X-RAYS AND MODERN MEDICINE: THEIR ROLE IN DIAGNOSTICS

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Abstract: In the present article, the broad application of X-rays in medicine for diagnostic and therapeutic processes is examined. Their main advantage is the ability to visualize the internal structure of the human body non-invasively. Radiography is used for detecting bone fractures, lung diseases, dental pathologies. Computed Tomography (CT) provides detailed images of internal organs. Angiography is used to study the structure of blood vessels and plays an important role in diagnosing and treating cardiovascular diseases. The use of X-rays together with modern technologies helps improve the accuracy of medical diagnosis and ensure patient safety.

Keywords: X-rays, ionising radiation, radiation safety, X-ray apparatus, Computed Tomography (CT), diagnostic images

Аннотация: В данной статье рассматривается широкое применение рентгеновских лучей в медицине для диагностических и терапевтических целей. Их основным преимуществом является возможность визуализации внутренней структуры человеческого организма без инвазивного вмешательства. Рентгенография используется для выявления переломов костей, заболеваний лёгких, стоматологических патологий. Компьютерная томография (КТ) предоставляет детализированные изображения внутренних органов. Ангиография применяется для изучения структуры кровеносных сосудов и играет важную роль в диагностике и лечении сердечно-сосудистых заболеваний. Использование рентгеновских лучей в сочетании с современными технологиями способствует повышению точности медицинской диагностики и обеспечению безопасности пациентов.

Ключевые слова: Рентгеновские лучи, ионизирующее излучение, радиационная безопасность, рентгеновский аппарат, компьютерная томография (КТ), диагностические изображения.

Annotatsiya: ushbu maqolada diagnostika va terapevtik jarayonlar uchun tibbiyotda rentgen nurlarining keng qo'llanilishi ko'rib chiqilgan. Ularning asosiy afzalligi inson tanasining ichki tuzilishini invaziv bo'lmagan holda tasavvur qilish qobiliyatidir. Rentgenografiya suyak sinishi, o'pka kasalliklari, tish patologiyalarini aniqlash uchun ishlatiladi. Kompyuter tomografiyasi (KT) ichki

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organlarning batafsil tasvirlarini beradi. Angiografiya qon tomirlarining tuzilishini o'rganish uchun ishlatiladi va yurak-qon tomir kasalliklarini tashxislash va davolashda muhim rol o'ynaydi. Rentgen nurlaridan zamonaviy texnologiyalar bilan birgalikda foydalanish tibbiy tashxisning aniqligini oshirishga va bemorlarning xavfsizligini ta'minlashga yordam beradi.

Kalit so'zlar: rentgen nurlari, ionlashtiruvchi nurlanish, radiatsiya xavfsizligi, rentgen apparati, kompyuter tomografiyasi(KT), diagnostik tasvirlar

Introduction:

The history of the X-ray apparatus begins on 8 November 1895 with the accidental discovery of X-rays by Wilhelm Konrad Röntgen. He noticed unknown rays on the screen while working with cathode rays during an experiment. These rays, although invisible, passed through paper and some materials and produced an image on the screen.

Literature Review and Methodology:

In 1896, Röntgen introduced his new discovery to the world and for the first time obtained an image of his wife's hand bones. This discovery led to revolutionary changes in medicine. In this article, X-rays are considered today one of the most important diagnostic tools in medicine. They are widely used in identifying various diseases, visualising fractures in bones, diagnosing lung and heart diseases. In addition to ordinary X-ray examinations, advanced methods such as Computed Tomography (CT) and angiography — which are likewise based on X-rays — are also applied. At the same time, it is necessary to observe safety precautions when using X-rays. Excessive radiation exposure may be harmful to health; therefore, physicians recommend these examinations only when necessary. In order to ensure a safe dose for patients, modern X-ray devices are equipped with technologies that reduce the amount of ionising radiation to a minimum.

