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RESEARCH ARTICLE

EVALUATION OF RADIATION DOSE TO THYROID GLANDS DURING DIAGNOSTIC MAMMOGRAPHY; A COMPARISON OF CRANIO CAUDAL (CC) AND MEDIO LATERAL OBLIQUE (MLO) VIEWS.

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Abstract

Objectives: Mammogram plays a major role in diagnosing breast cancers in the medical imaging sector though it can cause a radiation hazard on thyroid gland. This study was design to determine the association of Entrance Surface Dose (ESD) for thyroid between the Cranio Caudal (CC) and Medio Lateral Oblique (MLO) projections.

Methods: A total of 75 female patients with the mean age of 53.1 ± 8.9 years participated for the study. Breast was compressed in both the CC and the MLO views. ESD of the skin overlying thyroid was measured by an electronic pocket dosimeter at the level of the palpable thyroid cartilage. ESD for each projection, thickness of the compressed breast and the angle of the MLO view were recorded. The compression of breast thickness and the angle of MLO projections were evaluated with ESD of CC and MLO views. The data was analyzed using Minitab version 14.1.

Results: All the patients were subjected to mammogram ESD of CC range from 2.4 to 8.3µSv/hr and ESD of MLO range from 2.1 to 9.5 µSv/hr. ESD values in MLO projections were significantly higher thanCC projections ($p < 0.001$). In addition, ESD values of CC and MLO projections are significantly increased with compression of breast thickness (CC: $p = 0.032$, MLO: $p = 0.002$). However, no significant associations were found between ESD and the angle of the MLO views (RMLO: $p = 0.472$, LMLO: $p = 0.798$).

Conclusions: CC view might be effective for patients to be exposed to low amount of radiation to thyroid. In addition, radiation dose to the thyroid gland can be minimized, using proper compression of breast thickness.

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Introduction:-

Mammogram is a screening tool of breast imaging and it is the key to the successful long term control of disease, helping to detect breast cancers in their early stages (Akoto *et al*., 2011).The mortality rate of breast cancers can be reduced by 15-16% with the use of mammography (Jorgensen *et al*., 2011). It can be used for screening and for diagnostic purposes. Screening Mammogram is performed to detect breast cancer before symptoms occur.

During mammography, patient could face an increased risk of radiation exposure especially in radiosensitive areas like the thyroid gland and it's susceptible to radiation induced carcinogenesis particularly in childhood and adolescence (Sinnott *et al*., 2010). Several studies have reported that children has higher sensitivity to radiation compared with adults (3,4).. (Sinnott *et al*., 2010). Stochastic effect is one of the primary radiation effects which can do mutation to the thyroid glands (Hamada and Fujimichi, 2014). Scatter radiation is a type of secondary radiation that occurs when the useful beam intercepts any object, causing some x rays to be scattered during mammography.

In mammography, proper breast positioning can eliminate most adverse effects of radiations and increase the performance of mammogram images. Either for screening or diagnostic purpose, the recommended basic projections in mammography (Whitley *et al.*, 2005) are classified into two, one from the top Cranio Caudal (CC) and one from the side Medio Lateral Oblique (MLO) (Khair *et al*., 2012). The plane of the cassette holder can be angled anywhere from 30 to 60 degrees from the horizontal in MLO projection. In CC view beam is used perpendicular to the cassette holder.

Knowledge of radiation dose from mammography provides to reduce the radiation risks associated with mammography. Proper compression of breasts supports in spreading of the breast tissue , avoids distortion of the breast parenchyma which potentially influences image quality and reduces absorbed dose to the breast (Poulos*et al*., 2003).Although many records available about radiation dose to the breast and breast cancers from mammography,few studies have been reported about the association between mammography use with different projections. Therefore, this study was designed to investigate the Entrance Surface Dose (ESD) of the thyroid difference in between CC and MLO views during the routing mammogram procedures.

