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Estimation of Typical Values (DRL) in Angioplasties Performed at a Radiology Service of a Hospital in Southern Brazil

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Abstract: Interventional radiology involves diagnostic and therapeutic interventions using X-ray-emitting equipment. Due to the high radiation doses administered to patients during these procedures, there is a significant risk of severe tissue reactions resulting from prolonged exposure. To prevent unnecessary high doses during patient exposures, the International Commission on Radiological Protection recommends the use of Diagnostic Reference Levels (DRLs) as an effective tool for optimizing procedures in diagnostic or interventional radiology services. This study aimed to estimate the DRLs (typical values) resulting from interventional radiology procedures conducted in a public hospital in southern Brazil. To achieve this, a database was developed to facilitate the collection of information regarding exposures during interventional procedures, enabling the establishment of DRLs specific to a single facility, known as typical values. Patient and procedure data were collected and tabulated by the Radiation Protection Service (SPR) of the hospital through consultation with the interventional radiology service's logbook or, if necessary, the State Information System of Risk and Potential Benefit (SIERBP), followed by the application of exclusion criteria. After data collection, the typical doses received by adult patients undergoing these procedures were estimated through simple descriptive statistics, using the median of the data distribution and the standard deviation. The results obtained provide a better understanding of the necessary actions, whether optimization or protocol review, to ensure the radiological protection of patients. This approach has the potential to benefit not only the patients but also the entire professional team involved in the interventional radiology service.

Keywords: Radiological Protection, Interventional Radiology, Diagnostic Reference Levels, Radiation Exposure.

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Estimativa de Valores Típicos (DRL) em Angioplastias Realizadas em um Serviço de Radiologia em um Hospital no Sul do Brasil

Resumo: A radiologia intervencionista consiste em intervenções diagnósticas e terapêuticas através da utilização de equipamentos emissores de raios X e devido às doses elevadas de radiação administradas nos pacientes durante os procedimentos, em muitas situações, é possível ocasionar reações teciduais graves decorrentes dos longos períodos de exposição. Para prevenir doses elevadas desnecessárias durante essas exposições aos pacientes, a *International Commission on Radiological Protection* recomenda o uso de Níveis de Referência em Diagnóstico (DRLs) como uma ferramenta eficaz que contribui com a otimização em procedimentos realizados nos serviços de radiologia diagnóstica ou intervencionista. Este estudo teve como objetivo estimar os DRLs (valores típicos) decorrentes de procedimentos de radiologia intervencionista realizados em um hospital público do Sul do Brasil. Para isso, foi desenvolvida uma base de dados que possibilita a coleta de informações referentes às exposições realizadas durante os procedimentos intervencionistas, que por sua vez, permite estabelecer os DRLs de uma única instalação, conhecidos como valores típicos. Os dados dos pacientes e dos procedimentos foram coletados e tabulados, por intermédio do Serviço de Proteção Radiológica (SPR) do hospital, mediante consulta ao livro de registros do serviço de radiologia intervencionista ou, se necessário, do Sistema de Informação Estadual de Risco e Benefício Potencial (SIERBP) e posteriormente, sendo aplicados critérios de exclusão. Após a coleta dos dados, foram estimados, por meio de estatística descritiva simples, os valores das doses tipicamente recebidas pelos pacientes adultos, submetidos a esses procedimentos, por meio do valor da mediana da distribuição dos dados e do desvio padrão. Os resultados obtidos permitem um melhor entendimento sobre quais ações são necessárias, otimização ou revisão de protocolos, para garantir a proteção radiológica dos pacientes, podendo assim, trazer benefícios não só aos pacientes, como a toda equipe profissional envolvida em um serviço de radiologia intervencionista.

Palavras-chave: Proteção Radiológica, Radiologia Intervencionista, Níveis de Referência de Diagnóstico, Exposição à Radiação.

1. INTRODUCTION

Interventional Radiology (IR) consists of diagnostic and therapeutic interventions using X-ray emitting equipment. In Brazil, interventional procedures have grown by 77 per cent since 1960. The increase in demand for the procedures is also related to the great evolution of interventional radiology and the increasing sophistication of the equipment, replacing some more invasive treatment techniques, which results in benefits for patients [1-3].

Radiation doses in patients undergoing interventional procedures can be high enough to cause skin lesions and increase the likelihood of developing cancer over the years. There is also the risk of tissue reactions in Occupationally Exposed Individuals (OEIs), such as the formation of radio-induced cataracts [4].

The United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR), in its latest report, collected data from more than 50 countries and reported that IR is responsible for only 0.6% of all examinations and procedures carried out among imaging modalities, but contributes 8% of the collective effective dose in medical exposures. Although low when compared to other modalities, this contribution shows a significant increase, bearing in mind that in the previous assessment the contribution of IR represented only 1% of the collective effective dose [5].

