Mean Glandular Dose from Routine Mammography

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Abstract

A mammography examination facilitates the early detection of breast cancer. However, the potential risk of radiation-induced carcinogenesis is also increased with such a procedure. The objective of this research was to measure the mean glandular dose (MGD) from craniocaudal (CC) and mediolateral oblique (MLO) views in each breast and the total dose per woman (for both breasts and two views) from the exposure factor in patients undergoing mammography on six mammography x-ray generators in the lower region of northern Thailand. The values of compressed breast thickness (CBT), as well as the MGD calculated from the exposure and tube voltage both mAs and target/filter combination, were collected from 2,060 films from 515 women ranging in age from 28 to 91 years. Significant differences were found between MGD from CC and MLO projections. The MGD per film was 1.42$\pm$0.80 mGy for the CC projection and 1.56$\pm$0.86 mGy for the MLO projection, ($p<0.001$). The MGD per CC and MLO film was significantly related to CBT ($r = 0.610$, $p<0.01$ and $r = 0.596$, $p<0.01$ respectively). The result indicated that 96.1 % of CC films and 94.2 % of MLO films had doses less than 3.0 mGy as recommended by the American College of Radiology recommendations. This may ensure that the mammography examination in the lower region of northern Thailand is capable of achieving acceptable dose levels for patient safety.

Keywords: Mean glandular dose; Compressed breast thickness; Mammography

Introduction

In Thailand, breast cancer is the most common malignancy in women and the second leading cause of cancer death (exceeded only by cervical cancer) (National Cancer Institute, 1997). Early detection of breast cancer is the key to successful long-term control of the disease and good prognosis, while mammography of excellent quality is a fundamental prerequisite (Miller, 2005). Mammography should continue yearly after the age of 40 throughout a woman's life. However, the breast is a radiosensitive organ and has a tissue-weighting factor of 0.05 (International Commission on Radiological Protection,1991). Hence, the potential risk of radiation-induced carcinogenesis is increased with such a procedure (Bushong, 1993; Fung & Gilboy, 2001). Because the glandular tissues of the breast are more radiosensitive than adipose tissues, the estimation of mean glandular dose (MGD) has become an area of concern (Faulkner et al., 1995). As direct estimation of the MGD is not feasible, it is often estimated from the measurements of the breast entrance skin exposure and converted to MGD by applying conversion factors (American College of Radiology, 1999; Wu, 1991). The American College of Radiology (ACR) specifies that the MGD should not exceed 3 mGy per view for screen-film image receptors (American College of Radiology, 1994; Frank, 2005; Suleiman et al., 1999).

Most standard mammography workups include two views of each breast, the craniocaudal (CC) and mediolateral oblique (MLO) views. Even if there is a lump in only one breast, pictures will be taken of both breasts. Thus, the breasts can be compared and the other breast can be checked for abnormalities (Hackshaw et al., 2000). A number of research on MGD determination. (Bulling & Nicoll, 1995; Klein et al., 1997; Moran, 1994; Thilander et al., 1992; Wall & Roberts, 1992; Young et al., 1992) were conducted in European females. However, no research has studied the estimation of MGD, the exposure factor used in mammograms, and the compressed breast thickness (CBT) in Thai females.

The objective of this research was to measure the MGD from CC and MLO views in each breast and total dose per woman (for both breasts and two views) from the exposure factor in the patients undergoing mammography on six mammography x-ray generators in the lower region of

northern Thailand. Moreover, data on CBT were also collected.

Materials and Methods

Six mammography x-ray generators (Hospital A-F) in the lower region of northern Thailand were employed in this study. Data were collected from women undergoing mammography examinations over the period from December 2005 to April 2006 (aged from 28 to 91 years). Specification of each mammography x-ray generators are shown in Table 1. The quality control such as accuracy and reproducibility of kVp and time, and half value layer (HVL) were acceptable in all 6 mammography generators.The majority of films were recorded as having been taken at 28 kV.

The method for estimating the MGD to the breast of a patient consisted of collecting the data on CBT for each film with an indication of the tube voltage, and mAs and target/filter combination for each patient. Thereafter, breast entrance skin exposure was measured by using the ionization chamber placed in the x-ray field. The ionization chamber systems employed in this research consisted of a 6-cc chamber with an electrometer. The exposure measure (mR) was converted to the MGD according to ACR recommendations (American College of Radiology, 1999). Figure 1 shows the chamber with the electrometer setting.