Materials and methods:-

Study design and population:-

The study was designed as an observational descriptive study which was carried out to estimate ESD to the thyroid gland during routine mammography examinations. This study was performed at the cancer unit of the National Hospital of Sri Lanka (NHSL). Patients were attended to the mammography unit of NHSL from May to September 2016 was considered as the study population. Out of total patient, 75 patients above 40 years were randomly selected for the study. Thyroidectomy Patients and, patients who do not have family history of thyroid cancer and those who applied special compression force after taking the CC and MLO views were excluded from the study.

Collection of data:-

Prior to the study, the objectives of the study were explained briefly to the patients and written consent was obtained. All participants were instructed their participation is voluntary and can be withdrawn at any time from the study. Explanations were conducted in their native language to make the purpose of the study clear.

For each projection the breast was placed on a digital detector and was gradually compressed by the technologist. All patients were instructed to change positions in between projections. Surface thyroid dose in both CC and MLO views were measured. CC view was taken from above horizontally compressed breast and MLO was taken from the side and at an angle of a diagonally compressed breast. An Electronic Pocket Dosimeter (Polimaster) was used to measure the surface thyroid dose and the computer monitor was used to record patient's breast thickness and angles of both MLO views.

The appropriate exposure factors were selected according to the patient's breast thickness automatically by the digital machine. Both CC and MLO views were taken as two images each by two different research members to minimize the intra personal errors and calculated the mean of these measurements to evaluate final ESD values.

Breast tissue between the compression plate and the image receptor produced reasonable amount of scatter radiation dose. Standardized stable conditions were used during the data collection period. They are Ag/Rh of target for filtration combination, accuracy, calibration of Selenium digital mammographic unit, humidity of the room. Furthermore the radiological technologist was the same throughout whole data collection period.

The EPD was placed immediately below the palpable thyroid cartilage by the help of specially designed neck collar. The LORAD SeleniaTM digital mammography machine under the X ray tube model number M-113T and detector model number FFDM-L which was manufactured by Hologic, Inc. Dunbury, CT, 06810, USA.

Statistical analysis:-

Data were entered into Microsoft Excel 2007 and transferred into the Minitab version 14.1 for statistical analysis. Descriptive statistics were applied which included percentage, mean and standard deviation to describe the analyzed variables in this community. Nonparametric tests were used in this study since the ESD values were not normally distributed with different projections. The expressions of projections were considered as dependent variables while angle of MLO and compression breast thickness were considered as independent variables in these tests. Kruskal–Wallis test was applied to compare the difference of studied projections.That is between angle of MLO and compression of breast thickness in study groups. Pair-wise comparison of target studied projections was analyzed by the Mann-Whitney U-test. p value less than 0.05 was considered as statistically significant.In addition, all graphs were made by using Graphpad prism version 7 software.

Ethical consideration:-

Ethical approval for this study was obtained from the ethical review committee of Faculty of Medicine,General Sir John Kotelawala Defence University. Permission for this study was also obtained from ethical review committee of National Hospital of Sri Lanka.Informed written consent was obtained from each patient before the recruiting them for the study. All information provided by the respondents was kept confidential and analyzed only for research purpose.

Results:-

Socio demographic characteristics of patients:-

A total of 75 patients with the mean age of 53.1 ± 8.9 years were participated for the study. The age range of the respondents was 41-79 years and all of the studied patients were females. With regards to age groups, highest number of patients (19/75, 25%) were aged between 50-54 years while the minimum number of patients were seen in the age of more than seventy years (4/75, 5%). (Figure 1)

Association of Cranio Caudal (CC) and Medio Lateral Oblique (MLO) projections:-

ESD values of CC and MLO projections were obtained for both right and left sides and the average values of these projections were calculated for each patient. All the patients were subjected to mammogram ESD of CC range from 1.093 µSv/hr to 12.860 µSv/hr and ESD of MLO range from 2.435 µSv/hr to 19.990 µSv/hr. Mann-Whitney U test identified that ESD values in MLO projections (mean 9.12 ± SEM 0.46) were significantly higher than CC (mean5.57± SEM 0.33) projections (p < 0.001). Table 1 also confirmed that ESD values in MLO significantly higher than CC values. However, no significant difference was found between ESD values of CC and MLO projections and different age groups. (Figure 2) (Table 1)