The evolution of IR and the increased demand for interventional procedures have resulted in a rise in the number of patients exposed to radiation. Consequently, there has been an increase in reports of tissue reactions on patients' skin due to high dose rates and long exposure time during procedures, among other factors. thus highlighting the need for special attention in these procedures, as well as the indispensability of professional training on the risks related to this modality and the relevance of strategic planning to optimize exposure [3-6].

In order to prevent unnecessary high doses during these patient exposures, the International Commission on Radiological Protection (ICRP) has recommended the use of Diagnostic Reference Levels (DRLs) as an effective tool that contributes to optimizing procedures performed in diagnostic or interventional radiology services. DRLs can be categorized by the scope of x-ray rooms in which the procedures can be analyzed, ranging from National DRL, Local DRL and Typical Value. Typical Value is often utilized when the number of x-ray rooms is too small to permit determination of a local DRL value [7,8].

For IR procedures, such as angioplasties, $K_{a,r}$ and P_{KA} have been developed as estimators of the risk of radiation-related tissue effects and stochastic effects, respectively. These quantities are used to determine a DRL and evaluate the dose of ionizing radiation applied in an interventional procedure [8].

Based on the above, this research aims to estimate the typical values resulting from medical exposures in angioplasty procedures carried out in a public hospital in southern Brazil.

2. METHODOLOGY

This study consisted of prospective research with a quantitative approach and of an applied nature, seeking to generate data and benefits for the practice of optimizing radiological protection in angioplasty procedures.

The angioplasty procedures data were derived from one dedicated room for IR at University Hospital from southern Brazil, with the aid from the institution's Radiological Protection Service. The data retrieved from these exams were obtained from a floor-mounted digital angiograph by Siemens Healthineers, model Artis Zee®, equipped with a high-performance MEGALIX Cat Plus 125/20/40/80 X-ray tube and amorphous silicon flat detector, model AS40 High Dynamic Range, with fields of view (FOV) of 11 cm, 16 cm, 22 cm, 32 cm, 42 cm and 48 cm. All dosimetric data collected in this research were estimated

and extracted from the mentioned X-ray equipment. The data retrieved was categorized in a spreadsheet, consisting of the input name and type of the procedure, date of acquisition, clinical indication, P_{KA}, $K_{a,r}$, total fluoroscopy time, number of images and number of series. The secondary data acquired consisted of information regarding the patients: gender, age, body weight and height. The authors also included the Peak Skin Dose (PSD) for each exam in the primary data cataloged, which was manually estimated from dosimetric values obtained from the equipment.

In this study, the participant population was made up of adult patients aged 18 or over with no maximum age limit, of both genders, who underwent interventional procedures at the study site in the six-month period between the years 2023-2024. Patients who underwent interventional procedures in the aforementioned period were selected for data collection and had all the data required for this study filled in completely. The data collected and recorded is shown in Table 1.

This work was submitted for approval to the Ethics Committee and approved under protocol number: 6.336.194.

3. RESULTS AND DISCUSSION

The data collection phase of the research is already underway, with approximately 60 data points collected from various procedures. We used data from 22 angioplasty patients/procedures, of which 12 were male and 10 female, carried out between September and October 2023 at the participating service, representing 35.43% of our current sample. The evaluation was carried out considering both female and male sexes, but since no significant differences were found, gender was not discussed. Table 1 shows the minimum, maximum, 2nd quartile, 3rd quartile and mean values for both sexes.

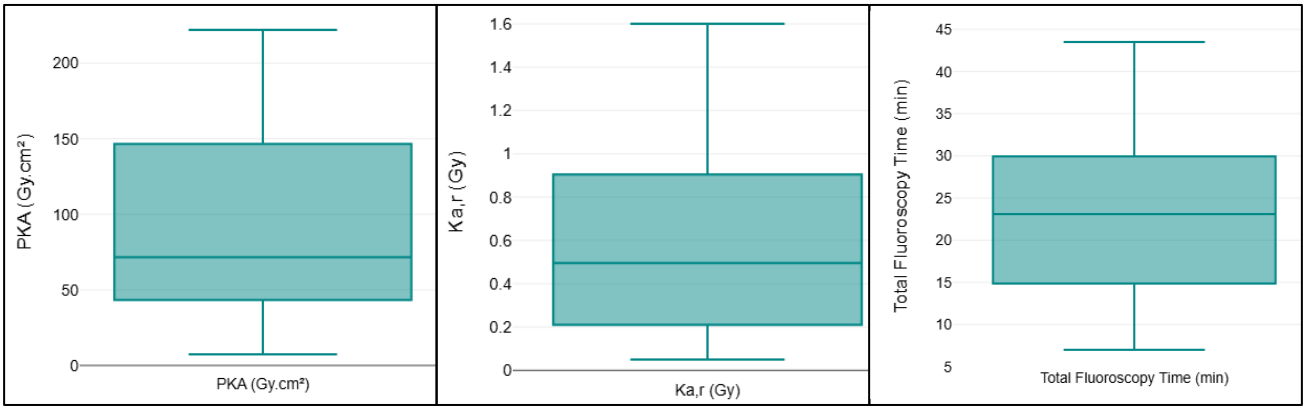
Table 1: Data related to 22 angioplasty procedures carried out in the IR department of the participating institution.

