Wróbel Grzegorz Paweł. Selected aspects of patient health in nuclear medicine. Journal of Education, Health and Sport. 2017;7(9):243-250. eISSN 2391-8306. DOI http://dx.doi.org/10.5281/zenodo.897895
http://ojs.ukw.edu.pl/index.php/johs/article/view/4840

The journal has had 7 points in Ministry of Science and Higher Education parametric evaluation. Part B item 1223 (26.01.2017).
1223 Journal of Education, Health and Sport eISSN 2391-8306 7

The authors declare that there is no conflict of interests regarding the publication of this paper.
Received: 15.08.2017. Revised: 10.09.2017. Accepted: 10.09.2017.

SELECTED ASPECTS OF PATIENT HEALTH IN NUCLEAR MEDICINE

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Abstract

Nuclear radiation plays an important role in nuclear medicine. The health risk to patients undergoing screening only concerns the fact of gamma-ray emission, of course, the magnitude of this risk is dose-dependent. The purpose of the study is to assess patient safety in ionizing radiation studies in the light of applicable laws. The principle of optimizing the health protection of people subjected examinations using ionizing radiation mainly concerns the choice of the best protection option under specific exposure conditions and the greater benefits of ionizing radiation to the potential damage that could be caused by radiation exposure. Unfortunately, in some cases, patients are unnecessarily exposed to ionizing radiation during the diagnostic process, often as a result of lack of supervision of doses or undue imaging studies by physicians. Due to the numerous evidence highlighting the negative impact of high doses of ionizing radiation on the human body, we are not able to accurately track and evaluate all mechanisms of its action.

Keywords: nuclear medicine, health care, radiopharmaceuticals

1. Introduction

The health risk to patients undergoing screening, in which radioisotopes are used, only concerns the fact of emissions by radioactive atoms, gamma-ray radiation; of course, the

magnitude of this risk depends on the dose of ionizing radiation. As for the dose of radiation absorbed by the individual organs of the patient (Figure 1), they are determined by the ratio of the absorbed radiation energy to the mass of the absorbing area, while the dosing unit absorbed is gray (Gy). The biological effects of ionizing radiation can be divided into so-called deterministic (tissue-organ) and stochastic (International Commission on Radiological Protection [ICRP], 2007). In the case of deterministic effects that occur as a result of the destruction by radiation of a significant part of the tissue or organ, they are not caused by the use of radiopharmaceuticals for diagnostic purposes, while considering the biological effects that are stochastic in nature, the probability of their incidence should be assumed because the causes of these effects are determined by the effects of ionizing radiation on somatic and reproductive cells; taking into account the further consequences of radiation exposure on the human body, it should be emphasized that cells that survive radiation may be carriers of mutation as a result of DNA damage. Mutations may lead to the development of malignant tumors and hereditary sequelae manifesting as malformations in the offspring of irradiated persons (ICRP, 1998; Lipiec & Płońska-Gościniak, 2013).

2. Purpose of work

The purpose of the study is to assess patient safety in ionizing radiation studies in the light of applicable laws.

3. Description of knowledge

The basic European document in the scope of health care in radiodiagnostic research is Directive 97/43 EURATOM of 30 June 1997 on the protection of persons against the risks related to ionizing radiation in relation to medical exposures, which contains the general principles of protection of people exposed to ionizing radiation used in medicine, that is:

• patients undergoing diagnosis or treatment;

• voluntary participants of scientific experiments;

• volunteers taking care of people exposed to medical exposures.

The directive also contains the basic elements of health care, i.a.:

• justification for the use of a diagnostic, therapeutic or experimental procedure,

• optimizing exposure to ionizing radiation by introducing and using diagnostic reference levels and accepted limits, and above all maintaining dose levels in medical exposures at the lowest reasonably possible level;

• formulation of the principles of the responsibility of persons conducting medical exposures;

• development of procedures, recommendations and criteria;

• training, acquiring and upgrading skills;

• supervising radiological equipment in terms of technical condition and quality of its operation;

• creation of a monitoring system supervised by the competent national authority, which has the task of monitoring and verifying the provisions introduced in accordance with the aforementioned Directive.

