STUDY ON THE FACTORS AFFECTING GLANDULAR DOSE IN DIGITAL BREAST TOMOSYNTHESIS

NUR ALIA NABIHAH BINTI AB AZIZ

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STUDY ON THE FACTORS AFFECTING GLANDULAR DOSE IN DIGITAL BREAST TOMOSYNTHESIS

BY

NUR ALIA NABIHAH BINTI AB AZIZ

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August 2020

DECLARATION

I hereby declare that this dissertation entitled 'STUDY ON THE FACTORS AFFECTING GLANDULAR DOSE IN DIGITAL BREAST TOMOSYNTHESIS' is the result of my own investigations, except where otherwise stated and duly acknowledged. I also declare that it has not been previously or concurrently submitted as a whole for any other degrees at Universiti Sains Malaysia or other institutions. I grant Universiti Sains Malaysia the right to use the dissertation for teaching, research and promotional purposes.

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NUR ALIA NABIHAH BINTI AB AZIZ.

Date: 17 August 2020

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LIST OF ABBREVIATIONS

AEC	Automatic exposure control
AGD	Average glandular dose
AMDI	Advanced Medical and Dental Institute
BI-RADS	Breast Imaging Reporting and Data System
CBT	Compressed breast thickness
CC	Cranio-caudal
CF	Compression force
DBT	Digital breast tomosynthesis
MLO	Medial lateral oblique
PACS	Picture archiving and communication system

LIST OF SYMBOLS

kVp	peak kilovoltage
mAs	ampere second
mGy	milli-Gray
mm	millimetre

ABSTRAK

Tomosynthesis Payudara Digital *(DBT)* adalah sejenis mamografi 3-dimensi yang menggunakan imej mammografi 2-dimensi untuk menghasilkan imej 3-dimensi. DBT menghasilkan dos radiasi yang lebih rendah daripada mammografi digital. Projek ini akan menfokuskankan kepada faktor yang mempengaruhi purata dos glandular (*AGD*) dalam DBT. Sejumlah 224 data dos digunakan di dalam projek ini dimana 57 adalah terdiri daripada projeksi RCC, 55 sampel adalah projeksi LCC, 57 sampel adalah RMLO dan 55 sampel adalah projeksi LMLO. Semua pemeriksaan yang terlibat menggunakan sejenis mesin mammografi yang sama iaitu *Siemens MAMMOMAT Revelation (Siemens Healthineer, German)* yang terletak di Unit Imejan Institut Perubatan & Pergigian Termaju (IPPT), Pulau Pinang. Perbandingan antara mod 2D dan 3D DBT, terdapat perbezaan nilai AGD di antara 2D dan 3D dimana 3D menunjukkan nilai AGD yang lebih tinggi dibandingkan dengan 2D mamografi. Terdapat korelasi atau hubungan positif di antara AGD dengan tetapan dedahan apabila analisis menggunakan ujian regrasi dan korelasi berganda di mana nilai R^2 adalah 0.562 dan 0.605 untuk sisi kanan dan kiri payudara. Terdapat juga hubungan positif diantara nilai AGD dengan ketebalan payudara dimana nilai R^2 adalah 0.207 dan 0.059 untuk sisi kanan dan kiri payudara. Payudara jenis D dan C mempunyai nilai AGD yang lebih tinggi daripada jenis A dan B. Ini membuktikan bahawa payudara yang lebih mampat mempunyai nilai AGD yang lebih tinggi daripada yang kurang mampat. Projeksi yang berbeza tidak memberi kesan yang tinggi kepada nilai AGD apabila menggunakan DBT.