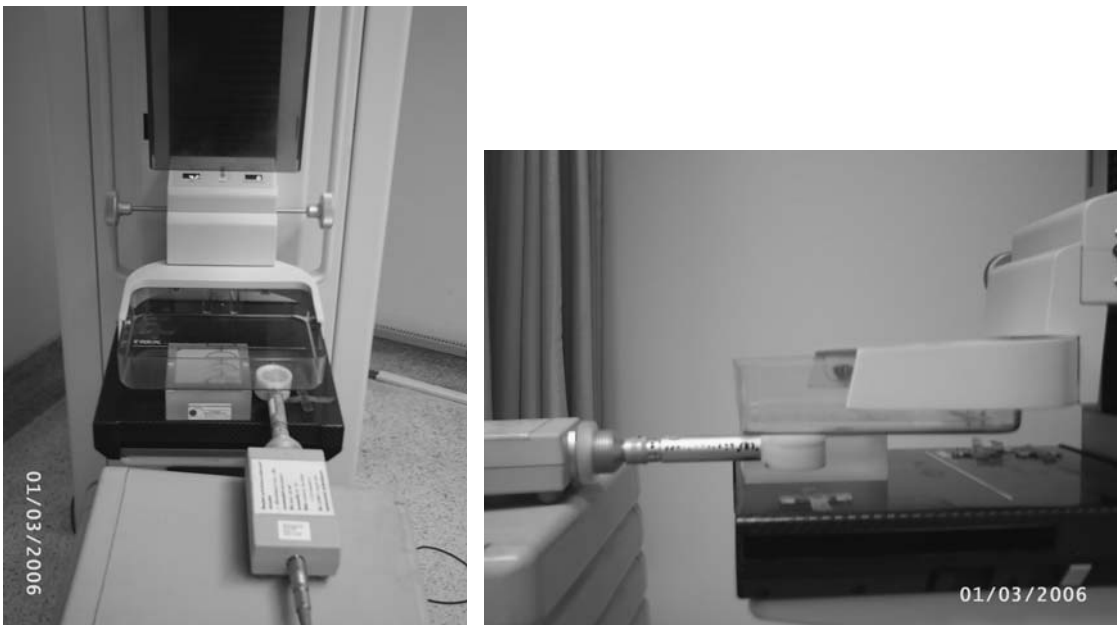

Figure 1 Chamber and electrometer setting.

Before measuring breast entrance skin exposure, quality control of mammography systems was evaluated including beam quality assessment (HVL Measurement), kVp, time accuracy, and reproducibility according to ACR recommendations (American College of Radiology, 1999).

The paired sample t-test was used to compare the differences in the MGD between CC and MLO projection. Correlation analysis with the Pearson correlation coefficients (1.00 = perfect correlation; 0 = no correlation at all) was used to test the relationship of CBT and MGD. A p-value of less than 0.05 was considered statistically significant.

All data were entered onto the Statistical Package for the Social Sciences (SPSS) for analysis. The data were analyzed in three parts: (i) MGD resulting per film from CC and MLO projections, (ii) MGD resulting per woman (complete examination or 4 films), (iii) the CBT in each projection.

Table 1 Specification of each mammography x-ray generator.

	Hospital A (n=186)	**Hospital B (n=49)**	**Hospital C (n=47)**	**Hospital D (n=48)**	**Hospital E (n=117)**	**Hospital F (n=68)**
Model	LORAD Model M -IV	GE medical system Model senographe 800 T	Planmed Sophie	Semens mammo mat 300	Villa Model Venus - HF	Philip mammo Diagnost UC
Focus to film distance (cm)	60	66	65	65	65	60
Target	Mo	Mo	Mo	Mo	Mo	Mo
Filter	Rh	Mo	Mo	Mo	Mo	Mo
kV range	20-35	22-35	20-35	23-35	24-40	22-49
mAs range	5-400	4-600	100-500	0-600	0.5-640	22-49

Results and Discussion

The value of breast thickness and MGD were collected from 2,060 films (1,030 films each for CC and MLO projections). The mean dose per film was 1.42±0.80 mGy for the CC projection and 1.56±0.86 mGy for the MLO projection. The mean dose per woman was 5.96±3.15 mGy. Significant differences were found between MGD from CC and MLO projections ($p < 0.001$). The CC doses tend to be less than the MLO doses. This may be due to the fact that the pectoral muscle overlying in the MLO projection causes greater attenuation and therefore higher exposure. The MGDs per CC and MLO films are significantly related to the CBT ($r = 0.610$, $p < 0.01$ and $r = 0.596$, $p < 0.01$, respectively).The MGD and CBT in CC and MLO projections are shown in Table 2.

