

Original Article: Translation of Radiation Protection in Nuclear Medicine

Ghazal Tanzifi¹, Amirhossein Ahmadi Vand Koshki¹

¹Department of Nuclear Engineering, Islamic Azad University, Central Tehran Branch, Tehran, Iran
(Email: Ahmadiamirhosein141@gmail.com)

Use your device to scan and read the article online



Citation Gh Tanzifi, A Ahmadi Vand Koshki, **Translation of Radiation Protection in Nuclear Medicine**, *EJCMPR*. 2024; 3(3):775-781.



<https://doi.org/EJCMPR/2024116>

Article info:

Received: 04 March 2024

Accepted: 18 Jun 2024

Available Online:

ID: EJCMPR-2406-1192

Checked for Plagiarism: Yes

Peer Reviewers Approved by:

Dr. Frank Rebout

Editor who Approved Publication:

Dr. Frank Rebout

Keywords:

Radiation, Nuclear Medicine, Health physics, Environment.

ABSTRACT

In recent years, the use of electromagnetic waves in human life has increased dramatically. According to statistics in 2012, there are more than four billion mobile phone subscribers. Therefore, there is an essential need to conduct extensive research in order to investigate and evaluate the biological effects of electromagnetic waves. Protecting humans and the environment against the harmful effects of radioactive materials and radiation devices through the establishment of relevant laws and regulations, as well as control and monitoring of their compliance, is called the science of health physics. Radiation protection is actually a profession that protects humans, the environment, and future generations from the biological effects of radiation based on the scientific principles formulated in the science of health physics. Despite the fact that the use of ionizing radiation is very useful and sometimes unique in various matters, failure to observe safety precautions can cause serious risks for employees, people, the environment, and even future generations. The potential dangers of such rays were discovered immediately after the discovery of radioactive materials more than a hundred years ago. With the progress in identifying hazards and the ability to measure ionizing radiation, relevant guidelines regarding protective measures have been expanded and developed. In general, the goal of radiation protection is to use the benefits of using radiation in various fields and reduce as much as possible the risks caused by its effects on employees, people, the environment, and future generations.

Introduction

Nowadays, Electromagnetic waves, including radio waves, present in electronic devices such as mobile phones, radios, and Wi-Fi are present in our daily lives. These waves are able to directly interact with the cells

of our body and have effects on our health. In in-vivo studies, irradiation of all kinds of animals by electromagnetic waves is desired. The research area ranges from behavioral studies to long-term risks. In these studies, toxicological methods are used to investigate various risk factors. In these studies, the radiation chamber

*Corresponding Author: Ghazal Tanzifi (ghazal.tanzifi0173@gmail.com)

must be designed in a way to include all biological and electromagnetic aspects. Radiation therapy is one of the common methods of treating malignant and benign tumors. Radiation therapy is performed with the aim of destroying tumor cells and protecting healthy tissues. High-dose radiation therapy kills cancer cells, or slows their growth by damaging DNA. Cancer cells whose DNA is too damaged stop dividing, or die. Damaged cells die and are broken down and removed by the body. Radiation therapy does not kill cancer cells immediately. It takes days or weeks for cancer cells to die from radiation therapy. Cancer cells then continue to die for weeks or months after the end of radiation therapy.

Genetic effects of electromagnetic waves

Research shows that some people may have a genetic sensitivity to electromagnetic waves. In fact, some genes can strengthen or weaken the effects of electromagnetic waves. This may lead to changes in the nervous and hormonal system that can lead to sleep disorders and stress in women.

Biological effects of electromagnetic waves

Electromagnetic waves can have many biological effects on body cells and tissues. Some research shows that these waves can lead to changes in cell activity, hormone production and central nervous system function. These changes may lead to disruption of women's sleep health and stress.

Physiological effects of electromagnetic waves

Electromagnetic waves can have many physiological effects on the nervous system and body functions. Some research shows that excessive use of electronic devices at night can disrupt sleep and its quality. Also, some people may be sensitive to electromagnetic waves, which can lead to stress and anxiety. In general,

electromagnetic waves can have effects on women's sleep health and stress. You can take measures to reduce the possible effects of electromagnetic waves on women's sleep health and stress. For example, limiting the use of electronic devices at night, using protective filters to reduce the emission of electromagnetic waves, and creating a suitable sleep environment using relaxing methods such as massage, breathing exercises, and relaxing music.

