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Development of a simulator with thyroid nodules for nuclear medicine

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Nuclear medicine is one of the methods used to diagnose diseases by the use of ionizing radiation. In this method, a radioisotope is injected into the patient and is directed to the body that should be evaluated. After this the patient is examined by a scintigraphic chamber, which will result in an image to view the organs evaluated. To verify the ability to view the chambers are made of quality control tests using simulators with objects that may have characteristics similar to that of human organs and systems. In this work, an object was made of acrylic thyroid simulator used for quality control in scintillation chamber for use in teaching morphological analysis of the thyroid. To simulate the thyroid nodules were included in the simulator of acrylic columns with different diameters. The analysis of thyroid scintigraphy was also used for quality control tests. These tests were conducted in scintigraphic chamber GE Millennium MG. In quality control was verified the spatial resolution of the equipment. The radiopharmaceutical used was ^{99m}Tc. The phantom image was closer to an image with the presence of thyroid nodules. The simulator thyroid tested in this work can now be used for quality control tests in other scintillation chambers, enabling students and professionals in nuclear medicine know more about the objects simulators.
Keywords: Nuclear medicine, quality control, phantom.

A medicina nuclear é um dos métodos usados para diagnosticar doenças através da utilização de radiações ionizantes. Neste método, um isótopo radioativo é injetado no paciente e é direcionada para o corpo que deve ser avaliado. Depois disto o paciente é examinado por uma câmara de cintilografia, que irá resultar em uma imagem para ver os órgãos avaliados. Para verificar a capacidade de visualizar nas câmaras são feitos os testes de controle de qualidade utilizando simuladores com objetos que podem ter características semelhantes dos órgãos e sistemas. Neste trabalho, foi desenvolvido um objeto simulador de tireóide acrílico usado para controle de qualidade em câmara de cintilação para uso no ensino de análise morfológica da tireóide. Para simular os nódulos da tireóide foram incluídos no simulador, nódulos de acrílico, com diâmetros diferentes. A análise da cintilografia da tireóide também foi utilizada para testes de controle de qualidade. Estes testes foram realizados em câmara cintilográfica GE Millennium MG. No controle de qualidade foi verificada a resolução espacial do equipamento. O radiofármaco utilizado foi o ^{99m}Tc. A imagem do phantom era mais perto de uma imagem com a presença de nódulos da tireóide. O simulador de tireóide testados neste trabalho podem agora ser usado para testes de controle de qualidade em outras câmaras de cintilação, permitindo que estudantes e profissionais em medicina nuclear possam saber mais sobre os simuladores de objetos.
Palavras-chave: Medicina nuclear, controle de qualidade, phantom.

1. INTRODUCTION

There are several methods for diagnosing diseases and to treat them. In some methods the ionizing radiation is widely used. As examples of this, the conventional radiology, the mammography, computed tomography (CT) and nuclear scintigraphy in nuclear medicine (NM) can be cited. The first three methods mentioned are used an external source of X-radiation beam generated by the X-ray machine to obtain the image of the organ been studied. On the other hand, in nuclear medicine the source of radiation ionizing is incorporated by the body to acquire images of the region of interest through the gamma cameras.

Procedures for diagnosis in nuclear medicine use pharmaceuticals emitters of gamma radiation that have been labeled with radionuclides (radiopharmaceuticals). These pharmaceuticals are administered to patient and the radiation emitted is detected. To thyroid scintigraphy it is used a capsule or liquid containing the radiopharmaceutical Iodine. The thyroid captures more iodine than other parts of the body, so that it can be analysed by means of the image produced by the detection of radioactive emissions.

The most used gamma radiation emitting radionuclides in nuclear medicine are the technetium-99m, iodine-123, iodine-131, indium-111, gallium-67, samarium-153 and thallium-201. After administration of the radiopharmaceutical, the patient is examined by a scintillation camera (gamma camera), which is a device capable of detecting the radiation emitted by the patient and of convert it as an image that represents the body or region evaluated [1].

Through the detection of gamma rays that are emitted by the disintegration of the radionuclide in the body it is possible to know the concentration of radioactive material in different organs, thereby obtaining information on the morphology and physiology of organs such as mapping of the liver, the kidneys, thyroid and cardiovascular system [2] .

With the scintigraphic images it is possible to detect physiological abnormalities. If the part of the body investigated is the thyroid, the anomalies that can be viewed are the nodules. The ideal case is that the large and small nodules can be viewed, so that they can be diagnosed at an early stage, allowing a more efficient and rapid treatment of the patient.

To verify the ability of visualization of the gamma chambers must be made quality control tests using phantoms. The phantoms can be objects made of materials with properties similar to that of a particular organ of interest, such as volume, size and density. These objects can too simulate some anomalies diagnosed in certain organs. The organs most simulated in nuclear medicine are heart, kidney and thyroid [3].