Association of breast compression thickness and ESD:-

The distribution of compressed breast thickness related to CC ranged from 2.4cm to 7.9 cm while in MLO it differs from 2.1cm to 9.5cm.Kruskal-wallis test was done for the analysis between breast thickness and ESD values for each projection. ESD values gradually increase with compressed breast thickness and the highest mean ESD values were shown in 6 – 7.99 group for CC(mean 6.89 ± SEM0.65) and 8 – 9.99 group for MLO(mean 11.97 ± SEM2.09).According to the result significant association was found between the compression of breast thickness and dose of projections (CC; p = 0.032, MLO; p = 0.002). (Figure 3,4 and 5)

Association of MLO angle and ESD:-

Kruskal-wallis test was done for the analysis between dose of MLO and the angles of MLO projections. Values of MLO angles were grouped into three categories; 35-39, 40-44 and 45-49 degrees. According to the result significant association was not found between the angles of MLO projections (L-MLO p = 0.798, R-MLO p = 0.472). ESD value was gradually increased with angle of MLO and the highest mean ESD values were shown in in the 45-49 angle group (L-MLO; mean 9.82 ± SEM 1.08 and R-MLO; mean 10.07± SEM 1.06). However no significant association was found between the angles of L-MLO and ESD values (L-MLO p = 0.798; R-MLO p = 0.472).

Table 1:-ESD values of CC and MLO projections in different age groups

Age (Years)	CC (mean ± SEM)	MLO (mean ± SEM)	*p* value
40 - 49	6.07 ± 0.53	9.42 ± 0.68	< 0.001
50 - 59	5.59 ± 0.53	8.56 ± 0.76	0.002
60 - 69	4.66 ± 0.72	8.78 ± 1.17	< 0.001
70 - 79	3.41 ± 0.77	11.70 ± 2.44	< 0.001
p value	0.210	0.348	

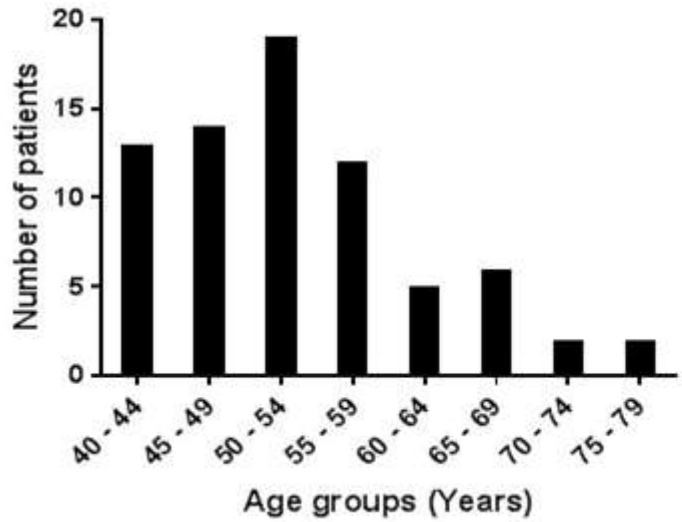

Figure 1:-Age distribution with number of patients

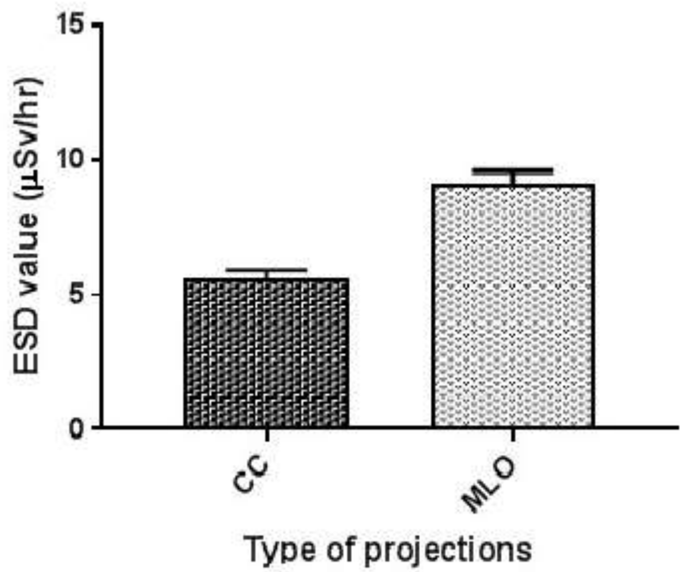

Figure 2:-ESD values to the thyroid gland in CC and MLO projections. Results are shown as mean standard errors (SEM)

