Patient Dose Research in Interventional Radiology Suites in Rio de Janeiro, Brazil

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Abstract

Fluoroscopy-guided interventional procedures offer a large number of benefits. However, these procedures contribute significantly to patient exposure. In interventional procedures, patient dose is difficult to assess for several reasons. Examinations are dynamic, with many variable parameters: X-ray field size, angle of incidence of the beam, magnification, beam quality, focus-skin distance, irradiation time, etc. One method to perform patient dosimetry is to measure kerma-area product (P_{KA}). This quantity is related to the total amount of imparted energy to the patient. The objective of this study was to quantify the radiation exposure of the patient by measuring P_{KA} in interventional procedures performed in catheterization rooms in Rio de Janeiro. Data were obtained in four hospitals from a sample of 339 patients undergoing interventional procedures, divided in 221 coronary angiography (CA), 96 percutaneous coronary angioplasties (PTCA) and 22 electrophysiological procedures (EE). In our country, the measurement of P_{KA} is not mandatory and many X-ray equipment does not have incorporated P_{KA} meters. On some devices the geometry of the head of the X-ray tube does not allow the direct placement of an ionization chamber at the exit of the collimation system. For these reasons, it was necessary to design PMMA supports for each equipment in order to attach the P_{KA} ionization camera without hinder the movement of the C arm. This paper presents different supports as a solution to cases where the P_{KA} meter is not incorporated to the equipment. The following results were obtained (third quartile for P_{KA}, third quartile for total irradiation time and third quartile for number of image): For CA, 7613 cGy.cm^2; 8.0 min; 1115; for PTCA, 6559 cGy.cm^2; 16 min; 1400; and for EE, 55838 cGy.cm^2; 30 min. Results were compared with data from literature. The relationship of P_{KA} with patient's weight was also studied. Optimization strategies for practices are proposed owing to improve the radiological protection of patients in interventional procedures.

Key Words: Interventional cardiology, patient dosimetry and kerma area product.

Introduction

The interventional cardiology is a complex practice that involves the use of ionizing radiation to guide small catheters, through the blood vessels, up to the heart, with the purpose of diagnosing or treating some heart diseases [1].

However, these procedures contribute significantly to patient exposure. In interventional procedures, patient dose is difficult to assess for several reasons: examinations are dynamic, with many variable parameters: X-ray field size, angle of incidence of the beam, magnification, beam quality, focus-skin distance, irradiation time, etc. Furthermore, the frequency of interventional procedures fluoroscopically guided increased by approximately one order of magnitude in the last decade. This is because there were major advances in training and dexterity of the professionals involved in these practices, in the effectiveness of medical devices and in the development of interventional fluoroscopic systems dedicated. Consequently, patients and hospitals have increased the possibilities of access to these minimally invasive procedures. This increase has been observed in both developed countries and developing [2].

Therefore, purpose of this study was to measure the levels of exposures, by measuring the kerma-area product, received by patients undergoing coronary angiography (CA), percutaneous transluminal coronary angioplasty (PTCA), and electrophysiological procedures (EE), in several institutions of Rio de Janeiro, Brazil.

Materials and Methods

This work was developed in four hemodynamic services in the Rio de Janeiro city. They were followed 339 procedures, divided among 221 examinations of coronary angiography, 96 coronary angioplasties and 22 electrophysiological procedures (electrophysiological studies and radiofrequency ablations).

The equipment assessed were Siemens Coroskop Plus TOP model, X-PRO Arcomax N model and Siemens Angiostar model. All equipment is C arm and the images are acquired digitally. The equipments were subjected to tests of quality control. In this work, the dosimetric quantity measured in patients was the kerma area product. Other non-dosimetric quantities and other parameters considered essential for patients' radiation protection were also measured, as the number of images obtained and irradiation time. Measurement kerma area product (P_{KA}) was carried out using the following meters: PTW, Diamentor E and M4-KDK. In our country, the measurement of P_{KA} is not mandatory and much X-ray equipment does not have incorporated P_{KA} meters. On some devices the geometry of the head of the X-ray tube does not allow the direct placement of an ionization chamber at the exit of the collimation system. For these reasons, it was necessary to design PMMA supports for each equipment in order to attach the P_{KA} ionization camera without hinder the movement of the C arm. This paper presents different supports as a solution to cases where the P_{KA} meter is not incorporated to the equipment (figure 1). The P_{KA} meter was calibrated when installed in an equipment of X-ray.

