NATIONAL DIAGNOSTIC REFERENCE LEVELS OF DIGITAL MAMMOGRAPHY IN THAILAND

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Abstract— **The patient radiation dose survey on national diagnostic reference level (NDRLs) of digital mammography was planned to be established in 2018 by Department of Medical Sciences, Ministry of Public Health, Thailand. The survey covered 157 from 456 digital mammography systems installed at various parts of Thailand. At least twenty patients had been selected per system which 3320 patients were included. The x-ray output and the entrance surface air kerma (ESAK) had been measured as part of the quality control of the mammography system to determine the mean glandular dose (MGD) from the routine techniques. The patient compressed breast thickness (CBT) had been recorded in relation to the MGD. The mean, 1st quartile, 2nd quartile (median), 3rd quartile, maximum and the standard deviation for MGD and ESAK were determined. The NDRLs were obtained from the third quartile of MGD, ESAK and compared to other NDRLs and RDRLs for further optimization on the mammographic protocols.**

Keywords— **DRL, digital mammography, MGD, ESAK**

I. INTRODUCTION

Breast is one of the highly radiosensitive organs. The annual screening of mammography for women aged 40–80 years is associated with a life time attributable risk, LAR, of fatal breast cancer of 20–25 cases in 100 000 (BEIR VII) [1]. The benefit and risk ratio for annual mammography is estimated to be greater than 50:1 for both the 40–80 and 50–80 year old screening groups, but drops to 3:1 for the 40–49 age group mammography. Mammography dosimetry is a complex issue. MGD depends on the breast size, compressed breast thickness (CBT), kVp, mAs, and compression force (CF). The MGD slightly decreases with increasing patient age. Current methods of dose optimization make assumptions of the breast composition of gland and other breast tissue at 50:50, and using Dance models [2] for estimating glandularity and patient-specific dose. According to the CBT from 20 to 50 mm, the MGD slightly increases with increased CBT then decreases, no difference in dose at CBT greater than 90 mm. ICRP[3] recommends MGD as a DRL quantity, even though it is a measure of organ dose rather than the amount of ionizing radiation used to perform a medical imaging task. Entrance surface air kerma (Ka, e) allows direct comparisons among mammography units with similar target/filter combinations. Incident air kerma (K_a, i) per mAs is derived from output measurements, made with the breast compression device in position. This is then multiplied by the mAs used to obtain the incident air kerma for the examination. Incident air kerma is required for the calculation of mean glandular dose. The relationship between incident air kerma and mean glandular dose is highly dependent on breast thickness and composition, as well as beam quality. MGD is calculated from the incident air kerma used for the examination for a specified thickness of compressed breast. The incident air kerma and MGD will depend on the size of the breast and its composition, which changes throughout a woman's life. For mammography, the recommended DRL 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 regulatory requirements. Establishing DRL values for different breast thicknesses is a more complex but better approach to refine the DRL process for mammography. When entrance surface air kerma or incident air kerma is used as the DRL quantity, evaluation program arrangements should be based on medical physicist's recommendations to ensure that dependence on breast thickness and differences in glandular dose are taken into account. Surveys of patients recommended as the main method of evaluating the amount of radiation applied in mammography as phantoms do not assess the full range of breast sizes for which examinations will be undertaken, and do not reflect clinical use of the equipment. Compliance with DRL values does not indicate that the procedure is performed at an optimized level with regard to the amount of radiation used. The *median* value of the national distribution can serve as an additional tool to aid in optimization, may be a desirable goal at which to aim using standard techniques and technologies, and represents a situation closer to the optimum use of the applied radiation.

ICRP recommends setting local and national DRL values based on DRL quantities for imaging examinations and procedures performed on patients [3]. Data on DRL quantities can be collected using surveys, registries, or other automated data collection methods. All dosimeters must be calibrated and should be traceable to a primary or secondary standard laboratory. The accuracy of DRL quantity data produced by and transferred from x-ray systems should be verified periodically by a clinically qualified medical physicist in diagnostic radiology.

II. MATERIALS AND METHODS

The hospitals in Thailand are classified according to the number of beds, such as *the community hospital* equipped with 10-120 beds, *general hospital* equipped with 121-500 beds, *regional hospital* with more than 500 beds. *Specialized hospitals* are cancer centres, psychiatric hospital, cardiac center, and etc. The survey covered 157 from 456 digital mammographic systems in Thailand. From all parts of the country, only 1 system was randomly selected from community hospital, 52 systems from general hospitals, 22 systems from regional hospitals and 82 systems from private hospitals as shown in Table 1. Select at least 20 women from each system with average CBT at 50 ± 5 mm.3320 women were included in the survey on MGD of 4 views of cranio-caudal (CC) and medio- lateral oblique (MLO) for left and right breasts per woman resulting in total 13,280 views in the survey Extract CBT, kVp, mAs, MGD and ESAK from the system displayed monitors, PACS and DICOM header.

Table 1 157 mammographic systems from the community, general, and regional hospitals, Ministry of Public Health, and private hospitals at various regions of Thailand included in this survey.

Number of mammographic systems					
Region	**Community Hospital**	**General Hospital**	**Regional Hospital**	**Private Hospital**	**Total**
North	1	15	2	12	**30**
Middle	-	9	12	41	**62**
North-East	-	14	4	12	**30**
East	-	2	2	10	**14**
South	-	12	2	7	**21**
Total	**1**	**52**	**22**	**82**	**157**

III. Results

The patient data on the compressed breast thickness (CBT, mm), the mean glandular dose, MGD (mGy) and the exposure techniques of kVp and mAs were recorded from PACS. Among the data distributions, the first quartile (25th percentile), the second quartile (50th percentile) or the median and *achievable dose*, the mean, the third quartile (75th percentile), the maximum and the standard deviation were determined for CBT, kVp, mAs and MGD as in table 2, 3, 4,5.