Important products to protect pregnancy health

1- Anti-wave belly band: strong support for your stomach against electromagnetic waves.

2- Anti-wave maternity clothing: stylish and comfortable design to protect you and your fetus from harmful waves.

3- Anti-wave blanket: It allows you to relax anywhere and anytime, while protecting your body from electromagnetic waves.

Ionizing rays with the ability to ionize atoms cause biological effects such as genetic effects, skin burns and cataracts, and the probability of their occurrence increases with increasing dose. Up-to-date studies confirm effects such as headache, dizziness, lethargy, heart palpitations and a decrease in the number of white blood cells, especially with increasing age in radiation workers. In this group, the average hemoglobin and platelets showed a significant difference, and chromosomal defects, reduction of different types of T lymphocytes, skin inflammation, respiratory allergy, chronic hepatitis B, presence of nodules in the thyroid, chromosomal failure and their structural damage are among others. There are signs. Infection and leukemia are also directly related to exposure as a result of immune system failure. In psychiatric studies, depression, poor memory function and anxiety have also been observed in these people. Recently, the use of new combinations of antioxidants is suggested to prevent the

complications mentioned in the kidneys, lungs, skin, digestive tract and brain. On the other hand, the hypothesis of hormesis, taking into account the possibility of positive aspects of ionizing radiation at low dose levels and their protective reaction against diseases, is proposed and it is caused by the function of the warning system to the peripheral cells of damaged cells, the activation of the DNA repair enzyme, the activation. Some genes know the destruction of damaged cells and tumors by the body's immune system. Paying attention to radiation protection regulations is effective in reducing the mentioned side effects. Ionizing radiation is one of the harmful factors in the work environment that can cause serious, irreversible and incurable damage to people who deal with radiation in some way. Because it is not possible to feel radioactive rays with any of the five senses, therefore contact with more than the allowed amount of ionizing rays can have effects on the hematopoietic system, digestive system, central nervous system and finally the whole body, or it may have its effects on. The next generations will appear. Compliance with the regulations, rules and regulations of radiation protection and the correct and appropriate use of personal protective equipment can greatly reduce these effects and damages.

The goals of radiation protection are:

- ✓ Avoid definitive effects.
- ✓ Reduce possible effects.

The basic principles of radiation protection are:

1- Activity justification: Any activity related to radiation sources should be justified. In other words, the benefit of radiation activity for the society should be more than its harm.

2- Optimizing protection: the probability of radiation exposure from radiation sources should be as low as possible, and protective

measures should be justified and feasible considering the economic and social criteria.

3- Adherence to dose limits: normal radiation exposure of people due to radiation activity should be limited so that it does not exceed the defined dose limits. The radiation exposure of people due to radiation activity is divided into three categories: occupational radiation exposure, public radiation exposure, and medical radiation exposure.

Principle of ALARA:

ALARA stands for as Low as Reasonably Achievable. This means that the amount of received dose should be justified and reduced to the minimum possible. In this regard, before starting the activity with Prato, it is necessary to calculate the profit and loss caused by working with it. This means that working with the beam is justified when the benefit is greater than the harm caused by doing that work.

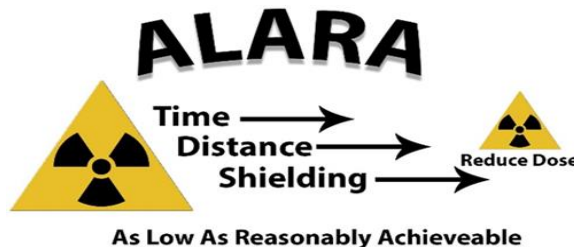


Figure 1. ALARA principle

Types of rays

Ray is a form of energy that spreads in vacuum or matter and is classified as follows:

1- Ionizing rays: If the energy of the beam is enough to release an orbital electron, ionization occurs when the beam hits the electron. In this case, the beam is called an ionizer. When the beam passes through the material, its energy causes orbital electrons to be removed from the atoms that make up the material and turns the atoms into positively charged atoms (positive ion molecules) and free electrons. This process is called ionization.