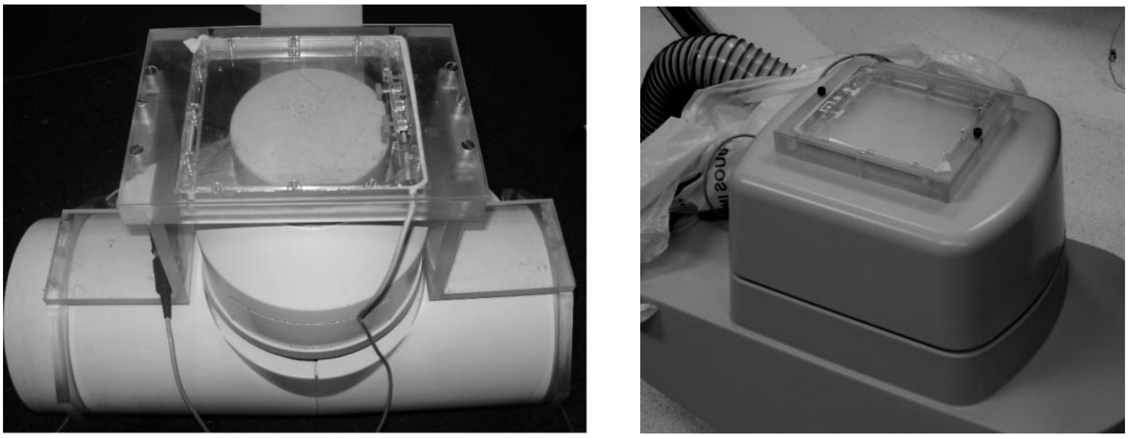

Figure 1. Supports for coupling the chamber to the output of X-ray tube constructed for the equipment.

Results

The table shows the results obtained in all the institutions studied. The range of values, the mean, standard deviation and third quartile values obtained for the procedures of CA, PTCA and EE are shown in table 1.

Table 1: Results obtained in patients' dosimetry.

	Irradiation Time (minutes)	**Number of images**	**Total $P_{K,A}$ ($cGy.cm^2$)**
CORONARY ANGIOGRAPHY [n=221]			
Range	1-35	306-2175	472-60694
Mean	6	927	7263
Standard Deviation	5	361	9720
3rd Quartile	**8**	**1115**	**7613**
PERCUTANEOUS TRANSLUMINAL CORONARY ANGIOPLASTY [n=96]			
Range	2-59	209-4813	750-31810
Mean	13	1155	6466
Standard Deviation	9	756	5998
3rd Quartile	**16**	**1400**	**6559**
ELECTROPHYSIOLOGICAL PROCEDURES [n=22]			
Range	2-59	209-4813	750-31810
Mean	13	1155	6466
Standard Deviation	9	756	5998
3rd Quartile	**16**	**1400**	**6559**

The P_{KA} values for CA are high if compared with diagnostic reference levels of reported by SENTINEL [3] was 6.5 minutes, 700 and 4.500 $cGy.cm^2$ for irradiation time, number of images and kerma area product, respectively. The P_{KA} values for CA obtained may be attributed to the fact that a greater image acquisition during procedures.

Moreover, the P_{KA} values for PTCA in this work are lower than those reported by SENTINEL [3] that was 15.5 minutes, 1.000 and 8.500 $cGy.cm^2$ for irradiation time, number of images and kerma area product, respectively. This can be explained by the fact that 51% of PTCA procedures of that make up the sample are originated from a service that showed a low patient entrance surface air kerma rate for the fluoroscopy mode, which has a greater percentage contribution to the value of total P_{KA}.

Table 1, observed that the doses administered to patients (Total P_{KA}) in electrophysiology procedures are larger than during CA and PTCA. This result is not surprising, because these interventions often require exposure times of the patient to fluoroscopy much longer than for CA and PTCA procedures [4]. In addition, from measurements of quality control, it was found that equipment where electrophysiological procedures presented deficiencies.

