Average Glandular Dose and Entrance Surface Dose in Mammography

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1. Introduction

Mammography is high in radiation dose in diagnostic X-rays. Diagnostic X-rays are indicated that the radiation dose is as low as reasonably achievable while maintaining adequate image quality. In general, dose evaluation for diagnostic X-rays uses entrance surface dose (ESD). But for mammography, it estimates average glandular dose (AGD), because mammary glands have relatively higher sensitivity to some adverse effects of radiation than skin and fatty tissues. Recently digital mammography systems such as computed radiography and flat panel detector have been increasing, in Japan. Therefore, the European Organization for Quality-Assured Breast Screening and Diagnostic Services (EUREF) protocol has been used to evaluate exposure. The EUREF protocol establishes limiting values including acceptable level and achievable level for AGD every 10 mm Polymethylmethacrylate (PMMA) phantom from 20 to 70 mm. Radiation dose in mammography is optimized under the condition of the levels of AGD and image quality. It is well known that ESD is high dose in mammography, but actual clinical data of ESD are not reported so much.

2. Objective

This study investigated AGD and ESD for patients whose doses were estimated from 200 mammographic examinations, and compared the patient-based ESD in mammography with breast surface dose for multidetector CT in order to assess the necessity of ESD for estimating the patient risk in mammography.

3. Material and Methods

The digital mammography system, Amulet (Fujifilm Solutions) has full-field flat panel detector. This system determines target material, filtration and tube voltage by compressed breast thickness (CBT) and adjusts to exposure output (mAs) using an automatic exposure control (AEC) system to obtain appropriate image density in clinical practice. AGD is estimated from technical parameters, which are half value layer, entrance surface air kerma , CBT and breast tissue composition. Technical parameters to calculate ESD are entrance surface air kerma (without backscatter), CBT and backscatter factor. The half value layer was measured by a non-invasive analyzer, NERO mAx8000 (Victroreen) and entrance surface air kerma was measured by an ionization chamber, Model9015 (Radcal).

3-1. AGD and ESD every thickness for PMMA

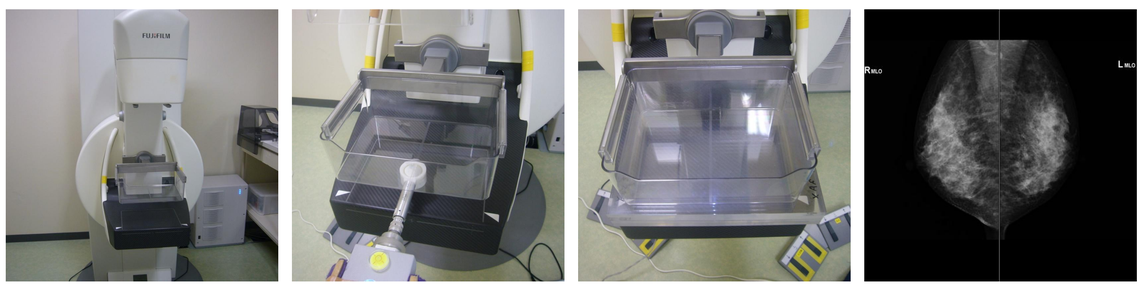
AGD and ESD were estimated using PMMA phantom every 10mm from 10 to 60 mm in clinical practice.

3-2. patient-based AGD and ESD

Patient-based AGD and ESD were estimated from 200 women (age 40 to 70) who had a mammography in Toyota memorial hospital.

3-3. Breast surface dose for chest CT scan

Breast surface dose in an anthropomorphic phantom was measured using thermoluminescent dosimeters (TLD) during chest CT scan.



4. Results

4-1. AGD and ESD every thickness for PMMA

The AGD over 45 mm PMMA satisfied the achievable level and every PMMA thickness was under the acceptable level (Fig 1). This unit satisfied the acceptable level by EUREF and was controlled exposure output lower than the standard levels as CBT increased.

4-2. patient-based AGD and ESD

The patient-based AGD was in the range of 0.5-3.5 mGy and the patient-based ESD was in the range of 2-20 mGy (Fig 2). The ESD was approximately four times higher than the AGD, and the ESD varied more widely than the AGD. Additionally, 10% of the total patients exceeded 10 mGy in ESD.

The distribution of patient-based AGD and ESD were higher than those of PMMA for each thickness (Fig 3). Amulet determines the fixed HVL by CBT, and thus radiation dose depends on density of breast. The density of patient breast was probably more than that of PMMA for each thickness. The ESD varied more widely than the AGD as CBT increased without the range of 40-50 mm, which was barely high coefficient of variation (CV) 27%, in Table 1. This variation in the ESD suggested that the more CBT increased, the more widely the difference of exposure output controlled by density is.

