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Original Article

Evaluation of scattered radiation and impact of local protective devices in an interventional cardiology laboratory

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ABSTRACT

Background: Medical applications are the main source of ionizing radiation exposure, and in this context the issue of occupational risk is particularly important. Although the different organs of the human body present different radiation sensitivities, specific assessments of the impact on the different regions of the interventionist's body with diverse radioprotection devices are rare in Brazil.
Methods: A scattered radiation test was performed using an ionization chamber in a fluoroscopy station, with standard radioprotection accessory kit of the equipment (lower skirt and upper movable shield, in two different positions), at sequential distances from the source, using acrylic phantoms as human chest simulation.
Results: Differences in radiation were identified in relation to distance and use of radioprotection devices. The median radiation reduction was 50.6% (interquartile range – IQ from 39.42% to 51.05%) using the lower skirt shield, 71.3% (IQ from 67.66% to 77.05%) with the addition of an upper shield in angulated position, and 84.7% (IQ from 83.75% to 85.87%) with the addition of an upper shield aligned with the lower shield. Significant differences were also found regarding height and distance from the source.
Conclusions: The use of the assessed local radioprotection devices was effective in reducing the overall radiological impact to the interventionist. However, there were radiation escape routes, especially with non-ideal positioning, demonstrating the importance of the additional use of individual protection devices.

Avaliação da radiação espalhada e do impacto dos dispositivos locais de proteção em laboratório de cardiologia intervencionista

Palavras-chave:
Radiação ionizante
Proteção radiológica
Diagnóstico por imagem

RESUMO

Introdução: As aplicações médicas representam a maior fonte de exposição radiológica ionizante e, neste contexto, é de especial importância a questão do risco profissional. Embora existam diferentes sensibilidades à radiação dos distintos órgãos do corpo humano, avaliações específicas do impacto nas diversas regiões do corpo do operador, com diferentes dispositivos de radioproteção, são raras em nosso meio.
Métodos: Teste de radiação espalhada foi realizado com câmara de ionização em estação de fluoroscopia, com jogo de acessórios de radioproteção padrão do equipamento (saia inferior e escudo móvel superior, em duas diferentes posições), a distâncias sequenciais em relação à fonte, utilizando fantoma de acrílico em simulação de tórax humano.
Resultados: Foram identificadas diferenças na radiação em relação à distância e ao uso dos dispositivos de radioproteção. A redução mediana da radiação foi de 50,6% (intervalo interquartil – IQ de 39,42% a 51,05%) com uso do escudo saia inferior, 71,3% (IQ de 67,66% a 77,05%) com adição de escudo superior em posicionamento angulado e 84,7% (IQ de 83,75% a 85,87%) com adição de escudo superior em linha ao escudo inferior. Diferenças significativas foram encontradas ainda em relação à altura e à distância da fonte.

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Conclusões: O uso dos dispositivos locais de radioproteção avaliados se mostrou efetivo na redução global do impacto radiológico ao operador, havendo, no entanto, vias de escape de radiação, especialmente com posicionamento não ideal, demonstrando a importância do uso adicional dos dispositivos de proteção individuais.

Introduction

Currently, medical applications are the main source of artificial ionizing radiation exposure in the population. Among the medical application fields, the issue of occupational risk is especially important, considering that the higher the exposure to the radiation source and the longer the exposure time, the higher the risk. In this context, interventional cardiologists are routinely exposed to ionizing radiation; among the professionals exposed to radiation, interventional cardiologists are those who accumulate the highest load received, mainly due to exposure to the scattered radiation from the patient receiving the primary beam of X-rays.[1] Consequently, interventionists that perform radiological interventional techniques adopt the as low as reasonably achievable (ALARA) principle,[2] limiting the duration of the exposure, increasing the distance from the radiation source and maintaining shields of radiological protection.

The national[3-5] and international[6-8] literatures describe the deleterious effects of ionizing radiation (Table 1), as well as maximum recommendation standards for cumulative occupational exposure, according to the affected area (Table 2).

