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The local diagnostic reference levels for breast screening using digital mammography at Songklanagarind Hospital

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ABSTRACT

Introduction: This work aimed to determine local diagnostic reference levels (local DRLs) for screening mammography at Songklanagarind Hospital on digital mammography.

Materials and methods: Retrospective data of screening mammography were collected from 400 patients from Songklanagarind Hospital, 200 patients from Tanyawej Breast Center and 200 patients from Premium Diagnostic Imaging Center. The patients were women aged between 40-75 years old with compressed breast thickness between 41-65 mm. and undertaken screening mammogram during 1st January 2019 – 31st October 2020. Patient data and exposure parameters collected were as follows: average glandular dose (AGD), entrance surface air kerma (ESAK), compressed breast thickness (CBT), compression force (CF), peak kilovoltage (kVp), tube current-time (mAs), target and filter (W/Rh, W/Al), and patient age.

Results: The result showed that the average glandular dose of FFDM (2D mode) and DBT (3D mode) for compressed breast thickness 41-65 mm were 1.41±0.43 and 1.68±0.39 mGy, respectively and the 75th percentile of FFDM (2D mode) and DBT (3D mode) were 1.65 mGy and 1.89 mGy, respectively. The average ESAK were 4.93±1.96 mGy in FFDM (2D mode) and 5.31±1.55 mGy in DBT (3D mode), respectively. The 75th percentile of ESAK in FFDM (2D mode) and DBT (3D mode) were 6.03 and 6.17 mGy, respectively. There were 24.88 % and 24.63% received the average glandular dose over the 75th percentile in FFDM (2D mode) and DBT (3D mode).

Conclusion: Local Diagnostic Reference Levels for FFDM (2D mode) and DBT (3D mode) at Songklanagarind Hospital were 1.65 mGy and 1.89 mGy. The Local DRLs in our study was safe and lower than the standard reference levels reported by the International Atomic Energy Agency at 3 mGy/view.

Introduction

Breast cancer accounts for 1.7 million deaths per year worldwide and many people are badly suffering from such type of cancer. Breast cancer accounts for 32% of cancer incidence and 18% of cancer deaths in women in the United States. Presently, breast cancer is the most common type of cancer in Thai women and has the second highest rate of mortality.[1] Mammography is the x-ray machine that is recommended for breast screening program because it is a low-cost, low-radiation-dose procedure and has the sensitivity for early detection and improved treatment.

The international Atomic Energy Agency (IAEA)[2] proposed diagnostic reference levels (DRLs), defined as investigational levels applied to easily measured quantity

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using standard phantom or representative patient, expressed mean glandular dose (MGD), Entrance surface air kerma (Ka,e) to help optimize radiation doses and identify unjustified doses. IAEA emphasized that DRLs should be derived from national or local data and the "As Low as Reasonably Achievable" or ALARA principle should be adhered to minimize potential hazards of ionizing radiation. Mammography dosimetry is a complex issue. The mean glandular dose depends on breast size, compressed breast thickness (CBT), kVp, mAs and compression force (CF). IAEA recommended MGD as a DRL quantity, even though it is a measure of organ dose rather than the amount of ionization radiation used to perform a medical imaging task.

In mammography, the recommended DRLs quantity is one or more of incident air kerma, entrance surface air kerma and MGD with the choice of quantity depending on local practices and regular requirement. A study by Singkavongsay A. et al reported the national diagnostic references levels of mammography in Thailand. They reported that the third quartile of the MGD in 2D was 2.04 mGy, the median was 1.59 mGy and the third quartile of ESAK was 9.74 mGy. NDRL on mammogram in 2D of Thailand was closed to Australia at 2.06 mGy and lower than Japan (DRLs). MGD was depended on breast density, age, and its composition. Digital Breast Tomosynthesis, age and breast density were not included in this study. Nguyen *et al*.[3] assessed the relationship between breast density and radiation dose by retrospective screening mammography data and found that breast thickness was primary determinant of dose. They stated that compressed breast thickness was a major factor in received AGD, breast density was a minor factor, and body mass index as well as patient's age had minimal impacts on dose levels. As Asian woman have denser breast tissue than Western women, it might affect the accuracy of radiation dose evaluation in this group of patients.