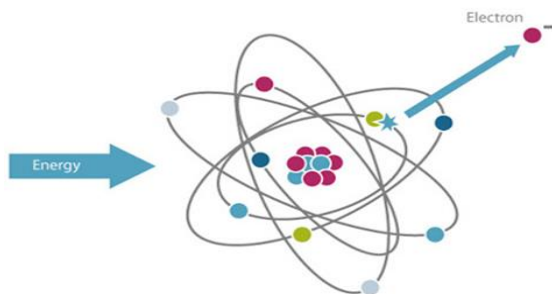


Figure 2. Ionizing rays

2- Non-ionizing rays: If the energy of the beam is not enough to release an orbital electron, by transferring energy to an orbital electron, atomic excitation occurs. In this case, the radiation is called non-ionizing.

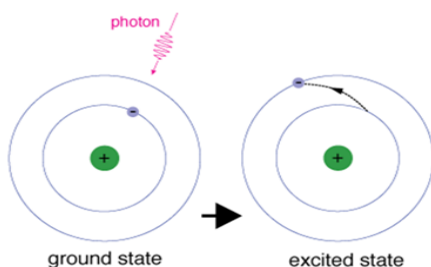


Figure 3. Non-ionizing rays

3- Particle beam: includes material particles of atomic or nuclear origin that have different velocities (energies) and in the form of particles with electrical charge (alpha, beta, proton, etc.) and without electrical charge (neutron, etc.) are divided.

4- Electromagnetic rays: They are electromagnetic waves that spread in space and are made of electric and magnetic fields, so electromagnetic rays are not material and do not have mass or electric charge. Electromagnetic waves are called by different names according to their energy:

- ✓ Radio waves.
- ✓ Microwave.
- ✓ Infrared.
- ✓ Infrared.
- ✓ Visible light.

- ✓ Ultraviolet.
- ✓ X ray.
- ✓ Gamma ray.

These names are arranged in order of increasing energy. Electromagnetic rays are divided into two groups, non-ionizing and ionizing, based on their energy. In addition to wave properties, electromagnetic waves also have particle properties. Electromagnetic waves when considered as particles are called photons. Charged particles or electromagnetic waves interact with matter, lose energy (velocity) and eventually stop.

5- Ionizing rays: Ionizing rays that cause ionization in the material, directly or indirectly ionize the material.

6- Direct ionizing rays: Beams of charged particles such as α particles and β particles directly ionize materials. α particles have a high ionization density and their ionization is hundreds of times that of β particles and so on.

7- Indirect ionizing rays: Gamma (γ) and X (X) rays ionize materials using secondary electrons produced through their interaction with matter. Uncharged neutrons lose their energy through collisions and are absorbed through interactions with matter. In this way, neutrons lose their energy (velocity) by directly hitting the nuclei of the material. They effectively lose energy by colliding with protons (hydrogen nuclei) that are roughly equal in mass.

α particles

α particles have a high ion density. The range of alpha particles in the air is about a few centimeters. Since α particles cause a lot of ionization, a sheet of paper is enough to stop them. The ability of alpha particles to penetrate matter is very limited. The thickness of the outer and dead skin layer of the human body is sufficient to absorb all alpha particles from

radioactive materials. Because α particles cannot penetrate the hard layer of the skin (the layer of dead cells on the surface of the skin), external irradiation of α particles does not cause a problem. If alpha-emitting radioactive material enters the body, it causes internal radiation and is extremely dangerous. The internal irradiation of any radioactive substance that emits α particles causes a large amount of local ionization in the tissues and the energy is transferred in a concentrated manner in that position. This significantly damages DNA and has severe biological effects.

β particles

β -particles, like α -particles, cause direct ionization of the material that passes through it, but due to the low ionization density, their biological effects are not as high as α -particles. External radiation of β particles can affect the skin and subcutaneous tissues. Depending on their energy, β particles can travel several meters in the air and penetrate to various depths in the tissue. β -particles travel several meters in the air and depending on their energy, a plastic sheet with a thickness of 1 cm or an aluminum plate with a thickness of 2 to 4 mm is enough to stop them. Thick plastic can block β particles. If β -emitting radioactive material enters the body, β -particles can penetrate the outer layer of the skin, or cause internal radiation.

Neutron particles

Uncharged neutrons lose their energy through collisions and are absorbed through interactions with matter. In this way, neutrons lose their energy (velocity) by directly hitting the nuclei of the material. They effectively lose energy by colliding with protons (hydrogen nuclei) of roughly equal mass. Because the mass of a neutron is about the same as that of a proton, a neutron beam is effectively stopped when it collides with a proton. Since the human body contains a lot of water, neutrons lose their

energy by colliding with hydrogen nuclei (protons) that make up water molecules. Neutrons can pass through the body, or cause internal radiation if they enter the body through inhalation, ingestion, or skin absorption. Materials such as concrete and hydrogen-containing organic materials such as water and polyethylene are suitable for protection against neutron radiation.