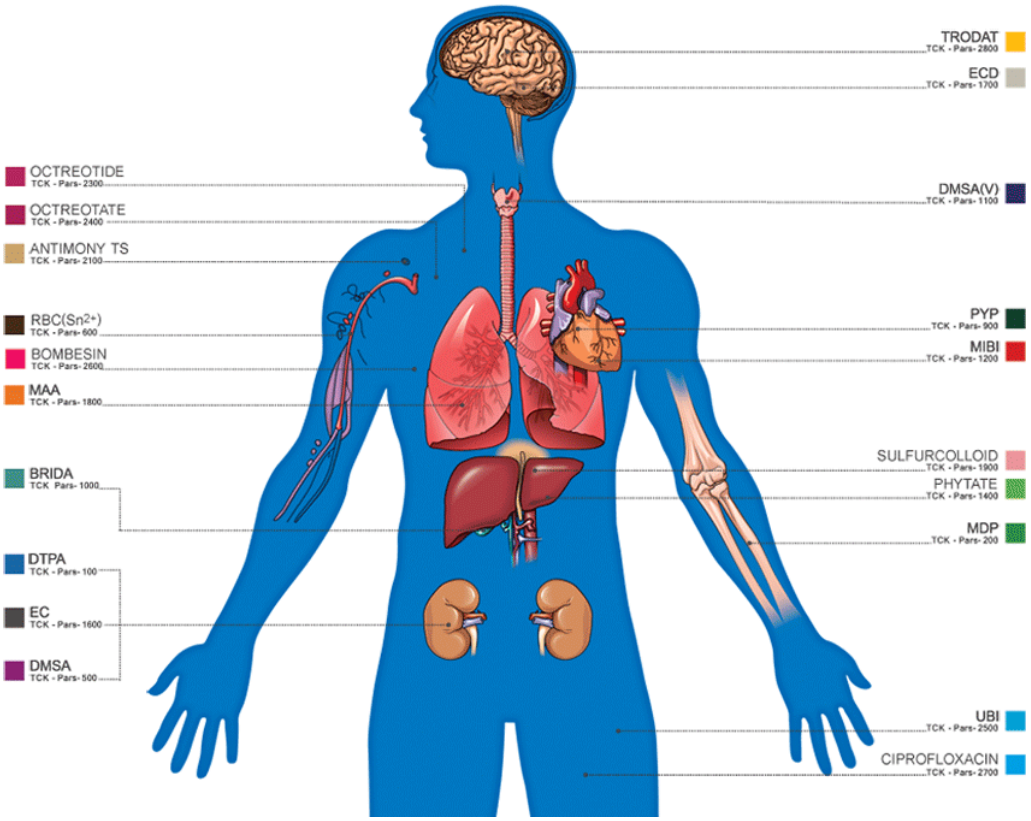

Figure 1. Tc-99m radiopharmaceuticals are used in nuclear medicine centers as diagnostic imaging agents.

This radionuclide is used in over 80% of all diagnostic procedures (Pars Isotope Company, 2017)

The principle of optimizing the health protection of people subjected examinations using ionizing radiation mainly concerns the choice of the best protection option under specific exposure conditions and the greater benefits of ionizing radiation to the potential damage that could be caused by radiation exposure.

The recommendations of the Directive in Poland are implemented through the Atomic Law Act and the Regulation of the Minister of Health of 25 August 2005 on the safe use of

ionizing radiation for all types of medical exposures (Atomic Law Act, 2000; Regulation of the Minister of Health, 2005).

The general justification for the use of ionizing radiation sources is that the expected social, economic or scientific benefits to be derived from this activity will be greater in relation to potentially damaging human health and the environment. With regard to medical exposure, it is assumed that there are three levels of justification. The first level, the most general, determines the use of ionizing radiation in medicine as acceptable because the benefits of its use outweigh the risks of exposure. The second level determines and in some way translates the medical procedure in reference to cases with the symptoms in question. Generally speaking, this justification is intended to demonstrate that the use of a particular diagnostic procedure or therapeutic approach in most cases has a significant impact on the correct diagnosis or improvement of the outcome. The third level of justification for the use of ionizing radiation sources refers to the application of a particular medical procedure to a particular patient. In the case of generally accepted simple tests, this justification is limited to determining whether the necessary information for a particular medical case is no longer available. Due to the complexity of diagnostic or therapeutic procedures, such general justification may be insufficient and it is therefore important that each case is individually considered by the radiologist and the clinician (ICRP, 1990; Article 8 of the Act of 29 November 2000, Atomic Law Act, Journal of Laws of 2007, No. 42, item 276).

Please note that the dose limits specified in the Ordinance of the Council of Ministers of 18 January 2005 on limit doses (Journal of Laws No. 20 item 168 of 3 February 2005) do not cover the exposure of persons exposed to ionizing radiation for medical purposes (Regulation of the Council of Ministers of 18 January 2005).

The patient protection strategy for exposure to ionizing radiation is generally presented in the form of recommendations that can be grouped into three basic categories:

1. General recommendations that apply to all uses of ionizing radiation in medicine, both diagnostic and therapeutic.

2. The technical condition of the equipment used is particularly important in relation to the equipment used for the particular treatment.

