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Level of occupational exposure during daily work in a Nuclear Medicine Department

Nível de exposição ocupacional durante trabalho diário em um Departamento de Medicina Nuclear

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Abstract

Workers of the Nuclear Medicine Department have a very complex geometric exposition. The source of irradiation is not collimated and irradiated for all direction, the interaction with many structural tissue is inside the body before could be detected outside. The professional who works in a Nuclear Medicine Department is exposed to this condition and different energies. This work proposes a good approach to estimate the mensal dose level according to the dose rate during their daily routine. To measure the dose rate, a Babyline 81 ionization chamber was used, and the most frequent exams using ^{99m}Tc were chosen. A previous study was conducted to determine the most frequent exams made in the Nuclear Medicine Department at the Central Army Hospital in Rio de Janeiro, and previous environment monitoring determine the places with higher exposure that could interfere in the measurement of this paper. The Renal scintigraphy with diethylenetriaminepentaacetic acid (DTPA) had an average dose rate of (2.50±0.25) μSv/h; for the Renal scintigraphy with dimercaptosuccinic acid (DMSA), it was of (1.20±0.25) μSv/h; for Bone scintigraphy using two different protocols, it was (2.63±0.30) μSv/h and (3.09±0.30) μSv/h. Exposition during elution, dose preparing and clinical procedure was considered a critical moment in the daily routine of the employee. The dose rate obtained in this study demonstrated that the professional cannot exceed the public dose limit in one day of his work routine. Therefore, for the Radioprotection Department, this is a good approach to make a radioprotection plan in the Nuclear Medicine Department.

Keywords: nuclear medicine, dosimetry, professional, dose rate.

Resumo

Os profissionais do Departamento de Medicina Nuclear têm uma exposição geométrica muito complexa. A fonte da irradiação não é colimada e irradiada para todas as direções, a interação com os diversos tecidos estruturais é feita dentro do corpo antes de poder ser detectada na parte de fora. O profissional que trabalha no Departamento de Medicina Nuclear está exposto a essa condição e a diferentes energias. Este trabalho propõe uma boa abordagem para estimar o nível de dosagem mensal de acordo com a taxa de dose durante sua rotina diária. Para medir a taxa de dose, utilizou-se uma câmara de ionização Babyline 81, e os exames mais frequentes que utilizam ^{99m}Tc foram escolhidos. Um estudo anterior foi realizado para determinar os exames de maior frequência feitos no Departamento de Medicina Nuclear do Hospital das Forças Armadas Central, no Rio de Janeiro, e o prévio monitoramento do ambiente determina os locais com maior exposição que poderiam interferir na medição deste trabalho. A cintilografia renal com ácido dietileno triamino penta-acético (DTPA) tinha uma taxa de dose média de 2,50±0,25 μSv/h; a cintilografia renal com ácido dimercaptosuccínico (DMSA), de 1,20±0,25 μSv/h; e a cintilografia óssea, utilizando dois protocolos diferentes, de (2,63±0,30) μSv/h e (3,09±0,30) μSv/h. A exposição durante a eluição, a preparação da dose e o procedimento clínico foi considerada um momento crítico na rotina diária do funcionário. A taxa de dose obtida neste estudo demonstrou que o profissional não pode exceder o limite de dose público em um dia de sua rotina profissional. Portanto, para o Departamento de Radioproteção, esta é uma boa abordagem para criar um plano de radioproteção no Departamento de Medicina Nuclear.

Palavras-chave: medicina nuclear, dosimetria, profissional, taxa de dose.

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Introduction

The Nuclear Medicine Service uses to carry out its examination a radionuclide that is chemically added to a compound able to bind to the cells, forming the organ to be examined, showing images of its physiology and in some cases its anatomy[1,2]. The Tecnecium-99m (^{99m}Tc) is the most commonly used radionuclide in the Nuclear Medicine Service because it has a half-life of 6.02 hours and an emission of a single photon of 140.0 keV, allowing a lower dose to the patient during the exam and a better image quality[3,4].

Several studies have been made about the quality of radiopharmaceuticals administered to patient considering dose levels administered, precision of activity measurements and contamination by Molybdenum[5]. These dosimetric indices are related to the patients and people accompanying the examination of Nuclear Medicine and their radiological protection levels[6-9], but are not enough to infer the doses received by the professional involved in Nuclear Medicine Service. Furthermore, literature is sparse on reports dose rate received by professional that handle radioactive sample in the Nuclear Medicine Service. For a more accurate dosimetric evaluation, it is necessary to know the workers exposure in each stage of the daily proceedings[9-13].

Literature reports two strategies to determinate the dose received by nuclear medicine professionals. One of them is based on dose rate measurements at a fixed reference distance of patient and determining the time that the professional remains at this distance. Other methodology is the direct reading of personal electronic dosimeters during the nuclear medicine procedures. In this study, a review of the professional procedures in Nuclear Medicine Service is presented to conduct an assessment of dose rate during the various exams stage, aiming to decrease the dose received by workers in Nuclear Medicine Service.