4-3. Breast surface dose for chest CT scan

The ESD for two-view mammography was equal to breast surface dose in chest CT scan (Table 2). As compared with the mean patient-based ESD for each CBT (Table 1), the mean ESD for two-view mammography over 40mm CBT was higher than breast surface dose in CT scan. As compared with other modality, ESD in a mammographic examination was clearly high.

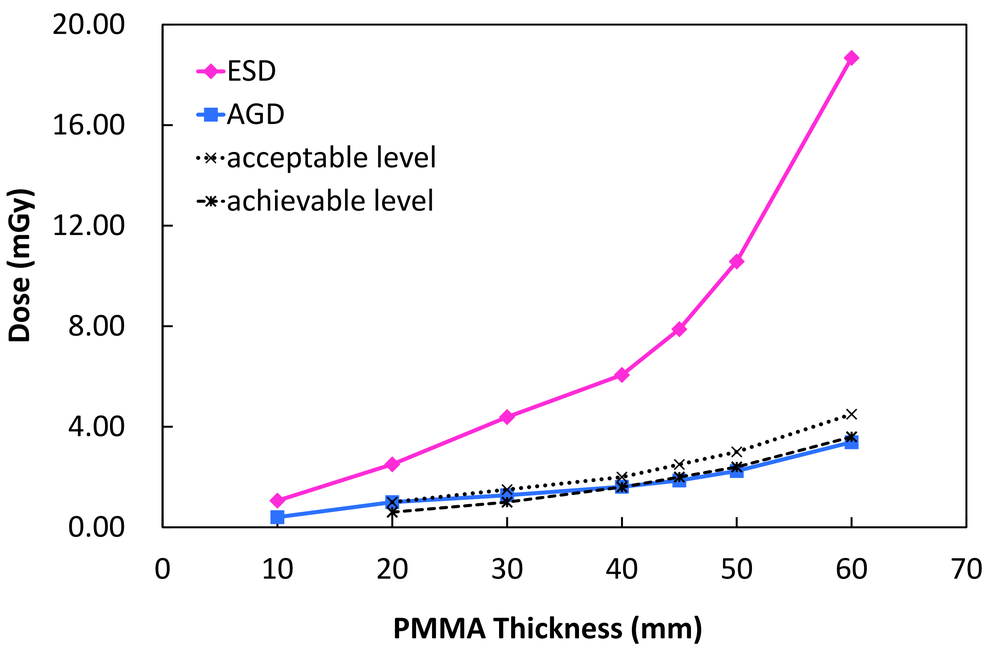


Figure 1. AGD and ESD every PMMA thickness and the limiting values for AGD

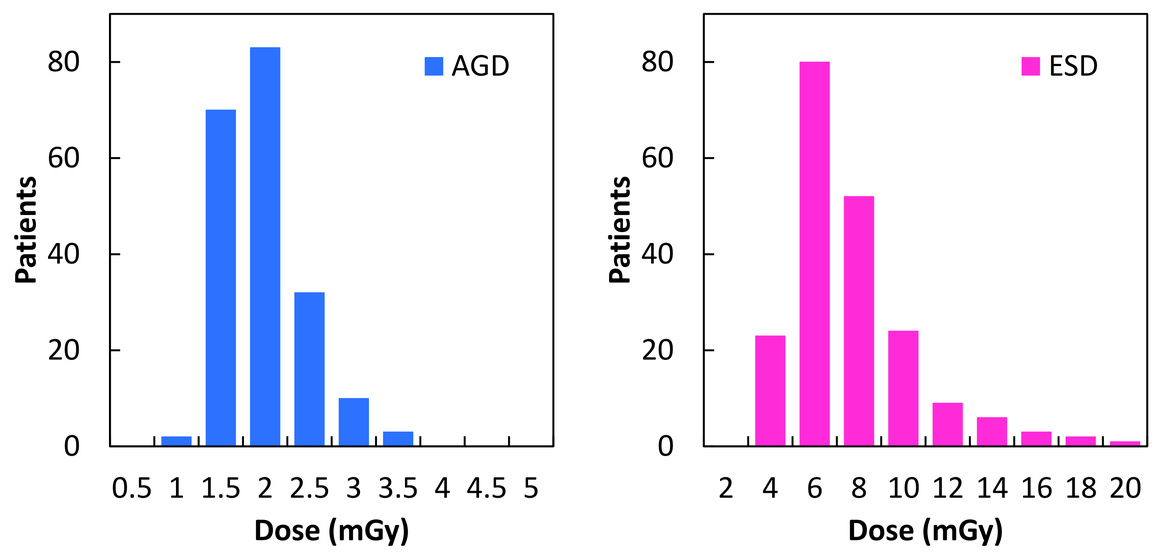


Figure 2. Histograms of patient-based AGD and ESD for 200 women

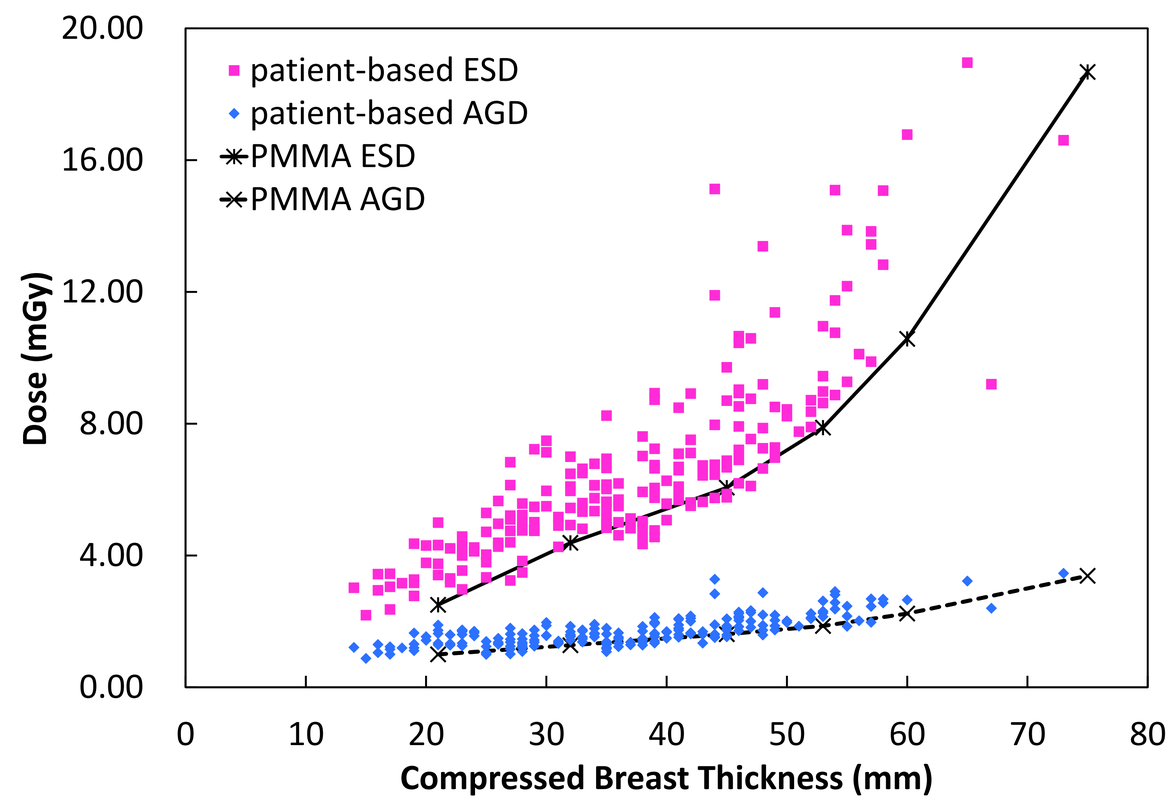


Figure 3. Distribution of patient-based AGD and ESD for CBT, and line charts of AGD and ESD for a breast equivalent to each PMMA thickness

Table 1. Mean patient-based AGD and mean ESD for CBT and CV

Compressed breast thickness (mm)	n	Patient-based AGD		Patient-based ESD	
		Mean (mGy)	CV (%)	Mean (mGy)	CV (%)
10 ≦ CBT < 20	12	1.19 ± 0.19	16	3.10 ± 0.55	18
20 ≦ CBT < 30	49	1.43 ± 0.23	16	4.51 ± 0.88	20
30 ≦ CBT < 40	58	1.54 ± 0.24	15	5.89 ± 1.06	18
40 ≦ CBT < 50	54	1.91 ± 0.36	19	7.67 ± 2.08	27
50 ≦ CBT < 60	23	2.31 ± 0.31	13	10.62 ± 2.39	23
60 ≦ CBT < 70	3	2.76 ± 0.42	15	14.98 ± 5.12	34
70 ≦ CBT < 80	1	3.46	—	16.60	—
total	200	1.71 ± 0.45	27	6.60 ± 2.88	44

Table 3. Breast surface dose in chest CT scan and mean patient-based ESD in mammography

Breast surface dose in chest CT scan (mGy)	Mean patient-based ESD in Mammography (mGy)	
	1 view	2 views
15.07	6.61	13.22

5. Conclusion

The ESD in mammography averaged 6.60 ± 2.88 mGy/view and the ESD for two-view mammography was nearly equal to the breast surface dose in chest CT scan. The patient-based ESD varied the range of 2-20 mGy and was higher as CBT increased. This study suggests that it is useful for the quality control in mammography to establish limiting values of ESD for each PMMA thickness as well as AGD.

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