ORIGINAL ARTICLE

The effect of different compression force on image quality and dose in full field digital mammography

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Abstract:

Breast compression is necessary and important in mammography to improve image quality and minimize the radiation given to the breast. However, the downsides of applying breast compression during mammography are pain and discomfort experienced by patients. This experimental study was carried out to investigate the effect of applying different compression force (Newton, N) of 30N, 45N and 60N on image quality and dose in Full Field Digital Mammography (FFDM). The study was done at Pantai Hospital Kuala Lumpur using Siemens Mammamot Inspiration FFDM. A set of CIRS012A breast phantom (4cm compressed thickness) was used as subject. TLD chips were used as dose measurement tool. Exposures were taken using Automatic Exposure Control (AEC) with fixed 28kVp and Tungsten/Rhodium (W/Rh) anode filter combination in only cranio-caudal (CC) projection. Criteria of image quality scoring were adapted from ACR Mammography Quality Control. Two experienced radiographers with at least 10 years of working experience in mammography scored the image independently. Analysis of variance (ANOVA) showed no significant difference between compression force and dose (p=0.296), and no significant difference between compression force and image quality (p=0.702). Pearson's Correlation showed no significant relationship between compression force and dose (r=0.289, p=0.451) and no significant relationship between compression force and image quality (r=0.01, p=0.91). In conclusion, applying different compression force does not significantly affect the image quality and dose in FFDM.

Keywords: Compression force; discomfort; dose; FFDM; image quality

1. INTRODUCTION

Breast cancer is a major concern for women in most parts of the world. In 2006, breast cancer was reported to be the most common cancer among female in Peninsular Malaysia [1]. It is also reported as the most frequent cause of cancer death among female in economically developing and developed countries [2]. In diagnosing the disease, mammography is the most effective tool for early detection before it becomes clinically palpable [3]. Consequently, regular mammography screening may significantly reduce the mortality of breast cancer [4].

Screening mammography is the gold standard or the benchmark for the early detection of the breast cancer [5]. The importance of performing mammography in women is to detect masses, microcalcification and to distinguish small abnormalities within the breast tissues which able to progress into breast cancer [6]. Furthermore, mammography has the ability to show subtle soft tissue masses, no palpable regions of breast cancer and microcalcification that has the potential to develop into breast cancer [7].

An advanced version of imaging tool for breast imaging after film screen mammography is Full Field Digital Mammography (FFDM). The development of digital mammography is increasing rapidly due to overcome the limitation of film screen mammography. Digital processing of images permits the variation of contrast to be manipulated [8]. Screening of breast cancer using digital mammography has the possibility of reducing the mortality due to breast cancer [9]. In addition, digital mammography also offers wide variation of exposure selection to be selected manually [7].

One of the crucial factors that affects the quality of image in mammography is the breast compression [10]. Breast compression is done when the breast is pressed against the breast support on top of detector by using a transparent plastic compression paddle [11]. The immobilization of breast tissue using compression plate while performing mammography is essential to guarantee good image quality and minimize absorbed dose to the breast tissues [5]. This is due to the effect of breast compression which is able to flatten the breast tissue into uniform thickness by spreading the breast tissue evenly, thus enhancing the visibility of the small abnormalities [12].

In mammography procedure, the distributions of force applied on the compression are subject variably according to radiographers in charge. Usually the considerations take place based on the contact area and natural variation of breast size and elasticity [11]. However, the downside of applying breast compression during mammography is the pain and discomfort experienced by many women [13]. Fear of pain has been identified to be the barrier of women to participate in mammography [14]. Women often decline for a mammography examination because the pain they will experience due to breast compression [15]. There were cases where women who had undergone the mammography refuse for the continuous examination due to the pain and discomfort [16]. Therefore, to overcome the pain and discomfort due to compression in mammography procedure, the idea of reducing the compression force exerted on the breast tissues is the main highlight in this study with the effect on image quality and dose being assessed.

2. MATERIALS AND METHODS

Data were collected using 4 cm thickness of breast phantom Computerized Imaging Reference System (CIRS) tissue equivalent mammography QA phantom (Model 012A) with glandularity of 50%. The selection of using 4 cm thickness of breast-shaped phantom is because Malaysian's women have average of 4 cm breast thickness with 50% glandular content as their breast composition [17]. The phantom breast detail component consists of 12 $CaCO_3$ specks groups of varying sizes, seven hemispheric masses of varying diameters, and five nylon fibers of varying diameters. FFDM used for this study was Siemens Mammomat Inspiration.

The breast phantom was placed on the FFDM bucky in cranio-caudal (CC) view and was compressed with three levels of compression force which are 60N (standard compression force), 45N and 30N. The exposure factor used already set using Automatic Exposure Control (AEC) system with constant exposure factor at 28kVp and Tungsten Rhodium (W/Rh) anode filter combination. For each level of compression, the breast phantom was exposed three times and dose was recorded using TLD-100H.