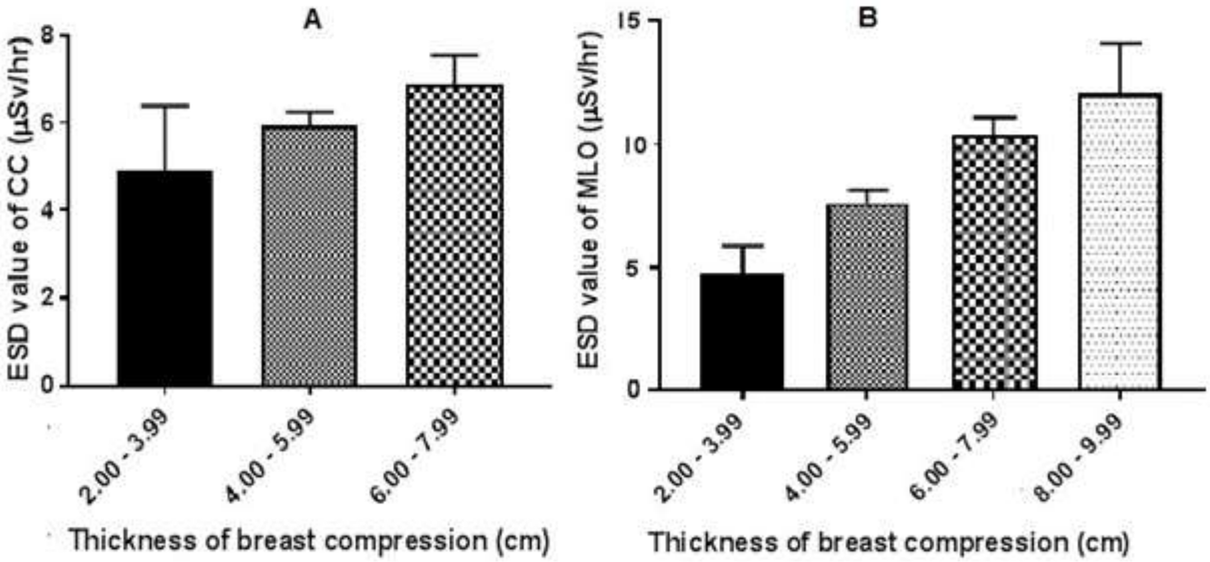

Figure 3:-Thickness of breast comparison and ESD values in A) CC and B) MLO projections. Results are shown as mean standard errors (SEM)