Digital X-ray device – This is the modern version of traditional X-ray technology, which allows images to be captured and stored in digital form. It uses X-rays to create high-quality images of the internal structure of the patient's body.

Operating principle:

1. X-rays pass through the patient's body.
2. A detector registers the degree of passage of the rays.
3. The data are converted into digital form and transmitted to a computer.
4. The physician views and analyses the high-quality, clear image on the screen.

Advantages of digital X-ray equipment:

- High image quality – Images are clear and sharp, enabling even the smallest details to be seen.
- Lower radiation exposure – Compared to conventional X-ray machines, the patient receives less exposure.

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- Fast results – The images appear on the screen within seconds.
- Ease of storage and sharing – Images can be stored electronically and exchanged among medical institutions.
- Capability of automatic problem detection – Some devices with artificial intelligence analyse signs of disease automatically.

Types:

1. Stationary digital X-ray – Used in large hospitals and clinics.
2. Mobile (portable) digital X-ray – Used in ambulances or in situations where the patient cannot be moved.
3. C-Arm X-ray – Used in surgical procedures for real-time imaging.
4. Dental digital X-ray – Specifically designed for identifying dental diseases.

Fields of application:

Traumatology and orthopaedics (fractured bones, dislocations). Pulmonology (lung diseases, including pneumonia, tuberculosis). Cardiology (assessment of heart and blood vessel condition). Dentistry (diagnosis of teeth and jaw problems). Oncology (early detection of tumors).

Mobile X-ray Device: Mobile or portable X-ray devices can be brought to the patient's side, which creates convenience in examining immobile or critically ill patients. For example, the “Cybermobil TS” mobile X-ray device is equipped with a high-frequency generator and provides maximum power from a standard power source.

C-Arm X-ray Apparatus: C-arm X-ray devices allow real-time imaging and are mainly used in surgical operations. Their portability and ability to capture images from different angles provide surgeons with additional information during the procedure.

Portable X-ray Devices: This type of device is distinguished by small size and light weight, which allows their use in field conditions or in situations requiring rapid diagnostics.

Mammography Devices: These are designed for detecting breast diseases, particularly early-stage tumors, and play a critical role in women’s health monitoring.

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Fluorographic X-ray Apparatus: Primarily used for mass screening of lung diseases. These devices allow high-volume examinations to be carried out quickly and efficiently.

Angiographic X-ray Equipment: Used to visualise blood vessels with contrast media. It plays a significant role in diagnosing and treating cardiovascular diseases.

Dental X-ray Apparatus: Developed specifically for detecting diseases of teeth and the oral cavity, these devices provide high-resolution images.
Intra-oral X-ray (taken inside the mouth)



- Periapical X-ray – Shows the complete structure of one or more teeth, the root, and bone condition.
- Bitewing X-ray – Used to check contact points between upper and lower teeth (mainly for caries detection).
- Occlusal X-ray – Used in paediatric dentistry to assess jaw development.

1. Principle of operation of X-rays: The X-ray apparatus converts specialized electrical energy into ionising electromagnetic rays (X-rays). These rays pass through the human body and are absorbed differently by various tissues:
- Bones and teeth – being dense, absorb more rays and appear white in the image.

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- Soft tissues (muscles, fat, organs) – absorb fewer rays and appear grey.
- Cavities and air-filled organs (lungs, intestines) – absorb almost no rays and appear dark on the image. Modern digital X-ray devices help display images on a computer screen clearly and with minimal radiation dose.

2. Harmful sides of X-rays:

2.1 Ionising radiation effect X-rays have ionising properties and can affect body cells. Continuous and high-dose exposure may lead to:

- Genetic changes – affecting DNA structure and causing incorrect cell division.
- Cancer risk – prolonged exposure to high radiation may increase the development risk of cancer.
- Effects on the nervous and blood-forming systems – possibly affecting bone marrow and blood cell production.

3. Risk for pregnant women

During pregnancy, ionising radiation may negatively affect the fetus. Therefore, X-ray examinations are performed only when necessary and with special protective means.

