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Letter to the Editor

Investigation of Mean Glandular Dose in Diagnostic Mammography in China*

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A survey of 420 exposures of mammography was performed with the parameters recorded. Entrance skin air kerma (ESAK) was measured and the mean glandular dose (MGD) was calculated according to the Dance's formula. Correlation analysis showed that several factors could affect the MGD level. Mann-whitney test and Non-parametric ANOVA analyses were used to compare the MGD level grouped by view type and radiographic systems. No significant difference was found in MGD between the craniocaudal (CC) group and the mediolateral oblique (MLO) group. The MGD level was higher in the CR group than in the other two groups. MGD was positively correlated with the compressed breast thickness (CBT). MGD varied with the half value layer (HVL) and increased first then decreased. The mean MGD level in China is about 1.6 mGy and is lower than the guidance level in the International Basic Safety Standards (IBSS).

Breast cancer is the most common cause of cancer-related deaths in women in Europe[1]. Early detection can substantially reduce its mortality. It was reported that mammography is the most effective procedure for screening breast cancer. It is important to ensure that the equipments can provide sufficient diagnostic information at a reasonably low radiation dose.

In the 'European Protocol on Dosimetry in Mammography', various dosimetric methods and quantities are described, which include entrance skin air kerma (ESAK), entrance skin dose (ESD) and mean glandular dose (MGD). MGD is the most appropriate dosimetric quantity to predict the risk of radiation-induced carcinogenesis. MGD cannot be directly calculated, but can be calculated from ESAK using the appropriate conversion factors[2-3].

Studies on MGD are reported in Europe and Asia[4-5]. However, few are available in China. This study was to investigate the technical parameters of mammography currently used in China, analyze the MGD influencing factors, and reveal MGD during performing mammography in China.

Mammography Equipment

Twenty-one pieces of equipment (17 from public hospitals and 4 from private hospitals) were included in this study.

One mammography system was selected from each sample hospital. Of the 21 pieces of equipment, 8 were DR system, 8 were CR system, and 5 were SFR system.

Patient Data

A total of 420 operations of mammography were performed in this study. Forms containing patient information (including age and weight) and mammographic parameters (including voltage, Output) were filled in by the technicians who performed the mammography. The compressed breast thickness (CBT) was measured with a ruler. The mammography data were analyzed.

Calculation of MGD

The MGD level for each acquired image was calculated as previously described[2-3] according to the formula MGD=K·g·c·s (1)

Where K is the entrance surface air kerma (ESAK) at the upper surface of breast, c and g represent the X-ray beam spectral characteristics and assumptions regarding the breast glandularity, s is the factor used to correct the differences in X-ray spectra generated by anode target/filter other than Mo/Mo.

ESAK and half value layer (HVL) data were recorded with a QA radio-dosimeter (model: Barracuda; RTI Corporation, Sweden) which was calibrated in the traceable Secondary Standard Dosimetry Laboratory at Shanghai Institute of

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Measurement and Testing Technology (SIMT). Two sets with a 99.9% purity aluminum filter were used to measure HVL which was corrected according to the inverse-square law for each individual breast thickness.

Statistical Analysis

The factors influencing MGD were analyzed by correlation analysis. The categorical variables were analyzed by nonparametric correlation analysis. The homogeneity of CBT and MGD in CC group and MLO groups was analyzed by unpaired Student's *t* test and Mann-Whitney test, respectively. Three kinds of radiographic system were compared by Kruskal-Wallis test.

Descriptive Statistics

The mean MGD was about 1.6 mGy, and the range of the MGD is from 0.39 mGy to 5.01 mGy. The average MGD was similar to that reported in previous studies[5-6]. However, it is higher than that reported in a Greece study[4] and lower than that in a UK study[7].

The range and distribution of CBT in this study were similar to those in a Malaysia study[5]. The mean CBT was lower in this study than in other studies[8-9].

Patient information and technical parameters are shown in Table 1.

Correlation Analysis

Correlation analysis showed that the MGD level was affected by 3 factors: output (mAs), CBT and type of radiographic systems.