Phantoms are used also in NM to evaluate the performance of collimators, calibration, physical parameters reconstruction, lesions delectability in image, volume sensitive, and other parameters. The quadrant bar phantoms and flood phantom are used to display and distinguish objects with different spatial frequencies for each collimator of the scintillation camera and analysis of the field uniformity (using a flood and a bar). The Jaszczak phantom has insertions of different sizes to simulate the radiopharmaceuticals absorption and to evaluate various conditions on a separate system of tomographic images [4, 5]. Besides these, there is the Rollo phantom that is used for verification of contrast and spatial resolution of the camera; brain phantom, such as 3-D Hoffman Brain Phantom; cardiac phantom (ECT phantom Kyoto); Picker type thyroid phantom [6]. Some simulators can also function like a dosimeter when carry off materials that can measure the absorbed dose, as termoluminescentes detectors or special polymer gels [7-12]. Some simulators such as the Jaszczak phantom are efficient for use in quality control procedures of planar and tomographic scintillation cameras [5].

Other authors are researching about phantoms and their applicability. Andrade et al. [13] developed a thyroid phantom to validate the use of iodine -123 in determining the ability of iodine uptake by the thyroid. In their work, the concern of the researchers was to eliminate possible sources of error because the substitution of the use of iodine -131 by iodine-123 in the study of thyroid gland diseases. Currently, the protocols of study of thyroid function tend to change with the availability of iodine -123, which is an isotope that allows improvement in image quality and quickness of obtaining results and analysis. Another advantage in the replacement is related to the half -life of iodine-123, which is 13 hours, considerably lower than that of iodine-131, which is 8 days [14].

In most cases, the thyroid scintigraphy is performed using technetium-99m, because the image quality is superior and provides a lower dose of radiation to the patient compared to that with an iodine-131, due to their physical characteristics (energy more lower and shorter half -life of 6 hours) and it is sufficient to evaluate the functionality of the thyroid nodules.

In this work was developed, with low financial cost, a thyroid phantom for quality control of scintillation cameras in nuclear medicine. The object contains thyroid nodules of varying sizes that allow assessing image quality parameters obtained by the cameras and to the practical exercises for professionals.

2. MATERIALS AND METHODS

The phantom was built using acrylic, with sides of 10 cm and height of 11 mm. The inside acrylic volume it was molded with the geometry of a thyroid. The representative thyroid volume is 31 mL. In order to simulate nodules that do not have the capacity to capture radioactive material, it was used in the thyroid volume three of acrylic columns with diameter of 3.5 mm, 5 mm and 8 mm, respectively. Acrylic was chosen as material to form the phantom because it presents density close to the human body (d acrylic = 1.19 g/cm^3; d human body ≈ d water = 1g/cm3) [17]. Figure 1 shows a photograph of the phantom built for us; to better visualization the object was filled with water mixed with a blue colorant.

Figura 1: Image of the thyroid phantom with three nodules.

The phantom filled with water was submitted to a series of evaluations, including observation of condition of leakage. After that it was approved and validated by the team that is developing the object and a radiation protection supervisor from the nuclear medicine institution. To evaluate the functionality of this object simulator were carried out three tests of quality control in a scintillation camera GE MILLENNIUM MG, belonging to a nuclear medicine service of Aracaju, SE Brazil. Technetium-99m was used in these tests. In the first test we used a sample of 37 MBq; in the second one 17 MBq and the third, a sample of 9.25 MBq. After each test it was monitoring procedures of standing still images in order to evaluate the spatial resolution of the scintillation camera.

3. RESULTS AND DISCUSSION

At the tests performed using the radioactive samples specified above, it was not possible to visualize the nodules (cylindrical columns) of 3.5 mm and 5.0 mm due to the reduced diameter of these artefacts. The areas of cross section of these cylindrical columns are smaller than the spatial resolution of the camera. Figure 2 shows the image of the phantom with thyroid volume filled with a sample of 9.25 MBq.

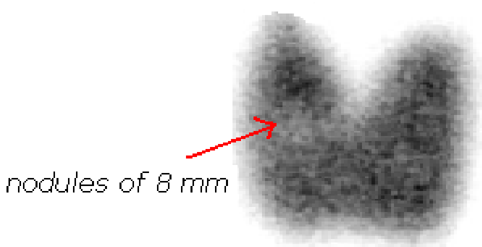

Figura 2: Image of the thyroid containing nodules of acrylic.

The nodule that could be observed in the image obtained of the filled phantom has a diameter of 8.0 mm. Thus it appears that the simulation of nodules can be made through the acrylic columns with a diameter from 7.9 mm because it is the diameter of the nail thinner of the Jascszak phantom which can be observed in test of spatial resolution of tomographic scintillation camera. The results of the simulations performed with the thyroid phantom showed uniformity in the images for all radionuclide activities, a homogenous distribution of activity in the volume, absence of artefacts and good spatial resolution tomographic. In future, new tests may be performed, such as analyses of the equipment sensitivity and the density counts when the phantom volume will be changed.

4. CONCLUSIONS

The quality control tests performed in the scintillation camera using the thyroid phantom developed by us allow the production images similar to a human thyroid. It was possible through the phantom images evaluate the resolution of the camera. The equipment acquired could produce an image of the nodule of 8mm, which has the same dimension of the spatial resolution tomography. Therefore, the results have proved satisfactory to development of a low cost thyroid phantom.

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