sciendo

DOI: 10.2478/rjom-2018-0003

Reviews

Cancer induced by exposure to ionizing radiations in medical personnel

Xenia Elena Bacinschi[1,2]

[1] Department of Oncology Radiotherapy, Institute of Oncology "Prof Dr Alexandru Trestioreanu," Bucharest, Romania
[2] Oncology, University of Medicine and Pharmacy "Carol Davila," Bucharest, Romania

Corresponding author
Xenia Elena Bacinschi
xenia_bacinschi@yahoo.com

Abstract

Ionizing radiation are classified as Class I carcinogens. The exposure to this factor increases the risk of developing cancer, and researchers aim to establish the relationship between the exposure and the risk levels, as well as guidelines which would limit exposure to it. The risks were assessed through studies related to the atomic bomb survivors, to the populations exposed to radiation for the purpose of diagnosis or therapy and to the professionally exposed populations – radiologists, radiotherapists, workers in uranium mines, operatives in the nuclear industry. The population of Japanese survivors of the atomic bombs is the largest population exposed and studied with an extremely wide age range (from the irradiation in utero to old people). This population, made up of 93.000 people, represents a major source of information used to determine the potential risk of low dose radiation exposure. Health professionals working with ionizing radiation have been studied ever since the 1890's. After the implementation of a radiation protection system, the doses received decreased only to increase again with the technical development and its use in a wide variety of specialties. Two recent studies on large cohorts and during long periods of time brought information about the cancer risk due to occupational exposure to ionizing radiation and shed light on the need to monitor exposed staff and re-evaluate radiological safety standards. This review is focused on recent literature concerning the radiation exposure of medical professionals.

Keywords: *cancer risk factors, ionizing radiation, medical exposure, professionally exposed*

Introduction

Ionizing rays are characterized by their capacity to produce (directly or indirectly) ions in the substance they pass through. They encompass a very wide range of wave lengths (x rays, α, β, γ, neutrons). Regardless of their type, they interact with cellular molecules and transform them. Among the most important transformations are those of cellular DNA. When the lesions cannot be repaired naturally, cellular death and harmful biological effects appear [1]. These effects have been studied since almost the beginning of the radiation usage. Cellular restoration can be imperfect; the restoring errors are essential within the DNA because genetic residual abnormalities can be transmitted through successive cellular divisions. The medical community has rapidly acknowledged the benefit brought by ionizing radiation in the diagnosis and treatment of diseases; not long afterwards, the risks of the prolonged exposure, such as the negative effects when in contact with organic materials, were highlighted. The first reaction to the prolonged exposure was the radio dermatitis. The first cancers described as being caused by high exposure to radiation were the skin cancers, at an interval of some years [2,3]; they were followed by leukaemia in radiologists and those who used to work with radioactive isotopes. A tendency to overstate has been witnessed in the past years concerning predictive calculations of negative effects in using ionizing radiation. The risk incidence is estimated using the (BEIR) VII model – Biological Effects of Ionizing Radiation (BEIR) VII report – whose main data source is the study of populations surviving atomic bombs. The data and the results of the study cannot be extrapolated to the population submitted to medical imagery, neither to those professionally exposed. In order to estimate the risk, the received doses were converted in effective doses, in spite of the indications from the International Commission on Radiological Protection that warn about the misleading results when using this method in epidemiologic studies [1,4]. The study of the exposure level on the carcinogenic mechanisms, on the dose effect/ benefit relationship, leads to the implementation of additional safety measures. Ionizing radiation is either from natural sources or emanates from nuclear activities of human origin. The sources of radioactivity of natural origin are: cosmic rays 7%, earth radiation 11%, the radioactivity of water, the radioactivity of human bodies (radioactive food), and the radioactivity of air (radon) 34%. The nuclear activities of human origin [1,5] are defined as activities that involve a risk of exposure to ionizing radiation for humans, in connection with artificial or natural sources of radioactive substances. These nuclear activities include those related to basic nuclear installations, those connected to the transportation of radioactive substances, or those from medical, veterinarian, industrial, research or military areas. The medical exposure represents more than a quarter of the medium global exposure to ionizing radiation, approximately 41%.