The aim of the study was to determine the local diagnostic reference levels (local DRLs) and the parameters for screening mammography in both FFDM and DBT modes at Songklanagarind Hospital, Thailand.

Materials and methods

The study was approved by the Human Research and Ethics Committee of the Faculty of Medicine, Prince of Songkla University, REC.64-010-7-2.

A retrospective descriptive study included 400 women aged between 40-75 years old with compressed breast thickness between 41-65 mm and undertaken screening mammogram during 1st January 2019 – 31st October 2020 at Tanyawej Breast Center and Premium Diagnostic Imaging Center, Songklanagarind Hospital. Women with breast implant, breast mastectomy, and breast conserving therapy were excluded.

Quality control of digital mammography system employed guideline from European Guidelines.[4] Mammographic studies were performed using Selenia Dimension Hologic and Fuji Amulet Innovality machine. Patient data and exposure parameters collected were as follows: average glandular dose (AGD), entrance surface air kerma (ESAK), compressed breast thickness (CBT), compression force (CF), peak kilovoltage (kVp), tube current-time (mAs), and target and filter (W/Rh, W/Ag, W/Al). Patient age on monitor screen was also recorded for verification. Each patient received 8 exposures in two modes (FFDM and DBT). The first 4 exposures were performed in FFDM to produce images in the RCC, RMLO, LCC and LMLO views. The second 4 exposures were performed in the DBT mode in the same view and compression. Patients with breast implants or who were imaged in special added positions were excluded from the study.

To determine DRLs, the 75th and 95th percentiles were calculated across the median AGD. Values for each mammography were then categorized according to their compressed breast thickness to range between 41-65 mm thicknesses. The R statistical analysis program was used to analyze the 75th and 95th percentiles, median, and histogram in this study.

Results

Four hundred women aged between 40-75 years old with compressed breast thickness between 41-65 mm were included in this study. The histogram shows the compressed breast thicknesses ranged between 41-65 mm. The result showed a normal distribution with mean and median of 55.22 and 55 mm. (Figure. 1), while image AGD showed a normal distribution that ranged from 0.9 mGy to 3.4 mGy with mean and median of 1.79 and 1.7 mGy, respectively (Figure 2).

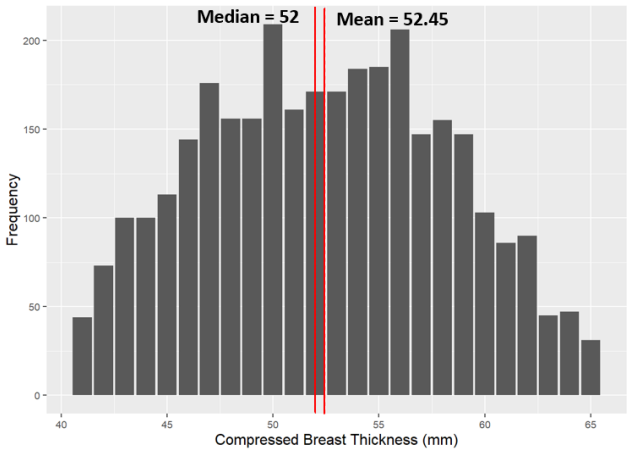

Figure 1. *Distribution of compressed breast thickness in FFDM (2D mode) and DBT (3D mode) in 1600 mammography images with median 52 mm. and mean 52.45 mm.*

