Rev Bras Cardiol Invasiva.
2014;22(4):320-3

Original Article

Pattern of Radiation Exposure in Healthcare Professionals During Coronary Angiography

Cristiano de Oliveira Cardoso, Cláudio Vasques de Moraes, Júlio Vinícius de Souza Teixeira, Leandro dos Santos Fischer, Gabriel Garcia Broetto, Bruna Santos Silva, Rogério Fachel de Medeiros, Rogério Sarmento-Leite, Carlos Antônio Mascia Gottschall

ABSTRACT

Background: Invasive cardiologic procedures expose physicians and nurses/technicians to the risks of ionizing radiation. The aim of this study was to determine the exposure patterns in healthcare professionals during cardiologic procedures. **Methods**: Prospective study including patients undergoing invasive cardiologic procedures between December 2011 and August 2012 using flat-panel detector fluoroscopy. Clinical, angiographic and radiation exposure characteristics were recorded in a dedicated database. Patterns of radiation exposure were determined in patients undergoing diagnostic cardiac catheterization. The correlation between surgeon and nurse/technician dose was also evaluated. **Results**: The sample included 119 patients undergoing catheterization. The patient mean air kerma dose and dose-area product was 549 ± 220 mGy and 29,054 ± 14,696 mGy.cm², respectively. Physicians and nurses/technicians were exposed to a mean effective dose of 0.47 ± 0.16 and 0.28 ± 0.13 mSv per exam, respectively. The correlation between physicians and nurses/technicians effective dose was 0.54 ($p < 0.001$). **Conclusions:** Physicians and nurses/technicians are exposed to low ionizing radiation doses during diagnostic cardiac catheterization. Nurses/technicians are exposed to approximately 60% of the operating physician's dose.

DESCRIPTORS: Cardiac catheterization. Radiation, ionizing. Radiation exposure. Radiation dosage.

RESUMO

Padrão de Exposição Radiológica em Profissionais da Saúde Durante Procedimentos Cardiológicos Invasivos

Introdução: Procedimentos cardiológicos invasivos expõem médicos e enfermeiros/técnicos de enfermagem aos riscos da radiação ionizante. O objetivo deste estudo foi determinar os padrões de exposição radiológica em profissionais da saúde durante procedimentos cardiológicos. **Métodos**: Estudo prospectivo incluindo pacientes submetidos a procedimento cardiológico invasivo entre dezembro de 2011 e agosto de 2012 em equipamento com detectores do tipo plano. Características clínicas, angiográficas e de exposição à radiação foram registradas em banco de dados específico. Os padrões de exposição à radiação foram determinados em pacientes submetidos ao cateterismo cardíaco diagnóstico. Correlação entre dose do médico operador e enfermeiro/técnico de enfermagem também foi efetuada. **Resultados**: Amostra incluiu 119 pacientes submetidos ao cateterismo. A dose de kerma no ar e o produto dose-área médio de radiação recebida pelos pacientes foram de 549 ± 220 mGy e 29.054 ± 14.696 mGy.cm², respectivamente. Médicos e enfermeiros/técnicos de enfermagem foram expostos à dose efetiva média por exame de 0,47 ± 0,16 e 0,28 ± 0,13 mSv, respectivamente. A correlação entre dose efetiva dos médicos e enfermeiro/técnico de enfermagem foi de 0,54 ($p < 0,001$). **Conclusões**: Médicos e enfermeiros/ técnicos de enfermagem são expostos a doses pequenas de radiação ionizante durante cateterismo cardíaco diagnóstico. Enfermeiros/técnicos de enfermagem são expostos a cerca de 60% da dose do médico operador.

DESCRITORES: Cateterismo cardíaco. Radiação ionizante. Exposição à radiação. Dosagem de radiação.

Catheterization laboratory procedures have been widely used for evaluation of coronary artery disease. As the number of invasive tests in modern cardiology increases, patients and the medical and nursing staffs are exposed to higher doses of ionizing radiation.[1,2]

Instituto de Cardiologia do Rio Grande do Sul, Fundação Universitária de Cardiologia, Porto Alegre, RS, Brazil.

Corresponding Author: Cristiano de Oliveira Cardoso. Rua José Albano Volkmer, 340/506 – Jardim do Salso – CEP: 91410-180 – Porto Alegre, RS, Brazil
E-mail: cro_cardoso@yahoo.com.br

Received on: 09/03/2014 • Accepted on: 11/26/2014

Currently, the ever more frequent reports of injuries[3,4] related to ionizing radiation are a constant concern for health teams. However, the Brazilian literature lacks contemporary data on the radiological exposure in health care workers.

This study aimed to determine the pattern of radiation exposure in healthcare workers during invasive cardiac procedures.

METHODS

This was an observational study with prospective data collection.

