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# Comparative Study of Procedures to Reduce Organ Dose in Neck CT Scans using Bismuth Shielding

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## 1. Introduction

Computed Tomography (CT) has been one of the most widely used tests for radiological diagnosis in medicine. The increase of CT tests is a global concern due to high doses of radiation in diagnostic tests. The dose evaluation in CT is one of many steps that may contribute to reducing patient doses [1]. The neck CT scans are commonly used for diagnosis of soft tissue, vascular changes, fractures, extent of injuries, dysplasia and other diseases with instability. A neck CT scan are performed from the occipital to the first thoracic vertebra, irradiating several radiosensitive organs, such as thyroid, eyes, and bone marrow. These organs are regarded to have greater stochastic risk for injury and future malignancy, especially with cumulative doses [2]. The aim of this work is to compare the reduce absorbed dose in the neck CT scan, with the use of bismuth shielding using a male anthropomorphic phantom in two different CT equipments.

## 2. Methodology

The experiment to observe the dose reduction due to the use of bismuth shielding was conducted by made a comparison of CT scans, using the standard neck positioning. CT neck scans were done on a GE CT scanner, LightSpeed model, with 64 channels (CT1) and a Toshiba CT scanner, Prime Aquillion model, with 80 channels (CT2). A CIRS ATOM 701 male anthropomorphic phantom model was used in neck CT scans. This phantom is composed by different materials to represent the human skeleton and others internal organs using materials physically and chemically similar to soft tissues of an adult human body [3]. The phantom's body is divided into slices with 2.5 cm thick. In the phantom's slices there are openings to place dosimeters [4, 5, 6]. Fig. 1 shows the positioning of the phantom in the gantry isocenter without and with bismuth shielding on the neck.

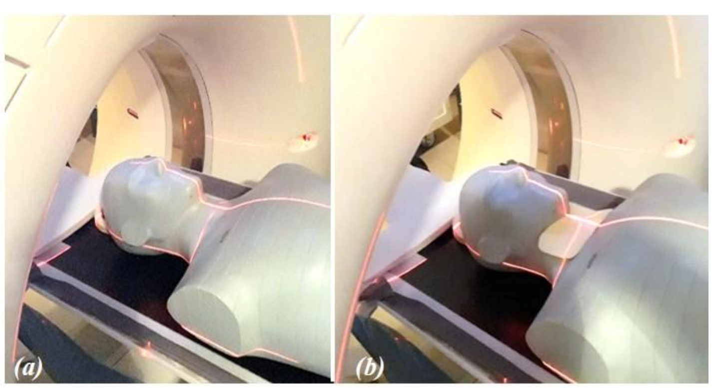


Figure 1: Phantom positioning in the gantry: without (*a*) and with bismuth shielding on the neck (*b*).

The parameters of the acquisition protocol used in this study are shown in Table 1.

Table I: Neck CT scan parameters.

| Scanner | Voltage (kV) | Electric current (mA) | Tube time (s) | Pitch | Distance (mm) | Thickness beam (mm) |
|---|---|---|---|---|---|---|
| CT1 | 120 | 175 | 0.8 | 0.984 | 200 | 40 |
| CT2 | 120 | 100 | 0.5 | 0.813 | 200 | 40 |

Radiochromic film strips were used to evaluate the punctual doses in organs such as thyroid, lenses, hypophysis, spinal cord, breasts, salivary and parotid glands. The Fig 2. shows the axial cervical CT images with and without a 1 mm thick piece of bismuth shielding on the phantom.

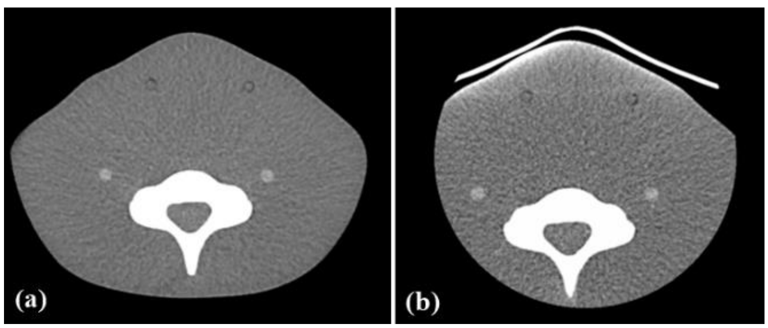


Figure 2: Axial neck CT images: without (*a*) and with bismuth shielding (*b*) on the neck.

Metrological reliability of the radiochromic films was demonstrated through homogeneity and repeatability tests and by calibrating it in a reference radiation for CT (RQT9) that were reproduced in the Calibration Laboratory of the Development Center of Nuclear Technology (CDTN/CNEN) [7].

## 3. Results and Discussion

Absorbed doses and standard deviation in the organs positions such as: thyroid, lenses, pharynx, hypophysis, breast, spinal cord in cervical area, parotid and salivary glands are shown in Table 2. These results allow us to observe that the use of bismuth shield led to a decrease in radiation dose deposited in the neck and all organs studied in both CT equipments.