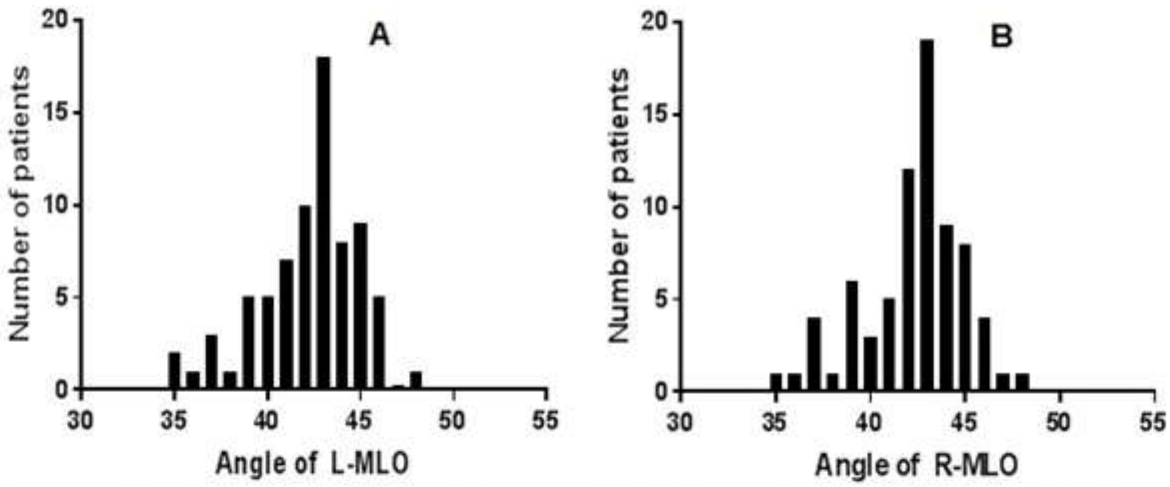

Figure 4:-Distribution of A) L-MLO and B) R-MLO angles with number of patients

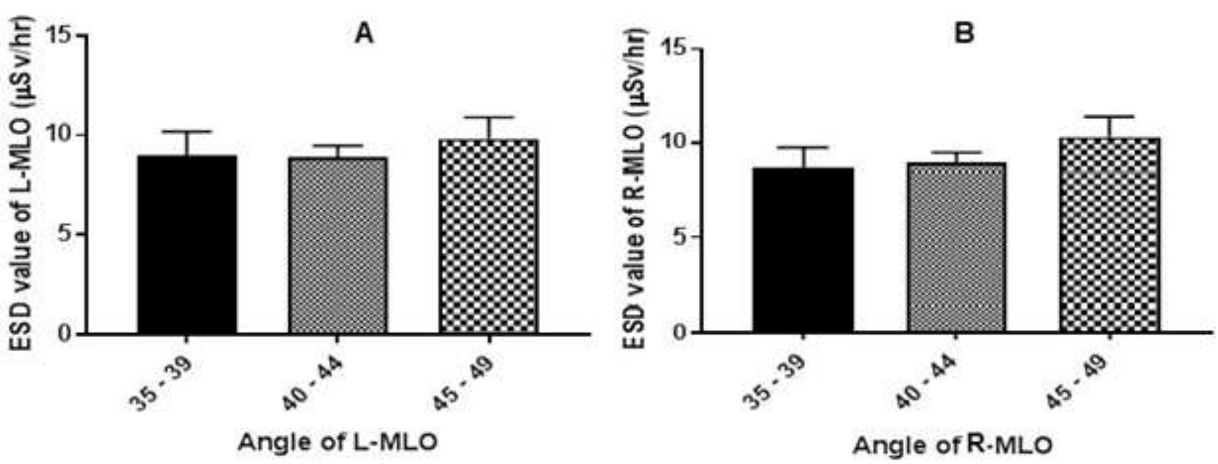

Figure 5:-ESD values and the angle of A) L-MLO and B) R-MLO projections. Results are shown as mean standard errors (SEM)

Discussion:-

In the present study, 1.7fold higher than ESD values in MLO projections were 1.7fold higher than CC projections ($p < 0.05$). Similarly,a previous study conducted in Sri Lanka evaluated thyroid skin dose from the MLO is on average 1.7 to 3.0 fold higher than the dose from CC (Herath *et al*., 2016).

During mammography, most of dispersed radiation goes back to the thyroid and only a small percentage reaches the gonads. Skin dose for the gonads rarely and almost never exceeds 0.1 mGy. However it can be noticed that the entrance skin dose for the thyroid varies according to compressed breast thickness for a complete examination (Kunosic *et al*., 2011).

Compressed breast thickness is considered as very important parameter in mammography. The main idea of this compression is to reduce the breast thickness and this will allow X-rays to penetrate through the breast more uniformly whereas inadequate compression would cause radiation penetration length to be increased and thus resulting in a higher amount of scatter radiation (Zeidan, 2009). Similar study done in Sri Lanka, showed the compressed breast thickness had contributed to the resulting AEDs where the breast thickness was high the resulting AED was also recorded as high (Herath *et al*., 2016).

Ionizing radiation produces some potential biological damage to human beings. The dose to critical organs of known sensitivity to the stochastic effects of radiation must be measured. With regards to mammography, the ATA does not recommend thyroid shields for mammography due to a lack of data to substantiate their use and the extremely low amount of radiation that reaches the thyroid. Furthermore, any risk to the thyroid is much lower than the benefit of mammography (Policy Statement on Thyroid Shielding during Diagnostic Medical and Dental Radiology, 2013).