Relation between MGD and View Types

MGD and CBT in CC and MLO groups were analyzed. Since the variable MGD could not satisfy the normality assumption, the difference in MGD and CBT between the two view types was verified by Mann-Whitney *U* test and unpaired Student's *t* test, respectively. The mean CBT in MLO and CC groups was 4.30 cm and 3.89 cm, respectively, 10% higher in the MLO group than in the CC group ($P<0.05$). However, no significant difference was found in MGD between the two groups.

It has been shown that the view type is one of the influencing factors for MGD in some previous studies[4,10]. The median MGD for MLO (1.47 mGy) was closely related with the CC view (1.45 mGy). However, the CBT between the MLO group and the CC group differed greatly. It was reported that the pectoral muscle was denser than the rest breast muscles, which may be a reasonable explanation for this phenomenon[4].

Radiographic Systems

The difference in 3 kinds of radiographic systems was analyzed by Kruskal-Wallis test, showing that the mean MGD was higher in the CR group than in other two groups. No significant difference was observed in the mean MGD detected by the DR and SFR systems.

Mann-Whitney *U* test showed that MGD was higher in CR system than in SFR and DR systems, which is similar to a previous study[7] . However, the sample size of SFR system was so small (5 SFR systems) that the confounding bias affected the result, indicating that more data of SFR system are needed to establish the relation of MGD with SFR and DR systems.

Relation between MGD and CBT

The samples were divided into 6 groups according to their CBT. Figure 1 shows the relation between MGD and CBT.

Table 1. Patient Information and Technical Parameters

Information and Parameters	Median	25% Values	75% Values	Mean	SD	Range
Age (y)	45	42	49	46.1	9.1	23-81
Weight (kg)	62	56	65	58	15.1	45-84
CBT (cm)	4.1	3.0	5.0	4.1	1.2	1.3-7.5
Tube (kV)	28	26	30	28.5	2.8	22-35
Output (mA s)	58	33	87	66.3	39.9	12.1-278
ESAK (mGy)	5.6	4.0	8.7	6.8	4.3	1.12-25.8
MGD (mGy)	1.4	1.1	2.0	1.7	0.8	0.39-5.01

Figure 1 displays the relation between MGD and CBT. The MGD increased with the increasing CBT. The MGD was determined by 4 variables, namely ESAK, g-factor, c-factor, and s-factor according to the equation (1). Both g-factor and c-factor were affected by CBT. The g-factor was negatively correlated with the CBT while the c-factor affected the MGD in the reverse direction. It was reported that the g-factor changed more rapidly with CBT than the c-factor while the MGD was positively correlated with CBT[2], suggesting that the thicker breast would increase the output of the mammographic equipments in AEC mode and it would increase the ESAK of the mammographic exposure.

It has been shown that CBT is one of the influencing factors for MGD[5]. Additionally, MGD does not increase with CBT indefinitely. In the present study, the MGD of the 2 cases in 7.0+ CBT group was lower than the MGD of the 6.0-6.9 CBT group. Consider the case number is too small the 7.0+ CBT group was merge into 6.0+ CBT group finally.

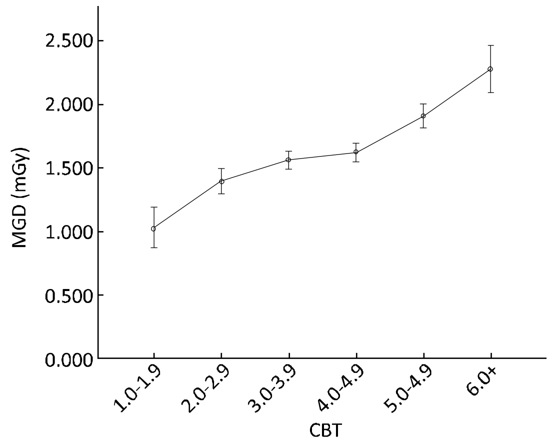

Figure 1. MGD for different CBT in 420 times of radiographic mammography. The error bars correspond to ±1 stand error on the mean.

