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ESTIMATION OF TYPICAL VALUES OF ADMINISTERED ACTIVITY FOR COMPLETE MYOCARDIAL SCINTIGRAPHY PROTOCOL IN SOUTH OF BRAZIL

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Abstract. *Nuclear Medicine (NM) is a medical specialty divided into diagnostic and therapeutic applications. The doses resulting from procedures in this practice come from activities administered to patients and contribute to the exposure of the population to ionizing radiation. Therefore, the optimization of radiological protection aims to balance the image quality of medical exams and the amount of radiation received by the patient, which should be optimized to the minimum value necessary for the diagnostic. The International Commission on Radiological Protection (ICRP) provides guidance on the establishment of reference levels for procedures in various modalities. In MN, diagnostic reference levels (DRLs) are based on the administered activities to patients and are considered an important tool for optimizing procedures. The objective of the present study was to estimate the typical values of administered activities resulting from Nuclear Medicine procedures performed in a private service located in the South region of Brazil. The applied methodology consisted of using secondary data retrospectively collected from the procedures registration systems in a nuclear medicine service performed in 2020. The data collected were: procedures type, radionuclide, date of the exam, administered activity (Bq), weight (kg), height (m), age (years), and gender of the patients, as well as the imaging equipment used by the service. The result obtained was average height: 1.7 m; standard deviation: 0.1; average age: 64.4 y; standard deviation 10.7; agemax. 88.0 y and agemin. 37.0 y; average weight: 79.5 kg; standard deviation: 13.5. The typical values, based on the median of administered activity (MBq) distribution of ^{99m}Tc, on myocardial scintigraphy in the stress phase was 1,221.0 MBq and for the rest 407.0 MBq. Based on the results of the present study, we expect to encourage the establishment of an efficient routine for recording and organizing data in Santa Catarina. In addition, we would like to emphasize the benefit of optimizing the administered activities and radiation protection practices for population and individuals. Through studies like this one, we hope to contribute to the estimation of DRLs in NM in Brazil and to stimulate the creation of a culture of recording doses and activities; to help optimize the administered activities and the practices involved; as well as to contribute with the provision of data for the estimation of collective effective dose from NM examinations.*

Keywords: *Nuclear medicine, radiation dosage, references values, radiation protection*

1. INTRODUCTION

According to the United Nations Scientific Committee on the Effects of Atomic Radiation [1], nuclear medicine (NM) is part of the four categories of medical practice that involve exposure to ionizing radiation.

The percentage contribution of NM ionizing radiation exposure to the general population has been presented in several studies. One of these studies, a consortium of more than ten countries, showed the impact of medical exposure on the European population. NM was ranked among the five procedures that most contribute to the collective effective dose in the participating countries, corresponding to 5% of the total. Even though the collective effective dose is relatively small in the overall context, there are significant variations in the contribution of this parameter between countries, ranging from 0.4 to 14.5% [2].

The doses resulting from NM exams are derived from the administered activities to patients and are numerically very diversified, considering different diagnostic exams. This diversity can be attributed to the lack of procedures standardizing and technological resources for image acquisition, besides team miscommunication, etc. [3], [4].

Therefore, there is a need to optimizing the patient's dose while reducing the dose inconsistency and maintaining the required image quality for the diagnostic. Thereby, specific diagnostic reference levels (DRLs) for image examinations can be applied to several patients' groups, providing information necessary for optimizing the radiation protection methods [5], [6].

In ICRP, the term DRL was first introduced in Publication No. 73 to represent the typical doses received in radiological procedures and identify unjustified exposures. Since then, DRLs have been used

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to optimize the radiation protection, avoiding unnecessary radiation doses to patients [7], [8], [9].

Therefore, the DRLs implementation supports revising, controlling, reducing medical exposure levels, and consequently optimizing the radiation protection. Based on this information, initiatives to establish typical values of administered activities, local and regional DRLs become necessary. Typical values are used when the number of healthcare facilities is too small to allow a local DRL value to be determined, and can be defined for a single facility to act as a local reference for optimization processes, similar to local DRLs [14].

Thus, the aim of this study is to estimate the typical values DRLs resulting from complete myocardial scintigraphy procedures with ^{99m}Tc performed in a private service in the Southern region of Brazil.

2. Methods

This retrospective study collected data from 576 myocardial scintigraphies with ^{99m}Tc-sestamibi performed in 288 adult patients between August and December 2020. The myocardial scintigraphy was divided into stress and rest stages and named "one-day -protocol." Initially, data from 754 procedures of myocardial scintigraphies were provided; however, after organizing the data, 178 were excluded. The exclusion criterion was determined based on the available information in the exams. The excluded procedures presented incomplete information, such as patients who performed only one of the stages, repeated statements, and exams executed in equipment not addressed in this study. The exams were gathered from a Nuclear Medicine Service (NMS) of a private institution of imaging diagnostic in Santa Catarina - Brazil.

The images were acquired in SPECT equipment with two heads (detectors), manufacturer Philips model CardioMD, dedicated to cardiac protocols. For resting phase acquisitions, a matrix of 64x64 was utilized, 32 projections of 45 seconds each, non-circular orbit, without attenuation correction. For the stress phase acquisitions, a matrix of 64x64 was used, 32 projections of 40 seconds each, non-circular orbit, without attenuation correction.