Medical practices using ionizing radiation

Presently, medicine cannot be conceived without the usage of ionizing radiation. These techniques have such a significant impact in an accurate diagnosis and in treatment that they could not been replaced by other methods despite important research efforts in this direction, even in the presence of acknowledged deleterious effects of ionizing radiation. As the use of radiation cannot be avoided, it is important to periodically update the knowledge in the area of safety measures.

Radiology: Radiation is used in order to establish a diagnosis; the exposure is external and the dose released depends on the examination type (chest radiography: the medium efficient dosage is of 0.05 mSv, the duration equivalent to natural exposure - 7 days; computerized tomography of the chest: medium efficient dose 5,7 mSv, the duration equivalent to the natural exposure - 2,4 years). The dose also depends on the practice, the equipment and the morphology of the patient.

Radiotherapy has a therapeutic purpose, curative or palliative; consisting of delivery of a quantity of radiant energy to a defined target volume, while simultaneously protecting the surrounding healthy tissues, justified by the critical analysis of the ratio between the individual or social benefits and the detrimental effects that radiation can cause.

Nuclear medicine has diagnostic and therapeutic purposes; used to establish the location of lesions, such as bone metastases; allows the functional assessment of an organ – the cardiac functioning. The released doses are compatible with those from radiography. Used for therapeutic purposes, it allows the therapy of thyroid cancer with radioactive ions, the therapy of the multiple bone metastases with strontium, samarium. In this case, the doses can be in the order of tens of Greys. Two important studies were recently published. Rajaraman's et al. (2016) research on more than 90,000 radiologic therapists revealed high risk for brain cancer, breast cancer, or melanoma among technologists who performed fluoroscopically guided interventional procedures [6]. As they have not checked for other possible confounders, these findings still need to be confirmed by other studies. Sun et al. (2016) used two cohorts, one comprising more than 27,000 Chinese medical x-ray workers and another one of more than 25,000 Chinese physicians who did not use x ray, respectively [7]. The risk of cancer in the case of exposure for the medical staff working in a cardiac catheterization laboratory could not be demonstrated [8]. The whole body dose is around 1 MSV/year in current radiology and nuclear medicine units, which is bellow the threshold recommended by the International Commission on Radiological Protection [9]. Cumulative professional radiological exposure is associated with a non-negligible lifetime risk of cancer attributable for the most exposed contemporary cardiac catheterization laboratory staff. The risk is well perceived in the radiology departments, but other medical professionals using X-ray sometimes ignore it and appropriate strategies have to be developed for these "non-classical" categories of medical staff users involved in interventional manoeuvres.

Surgical procedures imply intraoperative radiation. In an international orthopaedic practice survey, 77.4% of doctors employed 2D C-arm, 14.9% 3D C-arm and 17.3% mini C-arm for intraoperative imaging, but only half of them were using dosimeters during these procedures [10]. From these, almost 20% were banned form procedures involving radiation for a certain period of time in order to avoid achieving a yearly overdose. Also, protection equipment was not frequently enough used. As consequence, another study showed that current protection is not enough for the upper outer quadrant of female orthopaedic surgeons and that might explain the high incidence of breast cancer in this profession [11]. The intraoperative radiation is not limited to orthopaedic surgeons only. For example, due to the X ray exposure, even if all safety measures are properly used, a vascular surgeon could only perform 12 fluoroscopy guided fenestrated endovascular aneurysm repairs per week in order to not exceed the actual occupational limit of the annual dose [12]. Fixed imaging sources create more radiation exposure (particularly scattered radiation) than mobile sources [13]. Despite protection measures, a German study concluded that the dose-area product for lens found in a vascular interventional department is sufficient enough to be a risk for cataract [14].