4. How X-rays affect patients? A standard diagnostic X-ray examination in terms of dose is minimal and does not cause major harm to the human body. Modern digital X-ray machines emit less radiation than conventional apparatuses. X-ray examinations should be conducted only after a doctor's recommendation.

5. Methods of protection from X-ray radiation

1. Lead protective equipment During an X-ray examination, patients are provided with lead-covered aprons or a thyroid shield to protect them.
2. Minimising radiation dose Unnecessary and redundant X-ray examinations should be avoided. Alternative diagnostic methods (for example, ultrasound or MRI) may be used.
3. Use of modern technologies Digital X-ray devices produce less radiation. A dosimeter is used to monitor the radiation dose received by doctors and medical staff.

After the discovery of X-rays, it was difficult for a long time to determine their true nature. Because X-rays do not change direction under the influence of electric or magnetic fields, and due to their very short wavelength, it was difficult to study or prove their wave-like properties (for example, diffraction). In 1912 the German physicist Max von Laue and his students discovered that when X-rays pass through a crystal, X-ray diffraction takes place.

When an electron strikes a target (anode) material, part of its energy is spent on producing X-rays. If an electron that has passed through an electric field with potential difference U has kinetic energy eU (where e is the electron charge and U is the potential-difference, and V is the velocity attained), and during the collision

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the electron is decelerated to zero velocity, then its entire kinetic energy is converted into the energy of X-rays, i.e. $eU = h\nu$ or $\lambda_{max} = hc/eU$; here λ is the wavelength of the X-rays, ν the frequency of the electromagnetic wave, h is Planck's constant, c is the speed of light. Thus, the greater the potential-difference, the shorter the wavelength of the X-rays. X-rays of very short wavelength are called hard X-rays. Usually, X-ray tubes are supplied with voltages up to 50 kV. An electron passing through such a potential difference can reach velocities close to 0.4c. In a betatron, electrons can be given very high speeds. When these accelerated electrons are sent at a solid target, very short-wavelength X-rays are produced. The shorter the wavelength, the less the rays are absorbed by material. Therefore the X-rays produced in a betatron are, in particular, highly penetrating.

When the velocity of electrons is sufficiently large, in addition to the radiation produced by deceleration (so-called braking radiation), characteristic radiation begins to be observed—that is, radiation resulting from excitation of inner electron shells of the target atom.

In the optical properties of X-rays phenomena similar to those for light are observed: refraction and reflection, polarization and diffraction. They obey the absorption law similar to light, i.e. $I = I_0 e^{-\mu x}$, where I_0 is the intensity of the X-rays incident on the absorbing layer, I_x is the intensity after passing through a layer of thickness x, and μ is the coefficient of intensity attenuation. In the attenuation of X-ray intensity in matter, the strong binding of electrons in the material (i.e., electrons in inner atomic shells) contributes coherent scattering, and in weakly bound (outer) electrons incoherent (Compton) scattering as well as the photoelectric absorption are important. The absorption spectra of X-rays are used to determine the energy level/structure of atomic electron shells. The absorption coefficient of X-rays in matter is smaller compared to the absorption coefficient of light. For this reason X-rays can easily penetrate various materials.

X-rays are invisible to the eye, and special methods (photography, ionization) have been developed in order to detect them. In the photographic method the X-rays are not only recorded but also their intensity is determined. However, the measurement errors in this method are larger than in the ionization method. The ionization method is based on measuring the ionization of a gas induced by X-radiation in the material. The current through the ionised gas (when a certain potential difference is applied) is directly proportional to the intensity of X-rays.

Conclusion:

X-rays are an important tool in medicine for early detection of diseases and effective treatment. They enable examination of bones, internal organs and soft tissues. However, due to their ionising nature, excessive use may cause harm to the

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body. The use of modern digital technologies and protective measures reduces radiation impact to a minimum. X-ray examinations should be carried out only on a doctor's recommendation and with caution.

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