on a pedagogical analysis of materials prepared within the framework of the innovative project No.AM-PZ-2019062031 "Creation of multimedia textbooks for bachelor's and master's students in the disciplines of "Nuclear Energy", "Nuclear Medicine and Technologies", "Radiation Medicine and Technologies", and we would like to thank the authors of the textbooks.

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