EVALUATION IN THE USE OF BISMUTH SHIELDING ON CERVICAL SPINE CT SCAN USING A MALE PHANTOM

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Abstract

The cervical spine is the region of the column that articulates the head and chest. The tests of computed tomography (CT) performed in this region have as main objectives to diagnose fractures, dislocations and tumors. In CT scans the cervical spine volume is limited by the foramen Magnum and the first thoracic vertebra. In this region is the thyroid that is directly irradiated by X-ray beam during cervical scan. Based on this information, it was studied the dose variation deposited in thyroid and in nearby organs, such as: lenses, spinal cord in the foramen Magnum region and breasts, with and without the use of bismuth protector. In this study was used a male anthropomorphic phantom and thermoluminescents dosimeters (TLD-100) were required to register the individual doses in the organs of interest. CT scans were performed on a GE Bright Speed scanner of 32 channels. With the data obtained, it was found the organ dose variation. The largest recorded dose was in the thyroid. Comparing two scans it was possible to note that the use of the bismuth protector promoted a 26% reduction in the thyroid dose and an increase in the lens dose.

1.- INTRODUCTION

The Computed Tomography (CT) was considered a revolution for the medical diagnosis. Today, it is a very fast test that can be performed high quality images. However, CT may be associated with a high radiation dose to organs such as the thyroid, lens, breasts and spinal cord, when compared with conventional radiology. Several approaches based scanners have been used to significantly reduce the radiation dose of CT, but many of the resources used are implemented only in newer scanners and therefore are not available for a significant portion of the installed base of scanners today [MOURÃO, 2007; COAKLEY, 2011].

Based on this information, the use of bismuth shield aims to decrease the radiation dose absorbed in the organs, especially the thyroid which is a radiosensitive organ. Absorbed doses of radiation in the neck area can cause different kinds of disorders, with excessive or deficient hormone production, resulting in hyperthyroidism and hypothyroidism, or in addition, to being able to generate tumors [SHRIMPTON, 1998; WANG, 2012] .

2.- MATERIALS AND METHODS

The CT scans were carried out in a scanner GE Bright Speed model, with 32 channels. Thermoluminescent dosimeters were positioned in a male phantom, Alderson Rando model, to record the absorbed doses in specific organs.

2.1.- Thermoluminescent dosimeters

Rod shape LiF:Mg,Ti (TLD-100) TL dosimeters and a TL reader, model Harshaw 5500, were used to the measurements. The standard pre-reading (1 h at 400 °C followed by 2 h at 100 °C) heat treatment and post-reading of 10 min at 100 ^{o}C were adopted for TL dosimeters. The heat treatment was read at the reader with a range 50-300 ^{o}C for 26.6s. The metrological reliability of the TL system was trough demonstrated reproducibility and homogeneity of the batch tests and by calibrating it in a reference radiation for tomography (RQT9) were reproduced in the Calibration Laboratory of the Center of Nuclear Technology Development (CDTN/CNEN) [GOLDMAN, 2007].

A set of pre-selected dosimeters, with 7.5% reproducibility and 20% homogeneity was calibrated in terms of absorbed dose to air, on a beam range of ^{137}Cs in electronic equilibrium conditions. The calibration resulted in individual coefficients, varying in a range of 21.30 to 27.60 μGy.nC^{-1} for the entire batch of dosimeters. Figure 1 shows an image of the TL dosimeters. To obtain each dose measurement were used three dosimeters. The background dose was recorded, and this value was reduced by each organ dose measured [HARSHAW, 2003].

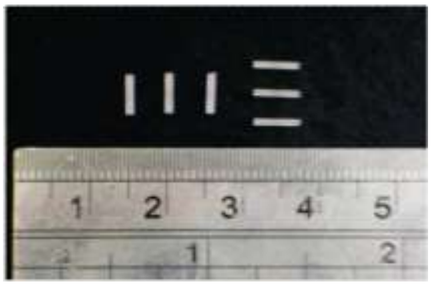

Figure 1. Image of Thermoluminescent dosimeters, rod model.

2.2.- The male phantom

To perform the neck CT scans am male anthropomorphic phantom, Alderson Rando model was used. This phantom is composed of a human skeleton surrounded by a material, physically and chemically similar to the soft tissues of an adult human body. The torso and head are structured into slices and 2.5cm thick. The slices that make up the body phantom have holes that allow placing dosimeters within the phantom. Fig. 2 presents the positioning of the male phantom in the isocenter of the gantry [REYNALDO, 2009; STANISZEWSKA, 2005].

Figure 2. Positioning of the male phantom in the gantry isocenter.

2.3.- The neck scans

Two neck CT scans using the same routine protocol to the cervical spine, with and without the use of a bismuth thyroid shielding, were made. The technique for obtaining images of the cervical spine in scans of the neck is a volume limited by the foramen magnum and the first thoracic vertebra. The protocol used in both neck scans is presented in Table 1.

