DOI: https://doi.org/10.36719/2663-4619/115/39-42

Aygün Sultanova
Naxçıvan Dövlət Universiteti
fizika üzrə fəlsəfə doktoru
https://orcid.org/0009-0006-7406-6055
aygunsultanova60@gmail.com

Fizika və təbabət

Xülasə

Fizika 5000 il əvvəl tibbin yaranmasından bəri sağlamlığa mühüm töhfələr vermişdir. Bu töhfələr çox və müxtəlif olmuşdur və olmaqda davam edir: diaqnoz (rentgen şüaları, nüvə təbabəti, klinik PET taraması, maqnit rezonans spektroskopiyası, maqnitoensefaloqrafiya, MRT ilə yüksək intensivlikli fokuslanmış ultrasəs); müalicə (radioterapiya, minimal giriş cərrahiyyəsi, müdaxiləli MRT, fotonik, miqyaslama nəzəriyyəsi); və diaqnostika və müalicənin kombinasiyası. Xəstəliyin molekulyar mexanizmləri daha yaxşı başa düşüldükcə və yeni texnologiyalar bu molekulyar proseslərin tədqiqinə imkan verdikcə bu töhfələr artacaq. Tibbi fiziklərin xüsusilə mühüm rolu var; məsələn, pasiyentlərin təhlükəsizliyində, fizikaya əsaslanan yeni sağlamlıq texnologiyalarının təhlükəsizliyinin təmin edilməsi.

Tibbi fizika fizikanın tibbə tətbiqidir. Xəstəliyin qarşısının alınması, diaqnozu və müalicəsində fizika anlayışlarından və prosedurlarından istifadə edir. Tibbi fizika tibbdə, bioloji və tibbi tədqiqatlarda və sağlamlıqla bağlı müəyyən fəaliyyətlərin optimallaşdırılmasında əsas rol oynayır.

Açar sözlər: *diaqnoz, radiasiya, nüvə təbabəti, maqnit rezonans, tibbi fizika*

Aygun Sultanova
Nakhchivan State University
PhD in Physics
https://orcid.org/0009-0006-7406-6055
aygunsultanova60@gmail.com

Physics and Medicine

Abstract

Physics has made important contributions to health since the inception of medicine 5,000 years ago. These contributions have been and continue to be many and varied: diagnosis (X-rays, nuclear medicine, clinical PET scanning, magnetic resonance spectroscopy, magnetoencephalography, MRI with high-intensity focused ultrasound); treatment (radiotherapy, minimally invasive surgery, interventional MRI, photonics, scaling theory); and the combination of diagnosis and treatment. These contributions will increase as the molecular mechanisms of disease are better understood and new technologies enable the study of these molecular processes. Medical physicists have a particularly important role; for example, in patient safety, ensuring the safety of new health technologies based on physics.

Medical Physics is the application of physics to medicine. It uses the concepts and procedures of physics in the prevention, diagnosis, and treatment of disease. Medical Physics plays a key role in medicine, in biological and medical research, and in the optimization of certain health-related activities.

Keywords: *diagnosis, radiation, nuclear medicine, magnetic resonance, medical physics*

Introduction

The application of the principles, methods, and techniques of physics to clinical practice and research has revolutionized the entire field of medical science to improve human health and overall well-being.

Medical physics is a branch of applied physics that uses the physical sciences to prevent, diagnose, and treat human disease. Medical physics can be divided into several subgroups: medical imaging physics, radiation oncology physics, non-ionizing medical radiation physics, nuclear medicine physics, medical health physics, and physiological measurements (Lancet, 2012).

Medical physics focuses primarily on the measurement of ionizing radiation, magnetic resonance imaging, and the application of physics-based technologies (lasers and ultrasound) in medicine.

