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Orgınal Article

Breast glandular dose and effectiveness of in-plane bismuth breast shield in routine pediatric female chest CT examination

Kız çocuklarında rutin toraks bt çekimlerinde meme glandüler dozu ve bizmut koruyucunun etkinliği

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Highlights

- Breast tissue exposed to radiation from MSCT of the chest is an area of particular concern in pediatric female.
- In-plane bismuth breast shielding offers an additional method of decreasing dose to female pediatric patients undergoing MDCT.

Abstract

Background: The aim of our study is to determine the radiation dose to which the breast is exposed in pediatric female undergoing routine thoracic multislice computed tomography (MSCT) and to investigate the effectiveness of bismuth shielding in reducing this dose. **Materials and Methods:** Twenty patients who were referred to the radiology department for routine thorax MSCT between January 2012 and April 2012 were included in the study. A Thermolucent dosimeter (TLD) (3x3x1mm; Harshaw Lif TLD-100; Saint-Gobain Industrial Ceramics, Solon, Ohio) was placed on both breast skins of the patients to measure the radiation dose. An in-plane bismuth breast shield was placed on the right breast, and the left breast was chosen as the unshielded side. Radiation doses in the shielded and unshielded breast were calculated and compared using the Paired-t test. **Results:** The mean radiation doses were calculated as 7.0075 mSv and 9.0730 mSv for the shielded right breast and the unshielded left breast, respectively. It was found that in-plane bismuth breast shielding could lower the radiation dose to the right breast by 22.76 %. The difference between the radiation doses of the shielded side of the breast and the unshieldeded side was found to be significant (p<0.001). No deterioration was detected in the image quality of the lung parenchyma on the side where bismuth shield was placed.**Conclusions:** In-plane bismuth shielding significantly reduces the radiation dose of the breast in pediatric female undergoing routine thoracic MSCT examination without impairing the image quality.

Keywords: Bismuth shield, breast shield, pediatric female, multislice computed tomography

ÖZ

Amaç: Çalışmamızın amacı rutin toraks çok kesitli bilgisayarlı tomografi (ÇKBT) çekilen kız çocuklarında memenin maruz kaldığı radyasyon dozunu belirlemek ve bizmut koruyucunun bu dozu azaltmadaki etkinliğini araştırmaktır.**Materyal ve metod:** Çalışmaya Ocak 2012- Nisan 2012 tarihleri arasında radyoloji bölümüne rutin toraks ÇKBT çekimi için yönlendirilen 20 hasta dahil edildi. Hastaların her iki meme cildine radyasyon dozunu ölçmek amacıyla birer adet Termolusent dozimetre (TLD) (3x3x1mm; Harshaw Lif TLD-100;Saint-Gobain İndustrial Ceramics, Solon, Ohio) yerleştirildi. Sağ memenin üzerine bizmut koruyucu yerleştirilmiş olup, sol meme korunmamış taraf olarak seçildi. Bu teknikle yüzeyel meme radyasyon dozu hesaplandı. Korunan ve korunmayan memedeki radyasyon dozları hesaplandı ve Paired-t test kullanılarak karşılaştırıldı.

Bulgular: Ortalama radyasyon dozları korunan sağ meme ve korunmayan sol meme için sırasıyla 7.0075 mSv ve 9.0730 mSv olarak hesaplandı. Bizmut koruyucunun sağ memenin maruz kaldığı radyasyon dozunu %22.76 oranında azaltabileceği görüldü. Memenin korunan tarafı ile korunmayan tarafının maruz kaldığı radyasyon dozları arasındaki fark anlamlı bulundu (p<0.001). Bizmut koruyucu yerleştirilen tarafta akciğer parankiminin görüntü kalitesinde herhangi bir bozulma saptanmadı. **Sonuç:** Bizmut koruyucu rutin toraks ÇKBT incelemesi yapılan kız çocuklarında görüntü kalitesini bozmadan memenin maruz kaldığı radyasyon dozunu belirgin miktarda azaltmaktadır.

Anahtar Kelimeler: Bizmut koruyucu, meme koruyucu, kız çocuğu, çok kesitli bilgisayarlı tomografi

Introduction

Computed tomography (CT) has grown rapidly since its introduction as an imaging modality in the 1970s.Short acquisition times and high diagnostic accuracy have started to be attained with the development of multislice computed tomography (MSCT), and the daily number of scans has increased exponentially (1). In the United States, CT accounts for approximately 17% of all imaging modalities and is responsible for approximately 50% of medical radiation (2). Radiation exposure, especially to superficial organs, is the main drawback of CT.Due to children's and young adult's rapid cell division and relatively long life expectancies, it is assumed that the cytochastic and potential oncogenic effects of ionizing radiation contained in CT are greater than in adults(3). Studies on the prevalence of breast cancer, particularly in women who survived the atomic bomb, have revealed results that radiation affects breast tissue (4).Utilizing bismuth shielding during CT scans is one method used to decrease the radiation exposure to delicate organs like the breast, eye, thyroid, and testicles. (5).