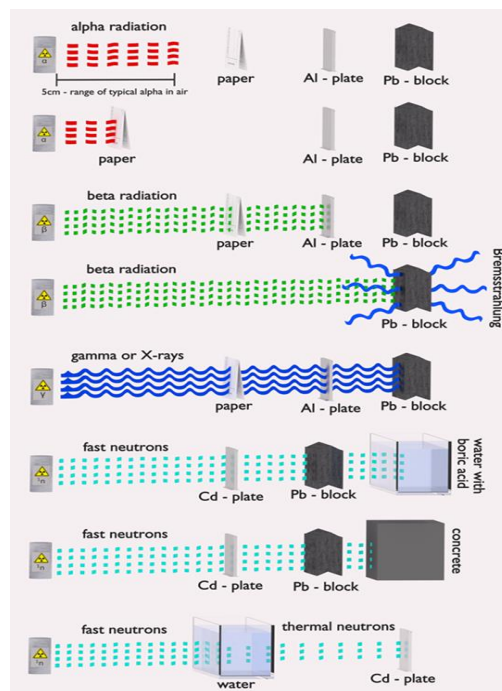


Figure 4. Gamma (γ) and X-rays (X)

Gamma (γ) and X (X) rays

Gamma (γ) and X (X) rays ionize materials using secondary electrons produced through their interaction with matter. Gamma (γ) and X (X) rays reach deep organs and tissues due to their high penetrating power, but they do not have a high ion density and their biological effects are similar to those of β particles. γ and X rays have a higher penetrating power than α or β particles, and depending on their energy, they travel tens to hundreds of meters in the air and gradually lose their energy due to collisions with atoms in the air. Because γ and X rays can be protected by using thick plates of lead or iron with high density, therefore iron and the like can be used to protect radiation generators.

Conclusion

One of the harmful factors in the work environment is ionizing radiation, which can cause serious, irreversible and incurable damage. Therefore, awareness, familiarity and application of the regulations of protection against ionizing radiation by employees can play an important role in their protection. Therefore, it is necessary to examine the awareness of these people, which leads to the creation of healthy behaviors in them. Based on the information obtained about the use of video clips, the level of awareness is relatively good, but for the rest of the cases, the level of awareness is not acceptable, and it seems that the level of education of the employees should be increased, as well as short courses. It should be held at appropriate intervals and in other cases, such as visits by atomic energy inspectors, leak detection and protection methods, full information should be provided to all employees. The collision of ionizing rays with biological systems causes ionization and stimulation of atoms and molecules and creates unnatural and harmful products in the biological environment. It seems necessary to accurately determine the prescription values and radiation dose of patients due to the side effects of ionizing radiation from radionuclides, in order to avoid unauthorized radiations to the patient and those around him. Accurate radiation dose calculations require complete data on the types of physical decay of radiopharmaceuticals and how they are distributed in the body. On the other hand, the level of biological function of body tissues in absorbing and excreting radiopharmaceuticals is one of the major factors and varies between people. Therefore, despite the administration of the same amount of radiopharmaceutical, the absorbed dose varies among people. Since the dose gradually decreases over time and finally reaches zero, how can the total patient dose be calculated

from the time of administration ($t = 0$) until the dose finally decreases to zero? The reliable calculation method and accurate determination of each patient's dose as well as the necessary protective measures are the main goals of this article. In nuclear medicine examinations, it is almost impossible to directly measure the radiation dose with a radiation detector, and this is done through a calculation using physical and biological data and special mathematical equations. A calculation method for determining the radiation dose is the absorption fraction method, which during four steps calculates the amount of radiation energy from the radionuclide in the source volume (S), calculates the amount of absorbed radiation energy in the target volume (T), calculates the average dose (D) dD/dt and calculating the average dose (D) leads to the determination of the patient dose. Physical data such as radionuclide radiation and absorption fractions of different sources and targets of a standard sample under the title of a single word called S factor for radionuclides used in nuclear medicine as well as different values of absorption fraction for different energies of X and γ rays in volumes. Different target and source have been extracted from the above equations by modern computer method and presented in tables. Due to the fact that large amounts of radioactive sources are moved in the nuclear medicine laboratory, when milking the generator, injecting or drawing radiopharmaceuticals, scanning the injected patient, there is a possibility of radiation exposure and contamination of the surrounding people and the user (technician, physicist or doctor) and There is an environment. For nuclear medicine purposes, the amount of radiation exposure is almost equivalent to the absorption dose, and the principles of reducing radiation exposure, i.e. distance, time, and proper protection, can be used to achieve the ALARA principle, the following relationship is recommended. Roentgen $E(R) = (n.G/d^2) \cdot e^{-m \cdot \Delta}$