The term "medical physics" was first introduced in 1778 in Paris by Félix Vic d'Azir, a French physician, anatomist, and secretary general of the Royal Society of Medicine. In 1814, the most appropriate definition of medical physics was presented in Nysten's revised medical dictionary. In this edition, medical physics was defined as "physics applied to the knowledge of the human body, its preservation, and the treatment of its diseases" (Guibelalde, Christofides, Caruana, Evans, van der Putte).

Research

Medical physicists are healthcare professionals who have been specially trained to apply the concepts and techniques of physics to medicine. They work primarily in clinical settings or in academic and research institutions. The primary roles and responsibilities of medical physicists include applying medical physics techniques to the diagnosis and treatment of human disease, and protecting healthcare workers and patients from the hazards of ionizing and non-ionizing radiation (International Atomic Energy Agency (IAEA), 2014).

Medical physicists who specialize in radiation therapy are primarily involved in the provision of radiation therapy to cancer patients, working in collaboration with oncologists and other therapists. Treatments mainly include brachytherapy, where a radiation source is placed inside the body, or external beam radiation therapy, where radiation generated by a linear accelerator is carefully delivered to affected tissues (Beyer, 2021).

Medical physicists specializing in medical imaging are involved in the development and maintenance of a variety of imaging techniques, including X-rays, computed tomography, and magnetic resonance imaging (Monograph, 2018).

Medical physicists specializing in nuclear physics perform functional imaging of patients, primarily using positron emission tomography (PET), gamma cameras, and biological agents labeled with radioactive markers (radiopharmaceuticals) (International Atomic Energy Agency (IAEA).

In X-rays, signals from a narrow X-ray beam pass through the affected area to create planar images. Similarly, cross-sectional X-ray images obtained after repeated scans are digitally assembled to create high-resolution, three-dimensional or four-dimensional computed tomography (CT) images for analyzing dynamic processes (Kostylev, Narkevich, 2008).

In addition to providing quantitative and reproducible anatomical images, CT can generate high-quality functional information through dynamic perfusion scanning. During the perfusion procedure, a contrast agent is administered and the affected area is repeatedly imaged at 3-5 second intervals for 30 seconds. These images are then stacked to create four-dimensional images. This technique is very useful for analyzing hemodynamic parameters, including blood flow and blood volume (Duck, 2014).

Magnetic resonance imaging .Magnetic resonance imaging (MRI) is a powerful noninvasive medical imaging technique that uses a strong, static magnetic field, magnetic gradients, and computer-generated radio waves to produce high-quality three-dimensional images of tissues and organs. The magnetic field applied to the body aligns photons from the body with that field. The radio waves are then stimulated, and MRI sensors are used to detect the energy (signal) released from the photons (International Atomic Energy Agency (IAEA), 2021).

In quantitative MRI, contrast differences between two tissues are maximized in a single image by exploiting the differences in the relaxation times of the two tissues. Images are quantified based on

the properties of a tissue. Commonly used techniques for quantitative MRI include arterial spin labeling for measuring cerebral blood flow and diffusion tensor imaging for microstructural analysis (Hasanov, Khalilova, 2023; Remizov, 2003).

Ultrasound. Ultrasound is a high-frequency sound wave that produces non-invasive images of various tissues and organs. Differences in mechanical properties at the interface of different organ tissues cause ultrasound to be reflected. These reflections are measured to create ultrasound images (Physica Medica, 2025; Rogatkin, Gilinskaya, 2007).

The main advantage of ultrasound over other medical imaging modalities (CT and MRI) is its cost-effectiveness and real-time imaging at the bedside. Ultrasound uses contrast-enhancing agents such as microbubbles for functional imaging. In addition to diagnosing disease, ultrasound is used for therapeutic purposes. For example, high-intensity focused ultrasound ablates diseased tissue within the body without damaging surrounding healthy tissue. Ultrasound is also used for targeted drug delivery (Dutta, 2022).

Nuclear Medicine. In nuclear medicine, radioactive probes are used to observe physiological processes. Probes are also used to deliver therapeutic doses. During the procedure, a very small amount of radioactive probe is injected into the body. The probe is then absorbed by the organ or tissue being examined. The radiation emitted by the probe as a result of the decay is detected by a gamma camera, which generates digital signals to analyze the functional state of the organ (Smith).