RADIAÇÃO REGISTER

The RADIAÇÃO Register is an institutional register that documents diagnostic and therapeutic procedures in interventional cardiology performed using a device with flat-panel detectors. Information related to radiation exposure and technical details of the procedures were prospectively recorded.

Sample

The radiation exposure patterns in the procedures performed on patients with indication of diagnostic cardiac catheterization were registered. All patients signed a free informed consent form, and the protocol was approved by the local Ethics Committee in Research (UP 4454/10).

Analyzed characteristics

For inclusion in the register, information regarding age, gender, risk factors for cardiovascular disease, clinical presentation and indication for the procedure, ventricular function, number of affected vessels, treated vessel, lesion characteristics, and success rate was collected and analyzed. Specific data on radiological exposure (dose received, dose-area product, and fluoroscopy time) were also collected.

Invasive cardiac procedures

Images were acquired using a single device with flat-panel detector (Philips Allura – Einthoven, the Netherlands) with three magnification fields (15, 20, and 25 cm) and double filter (copper + aluminum). Five projections for the left coronary artery, two for the right coronary artery, and one for left ventriculography were performed in order to obtain the images. The positions of the flat-panel detector were set at the following angles: (1) left coronary artery: 20° right anterior oblique (RAO), with a 20° caudal tilt; anteroposterior (AP) with a 20° caudal tilt; 40° left anterior oblique (LAO), with a 30° caudal tilt (spider view); 40° RAO with a 25°cranial tilt; AP with a 40° cranial tilt; (2) right coronary artery: 30° RAO; 30° LAO with a 30° cranial tilt; (3) left ventriculography: 30° RAO. All images were obtained with image acquisition at a speed of 15 frames per second. The examinations were performed by qualified interventionists and exclusively via the femoral access route. Due to the characteristics of the protocol, patients with coronary artery bypass graft surgery were excluded.

Radiological exposure parameters

The radiological exposure of healthcare professionals was measured using a digital dosimeter (Polimaster PM1621 – Arlington, United States) in each procedure. The effective dose (μSv) received was determined according to the following formula: effective dose = (dose of procedure – background radiation) × conversion factor. The background radiation was determined by the formula: procedure time (in seconds) × 0.00004 μSv/s, considering a conversion factor of 1.01. The dosimeter was reseted at the beginning of the procedure, and the final dose was measured at the end.

Two dosimeters were used: one for the operating physician conducting the procedure, and the other by a nurse/nursing technician who assisted the exam. All professionals used radiological protection equipment (an apron and thyroid shield, 0.5 mm thick), and the dosimeter was positioned over the lead apron. If the physician was performing the catheterization, top and bottom shields were used (skirt and shield) for added protection.

Statistical analysis

Data were analyzed using SPSS version 18.0, and the results were presented as means and standard deviations, or as absolute numbers and percentages. The correlation between dose of the operating physician and dose of the nurse/nursing technician was evaluated.

RESULTS

Between December 2011 and August 2012, 119 invasive cardiac procedures for diagnostic purposes were evaluated. Table 1 shows the clinical characteristics of patients included in the study.

In relation to angiographic characteristics, it was observed that 60 patients (50.4%) did not present coronary stenosis > 70%. Severe injury to one, two, or three vessels occurred in 35 (29.4%), 19 (16.0%), and five (4.2%) patients, respectively. The ejection fraction of the patients was 67 ± 15%. The mean procedural time was 15h06 m ± 4h03 m, and that for the fluoroscopy was 2h55m ± 4h03m , with contrast volume of 96.9 ± 10.7 mL per procedure. 9.45 ± 0.65 acquisitions per procedure were performed, with approximately 741 ± 101 frames per procedure. The mean number of frames per acquisition was 78 ± 10.

The radiation exposure of patients involved in the study, as well that of healthcare professionals, is shown

in Table 2. The correlation between dose effective of physicians and nurses/nursing technicians is shown in the Figure.

DISCUSSION

This study aimed to determine the radiological exposure of healthcare professionals directly involved in invasive cardiac procedures using hemodynamics devices with flat-panel detectors. The flat-panel detector technology has been incorporated in modern hemodynamics devices because, according to the manufacturers, this technology promotes greater image quality and, theoretically, a lower radiation exposure.[5,6]

Everyone who works with ionizing radiation should follow the "as low as reasonably achievable" (ALARA) principle.[7] In short, this principle states that radiation exposure should be kept as low as reasonably practicable. Although the ALARA concept is widely known, recent research has shown that approximately 80% of professionals working directly with ionizing radiation do not demonstrate adequate knowledge about its risks.[5] Therefore, the promotion of measures aimed at reducing the dose and to disseminate a consistent knowledge about its use is appropriate and relevant for all individuals exposed to this kind of biological effect.