In this study, we aimed to determine the radiation dose received by the superficial breast tissue and to determine the effectiveness of bismuth shielding in reducing the radiation dose in pediatric female who were referred to our department for routine thoracic MSCT examination.

Materials and Methods

Patient Selection

Our study was performed on a total of 20 pediatric female who were referred to our department for routine thoracic MSCT examination between January 2012 and April 2012. Patients with chest deformity and inability to stabilize the bismuth shield were excluded from the study. Demographic data of patients such as age, weight and height were obtained (Table 1). The patient's parents were informed about the study.Consent form was signed before CT examination. Approval was obtained from the local ethics committee for the study.

Table 1. Average Standard Deviations and Min-Max Values of Demographic Characteristics for Age, Weight and Height

Variables	Mean+SD	Min-max values
Age	10.0±4.2	2-16
Weight (kg)	34.2±15.6	10-62
Height (cm)	132.4±25.6	83-166

CT Examination

All CT scans were performed with a 128-channel MDCT device (Siemens Somatom Definition AS Siemens AG, Medical Solutions ,Computed Tomography, Forcheim, Germany).Scanning parameters were chosen as detector collimation 0.6 mm, gantry rotation time 0.5 sec, slice thickness 3 mm, average 280 mm field of view (FOV).Automatic tube current modulation was used during CT acquisition. The patients were placed in the gantry in the supine position. CT images were obtained from the thoracic inlet to the level of the adrenal gland.Two Thermolucent dosimeters (TLDs) (3x3x1mm; Harshaw Lif TLD-100; Saint-Gobain Industrial Ceramics, Solon, Ohio) were placed in the medial part of the nipple of 20 patients.All dosimeters were obtained from the same production center. The dosimeters were sensitive to radiation levels between 100 μGy and 1 Gy.Bismuth shields were obtained by placing bismuth coated latex sheets ((F & L Medical Products Co., USA) on a 1cm thick foam pad (Figure 1).The foam pad creates a distance between the bismuth latex and the chest wall, reducing the amount of radiation entering the body. In addition, image artifacts were prevented.TLD was placed on the right nipple and a bismuth shield was placed on it.Only TLD was placed on the left nipple.Bismuth shields were placed after scout images were taken.The superficial radiation dose of both breasts was calculated. The superficial radiation doses of the right breast with a bismuth shield and the left breast without a bismuth shield were compared.The relationship between the age, height and weight of the patients and the mean radiation doses was determined.

