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How Relevant is Torso Shielding to Radiation Protection During Head Computed Tomography Procedures?

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ABSTRACT

In this wort, it set out to find out whether using torso shielding actually helps reduce scatter radiation to the chest during head CT scans in adults. Fifty adult women scheduled for routine head CT scans took part in the study. Thermoluminescent dosimeters (TLDs) were stuck on the central area of both breasts. The left breast was shielded with a 0.35-mm lead apron, while the right breast went unshielded as a control. Standard head CT protocols was followed. After the scans, absorbed dose was quantified. Both breasts were evaluated statistically using paired-sample t-tests. Effective dose was estimated using standard ICRP-103 tissue weighting factors.

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1. INTRODUCTION

Computed tomography (CT) has become a very popular medical imaging modality due to its speed of imaging, good resolution, and capability for 3-dimensional reformatting. However, the dose from CT is higher when compared with other imaging modalities, and this is a source of concern in the medical imaging community globally [1, 2, 3]. The longstanding method of reducing radiation dose was focused on reducing exposure within the primary beam. Currently, scatter radiation arising from primary beam is also receiving increasing attention [4, 5, 6].

Scatter radiation during CT examinations is as a result of interaction of dense tissues with the primary x-ray beam. They then leave their primary region of interest (ROI) and travel towards other tissues with lower energy. Nonetheless, minute amount of dose to radio-sensitive organs is considered potentially harmful [7]. During head CT examinations, scatter radiation can travel as far as the chest and neck. These regions contain both the breasts and the thyroid gland which are radiosensitive [8]. Low dose to the breast have been reported to increase lifetime cancer risk, especially in women [3]. Although the absorbed scatter dose to the breast during head CT is small compared to the primary head dose, repeated imaging and cumulative exposure are the considerations in radiation protection [9].

Torso shielding using lead aprons or any other radiation-attenuating material has been proposed as a simple, low-cost strategy to reduce scatter radiation to organs outside the primary beam. Several phantom and dosimetry studies reported significant reductions of scatter to the chest during head CT when lead shielding is applied to the torso [8, 9]. These findings are of interest in in low- and middle-income countries like Nigeria where advanced dose-reduction technologies may be inconsistently available or underutilized [8].

Despite this interesting strategy, anecdotal evidence from our practice in Nigeria indicate that the clinical implementation of torso shielding during CT scan with lead apron or other accessories remains poor, isolated, and is not generally adopted by radiographers or enforced by regulatory agencies. This inaction seems to have some modicum of support from some authors who cautioned against routine patient shielding. Their concern is that shielding may interfere with automatic exposure control systems and may introduce image artefacts [10, 11]. However, most of these recommendations are primarily based on shielding within or near the primary beam, rather than on organs clearly outside the scanned region. Consequently, a gap was identified between global policy statements and the practical realities of CT practice in resource-limited settings, where shielding may offer a simple, cost-effective alternative to a more complex optimization strategy [12].

As a result of the ongoing debate and the paucity of locally-generated data, there is a further need to investigate torso shielding during head

CT examinations in order to have local empirical data to influence practice. This study therefore aims to evaluate the impact of torso shielding during routine adult head CT by quantitatively measuring scatter radiation reaching the chest and assessing the dose-reducing effect of a lead apron.

2 - Materials and Methods

2-1 Study Design and Setting

This prospective and cross-sectional, single-centre study was conducted from January to June 2025, in the Radiology Department of a regional teaching hospital in southeastern Nigeria. Ethical approval (CUS/EC/Rad/Vol.2A of 5th January, 2025) was obtained from the institutional departmental research ethics committee. Signed informed consent was also obtained from all adult participants. The facility is a 500-capacity hospital with multiple specialty clinics. The modalities installed in the Radiology Department includes magnetic resonance imaging (MRI), computed tomography (CT), direct digital radiography (DDR), digital fluoroscopy, digital mammography, and multiple ultrasound units. The department also has a full complement of radiographers, radiography trainees (interns), radiologist, nurses, biomedical engineers, and two medical physicists who are PhD scholars in local universities. Total daily throughput for the department is atleast sixty cases with CT having an average of ten.