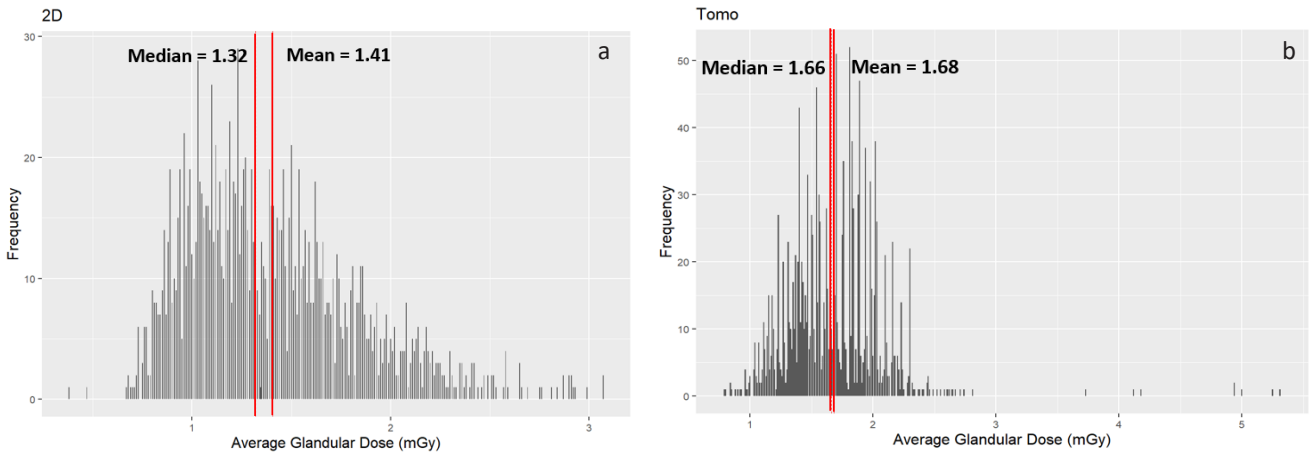

Figure 2. *Distribution of average glandular in 1600 mammography images for compressed breast thickness 41-65 mm. a: distribution of average glandular dose in FFDM (2D mode) with median 1.32 and mean 1.41 mGy, b: distribution of average glandular dose in DBT (3D mode) with median 1.66 and mean 1.68.*

Table 1 shows the parameters used in FFDM (2D) and DBT (3D) modes. Average kVp of FFDM (2D) performed in RCC, LCC, RMLO, LMLO view were 29.13±1.03, 29.16±1.04, 29.46±1.06, and 29.58±1.12, respectively. Average kVp of DBT (3D) performed in RCC, LCC, RMLO, LMLO view were 31±1.24, 31±1.31, 31±1.34, and 32±1.37, respectively. kVp used in DBT mode was significantly higher than that of kVp used in FFDM mode. The mAs values of DBT in RCC, LCC, RMLO, LMLO view were 52.84±7.89, 51.97±7.73, 53.73±7.27, and 54.71±7.33, respectively. These values were significantly lower than that of FFDM mode of 97±10.5 in RCC view, 96±10.72 in LCC view, 99±8.49 in RMLO view, and 101±8.03 in LMLO view, respectively. Mean CF was slightly different in the four views. The average CF of FFDM (2D) performed in RCC, LCC, RMLO, LMLO view were 66.03±20.58, 67.33±20.73, 87.41±24.21, and 96.24±26.83, respectively. Average CF of DBT (3D) performed in RCC, LCC, RMLO, LMLO view were 66.08±20.58, 66.99±20.65, 87.83±23.57, and 95.16±28.21, respectively. Mean CBTs were slightly different in the four views. The mean CBT in RCC and LCC projection mode was 52 mm and in RMLO and LMLO projection was 54 mm.

Table 1 Parameters used in full field digital mammography (2D mode) vs digital breast tomosynthesis (3D mode) in women aged between 40-75 years old at Songklanagarind Hospital.

View	kVp		mAs		CF (N.)		CBT (mm)	
Mode	2D	3D	2D	3D	2D	3D	2D	3D
RCC	29.13±1.03	31.00±1.31	97.00±10.5	52.84±7.89	66.03±20.58	66.08±20.58	52.00±5.37	52.00±5.39
LCC	29.16±1.04	31.00±1.31	96.00±10.72	51.97±7.73	67.33±20.73	66.99±20.65	52.00±5.54	52.00±5.55
RMLO	29.46±1.06	31.00±1.34	99.00±8.49	53.73±7.27	87.41±24.21	87.83±23.57	55.00±5.81	54.5±5.82
LMLO	29.58±1.12	32.00±1.37	101.00±8.03	54.71±7.33	96.24±26.83	95.16±28.21	55.00±6.06	55.00±6.06