3. Recommendations to protect a special group of patients for example children or pregnant women (Zdrojewicz, Z., Szlagor, A., Wielogórska, M., Nowakowska, D., Nowakowski J., 2016)

The most general recommendations concern the implementation of quality assurance, education and training systems for personnel involved in ionizing radiation research.

From the perspective of patient safety, the following should be highlighted:

1. Issues related to normal situations. At this point, the strategies of ensuring the quality of research focus on the optimization of activities and resources, while the actions aim to gradually improve the situation; this is largely due to increasing the qualifications of staff involved in the whole medical process, the security culture and the sharing of experience with other teams with a similar activity profile.

2. Issues related to the avoidance of emergency hazards. To adequately explain these issues, it is essential to acquire complete information about specific medical procedures, as well as the large amount of knowledge and experience of the safety system developer. Another important condition for the risk of emergencies is the control of computational tools that will make it possible to estimate the level of danger of undesired events. A summary of the patterns of action and steps taken to avoid emergencies is a basic mechanism for preventing these hazards and part of the quality assurance system.

3. Issues referring to extraordinary and emergency situations. In these situations, the most prevalent conditions do not allow for correct decisions, given the need to take swift action to avoid serious consequences. Due to the possibility of such occurrences, it is necessary to identify ways to counter them and procedures. In some cases, it is not possible to perform calculations or to analyze the different modes of operation of the apparatus, as it becomes necessary to prepare many scenarios in advance and prepare the choice that best fits the operating situation. The developed scenarios should cover different situations and predict, for example, the damage of the apparatus, the disappearance of a reading of the measuring apparatus, the occurrence of the atypical anatomy of the patient, etc. In the case of each of these situations, a procedural scheme should be developed. Keep in mind that anyone can be wrong, and any device may be damaged, so it is necessary to prepare the most effective procedures for eliminating or limiting the consequences of such events and preparing the equipment needed in such cases (Valentin, 2001).

Optimizing the exposure of the patient and the medical staff consists of (Atomic Law - Article 9 of the Act of 29 November 2000):

- eliminating clinically unjustified studies and treatments involving ionizing radiation;
- using other diagnostic and therapeutic methods that do not use ionizing radiation;
- minimizing exposure to radiation;

- minimizing exposure time to the minimum necessary;

- using the results of prior research in the treatment process;

- using personal protective equipment;

- using, where possible, compression of the organs examined;

- using good quality images;

- constant control and optimization of the processing of imaging results;

- optimizing exposure parameters to obtain a good image with the lowest possible patient exposure;

- using digital image transducers and recording techniques.

In the aspect of human exposure to ionizing radiation for scientific purposes in medical research, it is essential to keep the guidelines in line with the provisions of the Helsinki Declaration and be subject to the opinion of the relevant ethics committee. Radiological examinations, execution for criminal proceedings should not be included in medical exposures, but they can only be carried out in specific cases, on the basis of exposure regulations for the general population (Jaworowski, 1999).

Optimizing human exposure is realized throughout radiological protection through the so-called ALARA principle (As Low As Reasonably Achievable); this is the basic principle of radiological protection. According to this principle, it is important to minimize risk by maintaining the exposure at the lowest level, due to the costs, technology and the patient's health. The use of the ALARA principle in diagnostic studies using ionizing radiation will reduce the risk of exposure and ensure that the required results are achieved with the lowest possible radiation dose. The ALARA principle in terms of all elements of using radiation in medicine, i.e. from the design of the apparatus through diagnostic and therapeutic methods to everyday practice, is the most effective tool for radiological protection. In relation to the medical exposure of patients and thus the protection of human health, the ALARA principle is a guarantee in striving for the lowest possible exposure of humans, while it should be remembered to maintain the condition of appropriate image quality in diagnostics or the effectiveness of therapy (Barańska, D., & Biegański, T., 2002).

4. Conclusions

Nuclear medicine methods provide the opportunity for proper treatment and effective prevention by gaining information about the functioning and structure of internal organs without the need for surgical intervention. Isotopic testing is not dangerous. The absorbed dose does not exceed double the dose of x-ray examination of the lung and sometimes it is

significantly smaller. Isotope studies do not pose a real threat to the household members of the person being tested. Unfortunately, in some cases, patients are unnecessarily exposed to ionizing radiation during the diagnostic process, often as a result of lack of supervision of doses or undue imaging studies by physicians. As regards the exposure of patients to ionizing radiation, it is important to take precautionary measures against young children and adolescents in view of the increased level of radiation in these age groups, while in adults, it is important to remember that the reproductive organs of women and men were not exposed. Due to the numerous evidence highlighting the negative impact of high doses of ionizing radiation on the human body, we are not able to accurately track and evaluate all mechanisms of its action.

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