Table 2: Average absorbed dose of the organ positions in the phantom during a neck CT scans with and without the use of bismuth shielding.

| Organ position | Absorbed dose (mGy) | | | |
|---|---|---|---|---|
| | Without bismuth shielding | | With bismuth shielding | |
| | CT1 | CT2 | CT1 | CT2 |
| Eye Lens | 2.40 ± 0.66* | 8.62 ± 0.69 | 1.79 ± 0.51 | 3.29 ± 0.66 |
| Hypophysis | 12.89 ± 0.63 | 7.85 ± 0.88 | 12.35 ± 0.66 | 3.94 ± 0.78 |

| | | | | |
|---|---|---|---|---|
| Pharynx | 24.23 ± 0.79 | 12.29 ± 0.78 | 23.12 ± 0.89 | 11.47 ± 0.71 |
| Spinal Cord | 15.91 ± 0.89 | 11.16 ± 0.62 | 15.89 ± 0.79 | 10.05 ± 0.72 |
| Parotid Gland | 21.61 ± 0.75 | 7.16 ± 0.67 | 19.64 ± 0.59 | 4.49 ± 0.68 |
| Salivary Gland | 21.60 ± 0.62 | 17.32 ± 0.65 | 20.53 ± 0.68 | 13.52 ± 0.75 |
| Thyroid | 28.36 ± 0.98 | 31.36 ± 0.96 | 19.46 ± 0.82 | 13.71 ± 0.69 |
| Breast | 2.40 ± 0.67 | 1.82 ± 0.51 | 1.79 ± 0.66 | 1.31 ± 0.53 |

*Standard deviation

The absorbed doses varying from 1.32 to 31.36 mGy. The highest dose of 31.36 mGy happens in the thyroid without bismuth shielding in the CT2 and it was 13.71 mGy with the use of bismuth shielding obtained a dose reduction of 56.28%. In CT1 the absorbed dose in the thyroid without bismuth shielding were 28.36 mGy and 19.46 mGy with the use of bismuth shielding obtained a dose reduction of 31.38%. The doses were lower with the use of bismuth shielding for all organs, mainly in the thyroid. It is expected that thyroid shielding would degrade image quality and would increase the image noise, however the result of this work suggests that it might be an acceptable procedure to be used for dose reduction mainly during CT examinations that would provide high doses to radiosensitive organs. The analysis of noise in the image of the neck central slice presented acceptable values for soft tissues, less than 1%. The use of bismuth shielding is simple and efficient to reduce absorbed doses to the thyroid and nearby organs. The graphic showed in the Fig. 3 allow to observe the influence of bismuth shielding on absorbed doses in the organs studied.

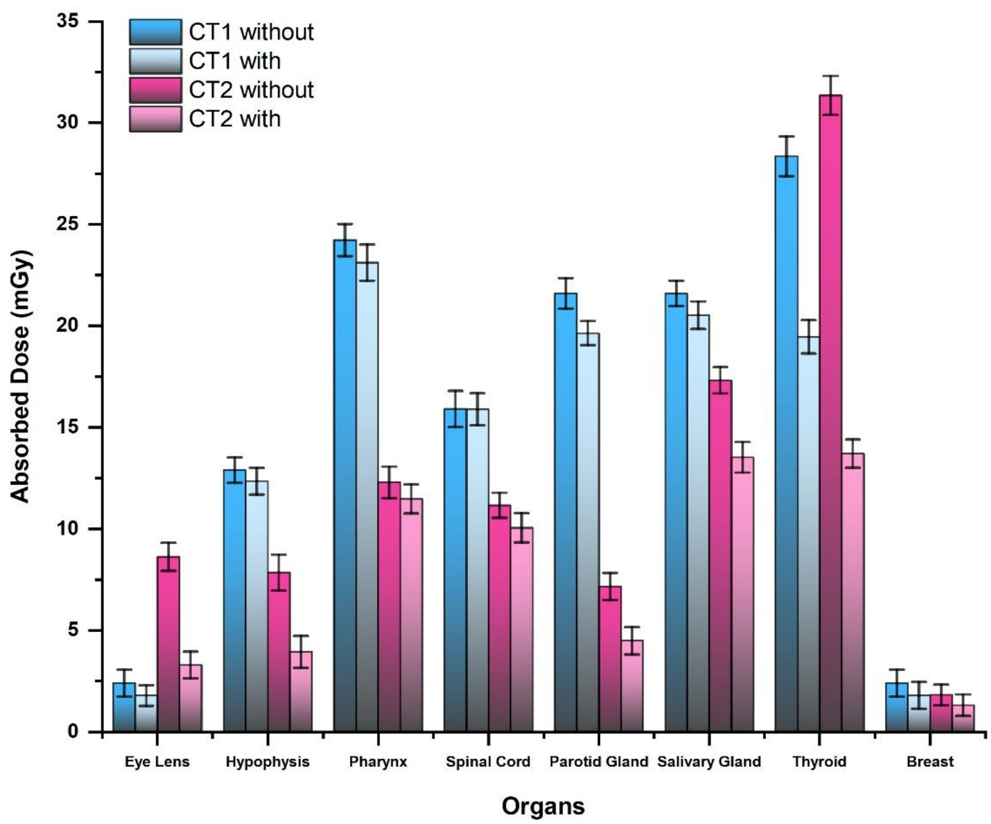


Figure 3: Influence of bismuth shielding on absorbed doses for some organ positions of the phantom.

## 4. Conclusions

The absorbed doses were determined during neck CT scans with and without bismuth shielding on thyroid of a CIRS ATOM male anthropomorphic phantom on two different CT's. Dose values were significantly reduced and they suggested that the use of bismuth would be, in some cases, a proper procedure for patient protection.

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