Note: *kVp: kilovoltage peak, RCC: right-craniocaudal, LCC: left-craniocaudal, RMLO: right-mediolateral oblique, LMLO: left-mediolateral oblique, mAs: milliampere-seconds, CF: compression force, N.: newton, CBT: compressed breast thickness, mm: millimeters, 2D: two-dimension, 3D: three-dimension.*

The results of radiation dose are shown in Table 2. AGDs were 1.41±0.43 and 1.68±0.39 mGy in FFDM (2D mode) and DBT (3D mode). The average ESAKs were 4.93±1.96 mGy in FFDM mode and 5.31±1.55 mGy in DBT mode, respectively. The third quartiles of AGD and ESAK in FFDM were 1.65 and 6.03 mGy, respectively. In DBT mode, the third quartiles were 1.89 and 6.17 mGy, respectively, which were higher than that of FFDM mode. The 95 percentiles of AGD and ESAK in FFDM were 2.14 and 8.60 mGy, respectively. In DBT mode, the 95 percentiles were 2.23 and 7.56 mGy, respectively, which were higher than that of FFDM mode.

Table 2 Average glandular dose in full field digital mammography (2D mode) compared to digital breast tomosynthesis (3D mode) in women aged between 40-75 years old at Songklanagarind Hospital.

	AGD (mGy)		ESAK (mGy)	
	2D	3D	2D	3D
1st Q	1.08	1.42	3.46	4.25
Median	1.32	1.66	4.45	5.05
Mean	1.41	1.68	4.93	5.31
75th Q	1.65	1.89	6.03	6.17
95th Q	2.14	2.23	8.60	7.56

Note: *AGD: average glandular dose, ESAK: entrance surface air kerma, 2D: two-dimension, 3D: three-dimension.*

Figure 3 shows the third quartiles and 95 percentiles of AGD in FFDM (2D mode) and DBT (3D mode) in 4 conventional views. The third quartiles and 95 percentiles of AGD in FFDM (2D mode) were 1.65 and 1.89 mGy, respectively. In DBT (3D mode), the third quartiles and 95 percentiles of AGD were 2.14 and 2.23 mGy, respectively, which were higher than that of FFDM (2D mode).

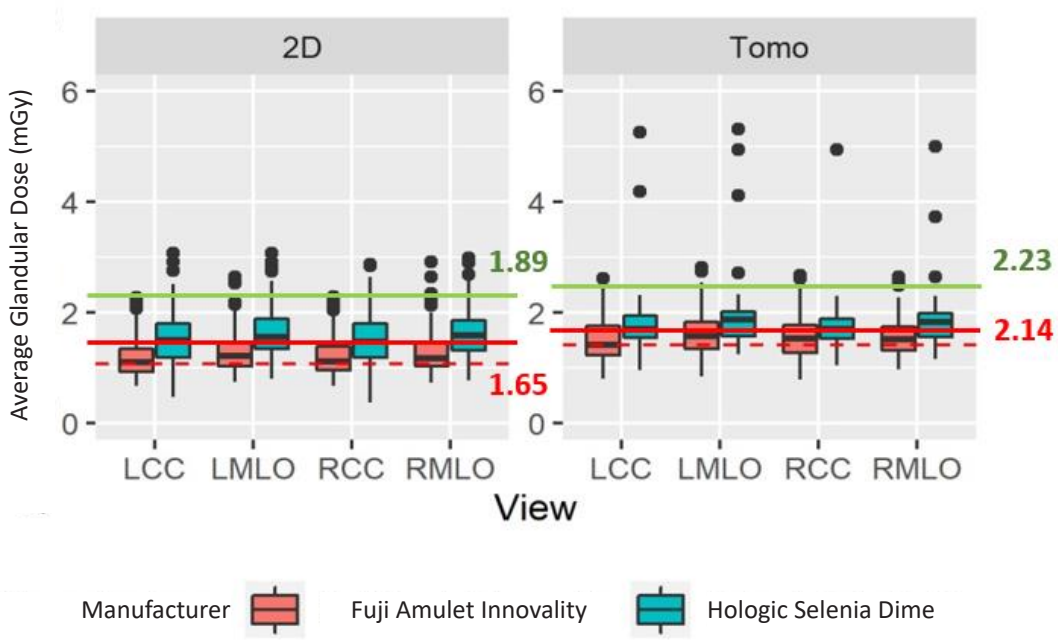

Figure 3. *Box and whisker plot of the average glandular dose in FFDM (2D mode) and DBT (3D mode) in RCC, LCC, RMLO, LMLO views.*