The relationship of P_{KA} with Body Mass Index (BMI) was also studied for CA and PTCA (figures 2 and 3).

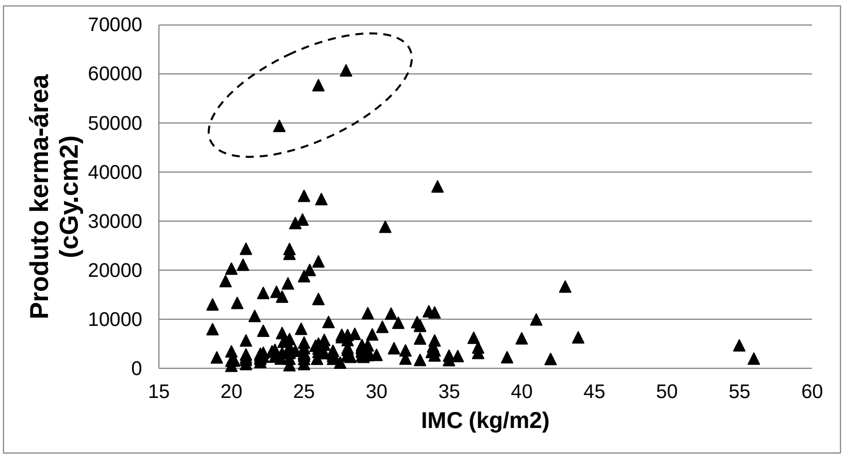

Figure 2. Relationship between P_{KA} and BMI for CA.

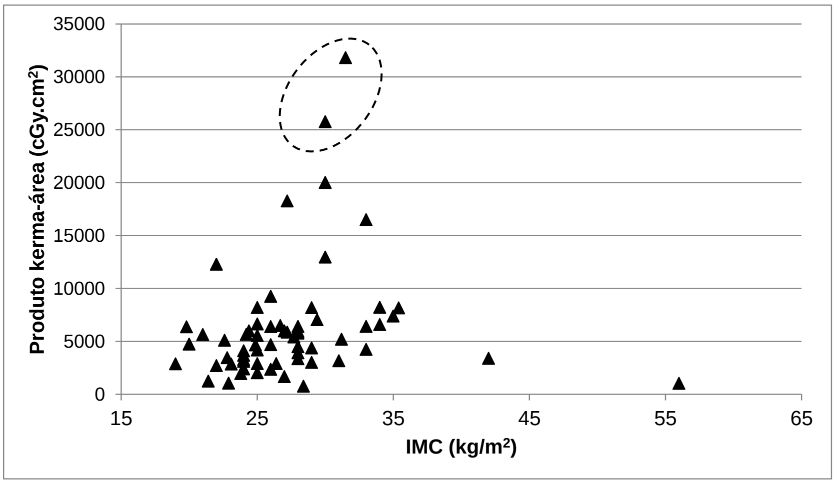

Figure 3. Relationship between P_{KA} and BMI for PTCA.

In Figure 2, the three points involved by dotted curve represent results of three atypical procedures performed in large public institution. The procedures required a sustained investigation due to difficulties in identifying the pathologies, requiring long exposure times. In figure 3, the two posted points correspond to procedures with high number of images (about 4000) and exposure times. (≈ 20 minutes).

A good correlation between P_{KA} and BMI is difficult to achieve, since P_{KA} depends on several factors, in addition the patient's weight and height, as the number of images obtained, pathology type and complexity of the procedure.

Conclusions

Optimization strategies for practices are proposed owing to improve the radiological protection of patients in interventional procedures. A IAEA Technical Cooperation project, BRA9056: "Supporting National Assessment of Quality Control and Radiation Protection in Interventional Cardiology Departments" is being developed involving the interventional cardiology society and health agencies to enhance the effectiveness of the optimization process. We intend to continue the survey in a significant number of hospitals to establish diagnostic reference levels for interventional cardiology.

Acknowledgments

This project had the following support:

- ✓ International Atomic Energy Agency – IAEA.
- ✓ Comissão Nacional de Energia Nuclear – CNEN.
- ✓ Conselho Nacional de Pesquisa – CNPq.

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