where E is the amount of radiation and n is the number of millicuries of the source and d is the distance from the source and m is the linear attenuation coefficient of the material and X is the thickness of the protective material and G is the constant of the radionuclide exposure. Therefore, observing the principles of protection and conscious use of radioisotopes in nuclear medicine can provide the necessary safety and increase the benefits of using ionizing radiation against its dangers.

References

- 1- M. Alkhorayef, et al. Assessment of occupational exposure and radiation risks in nuclear medicine departments. *Radiat. Phys. Chem.* 17 (2020) 108529 [[Google Scholar](#)], [[Publisher](#)], [[Crossref](#)]
- 2- A. Roguin, J. Goldstein, O. Bar. Brain tumours among interventional cardiologists: a cause for alarm. Report of four new cases from two cities and a review of the literature. *Euro Intervention* 7 (9) (2012) 1081-1086. [[Google Scholar](#)], [[Publisher](#)], [[Crossref](#)]
- 3- E. Vano, et al. Radiation cataract risk in interventional cardiology personnel. *Radiat. Res.* 174 (4) (2010) 490-495. [[Google Scholar](#)], [[Publisher](#)], [[Crossref](#)]
- 4- M. Doss. Linear no-threshold model vs. radiation hormesis. *Dose Response* 11 (4) (2013) 495-512. [[Google Scholar](#)], [[Publisher](#)], [[Crossref](#)]
- 5- NCRP, National Council on Radiation Protection and Measurements, Implementation of the principle of as low as reasonably achievable (ALARA) for medical and dental personnel, NCRP Report 107, National Council on Radiation Protection and Measurements, Bethesda, Maryland, 1990. [[Google Scholar](#)], [[Publisher](#)]
- 6- The 2007 Recommendations of the International Commission on Radiological Protection. ICRP publication 103. *Ann ICRP*. 37 (2-4) (2007) 1-332. [[Google Scholar](#)], [[Publisher](#)]
- 7- D.W. Townsend. Combined positron emission tomography-computed tomography: the historical perspective. *Seminars in Ultrasound, CT and MRI* 29 (4) (2008) 232-235. [[Google Scholar](#)], [[Publisher](#)], [[Crossref](#)]
- 8- M. Alnaaimi, et al. Occupational radiation exposure in nuclear medicine department in Kuwait. *Radiat. Phys. Chem.* 140 (2017) 233-236. [[Google Scholar](#)], [[Publisher](#)], [[Crossref](#)]
- 9- A. Kubo, C. Mauricio. TLD occupational dose distribution study in nuclear medicine. *Radiat. Measurements* 71 (2014) 442-446. [[Google Scholar](#)], [[Publisher](#)]
- 10- W. Chruscielewski, J. Olszewski, J. Jankowski, M. Cygan. Hand exposure in nuclear medicine workers. *Radiat. Protection Dosimetry* 101 (1-4) (2002) 229-232. [[Google Scholar](#)], [[Publisher](#)], [[Crossref](#)]
- 11- A. Al-Abdulsalam, A. Brindhavan. Occupational radiation exposure among the staff of departments of nuclear medicine and diagnostic radiology in Kuwait. *Med. Princ. Pract.* 23 (2) (2014) 129-133. [[Google Scholar](#)], [[Publisher](#)], [[Crossref](#)]
- 12- M. Martins, et al. Occupational exposure in nuclear medicine in Portugal in the 1999–2003 period. *Radiat. Protection Dosimetry* 125 (1-4) (2007) 130-134. [[Google Scholar](#)], [[Publisher](#)], [[Crossref](#)]

This journal is a double-blind peer-reviewed journal covering all areas in Chemistry, Medicinal and Petroleum. EJCMPR is published quarterly (6 issues per year) online and in print. Copyright © 2024 by ASC ([Amir Samimi Company](#)) which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.