The determination of the absorbed dose for the professional in each procedure in a Nuclear Medicine Service is complex and involves individual conductions evaluation during all nuclear medicine exam procedure, because we must examine the individual conduct of the professional to determine which employee routine is more hazardous. The purpose of this study was to conduct an assessment of dose rate during the various stages of examination, as well as a review of the procedures of the legal profession service[14,15], aiming to decrease the dose received by workers.

Material and methods

The survey was conducted at a Nuclear Medicine Department of Army Hospital in Rio de Janeiro. Four professionals were monitored during four months. For this monitoring, it was used the personal dosimetry and an ionization chamber model Babyline 81, of the manufacturer Eurisys Measures[16].

For data acquisition during the examination, the detector was positioned at 1.0 m away from the gantry of camera range and 0.8 m from the ground, normally in gonads region. The choice of this height is due to the fact that the gonads region are at a parallel height to the patient during the examination, the bladder of the patient retains most of the radioisotope[17] that was not added to the previous made to determine the relationship of the measurement at a height of 0.8 m and the height of 1.50 m, average height of the personal dosimeter in Brazil[18], to compare with other studies.

The protocol for bone scintigraphy at Department was the administration of 1110.0 MBq of ^{99m}Tc-MDP (^{99m}Tc-Metilnodifosforico Acid)[19,20], intravenously, waiting 3 hours for the complete fixation of radiopharmaceutical. The Department used two different protocols: a) Protocol 1 - the image can be obtained using a fixed counts value and a variable time acquisition; and b) Protocol 2 - the time of acquisition was fixed and the counts value was variable. In order to acquisition dose rate during the exam, we made 3 readings in each body section at each one minute during all examination for each protocol.

We measure the dose rate during the exam of flow bone, a previous exam for bone scintigraphy. For this, each acquisition data was made in a time interval of 15.0 s, and the ionization chamber was positioned close to the technician.

The dynamic evaluation of the kidney is made using the ^{99m}Tc-DTPA (^{99m}Tc-Dietilenotriaminopentactico Acid)[21,22]. For measurement, we decided to realize the reading of the dose rate at intervals of 2.0 min during the exam realization. The protocol used by the Service is an average administered activity of 407.0 MBq[23] and 40.0 min for acquisition time.

Kidney anatomic evaluation is made using 99mTc-DMSA (^{99m}Tc-Dimercapto Succinic Acid)[24], using an average activity of 296.0 MBq and a waiting time of 5.0 h[23]. The exam made is one static image for each gantry angle (0º, 180º, 135º and 225º), and we made three measurements for each gantry angle.

Measurement inside manipulation room was made to determine the levels of exposure. For this, we choose acquisition data during all process of radiopharmaceutical preparing. The measurement was made in five phases: background levels before manipulation and after all process, during generator $^{99}Mo/^{99m}Tc$ elution, during radiopharmaceutical preparing and activity separation to be administered to the patient.

To make this measurement, the detector was positioned at 0.80 m from the ground and 1.60 m from the table of manipulation. This distance was necessary because the readings should be taken during the proceedings without interfering in the routine and to minimize the scatter. Data was obtained in five readings in each 15.0 s in each stage of the process, and all readings were corrected[25].

All rooms of the Nuclear Medicine Service were monitored by radiometric survey, using an ionization chamber and an isotope identifier[26]. These values were used to determine the regions to be monitored and the factors that could influence the measures during this work.

Results

Bone scintigraphy

As mentioned, the analysis to the bone scintigraphy was done in two phases. The first phase is the measurement of bone flow, and the second phase is the study of two image protocols used by the medical team.

In the flow bone phase, the professional who have more exposition to the source is the nurse, responsible for administer the radiopharmaceutical to the patient. Five procedures were observed, and the average value of dose rate was (5.17±0.52) μSv/h and the time of stay was 15.0 min. In this case, all measurements were made with a fixed position of the professional during the job, being possible to calculate the absorbed dose.

Professional uses the protocol 1 to make our image normally using an average activity of 1417.1 MBq, resulting in a dose rate of (2.63±0.26) μSv/h and an average time of acquisition of 66.3 min. To be used protocol 2, the average activity administered was 1369.0 MBq, resulting in an average dose rate of (3.09±0.3) μSv/h and a total time of image acquisition of 42.6 min. In both protocol, the professional remains 16.0 min in a distance less than 1.0 m from the patient.

Renal scintigraphy

In exams of renal scintigraphy with DTPA, the average activity administered was 444.0 MBq and the average dose rate was (2.55±0.25) μSv/h, time of image acquisition was 37.0 min and 16.0 min of this time the professional remains less than 1.0 m from the patient.

In renal scintigraphy with DMSA, the low activity administered to the patient, 45.0 MBq, result in a low professional exposure, than the average dose rate was (1.20±0.12) μSv/h. The duration of exam was 18.4 minutes and 8.0 min of this time the professional stay less than 1.0 m from the patient.

Levels of background radiation

During the procedures inside the room, the technician handles the source to measure its activity and prepare the radiopharmaceutical. The range of dose rate in which the activity is submitted during measurement is 15.5-5.5 μSv/h, and for radiopharmaceutical preparing is 35.0-15.0 μSv/h.