2 -2 Participants

Fifty adult female patients aged 18 years and above referred for non-traumatic head CT scan were consecutively recruited. Patients were ambulant, clinically stable, and without contra-indications for CT. Gravid and very ill patients who found it difficult to remain stable during examinations were excluded. As a matter of departmental routine, the vital signs, height and weight of CT patients were always documented. This information influenced the speed of the procedure, the quantity of contrast media to be administered, and specific protocols to be applied.

2 – 3 CT Equipment and Scan Protocol

Head CT examinations were performed with a GE Revolution, 32-slice scanner (GE Healthcare, USA), installed in 2022. The scanner undergoes routine daily quality control, and quarterly preventive maintenance. Standard axial head CT protocols were followed with patients lying supine. The orbito-meatal (OM) baseline was positioned perpendicularly (90 degrees) to the headrest. Axial (x-axis) centering with LASER beam was coincident with OM baseline at the level of infra-orbital margin. Azimuth for the preliminary scout images was 180 and 90 degrees for postero-anterior and lateral, respectively. Subjects were finally scanned in axial mode with 120 kVp (tube potential), 200 - 250 mA (tube current), 1 second gantry rotation time, pitch of 1.5, and scan duration of 14 – 20 seconds. Anonymity of digital data was guaranteed with 'image anonymity' feature on the screen.

2 – 4 Dosimetry and Shielding

Fifty female subjects were prospectively and consecutively enlisted over a six-month period. One hundred thermoluminescent dosimeter chips (TLD-100 LiF: Mg, Ti) with multidirectional energy response and which were annealed and calibrated at a regional dosimetric centre were used as scatter dose detectors. The TLD chips were enclosed in small, black radiolucent polythene sachets before and after CT irradiation to shield them from background radiations. Each patient lay supine with hands extended along the body. Each breast had a TLD chip affixed at its mid-craniocaudal point and held in place by transparent adhesive tapes. In addition, a 30 x 30 cm gonad shield with 0.35mm lead equivalent was used to shield the left TLD cum breast all through the investigations. The right breast went without a shield to serve as the control. The TLDs were carefully retrieved after pre-contrast series, carefully packed and then sent for reading at the dosimetry centre where they were initially annealed and calibrated.

3 - Data analysis

Data were analyzed with statistical packages for social sciences, version 28.0 (SPSS Incorporated, Chicago, Illinois, USA). Absorbed dose (mGy) were subjected to statistical analysis. The ICRP 103 tissue weighting/conversion factor of 0.12 for breast was used to calculate effective dose. The formula applied was E (effective dose) = k (conversion factor/tissue weighting factor, W_T) x W_R (radiation weighting factor; 1 for x-ray) x mGy (dose from TLD). Central tendencies and dispersion were noted. Furthermore, a paired-sample t-test was done to test for statistically significant difference in mean absorbed dose by both breasts. Difference found justified the necessity for shielding during radiographic examinations.

4 - Results

Participants' age ranged from 18 to 50 years (average: 36 ± 8.2 years). Their average height was 161 ± 4 cm and mean weight was 77.6 ± 7.2 kg, translating to an average BMI of 29.72 ± 3.05 kg/m² (pre-obsesity). Shielding indeed cut down breast scatter dose during head CT. The left, shielded breast turned up 3.00 ± 0.80 mGy, while the right, unshielded breast produced 6.60 ± 2.25 mGy which is evidence of a 55 % reduction (p = 0.001). Effective dose also dropped from 0.792 mSv to 0.36 mSv. Fig. (1) is an image demonstrating shielding during medical imaging while Fig. (2) shows an actual head CT image with positioning indicators. The type of TLD used to quantify dose is shown in Fig. (3).