IV. Discussion and conclusion

Eighty seven percent of the mammographic system in Thailand is the digital mammogram while the other thirteen percent is computed radiographic system and had not been included in this survey. Such the CR system will be obsoleted in the near future. Among 157 digital mammographic systems in this survey, the x-ray target materials were molybdenum (Mo), rhodium (Rh) and tungsten (W). The filters were molybdenum, rhodium, and silver (Ag). The target/filter combinations were Mo/Mo, Mo/Rh, Mo/Ag, Rh/Rh, Rh/Ag, W/Rh, and W/Ag which result in various exposure techniques and the MGD according to the CBT, the breast tissue composition and the breast glandularity.

Table 2 Technical parameters on tube voltage (kVp) for cranio- caudal (CC) and medio- lateral oblique (MLO) views on right and left breasts and mean values at 25th percentile (1st Quartile), median (2nd Quartile) and achievable dose, 75th percentile (3rd Quartile), maximum and standard deviation.

kVp					
	RCC	LCC	RMLO	LMLO	Mean
1st Q	28	28	28	28	28
Median	29	29	29	29	29
Mean	28.9	29	29.3	29.3	29.1
3rd Q	30	30	30	30	30
Max	35	35	35	35	35
SD	1.7	1.7	1.8	1.8	1.8

Table 3 Technical parameters on tube current time (mAs) for cranio caudal (CC) and medio lateral oblique (MLO) views on right and left breasts and mean values at 25th percentile (1st Quartile), median (2nd Quartile) and achievable dose, 75th percentile (3rd Quartile), maximum and standard deviation.

mAs					
	RCC	**LCC**	**RMLO**	**LMLO**	**Mean**
1st Q	82	80	75.9	76	78.5
Median	110.8	109.7	109	106	108.9
Mean	120.3	119	114.3	111	116.2
3rd Q	148.1	147.6	148	144	146.9
Max	384	447	420	400	412.8
SD	55.5	56.3	59.4	55.6	56.7

Table 4 Compressed breast thickness (CBT, mm) for cranio caudal (CC) and medio lateral oblique (MLO) views on right and left breasts and mean values at 25th percentile (1st Quartile), median (2nd Quartile), 75th percentile (3rd Quartile), maximum and standard deviation.

CBT (mm)					
	RCC	**LCC**	**RMLO**	**LMLO**	**Mean**
1st Q	45	45	46	46	45.5
Median	51	52	53	53.3	52.3
Mean	51.9	52.3	53.6	53.7	52.9
3rd Q	58	58	60	60	59
Max	100	93	95	96	96
SD	10.4	10.6	10.8	11	10.7

Table 5 Mean Glandular Dose (MGD, mGy) for cranio – caudal (CC) and medio lateral oblique (MLO) views on right and left breasts and mean values at 25th percentile (1st Quartile), median (2nd Quartile) and achievable dose, 75th percentile (3rd Quartile), maximum and standard deviation.

MGD (mGy)					
	RCC	**LCC**	**RMLO**	**LMLO**	**Mean**
1st Q	1.23	1.22	1.29	1.18	1.23
Median	1.57	1.57	1.62	1.58	1.59
Mean	1.72	1.7	1.74	1.69	1.71
3rd Q	2.05	2.06	2.04	2.01	2.04
Max	5.29	5.05	5.69	6.42	5.61
SD	0.68	0.67	0.66	0.78	0.70

Table 6 National Diagnostic Reference Levels of MGD among Thailand Australia and Japan in comparison to regional diagnostic reference level of the International Atomic Energy Agency (IAEA). The ESAK (mGy) from Thailand and IAEA are displayed in the table

NDRLs & RDRLs (mGy)				
	Thailand	**Australia**	**Japan**	**IAEA**
MGD (mGy)	2.04	2.06	2.4	3
ESAK(mGy)	9.74		-	11

In this survey, the national authority at the Department of Medical Science, Ministry of Public Health had planned and requested the government budget in 2018 to arrange the quality control test of the mammographic system in Thailand [4]. The incident air kerma and the entrance surface air kerma of all mammographic systems in Thailand had been determined by following the technology as mentioned in IAEA TRS 457[5]. The cooperation between the national authority and the professional societies such as Royal College of Radiologists of Thailand, Radiological Society of Thailand, Radiological Technologist Society of Thailand, and Thai Medical Physicist Society had been set up to establish the mammogram guidelines for training the users on the concept of LDRLs, NDRLs on digital mammogram with the applications of the guidelines, the methodology on data collection and analysis [4].

The first NDRLs on the digital mammogram system is established in 2019 in Thailand. From 157 mammographic systems, 3320 Thai women with the average CBT was 52.9± 5 mm, the third quartile of the MGD was 2.04 mGy, the mean was 1.71 mGy, the median and the achievable dose (2nd Q) was 1.59 mGy. The third quartile of ESAK was 9.74 mGy. NDRLs on mammogram of Thailand had been compared to other countries, it was close to Australia at 2.06 mGy and lower than Japan DRL (2015) which was 95th percentile at 2.4 mGy. RDRLs established by IAEA, MGD was 3 mGy and ESAK was 11 mGy as in table 6.

NDRLs in mammography should be stratified according to CBT and detector technology. The age and breast density may need to be taken into account. The digital mammographic system with the digital breast tomosynthesis (DBT) would be increasing at the tertiary care hospital such as cancer center, university hospital and private hospital. The national survey on DRLs in digital mammogram with DBT is planned in the next three years and established in 2025.

Reference

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