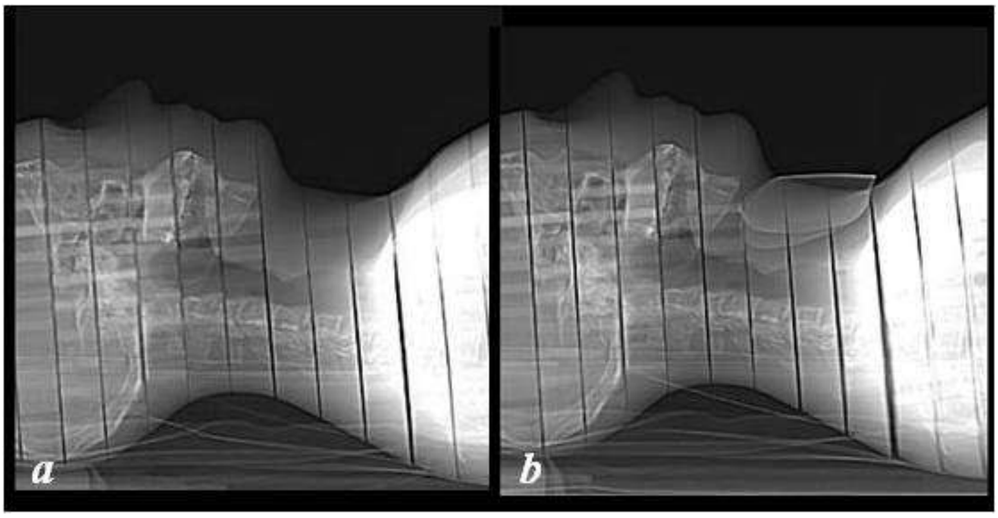

Figure 3. Topogram side of the neck: (a) without and (b) with bismuth shielding.

Table 1.- Scan Parameters.

Voltage (kV)	Electric current (mA)	Time (s)	Pitch	Distance (mm)	Thickness (mm)
120	10	1	0.938	170	10

The dosimeters were used to record specific doses inside the phantom, positioned in the lens, thyroid, spinal cord - nearby the foramen magnum, and in the breasts. The Fig. 3 presents the scout images, without (*a*) and with (*b*) bismuth thyroid shielding.

3.- RESULTS

The Table 2 shows the recorded doses in the lens, the thyroid, spinal cord nearby the foramen magnum region, and breasts. These results allow us to observe that the use of bismuth shield led to a decrease in radiation dose deposited in the thyroid, but increased the energy deposited in the lens.

Table 2.- Absorbed Dose (mGy)

Organ	Shielding	
	Without	With
Right lens	5.24±0.12	7.63±0.38
Left lens	5.18±0.23	7.72±0.50
Thyroid	33.07±0.2	25.35±1.07
Spinal cord	21.98±0.19	22.42±0.49
Right breast	0.42±0.02	0.49±0.02
Left breast	0.45±0.04	0.41±0.03

4.- DISCUSSION

The two scans were acquired with the same acquisition protocol, as shown in Table 1. Comparing the recorded doses in the scan with and without bismuth shielding respectively, it is possible to observe that there was a reduction of the deposited dose in the thyroid and a small increase in the lens doses. The dose measurement in the posterior region of the phantom, in the spinal cord nearby the foramen magnum, there wasn't a considerable dose variation, as well as in the breasts.

The decrease in thyroid dose was desired due to the use of bismuth shielding. However, the increasing the dose in the crystalline happens possibly due to an increase of scattered radiation at the anterior region of the phantom caused by the use of the bismuth shielding. The graphic showed in the Fig. 4 allow observing the organ dose variations.

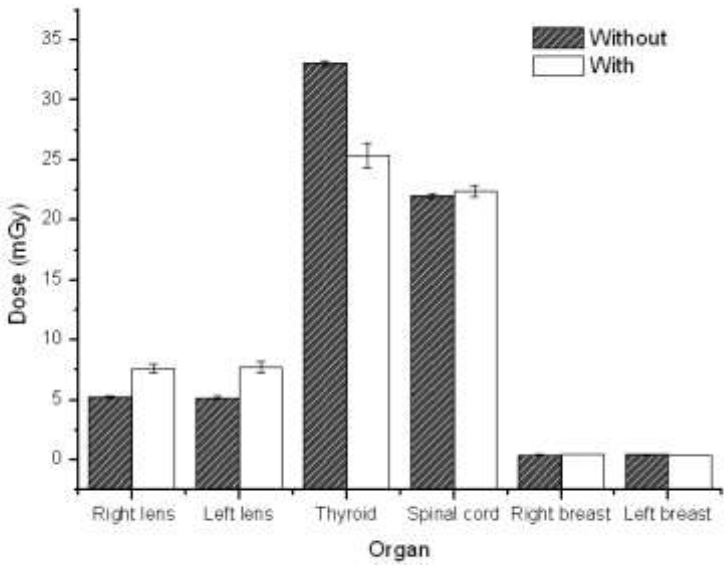

Figure 4. Organ doses recorded, with and without shielding.

5.- CONCLUSIONS

The use of bismuth thyroid shielding promoted a reduction of the dose of radiation deposited in the thyroid. As the conditions used for both scans were the same, it can be observed that there was no significant change in the dose in the posterior region of the object, considering the volume where happens the direct incidence of the beam. The measurement of the scattered radiation breasts not promoted considerable variation in deposited dose. However, the use of shielding promoted a small increase in lens doses, i.e. an increase of scattered radiation in the anterior head area. Future experiments should verify whether this increase is reproduced. The analysis of the image quality should be observed for region of interest: cervical column and soft tissue of the neck.

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