The authors have previously demonstrated the current patterns of radiological exposure during diagnostic and therapeutic procedures.[1] In addition, they determined that weight,[8] type of procedure,[9,10] and the radial access route[11] are important predictors of increased radiation exposure. However, until recently, individual occupational exposure with the use of flat-panel detector devices was unknown. It was observed that the mean individual effective doses per examination were relatively low during a diagnostic cardiac catheterization, both for physicians (0.47 µSv) and for nurses/nursing technicians (0.28 µSv). Nevertheless, the present findings demonstrate that nurses/nursing technicians are exposed to 60% of the radiation received by the operating physician. These are important findings, since the effective dose received by nurses/nursing technicians correlates

TABLE 1
Clinical characteristics of patients

Variable	n = 119
Age, years	58.2 ± 10.2
Male gender, n (%)	68 (57.1)
White, n (%)	105 (88.2)
Weight, kg	82.8 ± 17.7
Height, cm	167.0 ± 12.1
Active smoking, n (%)	40 (33.6)
Hypertension, n (%)	92 (77.3)
Diabetes, n (%)	40 (33.6)
Using insulin	11 (9.2)
Dyslipidemia, n (%)	55 (46.2)
Family history of CAD, n (%)	52 (43.7)
Prior percutaneous coronary intervention, n (%)	26 (21.8)
Previous myocardial infarction, n (%)	23 (19.3)
Previous stroke, n (%)	4 (3.4)
Medications in use, n (%)	
Acetylsalicylic acid	92 (77.3)
Clopidogrel/ticlopidine	16 (13.4)
Beta-blocker	82 (68.9)
Nitrate	34 (28.6)
Statin	61 (51.3)
ACEI	64 (53.8)
Calcium antagonist	17 (14.3)
Diuretic	41 (34.5)
Aldosterone antagonist	18 (15.1)

CAD, coronary-artery disease; ACEI, angiotensin-converting-enzyme inhibitors.

TABLE 2
Mean radiological exposure parameters per procedure

Variable	Value
Radiological exposure of patient	
Air kerma, mGy	549 ± 220
Dose-area product, mGy.cm^2	29,054 ± 14,696
Radiological exposure of the operating physician	
Effective dose, µSv	0.47 ± 0.16
Radiological exposure of the nurse/nursing technician	
Effective dose, Sv	0.28 ± 0.13

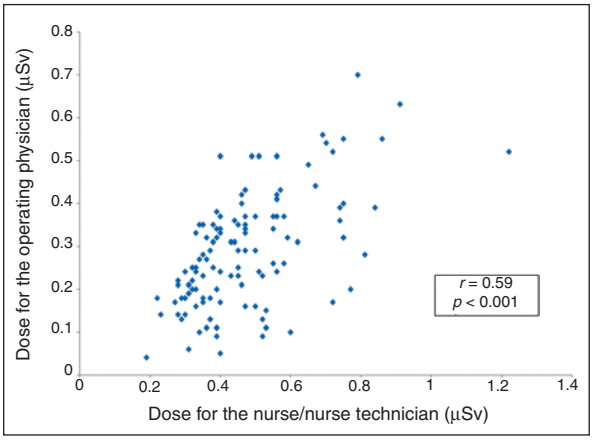

Figure – Occupational exposure correlation among healthcare professionals.

directly with that received by the operating physician. This result is significant and confirms the need for the use of the maximum radiation protection possible when exposed to ionizing radiation.[12]

The ordinance 453 of the Brazilian Ministry of Health[13] determines that the average annual effective dose should not exceed 20 mSv in any period of 5 consecutive years, and it cannot exceed 50 mSv in any one year. It is critical that measures are taken in order to promote a dose reduction for patients and healthcare professionals; such measures have been increasingly stimulated by scientific societies.[12,14,15] The international literature has shown that simple actions can promote a significant reduction in radiation exposure. Often, patients undergoing cardiac catheterization have their left-ventricular function assessed by echocardiography or other imaging method. Lin et al.[16] demonstrated that left-ventriculography suppression promotes a reduction of 10% in the dose-area product. In agreement with this finding, Abdelaal et al.[17] evaluated, in a randomized way, two image acquisition methods: with 7.5 and 15 frames/second. This simple reduction in exposure rate produced a significant 30% reduction in the dose for the operating physician and of 19% for the patient. The authors are not advocating a change in technique, but it is critical that all professionals involved in radiological examinations are aware that simple measures can reduce the dose in their procedures. Therefore, it is up to the professional to define the strategy to be used.

The present study had limitations that should be considered. This was a single-center analysis, with a small number of patients. Patients undergoing coronary angioplasty, those who had undergone coronary artery bypass graft surgery or procedures by radial access route were not included. However, due to the lack of national data, this article can serve as a reference for future studies.

