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Radiation dose to breasts from a cardiac computed tomography angiography scanogram can be reduced by switching tube position

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Background/aim: In a computed tomography (CT) examination, scanogram images are used to determine the range of the area to be imaged before scanning. The importance of scanogram image exposure has increased since total examination radiation has decreased due to technological advancements. The purpose of this study was to determine and compare radiation doses delivered to patients while the tube was in anterior-posterior (AP) and posterior-anterior (PA) positions during a CT angiography scanogram.

Materials and methods: The radiation doses absorbed by the breast tissue of 55 female patients who underwent cardiac dual-source computed tomography (DSCT) angiography were determined using thermoluminescent dosimeters (TLD-100, Harshaw, MA, USA). Four patients were excluded from the study for various reasons.

Results: Radiation doses absorbed by the breasts were significantly lower when the tube position was switched during the scanogram. The absorbed doses, calculated from scanogram exposures, were 520 ± 50 μ Sv for the AP projection and 410 ± 45 μ Sv for the PA projection. Total skin doses from the DSCT examinations were 18.9 ± 2.3 mSv.

Conclusion: We attributed the approximately 20% lower doses to the position of the scanogram tube, which was in the PA position.

Key words: Multidetector CT radiation dose, cardiac CT angiography, scanogram, X-ray tube position

1. Introduction

Computed tomography (CT) is a diagnostic method that requires special attention to be paid to ionizing radiation for the safety of both the patients and the staff. Background radiation constitutes 82% of the total annual radiation exposure, and the remaining 18% comes from manmade sources. In the last decade, the rate of radiation exposure from radiological examinations began to exceed the rate of exposure from natural sources due to the increasing number of CT examinations (1). Multidetector CT (MDCT) poses an especially high risk because of its critical dose values (2). In particular, women who undergo cardiac MDCT examinations are at risk because some tissues, such as breast tissue and the spinal cord, are relatively sensitive to radiation and are inevitably irradiated. The International Radiological Protection Commission has proposed higher breast radiosensitivity than was stated in their guidelines in 2008. Accordingly, an increase from 0.05 to 0.12 (140%) was proposed as a breast tissue weighting factor (3,4). Precise dose distributions in tissues can be predicted using both numerical studies and phantom studies (4–6). In

this regard, the scanogram (or scanogram image) plays an important role in reducing exposure during modern CT imaging relative to the entire examination (5). This reduction depends on the development of methods such as organ-specific adjustment of X-ray kV or mA, and iterative reconstruction that reduces the patient's total effective dose to 1 mSv. The major differences between the dose in the affected breast tissue and the total body dose depend on the position of the tube. Studies investigating the values of CT dosing during scanograms have been very limited up until now (7).

The purpose of this study was to determine and compare the radiation doses delivered to patients' breasts while the tube was in the anterior-posterior (AP) and posterior-anterior (PA) positions during CT angiography scanograms.

2. Materials and methods

In this prospective study, doses to breast tissue were determined using thermoluminescent dosimeters (TLD-100, Harshaw, MA, USA) in the case of 55 female patients

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who applied to the radiology unit with preliminary cardiac diagnoses between January and April 2014 and underwent cardiac dual-source computed tomography (DSCT) angiography (256-slice, Siemens Somatom Definition Flash, Erlangen, Germany) examinations with standard settings (kVp = 120 and mAs = 250–300). This study was approved by the local ethics committee and can be tracked under ATA.01.0.00/9. All patients were informed of the side effects and gave consent for the data obtained to be used for scientific purposes only. Four patients with nondrooping breasts were excluded from the study because the absorbed doses could not be measured. Age, chest circumference, cup size, average \pm SD and minimum values of the circumference over the bust, and body mass index (BMI) are shown in Table 1. The cup size was taken from each patient and calculated by subtracting the torso circumference from the over-bust chest circumference (8).