Discussion

The histogram of compressed breast thickness and the average glandular dose indicated normal distribution in Figure 1 and 2 were similar to the distribution reported in Suleiman et al. study.[5] Overall, it was found that our reported median compressed breast thickness and median average glandular dose were less than Suleiman et al study in 2016.

According to average glandular dose in Table 1 and Figure 3, there were 24.88% received average glandular dose over the 75th percentile in 2D technique. There were 24.63% received average glandular dose over the 75th percentile in tomosynthesis technique. There were 4.88% and 4.10% received average glandular dose over the 95th percentile in FFDM (2D mode) and DBT (3D mode), respectively. The protocol setting at Songklanagarind Hospital was effective and suitable for diagnostic breast screening.

Table 3 Mean, median, 75th and 95th percentile of digital mammography in FFDM (2D mode) and DBT (3D mode).

	Mode	Mean (mGy)	Median	75th Percentile	95th Percentile
Songklanagarind Hospital	2D	1.41	1.32	1.65	2.14
	Tomosynthesis	1.68	1.66	1.89	2.33
NDRLs Thailand[6]	2D	1.72	1.59	2.04	-
Ritlumlert N.[7]	2D	1.36	-	1.67	-
	Tomosynthesis	1.63	-	1.81	-
NDRLs Japan [8]	2D	1.84	-	-	2.40
	Tomosynthesis		-	-	-
IAEA recommended [2]	2D	3	-	-	-
	Tomosynthesis	-	-	-	-

As shown in Table 3, median AGD and 75th percentile of FFDM (2D mode) for median compressed breast thickness of 52 mm were 1.32 and 1.65 mGy, respectively. These values were lower than 1.59 and 2.04 mGy reported in NDRLs Thailand[6] in 2020 which employed similar methods to estimate the dose with median compressed breast thickness of 52.3 mm. The 75th percentile of FFDM (2D mode) and DBT (3D mode) for mean compressed breast thickness of 52.45 mm were 1.65 and 1.89 mGy., respectively. Comparing to the study of Ritlumlert N.,[7] the 75th percentile for mean compressed breast thickness of 52.83 mm were 1.67 and 1.81 mGy. Result from this study was lower than Ritlumlert N. study in FFDM (2D mode) and higher than Ritlumlert N. study in DBT (3D mode). Regarding to Ritlumlert N. study, they used the different mammography machine compared to this study. The 75th percentile of DBT (3D mode) in this study that higher than Ritlumlert N. study received by symptomatic women could be explained by the inclusion of younger women with denser breasts.

More recent study in NDRLs Japan [8] reported mean AGD and 95th percentile of FFDM (2D) of 1.84 and 2.4 mGy, respectively. These values were higher than 1.41 and 2.14 mGy reported in this study. Local DRLs in this study was safe and lower than the standard reference levels reported by the International Atomic Energy Agency at 3 mGy/view.

Moreover, the differences compressed breast thickness ranges and the symptomatic women different image detector technology might contribute to higher doses. The results suggested some potential for optimization of the protocol setting (kVp, mAs, CF) included in this study. DRL values in mammography should be specific to breast thickness and image detector technology as large variations between compressed breast thickness ranges and image detector technologies were found.

Conclusion

The Local Diagnostic Reference Levels for FFDM (2D mode) and DBT (3D mode) at Songklanagarind Hospital were 1.65 mGy and 1.89 mGy. The Local DRLs in this study are safe and lower than the standard Reference Levels reported by the International Atomic Energy Agency at 3 mGy/view.

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Conflict of interest

There are no conflicts of interest to disclose.

Ethic approval

Human Research Ethics Committee under project number REC.64-010-7-2

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