CONCLUSIONS

Physicians and nurses/nursing technicians are exposed to small doses of ionizing radiation during diagnostic cardiac catheterization. Nurses/nursing technicians are exposed to approximately 60% of the dose of the operating physician.

CONFLICT OF INTERESTS

The authors declare no conflicts of interest.

FUNDING SOURCE

None.

REFERENCES

1. Cardoso CO, Sebben JC, Fischer LS, Vidal M, Broetto GG, Silva BS, et al. Padrão de exposição radiológica e preditores de superexposição dos pacientes submetidos a procedimentos cardiológicos invasivos em equipamentos com detectores planos. Rev Bras Cardiol Invasiva. 2011(1):84-9.
2. Vano E, Ubeda C, Leyton F, Miranda P, Gonzalez L. Staff radiation doses in interventional cardiology: correlation with patient exposure. Pediatr Cardiol. 2009;30(4):409-13.
3. Roguin A, Goldstein J, Bar O. Brain malignancies and ionising radiation: more cases reported. EuroIntervention. 2012; 8(1):169-70.
4. Roguin A, Goldstein J, Bar O. Brain tumours among interventional cardiologists: a cause for alarm? Report of four new cases from two cities and a review of the literature. EuroIntervention. 2012;7(9):1081-6.
5. Gurley JC. Flat detectors and new aspects of radiation safety. Cardiol Clin. 2009;27(3):385-94.
6. Trianni A, Bernardi G, Padovani R. Are new technologies always reducing patient doses in cardiac procedures? Radiat Prot Dosimetry. 2005;117(1-3):97-101.
7. International Commission on Radiological Protection (ICRP). Recommendations. Oxford: Pergamon Press; 1977. (Publication, 26).
8. Vargas FG, Silva BS, Cardoso CO, Leguisamo N, Moraes CAR, Moraes CV, et al. Impacto do peso corporal dos pacientes na exposição radiológica durante procedimentos cardiológicos invasivos. Rev Bras Cardio Invasiva. 2012(1):63-8.
9. Medeiros RF, Sarmento-Leite R, Cardoso CO, Quadros AS, Risso E, Fischer L, et al. Exposição à radiação ionizante na sala de hemodinâmica. Rev Bras Cardiol Invasiva. 2010(3):316-20.
10. Azevedo EM, Gomes HB, Yordi LM, Moura MRS, Laguna A, Fischer LS, et al. Impacto das lesões complexas na exposição radiológica durante intervenção coronária percutânea. Rev Bras Cardiol Invasiva. 2013(1):49-53.
11. Mattos EI, Cardoso CO, Moraes CV, Teixeira JVS, Azmus AD, Fischer LS, et al. Exposição radiológica em procedimentos coronários realizados pelas vias radial e femoral. Rev Bras Cardiol Invasiva. 2013(1):54-9.
12. Chambers CE, Fetterly KA, Holzer R, Lin PJ, Blankenship JC, Balter S, et al. Radiation safety program for the cardiac catheterization laboratory. Catheter Cardiovasc Interv. 2011; 77(4):546-56.
13. Brasil. Ministério da Saúde; Agência Nacional de Vigilância Sanitária. Portaria n. 453, de 1 de junho de 1998. Aprova o Regulamento Técnico que estabelece as diretrizes básicas para proteção radiológica em radiodiagnóstico médico e odontológico, dispõe sobre o uso dos raios-xdiagnósticos em todo território nacional e dá outras providências [Internet]. Brasília; 1998 [citado 2013 dez. 15]]. Disponível em: http://www.conter.gov.br/uploads/legislativo/portaria_453.pdf
14. Kim KP, Miller DL. Minimising radiation exposure to physicians performing fluoroscopically guided cardiac catheterisation procedures: a review. Radiat Prot Dosimetry. 2009;133(4):227-33.
15. Brasselet C, Blanpain T, Tassan-Mangina S, Deschildre A, Duval S, Vitry F, et al. Comparison of operator radiation exposure with optimized radiation protection devices during coronary angiograms and ad hoc percutaneous coronary interventions by radial and femoral routes. Eur Heart J. 2008;29(1):63-70.
16. Lin A, Brennan P, Sadick N, Kovoor P, Lewis S, Robinson JW. Optimisation of coronary angiography exposures requires a multifactorial approach and careful procedural definition. Br J Radiol. 2013;86(1027):20120028.
17. Abdelaal E, Plourde G, MacHaalany J, Arsenault J, Rimac G, Déry JP, et al. Effectiveness of low rate fluoroscopy at reducing operator and patient radiation dose during transradial coronary angiography and interventions. JACC Cardiovasc Interv. 2014;7(5):567-74.