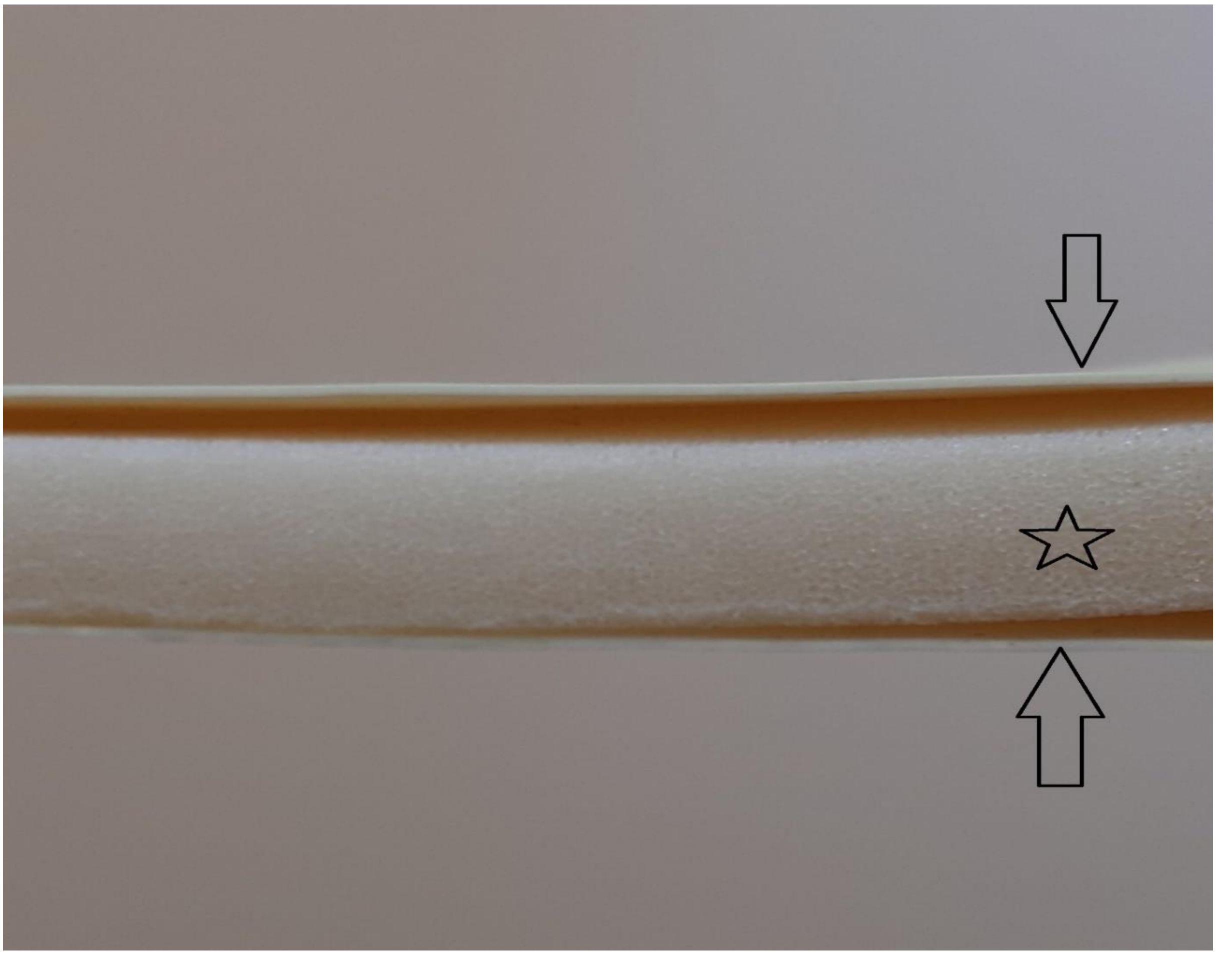

Figure 1. An in-plane bismuth shield. Open arrows show bismuth coated latex. Asterisk show foam

Statistical Analyses

The statistical analysis was performed using the SPSS (Statistical Package for Social Sciences for Windows) 15.0 program.Descriptive statistical methods (mean, standard deviation, frequency) were used while evaluating the study data.Paired samples t test was used to compare the normally distributed quantitative data. Pearson correlation analysis was used to evaluate the relationships between age, height and weight, and radiation dose.The significance level used to evaluate the results was $p<0.05$, with a 95% confidence interval.

Results

A pediatric radiologist evaluated the results of the MSCTexamination. The right breast tissue and skin, where the bismuth shield was positioned, showed minimal artifact.Between the sections with and without bismuth shielding, there was no difference in the image quality of the lung parenchyma and mediastinum.The age range for the cases in our study was 2 to 16 years, with a mean age of 10±4,2. The mean superficial radiation dose levels of the shielded right breast and unshielded left breast were determined to be 7,0075±5,187 mSv and 9,0730±6,382 mSv, respectively (Table 2). The mean superficial radiation dose of the shielded right breast was observed to be statistically significantly lower than the mean superficial radiation dose of the unshielded left breast($p<0,001$) (Table 3).These results revealed that bismuth shielding decreased the superficial radiation dose to the right breast by 22.76 %. There was no statistically significant relationship between age, height and weight, and mean radiation dose levels in the shielded and unshielded breasts ($p>0,05$) (Table 4).

Table 2. Standard deviations and min-max values of the mean superficial radiation doses of shielded right breast and unshielded left breast

Variables	Mean+SD (mSv)	Min-max values (mSv)
Shielded right breast	7.0075±5.187	3.59-21.70
Unshielded left breast	9.0730±6.382	4.30-29.60

Table 3. Comparison of mean superficial radiation doses of bismuth shielded right breast and unshielded left breast with Paired Sample T-test

Variables	TLD Mean dose (mSv)	*P*
Shielded right breast	7.0075±5.187	<0.001
Unshielded left breast	9.0730±6.382	

TLD: Thermolucent dosimeter, **mSv :** milisievert

Table 4. Correlation of age, weight and height, and mean superficial radiation doses of shieldeded right breast and unshielded left breast

Variables	Shielded right breast		Unshielded left breast	
	p	*r*	*p*	*r*
Age	0.201	0.395	0.236	0.316
Weight (kg)	0.026	0.913	0.108	0.652
Height (cm)	0.022	0.925	0.096	0.687