Figure 1 shows a comparison between the levels of background radiation in two weeks studied, demonstrating the difference between manipulators and theirs performance during the same active manipulated.

Discussion

For bone scintigraphy, dose rate was 2.63-5.17 μSv/h. Gomez-Palacios et al.[12] find for the same condition dose rate of 3.5-8.8 μSv/h, demonstrating great agreement between studies using the same irradiation geometry. This conclusion is possible considering that Chiesa et al.[10] find for the same exam the accumulate dose of 0.3 μSv, and, if we calculate the accumulate dose using ours methodology, we find values between 0.87-1.03 μSv. This difference is explained, because in this article the authors used a fixed detector in the professional and the personal still in movement, so all radiation were not detected.

For the comparison between protocol 1 and 2, the radioprotection service could not say which protocol have better image, but the value of dose rate in protocol 2 is highest than in protocol 1. However, in this work is not possible to study new Protocols, in which the machine chose a better protocol to be used. Probably, new machines reduce the exposition time of the professional, because reduce the time with patient contact.

Results for renal scintigraphy with DTPA show similarity of results obtained by Chiesa et al.[10]. The dose rate observed was (2.55±0.25) μSv/h, but this value could be modified

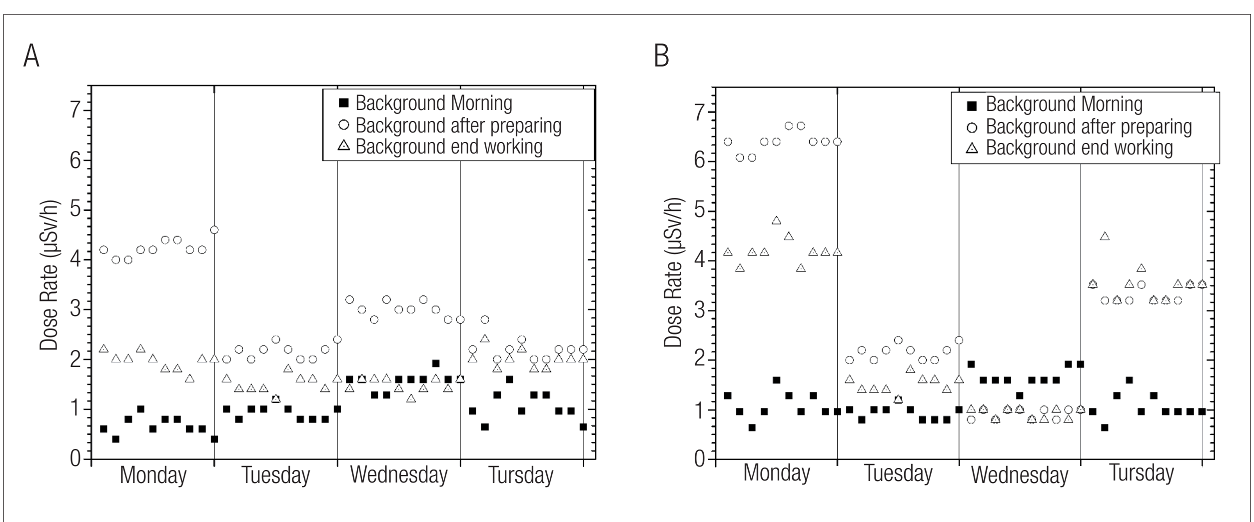

Figure 1. Difference between manipulators and the results at background levels. The graphic (A) demonstrates the performance of technician A and graphic (B) demonstrates the performance of technician B.

during the time of exam, because in this kind of exam the patient need leave the room before to finish all image and return to finish the sequence of image, and this difference results in a decrease of the dose rate of ±0.3 μSv/h. The dose rate for renal scintigraphy with DMSA was (1.20±0.12) μSv/h. This is the exam with the lowest level of dose rate find in this work and other papers, like Chiesa et al.[10] and Mountford et al.[9].

The background levels measured in the manipulation room may contribute to the adoption of safe practice. In the study of Smart[13], it was demonstrated using a pocket GM-tube dosimeter that preparing the radiopharmaceutical to administration is the third higher exposure time during the daily routine of the technician. This is demonstrated in the Figure 1 and it is possible observe in each procedure of the radiopharmaceutical preparation which one have more probability to higher radiation exposure.

We observe from the numeric difference that two different manipulators work in the same area with the same activity and result in different background levels in the room. The lower level is the result of using all radioprotection shields; the source is exposed only for a little time. The sources no shielded kept under the metallic structure for ventilation increase the background levels, which results in radiation interaction, causing a greater spread inside the room. An easy way to solve this problem is to keep all possible sources shielded.

Conclusion

This study contributes to the professional responsible for the radioprotection service to be able to implement a plan of radioprotection based on numerical values. The results demonstrated that the probability of the nuclear medicine professional receiving in a single day of work more than the limit dose for the public is negligible.

The highest potential dose for the professional in a daily work is separate by function: for the nurse, the highest exposure is during radiopharmacy administration to the patient; for the technician, the highest exposure occurs during the radiopharmacy preparing; and, for the radiologist, the highest exposure is during the patient interview after the exam.

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