According to the previous studies of radiation dose to organs and tissues from mammography (Monte Carlo and phantom study) based on the primary X-ray field from standard mammograms, it was conservatively estimated that the dose to the thyroid gland might be 10% of the skin dose overlying the thyroid (Whelan *et al*., 1999).

AED received by the skin overlying thyroid gland during a routine mammographic examination under normal clinical settings was found to be within the range of 16 to 24 µGy. However no significant difference was found when compared in respect to the side being imaged.

In the present study, a significant associations was found between breast compression thickness and type of projections. Kunosic et al. 2011 reported that most of dispersed radiation goes back to the thyroid and also it can be noticed that the ESD for the thyroid varies according to compressed breast thickness (Kunosic, Ceke & Basic 2011). This study further proved that ESD is high with compressed breast thickness. Therefore using proper adequate compression radiation dose to the thyroid gland can be minimized.

The angle of an MLO allows more of breast tissue to be imaged (It covers the main area of the breast) as well as the tissue in the armpit. It showed glandular as well as fatty tissue, and it covers a larger area than a CC view. In MLO, the plane of the cassette holder angled anywhere from 30 to 60 degrees from the horizontal. The angle of an MLO allows more of breast tissue to be imaged (It covers the main area of the breast) as well as the tissue in armpit. It showed glandular as well as fatty tissue, and it covers a larger area than a CC view. In the present study we found that the range of angle was 35 to 49 and the angle differed from patient to patient.However, no significant association was found between the values of ESD in MLO and the angles of MLO.

One of the limitations of this study was only one EPD was applied around the thyroid area, which could cause the difference in ESD. Applying two EPD on the skin around the thyroid may have increased the accuracy of the results. Two EPDs would simulate both thyroid lobes separately. Appyling four or five microchip devices around the thyroid area and taking the average value, could have increased the accuracy of the results.

The patients who need to follow up with frequent mammograms might have to be exposed to considerable amount of radiation to thyroid. In these patients carrying out limited protocols such as CC view might be effective in reducing the thyroid dose. Modify the MLO (eg oblique) view might overcome the issue of exposing the thyroid to high amount of radiation in MLO view.Researches show that in bilateral mammography with 2 incidents, dose can receive to thyroid cancer is about 30 minutes of background dose in a year to 1 person (Rafizadeh 2015). Previous studies reported that thyroid shields are not important for mammography (Nagda, 2012**,** Rafizadeh, 2015). Thyroid shield can slip out of place and can cause artifacts. Thyroid shield can interfere with the quality of mammography exams. Therefore, mammographic technologist has to repeat the image and patients are exposed to more radiation. Therefore the thyroid collar is unnecessary for mammograms.

This study found that there is a significant associations between breast compression thickness and type of projections. The previous study proved that during the mammography, most of dispersed radiation goes back to the thyroid and also it can be noticed that the ESD for the thyroid varies according to compressed breast thickness (Kunosic *et al*., 2011). This study further proved that ESD is high with compressed breast thickness. Therefore usage of proper compression radiation dose to the thyroid gland can be minimized.

Conclusion:-

ESD of MLO projection was significantly higher than ESD of CC projection. There is a significant association between CC and MLO projections ($p<0.05$). Similarly, compression of bast thickness of MLO showed a marked significant difference than CBT of CC.In addition, significant associations were found between breast compression thickness and type of projections. The value of ESD increase simultaneously with the compression of breast thickness in both projections, thus sharpening increments in MLO projection. The high value of CBT in MLO might cause the greater ESD of MLO. Therefore, the radiation dose to the thyroid gland can be minimized, using proper compression.

Educational programs to the public and medical staff about the radiation risk and importance of the thyroid gland protection in mammogram can be arranged. By conducting these sessions knowledge regarding radiation protection will improve and simultaneously would alleviate the fear of patients for mammograms. Future research considering age, height, weight, distance between the tube and simulated breast, compression force, kVp and mAs are important to validate data on ESD values of different projections.

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