The gamma camera produces two-dimensional images while remaining stationary. In single-photon emission computed tomography, the camera rotates to produce axial slices of the target organ. These slices can be used in PET scans to produce three-dimensional images (Leshchenko, Il'ich, 2012).

Radiotherapy. Radiation therapy involves the delivery of ionizing radiation to the body to destroy and eliminate cancer cells. High-energy photons are used for deep-seated tumors. High-energy electrons are used for superficial tumors. In addition, charged particles, including protons, are used in radiotherapy. Medical imaging is performed throughout the treatment procedure to ensure safe and targeted delivery of radiation and to assess radiation-related changes in anatomy (Rubin, 2004).

Conclusion

Medical physics uses the concepts and procedures of physics to prevent, diagnose, and treat disease. Medical physics plays a fundamental role in medicine, biological and medical research, and in the optimization of certain health-related activities. Medical physics includes fields such as radiotherapy physics, diagnostic radiology physics, nuclear medicine physics,and radiation protection.

Other areas of interest in medical physics include the measurement of ionizing radiation, magnetic resonance imaging, and the application of lasers, ultrasound, and other technologies used in medicine from physics concepts. The duties of medical physicists cover a wide range of activities in modern hospitals where radiation technology is used. Medical physicists play a vital role as part of a team of healthcare professionals in ensuring the safe and effective use of radiation in medicine.These quality objectives include radiation-related technologies, radiation therapy dose planning and verification, diagnostic imaging optimization and dose reduction, and data management, all of which are based on a deep understanding of the principles of radiation physics and radiation technology.

References

1. Beyer, T. (2021). Medical physics and imaging – A timely perspective. *Frontiers in Physics*.
2. Duck, F. A. (2014). The origins of medical physics. *European Journal of Medical Physics*.
3. Dutta, S. S. (2022, November 10). The role of physics in medicine.
4. Guibelalde, E., Christofides, S., Caruana, C. J., Evans, S., & van der Putte. (n.d.).
5. Hasanov, E. R., & Khalilova, Sh. G. (2023). Instability in multi-valley semiconductors in external electric and magnetic fields. *Vestnik Kazakhstan*, (2)110, 66–70.

6. International Atomic Energy Agency (IAEA). (2014). *Radiation protection and safety of radiation sources: International basic safety standards*. https://wwwpub.iaea.org/MTCD/Publications/PDF/Pub1578_web-57265295.pdf
7. International Atomic Energy Agency (IAEA). (2021, February 15). IAEA launches guide to promote recognition of medical physicists as health professionals.
8. International Atomic Energy Agency (IAEA). (n.d.). *Guidelines for the certification of clinically qualified medical physicists*. https://www-pub.iaea.org/MTCD/Publications/PDF/TCS-71web.pdf
9. Kostylev, V. A., & Narkevich, B. Y. A. (2008). *Meditsinskaya fizika*.
10. Lancet. (2012). Physics and medicine. *The Lancet*.
11. Leshchenko, V. G., & Il'ich, G. K. (2012). *Meditsinskaya i biologicheskaya fizika*.
12. Monograph. (2018, March 27). *Medical physics – International Organization for Medical Physics*.
13. Physica Medica. (2025, February 4). *European Journal of Medical Physics*.
14. Remizov, A. N. (2003). *Meditsinskaya i biologicheskaya fizika*. Moscow.
15. Rogatkin, D. A., & Gilinskaya, N. Y. U. (2007). *Izbrannyye voprosy fiziki dlya fizioterapevtov*.
16. Rubin, A. B. (2004). *Biofizika*. Moscow State University Press.
17. Smith, P. H. S. (n.d.). The role of medical physics in relation to medical devices. *World Health Organization*.

Received: 15.12.2024
Accepted: 31.03.2025