Relation between MGD and HVL

The samples were divided into 5 groups according to their HVL. Figure 2 shows the relation between MGD and HVL.

Figure 2 shows the trend of MGD changed with HVL. The MGD reached its peak at the 0.4-0.45 mmAl HVL. It can be interpreted by the fact that the g- and c-factors were positively correlated with HVL[3] because the higher HVL increased the energy deposit in breast gland tissues whereas ESAK was negatively correlated with HVL because the higher HVL decreased the necessary output (mA·s product) of the exposure.

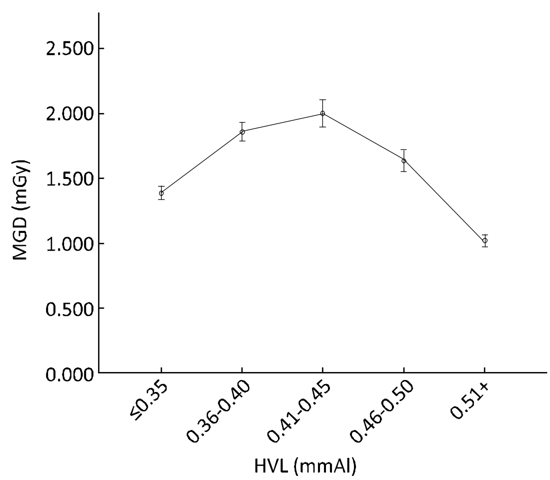

Figure 2. MGD for different HVL. The error bars correspond to ±1 stand error on the mean.

Additionally, HVL is not the only equipment factor affecting the ESAK. Radiographic system and SID could also influence ESAK, which can explain the lower ESAK in the first HVL group than in the second HVL group.

In conclusion, Mean MGD level in our study for mammography practice in China is 1.6 mGy. Output (unit: mAs), the type of radiographic systems and CBT could influence the MGD level.

Additionally, the limitation of this study is that the age-dependent glandularity correction factor (c-factor) was studied as previously described[3], which cannot be applied in Chinese females.

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REFERENCES

1. Boyle P and Ferlay J. Cancer incidence and mortality in Europe, 2004. Ann Oncol, 2005; 16, 481-8.
2. Dance DR, Young KC, and van Engen RE. Further factors for the estimation of mean glandular dose using the United Kingdom, European and IAEA breast dosimetry protocols. Phys Med Biol, 2009; 54, 4361-72.
3. Dance DR, Skinner CL, Young KC, et al. Additional factors for the estimation of mean glandular breast dose using the UK mammography dosimetry protocol. Phys Med Biol, 2000; 45, 3225-40.
4. Tsapaki V, Tsalafoutas IA, Poga V, et al. Investigation of breast dose in five screening mammography centres in Greece. J Radiol Prot, 2008; 28, 337-46.
5. Jamal N, Ng KH, and McLean D. A study of mean glandular dose during diagnostic mammography in Malaysia and some of the factors affecting it. Br J Radiol, 2003; 76, 238-45.
6. Ciraj-Bjelac O, Avramova-Cholakova S, Beganovic A, et al. Image quality and dose in mammography in 17 countries in Africa, Asia and Eastern Europe: results from IAEA projects. Eur J Radiol, 2012; 81, 2161-8.
7. Oduko J, Young K, and Burch A. A Survey of Patient Doses from Digital Mammography Systems in the UK in 2007 to 2009. 2010; 6136, 365-70.
8. Robinson M and Kotre CJ. Trends in compressed breast thickness and radiation dose in breast screening mammography. Br J Radiol, 2008; 81, 214-8.
9. McCullagh JB, Baldelli P, and Phelan N. Clinical dose performance of full field digital mammography in a breast screening programme. Br J Radiol, 2011; 84, 1027-33.
10. Baldelli P, McCullagh J, Phelan N, et al. Comprehensive dose survey of breast screening in Ireland. Radiat Prot Dosimetry, 2011; 145, 52-60.