Data	Minimum	Maximum	Quartile 2 (Median)	Quartile 3 (75th percentile)	Mean ± SD
Fluoroscopy Time (min)	7	43.5	23.1	29.95	23.3 ± 10.5
P_{KA} (Gy.cm²)	7.39	222.01	71.72	146.53	99.82 ± 67.92
$K_{a,r}$ (Gy)	0.05	1.6	0.5	0.91	0.61 ± 0.49
Age (a)	44	89	71	78	69.82 ± 12.53
Weight (kg)	52	120	68.5	77.75	71.09 ± 15.59

Based on the ICRP recommendations, the typical dose value in an IR procedure is established using the 2nd quartile (median value) [8]. For this study, the typical values for the angioplasty procedure were: P_{KA} 71.72 Gy.cm²; $K_{a,r}$ 0.5 Gy and total fluoroscopy time of 23.1 minutes.

With the values obtained, boxplot graphs were also generated with the values of P_{KA}, $K_{a,r}$ and total fluoroscopy time by 2nd and 3rd quartile, for both sexes, shown in Figure 1.

Figure 1: Graphical representation of P_{KA}, $K_{a,r}$ and total fluoroscopy time, showing the minimum values (bottom line), Q1 (bottom line of the box), median (continuous line inside the box), mean (dashed line inside the box), Q3/75th percentile (top line of the box) and maximum (top line).



In a study carried out in the state of Minas Gerais, Brazil, data on 698 angioplasty procedures carried out in 24 IR services was collected by the State Health Surveillance. In this study, the DRLs were established on the basis of the 3rd quartile, which is in line with

the ICRP guidelines, because when you want to establish a DRL at a local level, for example in a state where several services from different cities are included, the value used as a reference is the 3rd quartile. The typical P_{KA} values presented in this study were 102 Gy.cm^2 and the total fluoroscopy time was 824 seconds (13m44s) [9], so we can compare them with the 3rd quartile values presented in Table I, where the P_{KA} was 146.53 Gy.cm^2 and the total fluoroscopy time was 29.95 min. With this data we can see that the participating IR service has so far presented higher values than those presented in the survey carried out in Minas Gerais.

This comparison does not necessarily mean that the participating service has a very different reality from the one presented in the survey, since the typical values presented in Figure 1 are related to just one service and the DRL value established by the survey encompasses a set of services in several cities in one state. It is also important to emphasize that differences in technologies and the physical characteristics of the population served by a specific health service can influence the discrepant established DRL values. However, the approximate values show the relevant trend of the current research, reinforcing the significance of the results obtained.

4. CONCLUSIONS

DRLs were introduced to indicate deviations in values in patient radiation doses underwenting medical imaging examinations and procedures. If a procedure-related DRL is exceeded, an investigation should be carried out to determine the possible reasons and if corrective action is required, a plan should be implemented and documented immediately. DRLs should not be used as a trigger level for individual patients or procedures, nor are they thresholds or dose limits [6,7].

With the aim of the research in mind, the final result of the estimation of typical values for the angioplasty procedures carried out in the participating service were considered to be P_{KA} 71.72 Gy.cm^2; $K_{a,r}$ 0.5 Gy and total fluoroscopy time of 23.1 minutes, establish by de 2nd

quartile; however, the values of the 3rd quartile, P_{KA} 146.53 Gy.cm^2 and total fluoroscopy time 29.95 min. were used for comparative purposes with the available national literature of services of the same size and using similar technologies[9].

This type of analysis is significant for highlighting the importance of professional training and education in relation to radiological protection applied in interventional radiology, which promotes optimisation of practice, bringing benefits to patients and occupationally exposed individuals involved in interventional radiology services.

However, this study was limited due to the lack of standardization and organization of the data input by the operators at the radiology service, in which many procedures were registered with various nomenclatures or even incompletely filled. This limitation caused a reduction of potential exams to be used in this study.

The values obtained in this study should be reviewed periodically, especially after implementing measures to improve the standardization of input data and optimization of protocols. This periodic review will enhance the delivery of more accurate and up-to-date DRL values.

The authors suggest a development of an internal computerized system that can assist in data collection from the equipment and possibly automatically feed an exclusive database for establishing and updating typical values of DRLs of the institution itself. They also hope to provide guidance to the participating service on the radiological protection measures that should be taken, such as the revision and optimisation of protocols, benefiting not only the patient undergoing angioplasty procedures, but also the entire professional team participating in the IR service, as well as contributing to the promotion of scientific production in the area.

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CONFLICT OF INTEREST

All authors declare that they have no conflicts of interest.

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