Table 1. Demographics of the subjects

Parameter	Range	Mean ± SD
Age (years)	18 – 50	36 ± 8.0
Height (cm)	152 – 172	161 ± 4.0
Weight (kg)	55 – 89	77.6 ± 7.2
BMI (kg/m²)	21.8 – 34.6	29.72 ± 3.05

Table 2: Absorbed and effective dose

Parameter	Shielded (Left Breast)	Unshielded (right breast)	Dose difference	Significance
Absorbed dose (mGy)	3.00 ± 0.80	6.60 ± 2.25	3.6 (55% reduction)	p = 0.001
Effective Dose (mSv)	0.36	0.792	0.432	

Fig. 1. Torso, thyroid and eye lens' shielding in medical imaging

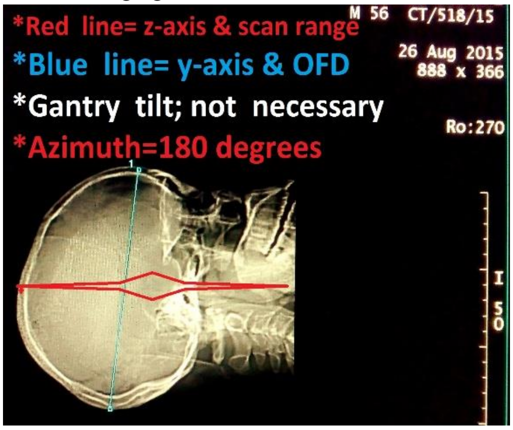

Fig. 2. Head CT image showing positioning landmarks

Fig. 3. Similar TLDs are used for the exam and for personal radiation monitoring

5 - Discussion

This study demonstrates that torso shielding significantly reduces scatter radiation to the chest during routine adult head CT examinations. The observed 55% reduction in absorbed breast dose is a confirmation that a meaningful proportion of scatter radiation generated during head imaging reaches radiosensitive organs outside the primary scan field. Although the absolute scatter dose to the breast is relatively low compared with the primary head dose, the magnitude of dose reduction achieved with a simple lead apron proves that the intervention is clinically relevant.

The breast is among the most radiosensitive organs, with well-documented associations between low-dose ionizing radiation exposure and increased lifetime cancer risk. While a single head CT contributes only a small scatter dose to the breast, repeated imaging is a matter of grave concern to the radiation protection community [9]. The present findings are consistent with previous phantom and patient-based investigations reporting substantial attenuation of breast dose from scatter radiation during head CT when torso shielding is applied [8, 9, 13]. The agreement between the present findings and previous studies strengthens the evidence base supporting the effectiveness of torso shielding for organs located outside the primary beam [3].

Despite these evidence, the clinical implementation of torso shielding in CT remains debated. Some authors have cautioned against routine patient shielding, citing concerns about interference with automatic exposure control systems and image artefacts [10, 11]. However, most of these recommendations are primarily based on shielding within or near the primary beam, with limited emphasis on shielding organs clearly outside the scanned region. In contrast, the torso shielding strategy adopted in the current study did not interfere with the primary beam, and so had little or no likelihood of interaction with exposure control systems or image quality.

In resource-low countries where access to regular, additional training on dose-reduction techniques may be limited [8], torso shielding offers a practical, low-cost strategy in radiation protection. Implementation requires only personal motivation and neither additional training for radiographers nor does it require changes to scanning protocols. Even in high-resource environments, these findings reinforce the continued relevance of basic radiation protection measures alongside technological optimization strategies [3, 12].

This study has limitations that the authors wish to acknowledge. The dose measurements focused on scatter radiation to the breasts alone, and did not evaluate potential effects on other radiosensitive organs such as the thyroid. Furthermore, the quantity of TLDs used was few, due basically to cost. It is our impression that more TLDs may give more accurate results. We consider this therefore a pilot study and hope that future studies by us or others will receive funding to incorporate larger TLD sample sizes.

Overall, this study provides empirical evidence that torso shielding significantly reduces scatter radiation to the breast during adult head CT examinations. These findings will contribute to the ongoing discussion on practical dose optimization strategies in CT imaging. So, how relevant is torso shielding to radiation protection during head computed tomography procedures? Very relevant.

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Results

Shielding reduced the absorbed dose to the left breast down to 3.00 ± 0.80 mGy, while the unshielded right breast clocked in at 6.60 ± 2.25 mGy, a 55% drop ($p < 0.001$). Scatter radiation contributed close to 9% of the total head CT dose to the chest.

6 - Conclusion

Torso shielding indeed cuts down scatter radiation to the chest during head CTs in adult women. It is a simple, cheap way to protect patients from unnecessary irradiation, aligns with ALARA principles, and does not interfere with image quality.

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