***r*:** pearson correlation coefficient

Discussion

Thorax MSCT is a non-invasive imaging method used in the diagnosis of lung, mediastinum, heart and chest wall diseases. The need for sedation in children is significantly reduced by short examination times.Although the breast is not the target of examination, the main drawback of this imaging technique is that it reveals it to ionizing radiation.In recent large-scale epidemiological studies, it has been shown that the risk of cancer in children and young adults increases due to radiation exposure after CT examination (6-9). Studies on women who survived the atomic bombing of Japan and on patients who underwent numerous radiographs due to benign conditions like tuberculosis and scoliosis resulted findings demonstrating that cancer develops in the breast tissue after exposure to ionizing radiation (4, 10-12).It is estimated that exposure to 10 mGy radiation in a woman younger than 35 years of age increases the lifetime risk of developing breast cancer by 13.6% (13).

Various methods are used to reduce the harmful effects of ionizing radiation originating from computed tomography.These can be listed as reducing the tube current, increasing the section thickness and pitch value, decreasing the tube voltage, shortening the gantry rotation time, increasing the table speed and using X-ray filters (14).The main drawback of these dose reduction methods is that the image quality may deteriorate and the diagnostic efficiency may decrease.In addition to these methods, bismuth shields can be used to reduce the radiation exposure of superficial organs such as breast, thyroid, lens and testis.With bismuth shields, some of the X-rays that may affect the superficial organs are prevented. In this study, we placed a bismuth shield on the right breast of pediatric female who underwent thorax MSCT. We used automatic tube current modulation protocol during shooting. We observed that bismuth shielding reduced the superficial radiation dose in the right breast by 22.76 %. We did not see any differencesin image quality between the shielded and unshielded lung.Fricke et al. showed that the mean dose protocol and the use of bismuth shielding in pediatric female with thoracic and abdominal CT reduced the radiation dose of the breast by 29%, similar to our study, and did not cause any deterioration in image quality (15). In the study conducted by Coursey et al. to investigate the effectiveness of automatic tube current modulation and bismuth shielding in reducing the breast radiation dose in thorax CT taken using an anthropomorphic phantom representing a 5-year-old girl, bismuth shielding alone decreased the radiation dose by 26%, automatic tube current modulation and bismuth shielding together reduced the dose by 52% . In the same study, an increase in noise level was found (16). An increase in the noise level might have been observed because this study used a phantom and quantitative values to assess the image quality.

It has been demonstrated in the literature that bismuth shielding alone or in combination with various other dose reduction techniques can lower the breast radiation dose in adults by an average of 27.9% to 57% (17-24).We believe that the emergence of such disparate results across studies is a result of the use of other dose reduction techniques, such as automatic tube current modulation and low peak kilovoltage (kVp), in addition to bismuth shielding in some studies.In some of the aforementioned studies, it was determined that the image quality deteriorated after the use of bismuth shielding.The qualitative and quantitative evaluations created in various ways could be the consequence of the variations between the studies in image quality.The pediatric radiologist evaluated the diagnostic applicability of the thorax MSCT images we obtained for this study only qualitatively, and all of the patients in our study had quite images.

Limitations

The first limitation of the study was the relatively small number of patients. A phantom should be used to calculate the breast glandular tissue radiation dose. In this study, only the superficial radiation dose of the breast and the effectiveness of bismuth shielding were investigated. Not using phantom in this study can be considered as another limitation.We were also unable to objectively assess the image quality due to this limitation.

Conclusion

With the technological developments in CT, there is a significant increase in the number of MSCT examinations performed on children.In the light of current information, it is known that breast cancer secondary to radiation can develop.For this reason, it is important to follow the ALARA (as low as reasonably achievable) approach and administer MSCT at the lowest dose possible, especially in situations when the requirement of MSCT in children must be thoroughly assessed.In this study, we found that bismuth shielding effectively reduced the superficial radiation dose received by the breast in pediatric female who underwent thorax MSCT.We recommend the use of bismuth shielding in MSCT scans where superficial radiosensitive organs such as breast, thyroid, eyes and gonads are in the examination area.

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Ethical Approval:*Ethical approval was taken from the Istanbul University, Cerrahpaşa Medical Faculty, Clinical Research Ethics Committee. Dated: 03/05/2011. Numbered:B-34. We conducted this study according to the principles of the Declaration of Helsinki.*

Author Contributions: *Author Contributions: Concept: D.O, AI Literature Review: D.O Design: D.O, O.E, K.Y, K.F Writing manuscript: D.O Critical revision of manuscript: A.I*

Conflict of Interest: *The authors have no conflicts of interest to declare.*

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