From the above mentioned research, we could conclude that we should not consider X-ray exposure in medical departments as a "closed and solved" case and that alert on the risk should be maintained. There is definitely a need to monitor the exposed medical personnel, including the lifetime impact, to continue to improve the safety measures and, if possible, to adapt procedures in order to minimize risk. Concerning exposure effects, probably we must not limit ourselves only to the classical effects (dermatitis, cancer, medullar aplasia etc.), which are generally linked to high exposure. New genetic and genomic techniques could offer a better detection of interesting biomarkers, long before clinical manifestations. Classical monitoring biological effects (decentred chromosome assays or micronuclei detection) have been improved by the new laboratory techniques. Large scale availability to test for chromosome translocations using FISH technique, phosphorylation of histone H2AX a rapid essay for the short term exposure, and the gene expression profiling will change our understanding of the biological subclinical effects of ionizing radiation and will allow better estimation of occupational limits [15].

Both patients and medical staff should benefit from a better characterization of radiation biological effects. Until the arrival of new results from ongoing studies, the current strategies to reduce exposure, as low as reasonably achievable, need to be integrated in all medical departments using ionizing radiation.

Conclusion

Studies show that an excessive cancer risk exists for those professionally exposed, be it radiologists, underground miners or nuclear workers. Although some ideas have already emerged from these studies, more detailed follow-ups are needed in order to draw reliable conclusions. Among others, health state monitoring has to be uninterruptedly continued, while all measures of radioprotection need to be implemented [16].

References

1.Hendee, WR, O'Connor, MK. Radiation risks of medical imaging: separating fact from fantasy. Radiology 2012;264:312-21.
2.Miller, RW. Delayed effects of external radiation exposure: a brief history. Radiation Research 1995;144:160-9.
3.UNSCEAR sources and effects of ionizing radiation. New York United Nations, Studies of radiation-exposed population, 2000.
4.United Nations. Scientific Committee on the Effects of Atomic Radiation. Effects of ionizing radiation: UNSCEAR 2006 Report to the General Assembly, with scientific annexes (vol.2). United Nations publications; 2008, p. 344.
5.NRC (National Research Council : Health risks from exposure to low levels of ionizing radiation BEIR VII Washington DC National Academy Press 2006.
6.Rajaraman P, Doody MM, Yu CL. Cancer Risks in US Radiologic Technologists Working With Fluoroscopically Guided Interventional Procedures, 1994-2008. AJR Am J Roentgenol 2016;206:1101-9.
7.Sun Z, Inskip PD, Wang J. Solid cancer incidence among Chinese medical diagnostic x-ray workers, 1950–1995: Estimation of radiation-related risks. International Journal of Cancer, 2016;138:2875-83.
8.Venneri L, Rossi F, Botto N. Cancer risk from professional exposure in staff working in cardiac catheterization laboratory: insights from the National Research Council's Biological Effects of Ionizing Radiation VII Report. Am Heart J 2009 ;157:118-24.
9.Al-Abdulsalam A, Brindhaban A. Occupational radiation exposure among the staff of Departments of Nuclear Medicine and Diagnostic Radiology in Kuwait. Med Princ Pract 2014;23:129-33.
10.Joeris A, Goldhahn S, Kalampoki V. Intraoperative Radiation Exposure of Orthopaedic Surgeons – Mismatch. Occup Med Health Aff 2018;6:2.
11.Valone LC, Chambers M, Lattanza L. Breast Radiation Exposure in Female Orthopaedic Surgeons. J Bone Joint Surg Am 2016;98:1808-13.
12.Kirkwood ML, Guild JB, Arbique GM. Surgeon radiation dose during complex endovascular procedures. Journal of vascular surgery 2015;62:457-63.
13.Kendrick DE, Miller CP, Moorehead PA. Comparative occupational

radiation exposure between fixed and mobile imaging systems. J Vasc Surg 2016;63:190-7.
14.Attigah N, Oikonomou K, Hinz U. Radiation exposure to eye lens and operator hands during endovascular procedures in hybrid operating rooms. J Vasc Surg 2016;63:198-203.
15.Zeegers D, Venkatesan S, Koh SW. Biomarkers of Ionizing Radiation Exposure: A Multiparametric Approach. Genome Integr 2017;8:6.
16.Rapport de l'ASN sur l'état de la sûreté nucléaire et de la radioprotection en France en 2017. Available: https://www.asn.fr/Informer/Publications/Rapports-de-l-ASN/La-surete-nucleaire-et-la-radioprotection-en-France-en-2017 [Accessed 22 10 2018].