TLD-100 chips ($3.2 \times 3.2 \times 0.89$ mm) were annealed at 400 °C for 1 h just before each exposure. Then three steps of calibration were performed using TLDs and a TLD reader (Harshaw TLD 4500; Thermo Fisher Scientific Inc., Waltham, MA, USA), as described by the manufacturer. TLDs were calibrated in air with a Farmer-type ion chamber and a monitor (Multidata Systems, St. Louis, MO, USA). The chamber correction factor was obtained from the calibration laboratory of the Turkish Atomic Energy Authority (Turkish acronym: TAEK), which is traceable to international primary standard laboratories. Energy corrections for X-rays were done using the US National Institute of Standards and Technology X-ray mass energy absorption coefficients for the tissue and air database available on its website (9). Three dosimeters were placed on each patient, one under the breast and two on the skin at the same level. The dosimeter under the breast (inframammary crease) and one of the dosimeters on the skin was removed after the scanogram, while the remaining one was left on the skin inside the areolar region to determine the total exposure of the breast following the examination (Figure). Thirty minutes after irradiation, all dosimeters were read with a calibrated time temperature profile and the absorbed doses were determined simply

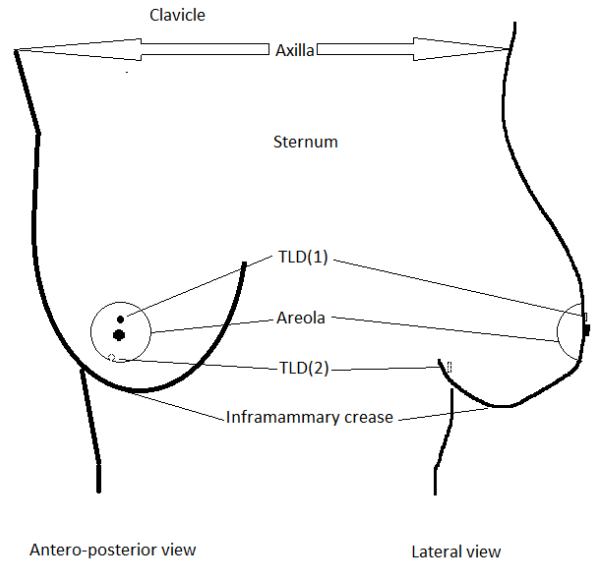


Figure. Antero-posterior and lateral view of TLD positions over breasts.

by subtracting under-breast TLD dose values from over-breast values. SPSS 20 (IBM Corp., Armonk, NY, USA) was used and a significance value of $P < 0.05$ was applied during the evaluation of the differences between the groups.

3. Results

The tube was set in the PA position for 26 patients and in the AP position for 25. The absorbed doses from the scanogram images were calculated as 520 ± 50 μ Sv for the AP projection and 410 ± 45 μ Sv for the PA projection. Total skin doses from the DSCT examinations were 18.9 ± 2.3 mSv (Table 2).

4. Discussion

In the general population, the total dose from CT varies based on exam type, device, and number of applications encountered (10). For this reason, CT must be used

Table 1. Average age, BMI, and cup sizes.

n = 51	Average \pm SD	Minimum	Median	Maximum
Age (years)	54.9 \pm 11.8	16	58	74
BMI (kg/m ²)	33.4 \pm 9.5	18.1	35.8	45.8
Chest circumference (cm)	106.3 \pm 16.5	75	114	138
Circumference over bust (cm)	111.5 \pm 15.5	69	128	128
Breast cup size (cm)	10 \pm 4	6	11	17

Table 2. Comparison of measured breast and skin doses according to tube position.

Dose (mSv)	Tube position		Total examination
	AP (n = 25)	PA (n = 26)	
Skin dose	3.5 ± 0.3	2.8 ± 0.2	18.9 ± 2.3
Calculated absorbed breast dose (mGy)	0.520 ± 0.050	0.410 ± 0.045	-
DLP (mGycm)	200	200	1030 ± 25

AP: Anterior-posterior; PA: posterior-anterior; n: number of patients, DLP: dose length product.

carefully and in accordance with the ALARA concept; namely, it should be as low as reasonably achievable. A CT should be duly justified and should be avoided when other diagnostic tools can be used instead. In addition, patients should be informed of the potential risk of overexposure, because there is no central exposure record monitoring system in Turkey. Common parameters that can contribute to reducing the dose received via a CT include tube current, tube rotation time, peak voltage, pitch, and collimation. Electrocardiography used for tube current modulation can be applied because the prospective axial scan and high-pitch spiral scan include repeated CT data and added exposure (11,12). Based on the results of this study, we can add one more parameter to cardiac MDCT angiography examinations: the tube position during the

scanogram image. By changing the projection from AP to PA, not the total dose but rather the scanogram radiation is reduced by approximately 20%. Since the total amount of CT radiation has decreased as a result of technological advancements, the ratio of scanogram exposure to total exposure and thus the importance of scanogram image exposure have increased. Other simple techniques can be used to reduce the radiation delivered to breast tissue, such as displacing the breasts from the exposed region of interest. In conclusion, there are still a number of measures that can be applied to reduce CT radiation doses.

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