Doses for CC and MLO projections according to the CBT are shown in Figure 2 and 3. The results indicated that doses for 96.1 % of films of CC projection and 94.2% of films of MLO projections were less than 3.0 mGy. Moreover, 79.8% and 72.4% of films for CC and MLO projections were lower than 2.0 mGy. The American College of Radiology recommends that the MGD should not exceed 3 mGy per view and the result from this research showed that only 4.3 % of the films of CC projection and 5.8 % of MLO projections were higher than the standard dose. This may ensure that the mammography x-ray generators in the lower region of northern Thailand are capable of achieving an acceptable dose for patient safety.

Mean CBT of the CC and MLO projection were 3.74±1.43 cm and 3.77±1.64 cm, respectively. However, the measurement of breast thickness might vary because there was no standard method for measuring the thickness of the breast and the values were obtained from individual practice by each radiation technician.

The CBT, MGD per film, and MGD resulting per woman as classified by age group are shown in Table 3. It indicates that the MGD tends to decrease with increasing age because of the decrease in glandular tissues.

In a similar study, Burch & Goodman (1998) reported a pilot survey of radiation doses received in the United Kingdom breast screening program. The result demonstrated that the dose per film was 1.7 mGy for the MLO view (mean thickness 57 mm) and 1.4 mGy for the CC view (mean thickness 52 mm). Wall & Roberts (1992) reported that mean thickness of breast was 55±13 mm and mean dose per film was 2.0 mGy. The MGD estimation in these two studies were based on the assumption that all breasts had a standard 50:50 ratio of adipose to glandular composition. However, the women in this study were from different geographical areas and different ethnic groups. Thus the breast thickness was less than those of other two studies. Since the CBT influences the length of x-ray passage through the breast, the mean MGDs reported in present study thus were lower than the values reported in the previous two studies (Burch & Goodman, 1998; Wall & Roberts, 1992).

Conclusions

The study of MGDs in the present study revealed that the mean MGD per film was 1.42±0.80 mGy for the CC projection and 1.56±0.86 mGy for the MLO projection with significant differences of the MGDs from CC and MLO projections ($p < 0.001$). Overall, 96.1 % of CC films and 94.2 % of MLO films had doses less than 3.0 mGy. This study ensures that the mammography x-ray generators in the lower region of northern Thailand are capable of achieving acceptable dose levels for patient safety. In addition, the CBT had a mean value of 3.74±1.43 cm and 3.77±1.64 cm for CC and MLO projections, respectively. The MGD per CC and MLO film was significantly related to the CBT.

Table 2 Mean glandular dose and compressed breast thickness in each projection classified by hospital.

		Hospital A (n=186)	Hospital B (n=49)	Hospital C (n=47)	Hospital D (n=48)	Hospital E (n=117)	Hospital F (n=68)	Average (n=515)
Mean glandular dose (mGy)	Craniocaudal view	1.44±0.90 (0.39-4.59)	1.97±0.95 (0.73-4.91)	1.64±0.69 (0.58-3.43)	1.34±0.77 (0.26-2.86)	1.52±0.45 (0.59-2.65)	0.70±0.41 (0.18-2.25)	1.42±0.80 (0.18-4.91)
	Mediolateral oblique view	1.73±0.88 (0.51-4.60)	1.39±0.76 (0.36-4.14)	1.85±0.71 (0.90-3.48)	2.00±1.28 (0.19-5.24)	1.59±0.45 (0.64-2.84)	0.68±0.49 (0.18-2.71)	1.56±0.86 (0.18-5.24)
	Dose per women	6.33±3.42 (1.88-18.39)	6.72±3.19 (2.16-18.08)	6.97±2.65 (3.30-13.63)	6.69±3.91 (0.89-15.41)	6.21±1.78 (2.45-10.97)	2.77±1.76 (0.71-9.11)	5.96±3.15 (0.71-18.39)
Compressed breast thickness (cm)	Craniocaudal view	4.57±0.91 (3.10-7.05)	4.73±1.00 (2.35-6.60)	4.77±0.70 (3.40-6.45)	2.76±1.77 (1.26-6.85)	2.99±0.87 (1.50-5.00)	2.12±1.00 (0.50-4.75)	3.74±1.43 (0.50-7.05)
	Mediolateral oblique view	5.04±0.91 (3.45-7.40)	4.27±1.01 (1.75-6.30)	5.07±0.73 (3.85-6.75)	3.20±2.04 (1.38-7.30)	2.39±0.75 (1.00-4.50)	2.04±1.01 (0.50-5.00)	3.77±1.64 (0.50-7.40)