Images were evaluated on the workstation in Digital Image and Communication in Medicine (DICOM) format by two radiographers with experience more than 10 years in mammography. Image quality was evaluated through qualitative assessment by using weighted scoring protocol adapted from American College of Radiology (ACR) Mammography Quality Control Manual [18]. Evaluators were not allowed to manipulate the brightness and contrast of the monitor and also the usage of magnification tools while in the process of evaluating the breast radiographs is not permitted.

The average glandular dose (AGD) values were determined based on the Half Value Layer (HVL) and Entrance Surface Air Kerma (ESAK) [19]. The ESAK values were obtained based on the reading each of the TLDs.

Statistical analyses were performed using Statistical Package for the Social Sciences (SPSS) version 22.0. One-way analysis of variance (ANOVA) was used to test the mean difference between AGD and compression force, and the difference between image quality and compression force. Pearson's Correlation was used to test the relationship between compression force and dose, and the relationship between compression force and image quality.

3. RESULTS AND DISCUSSION

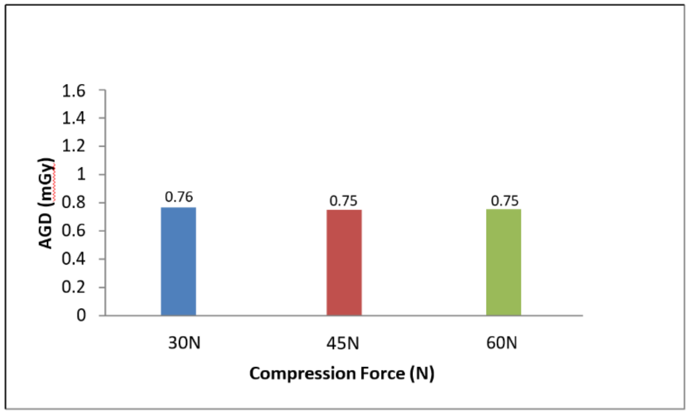

Figure 1: Mean AGD for each compression force

Figure 1 shows the result of AGD against different amount of compression force. It is shown that as compression force decreased from 60N to 45N, no change is detected in term of AGD value. However, as further reduction of compression force applied up to 30N, the AGD value increases slightly. There is no significant difference between compression force and dose (p=0.296) and no significant relationship (r=0.289, p=0.451) between compression force and dose.

Figure 2: Image quality score for each compression force

Figure 2 shows the result of image quality score which includes fibre, speck, mass and total score for different amount of compression forces applied. As compression force decreased from 60N to 45N, value of mass score, speck score and total score decreased. Only image quality score of fibre increased when the compression decresed from 60N to 45N. As compression force further reduced to 30N, fibre score decreased while score value for mass and total score increased. Only score of speck was constant from the previous force. It is shown on figure 2 that the pattern of image quality score is fluctuating when different amount of compression force applied. No significant difference (p=0.702) and no significant relationship (r=0.01, p=0.91) were observed between compression force and image quality.

Adequate compression is very important in mammographic procedure to reduce the amount of dose received by patient [20]. This is due to lower overall attenuation by the compressed breast to the incident x-ray beam, allowing radiation dose to be reduced [21]. This explains why 45N force applied in this study gave lower dose value compared to less compression force of 30N. However, applying different compression force of 60N and 45N do not change the value of dose in this study. This may be due to unchanged compressed breast thickness between 60N and 45N. Increasing compression force in mammography without compressed breast thickness reduction gives no benefit [22]. The outcome of this study can be supported by the previous study which mentioned that reduction in breast compression force resulted in limited impact on AGD [23]. Thus, between 45N and 60N, 45N of compression force is preferable in term of dose optimization as it gives lesser dose with lesser compression force.

For image quality assessment, the score of fibre, mass and specks did not rely on the compression force given as the value of each score wss fluctuating. As the force decreased from 60N to 45N, value of mass, speck and total score reduced. Applying insufficient compression lowers the specificity of mammography due to a lack of minimization of tissue superimposition [24]. Thus, it affects image quality. In contrast, the value of fibre score increases when compression force is reduced from 60N to 45N. Stronger compression force reduced the visibility of a subset tumors in spot compression mammography [25]. This is due to mischaracterized of softer tumors, which become less conspicuous and the cancer tissue may spread out and lose contrast [24]. Further reduction of compression force from 45N to 30N gives the same score for speck value, increase value for total score and mass score, and decrease value for fibre score. This fluctuation is due to architectural changes of the breast parenchyma which are less conspicuous under lower and higher pressure [24].

Since there is no significant difference and significant relationship between three different compression forces applied in term of image quality and dose, it is possible for radiographer to reduce compression force up to 45N or 30N when using FFDM. The result of this study is comparable to the study in previous which reported that reduction in compression force which at 50% reduction did not exhibit any significant change in blurring for the breast tissue details [26]. The reduction is very important as it may reduce pain and discomfort to the patient. Increasing compression force gave reduced phantom thickness up to a point after which no image quality benefits were achieved and patient suffered discomfort and pain [20].

4. CONCLUSION

In summary, the reduction of compression force does not significantly affect the image quality and AGD in FFDM. Therefore, the reduction of compression force is feasible due to minimal effect on image quality and AGD. Moreover, reduction in breast compression provides reduction in pain and discomfort experienced by the patient.

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