Table 1
Effect of acute radiation exposure in adults.[3]

Type	Dose absorbed	Symptomatology
Infraclinical	Lower than 1 Gy	Absence of symptomatology in most individuals
Minor overall reactions	1 to 2 Gy	Asthenia, nausea, vomiting (3 to 6 hours after exposure)
Mild hematopoietic	2 to 4 Gy	Impaired bone marrow function (lymphopenia, leukopenia, thrombocytopenia, and anemia); recovery in 6 months
Severe hematopoietic	4 to 6 Gy	Severely impaired bone marrow function
Median lethal dose (DL50)	4.0 to 4.5 Gy	Death of 50% of irradiated individuals
Gastrointestinal	6 to 7 Gy	Diarrhea, vomiting, bleeding, death in 5 to 6 days
Pulmonary	8 to 9 Gy	Acute respiratory failure, coma, and death in 14 to 36 hours
Cerebral	Higher than 10 Gy	Death in a few hours

Table 2
Limits of equivalent radiation doses for interventionists.

Area of exposure	mSv/year
Crystalline lens	20
Thyroid	150
Skin	500
Annual Effective Dose	20 for 5 consecutive years of work OR 50 in 1 year

Source: *Comissão Nacional de Energia Nuclear* (CNEN portuguese for National Nuclear Energy Committee). Diretrizes Básicas de Proteção Radiológica. Rio de Janeiro: Ministério da Ciência, Tecnologia e Inovação; 2014 [cited 2016 Jan 30]. Available: http://appasp.cnen.gov.br/seguranca/normas/pdf/Nrm301.pdf

Usually, the standard radiation protection set includes individual protection equipment, such as radiation protection apron and thyroid collar, both with 0.5 mm of lead equivalence, and goggles, constructed with 0.75 mm lead glass. Moreover, local protection devices at the fluoroscopy station, such as a skirt-type lead vinyl shield in the lower region of the table (with or without an additional folding bulkhead), and movable suspended glass shield with lead vinyl curtain, both with 0.5 mm of lead equivalence, are universally used, providing interventionists with protection against 95% of the total radiation to which they are exposed.[9]

The equivalent dose limits differ between the several regions of the interventionist's body, according to radiation sensitivity; the crystalline lens is considered the limiting organ. Although an international guideline[10] recommends the use of three dosimeters to highly exposed individuals (including a personal dosimeter under the lead apron), the Brazilian guideline establishes a single measurement at chest level, outside the apron,[4] and the individual dose or effective dose equivalent is estimated from the exposure measured by this single dosimeter. The calculation of the total impact is performed by multiplying the dose recorded in the chest by the correction factor for photons (factor f = 1.14 Sv/Gy) and expressed in Sv.[11]

This is the most direct of the available measures of interventionists' cancer risk in daily practice; this value is usually presented in the monthly reports of occupational exposure. A review of the risks and adverse effects of ionizing radiation in interventional cardiology has been recently published, presenting detailed aspects of Brazilian and international standards, with important recommendations for the protection of patients and staff.[5]

Although there are different sensitivities to radiation and more sensitive organs, such as the gonads, and thyroid, specific evaluations for the interventionist, focused on the different regions of the body, are rare.[12] To the best of the authors' knowledge, the literature does not present an evaluation of the differential impact in the most sensitive organs using the different local radioprotection devices available at the fluoroscopy station.

The objective of the present study was to evaluate the impact of scattered radiation with the use of different radiation protection equipment available at the fluoroscopy station (lead vinyl shield with lower skirt and movable glass shield with lead vinyl curtain), in a controlled simulated catheterization laboratory environment, testing variations regarding the height and the distance from the source.

Methods

The radiometric field test for scattered radiation was carried out using a RadCal 1,800 cm^3 ionization chamber and correction factor of 1, with 48% ambient air humidity, 93 Kpa atmospheric pressure, and 25°C temperature, in a previously calibrated fluoroscopy station (Philips, Allura Xper FD20), in the 48-cm field in standard georeset position, without angulation. The standard positioning of the X-ray tube in the georeset position was suspended 50 cm from the ground, with a 40-cm distance between