The exam protocol for the resting phase can be described as follows: the administered activity to the patient is calculated by means of the Body Mass Index (BMI) and injected through venous access. The patient is oriented to drink water and walk for an interval of 30 to 60 minutes. Furthermore, the patient is positioned on the stretcher of the equipment in dorsal decubitus, and the image acquisition is initiated.

Related to the stress phase: the administered activity must be three times the injected activity in the first phase, not exceeding the total activity of 1,554.0 MBq. It is essential to highlight that a 2-hour interval between the two injections must be taken. Moreover, this second stage can be performed in 3 different ways:

- physical stress on the ergometric treadmill, where the activity is administered to the patient when the required heart rate is reached. The heartbeat rate is verified by means of ECG and sphygmomanometer under supervision of a cardiologist physician.
- pharmacological stress induced by dipyridamole, where the patient is positioned on the stretcher and receives an injection of dipyridamole during 4 minutes. From 3 to 5 minutes after dipyridamole injection finishes, radiopharmaceutical injection occurs. Aminophylline is administered 2 minutes after radiopharmaceutical injection for dipyridamole side effects.
- stress with dobutamine, where the patient is positioned on the stretcher, the injection of dobutamine is started through the infusion pump, and after the patient reaches the desired heart rate the radiopharmaceutical is injected.

After finishing the stress phase, the patient is advised to drink water and walk for an interval of 15 to 45 minutes. Then the patient is positioned on the stretcher of the equipment in dorsal decubitus with the left arm above the head and the detector as close as possible to the chest, the ECG is connected, and then the image acquisition begins. At the end of the exam, images are evaluated based on their quality by the radiology technologists and/or by the physician too. Depending on the exam quality, it is decided whether the patient needs to repeat some images or not. The images are then processed and reported, and the patient is released.

The present study was submitted and approved by the National Cancer Institute Ethics Committee (CAAE nº 29217520.7.0000.5274 in July 2021). Furthermore, the exams of a specific period were anonymized and collected from the procedures systems platform of the respective NMS.

Data as procedure type, radionuclide, date of examination, administered activity (Bq), patients' weight (kg), height (m), age (years), gender (m/f) were collected and organized in a spreadsheet (Excel®, Microsoft, 2021). Furthermore, a descriptive statistical analysis of the data was performed. Typical values (DRLs) were estimated for myocardial scintigraphy with ^{99m}Tc-sestamibi (during stress and rest phases) by calculating the median values of the patients' administered activity (MBq), as recommended by ICRP 135 [14]. The results were organized and analyzed as follows: characteristics of the sampled population [age (years), weight (kg), height (m), and BMI (kg. m-2)]; and typical values.

3. Results and discussion

Table 1 shows the general attributes of the study population, in total 576 procedures corresponding to 288 patients who performed stress and rest stages.

Table 1. Characteristics of the study population.

	Age (years)	Weight (kg)	Height (m)	BMI ($kg.m^{-2}$)
Min	37.0	46.0	1.4	18.2
Max	88.0	125.0	1.9	41.5
Mean	64.4	79.5	1.7	28.3
Standard deviation	10.7	13.5	0.1	4.0

There are several methods to estimate DRLs, such as those that use the median of the maximum and minimum administered activity, those that apply the P75 of the mean, or those that consider the P75 of the

interval of administered activities [4]-[10]. In this study, we chose to use the method based on the median value of distribution of the interval of administered activities, as used in some European countries [11], [12], because in Brazil, there are still no DRLs officially established by national regulatory bodies [13].

Table 2 presents the results for typical values of administered activities (MBq) for ^{99m}Tc-sestamibi in myocardial scintigraphy procedures, characteristics of the sampled population, equipment type, and image acquisition protocol.

Table 2. Estimated typical values of administered activities for the stress and rest stages.

	Administered activity [MBq]				
Procedural steps	Min	Max	Mean	SD	Median
Rest	370.0	518.0	405.6	0.8	407.0
Stress	962.0	1,665.0	1,245.3	3.1	1,221.0

*SD = standard deviation.

Although there are no DRLs officially established in Brazil yet, we compared the typical values of administered activities found with those DRLs published in another national study. In that study, the DRLs found for the same procedure were: 444.0 MBq for the rest phase and 1,110.0 MBq for the stress phase [4]. In comparison with our results, 407.0 ± 0.8 MBq for the rest and 1,221.0 ± 3.1 MBq for the stress, the typical values are similar to the DRLs values practiced in other services in Brazil.

This study presented some shortcomings: to analyze data from a single Nuclear Medicine Service in Santa Catarina; for this reason, the estimated DRLs are specific to this institution, although this sample could be used as an initial parameter. Therefore, they do not represent other NMS in Brazil. Moreover, data from a brief period (about five months) were analyzed due to the change in the recording procedure system at the clinic, changed from manual to automated form.

In further stages of this study, the period of the sampled data will be expanded to one year, as recommended by the ICRP.

4. Conclusion

The aim of the study was reached since we estimated and determined typical values of administered activities derived from myocardial scintigraphy procedures with ^{99m}Tc performed in a private service in the Southern region of Brazil.

Based on the results of the present study, the authors expect to encourage the establishment of an efficient routine for recording and organizing data in Santa Catarina. In addition, we would like to emphasize the benefit of optimizing the administered activities and radiation protection practices for population and individuals.

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