Note.
Each data represents mean±SD and range in parenthesis

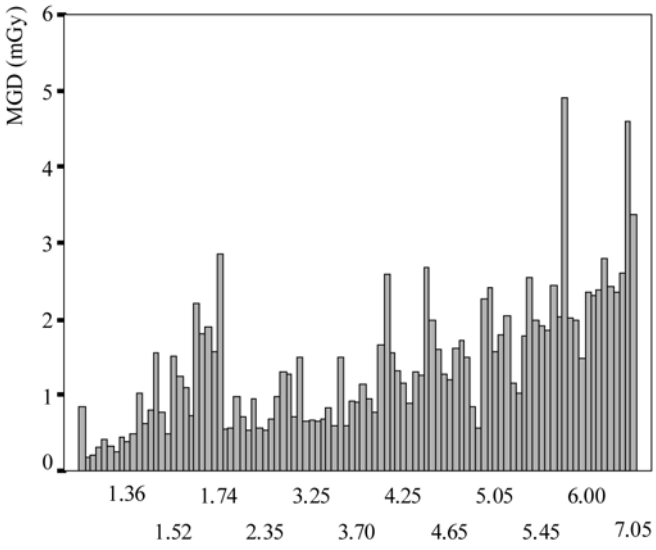

Figure 2 The MGD for craniocaudal projection according to compressed breast thickness.

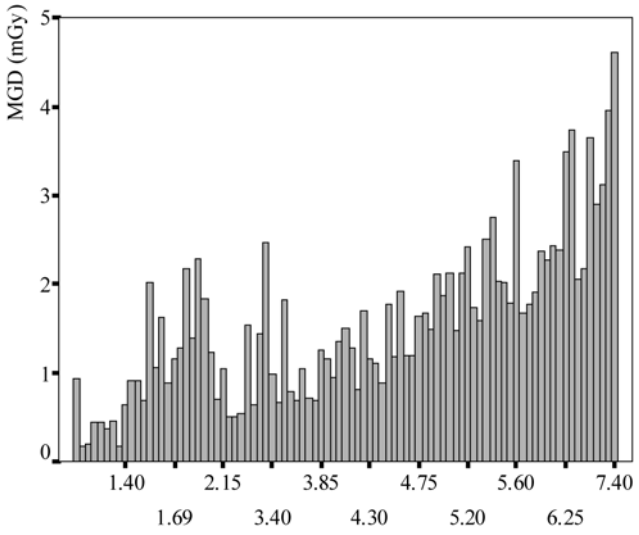

Figure 3 The MGD for mediolateral oblique projection according to compressed breast thickness.

Table 3 Compressed breast thickness, mean glandular dose per film and mean glandular dose resulting per woman.

Age (years)	N (%)	Compressed breast thickness (cm)		Mean glandular dose per film (mGy)		Mean glandular dose per woman (mGy) (mean±SD)
		CC (mean±SD)	MLO (mean±SD)	CC (mean±SD)	MLO (mean±SD)	
30-35	21(4.1)	3.09±1.33	2.74±1.36	1.59±0.99	1.45±0.89	6.09±3.69
36-40	91(17.7)	3.82±1.39	3.97±1.63	1.46±0.75	1.74±0.92	6.42±3.18
41-45	106(20.6)	3.70±1.41	3.76±1.55	1.41±0.81	1.57±0.88	5.96±3.08
46-50	134(26.0)	3.87±1.49	3.90±1.76	1.56±0.94	1.73±1.01	6.57±3.74
51-55	65(12.6)	3.87±1.59	3.88±1.68	1.32±0.72	1.44±0.73	5.52±2.74
56-60	66(12.8)	3.73±1.31	3.81±1.63	1.21±0.58	1.29±0.50	5.00±2.05
61-65	15(2.9)	3.18±0.88	3.18±1.07	1.16±0.52	1.26±0.49	4.84±1.98
> 66	17(3.3)	3.11±1.21	3.15±1.50	1.32±0.65	1.21±0.49	5.06±2.17
Total	515	3.74±1.43	3.77±1.64	1.42±0.80	1.56±0.86	5.96±3.15

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