

Radiation Risks and the Importance of Radiological Protection in Interventional Cardiology: A Systematic Review

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ABSTRACT

We discuss some aspects related to the legal framework, international recommendations and training programs on radiological protection; image quality and equipment; the biological effects and risks of ionizing radiation; lesions in patients and operators; patient's reference levels; occupational dose limit and preventive actions. The use of ionizing radiation involves risks that are justified in diagnostic and therapeutic procedures. The awareness and knowledge of these risks minimizes the damage, optimizing the quality of images and safe use of ionizing radiation. There is evidence of radiation induced cataracts in individuals who work in catheterization laboratories. Several studies suggest there may be a significant risk of lens opacity, if radiological protection devices are not properly used. Additionally, these interventional procedures are performed in Latin America, usually by medical specialists in collaboration with nurses, technologists and technicians, who often do not have adequate training in radiological protection.

DESCRIPTORS: Diagnostic imaging. Radiation protection. Radiation, ionizing. Radiation injuries. Review.

RESUMO

Riscos da Radiação X e a Importância da Proteção Radiológica na Cardiologia Intervencionista: Uma Revisão Sistemática

Discutimos aqui aspectos vinculados ao enquadramento legal, a recomendações internacionais e a programas de formação em proteção radiológica; ao angiográfico e à qualidade da imagem; aos efeitos biológicos e aos riscos das radiações ionizantes; às lesões em operadores e pacientes; aos níveis de referência do paciente; ao limite de dose ocupacional e a suas medidas de prevenção. O uso das radiações ionizantes acarreta riscos, que, contudo, justificam-se em procedimentos diagnósticos e terapêuticos. A consciência e o conhecimento desses riscos minimizam o dano, otimizando a qualidade das imagens e o uso seguro das radiações ionizantes. Tem-se demonstrado a ocorrência de cataratas radioinduzidas em trabalhadores de laboratórios de cateterismo. Diversos estudos sugerem que pode haver um risco significativo de opacidade do cristalino, caso não se utilizem adequadamente os dispositivos de proteção radiológica. Adicionalmente, esses tipos de procedimentos intervencionistas são realizados na América Latina, geralmente por médicos especialistas, com a colaboração de enfermeiros, tecnólogos e técnicos, que, muitas vezes, não têm formação adequada em proteção radiológica.

DESCRITORES: Diagnóstico por imagem. Proteção radiológica. Radiação ionizante. Lesões por radiação. Revisão.

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Medical applications represent the main source of artificial exposure of the world's population to ionizing radiation. The National Council on Radiation Protection and Measurements (NCRP),¹ in the United States, estimated that radiation exposure aimed at the production of medical images has increased by 600% between 1980 and 2006. According to the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR),² interventional cardiology procedures represent the third largest contribution to the collective dose (a collective dose characterizes radiological impact of a procedure or ionizing source), after computed tomography and nuclear medicine.

The introduction of new imaging technologies in the diagnosis and therapeutic field and the ongoing modernization of X-ray machines have broadened the spectrum of interventional cardiology activity, currently responsible for several procedures in coronary, valvular, and congenital diseases. To ensure that equipment functions adequately and to properly manage the radiological risks, quality assurance and control programs should be established in interventional cardiology services, as recommended by the International Atomic Energy Agency (IAEA).

Due to high levels of exposure that can be produced by some interventional cardiology procedures, it is possible to observe secondary effects in patients submitted to high doses (deterministic), or proportional to the received doses without limit (stochastic). However, as the procedure requires the presence of the physician at the patient's side, it is also possible that these deterministic effects occur in the professionals, such as cataracts and epilation.

International recommendations and legal framework for radiation protection

Unlike the scenario in Europe and the United States,³⁻⁷ there is not enough legal framework to regulate the safe use of ionizing radiation in medicine in Latin America generally. The awareness that there are interventional procedures that can result in high radiation doses to the patient and the technician has motivated the international organizations to publish recommendations to help combine the needs of interventional cardiology and high safety standards. Thus, the 97/43/Euratom European Directive⁵ on medical exposures determines requirements for the practice of interventional cardiology. A guide published by the European Commission, aiming at the education and training in radiation protection for medical exposures, also contains recommendations on training and accreditation programs.⁶⁻⁸

The document "Radiation Safety in the Practice of Cardiology",⁴ published jointly by the American College of Cardiology (ACC), the North American Society of Pacing and Electrophysiology (NASPE), the Society

for Cardiac Angiography and Interventions (SCAI), and the American Society of Nuclear Cardiology (ASNC), establishes recommendations on radiation protection, so that cardiology procedures can be performed with appropriate safety levels. Likewise, the publication "Normas de Seguridad del OIEA N^o GSR Part 3"⁹ and publications 60, 103, and 105 of the International Commission on Radiological Protection (ICRP)¹⁰⁻¹² institute the basic criteria for radioprotection by establishing principles of justification, optimization, and limitation of doses for occupationally exposed individuals (OEI), as well as dose reference values for medical practices.

Chambers et al.,^{13,14} who were members of SCAI, published an article whose practical approach was to assist interventional cardiology services to establish safety and radiation protection programs. They reviewed the following: basic terminology for planning the dose before the procedure; managing the dose in real time; documentation of radiation dose in the records; notification of high dose to the patient and the referring physician; protection elements and imaging equipment; and training. The article also stated that the doctors and medical staff involved in catheterization should be trained in the basic principles of radiation physics, safety, and radiation protection. A medical physicist should participate, together with the medical staff, in the selection of equipment, staff education, and dose measurement. Better image quality with optimized radiation exposure ensures the best patient care, as well as improves practice.

The ICRP Publication 85¹⁵ recommends the use of three dosimeters for more exposed individuals. It is suggested to place a main personal dosimeter under the lead apron at chest level, directed to the radiation source; a second dosimeter should be located above the apron at the neck level; and a third near the eye (crystalline lens) or the hand (Figure 1) region. The Brazilian normative rules require the use of a dosimeter at chest level, outside of the lead apron.¹⁶

The IAEA recommends including in radiation protection legislation the implementation of quality assurance and control programs, with acceptance tests and "commissioning" or characterization of systems that produce ionizing radiation used during interventional procedures. In Brazil, in 1998 the Brazilian National Health Surveillance Agency (Agência Nacional de Vigilância Sanitária – ANVISA) of the Ministry of Health published the SVS/MS 453/98 Administrative Rules,¹⁶ which establishes requirements for radiation protection and quality control for medical, dental, and interventional radiology.

Although there is not yet a specific regulation for the use of ionizing radiation in interventional cardiology, a regulatory standard – Safety and Health at Work in Healthcare Services, known as NR-32,¹⁷ establishes

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