ABSTRACT

Digital breast tomosynthesis (DBT) is the type of 3 -dimensional mammography that construct three-dimensional images based on the series of 2-dimensional images. DBT is said to has lower radiation dose than the digital mammography. This study focuses on the factors that affecting the average glandular dose (AGD) in DBT. A total of 224 dose data were included in this study, which is 57 samples for RCC, 55 samples for LCC, 57 samples for LMLO, and 55 samples for LMLO projections. All examinations were performed using the same mammographic unit which is Siemens MAMMOMAT Revelation (Siemens Healthineer, German) at Imaging Unit, Advanced Medical and Dental Institute (AMDI), USM, Penang. For the comparison between 2D and 3D mode in DBT, the different is statistically significant where 3D shown a higher mean of AGD than 2D modes. The multiple regression and correlation tests were used to evaluate the correlation between AGD with exposure setting and breast thickness. There is a positive correlation between the AGD with exposure settings and breast thickness. The mAs and kV settings have a linear relationship with AGD with R^2 value of 0.562 and 0.605 respectively for right and left side of the breast. The correlation value of R^2 obtained for breast thickness is 0.207 and 0.059 respectively for right and left breast. The denser breast (breast glandularity type D and C) has higher AGD value than less dense breast (type A and B). There is no statistically significant difference of AGD for different mammographic projections.

CHAPTER 1: INTRODUCTION

Cancer persisted as one of the five principal causes of national mortality and Ministry of Health (MOH) Malaysia stated that cancer contributed 13.02 % of all deaths in Malaysia in 2014 (MOH, 2017). Breast cancer is the most common death-leading cancer in women and the second most common cancer of all cancer detected. There were over 2 million cases detected worldwide in 2018 (World Cancer Research Fund, 2018). Based on the Malaysian National Cancer Registry Report for 2007-2011 by MOH Malaysia, female breast cancer was accounted for 32.1% of all cancer among females in Malaysia and Chinese population stated the highest incidence of breast cancer followed by Indians and Malay population (MOH, 2016). Most breast pathologies such as masses, calcification, and lump that could be signs of cancer can be seen through a mammogram

1.1 MAMMOGRAPHY

Mammography is a type of x-ray imaging that uses low energy x-rays to examine the breast and uses standardised views of breasts for the assessment of breast lesion (Mammography, n.d). Mammogram is a mammography exam that is needed for the early detection of cancer and any other breast disease. Based on the definition from National Cancer Institute (NCI), mammogram is a non-invasive medical test that helps the doctor to detect and diagnose breast disease in women that experiencing symptoms such as lump, mass, pain, skin dimpling, or nipple discharge (NCI, 2016). It is used as a screening tool for the detection of early breast cancer. Mammography is a safe procedure that only feels pain during examination due to compression applied to breast tissues.

Mammograms consist of screening mammogram, diagnostic mammograms and surveillance mammograms. Screening mammogram is needed to detect breast cancer at early stage in asymptotic women. It is usually performed on women that are 40 years old and above. For those ages below 40 years old, they should undergo breast ultrasound instead of mammography for screening of any unusual changes in the breast. The MOH Malaysia suggested that screening mammography can be performed on women from 50-74 years old and for women of age 40-49 with low and intermediate risk should not performed mammography screening routinely (MOH, 2010).

Diagnostic mammogram is used to find abnormal clinical findings or diagnosis of previously identified breast abnormality during screening such as breast lump or mass. It is done after an abnormal screening mammogram to further diagnose the screening result. Surveillance mammography is needed to assess any recurrence of malignancy or lump in women with known breast cancer history. Diagnostic mammogram can be done using general mammography or tomosynthesis, and it takes longer acquisition time during the procedure comparable to screening mammography and the total dose is higher as more images are needed to obtain multiple views of the breast from multiple angles (NCI, 2016).

Screening mammography gives chance to women undergoing their normal daily lives by reducing the number of deaths from breast cancer among women aged between 40 to 74 years old, especially for older women age over 50 years old (Mandelblatt *et al.*, 2009). However, no study has shown any benefit from regular screening mammography in women under age 40 (NCI, 2016). There are two main mammographic projections which is medio-lateral oblique (MLO) and cranio-caudal (CC) view.

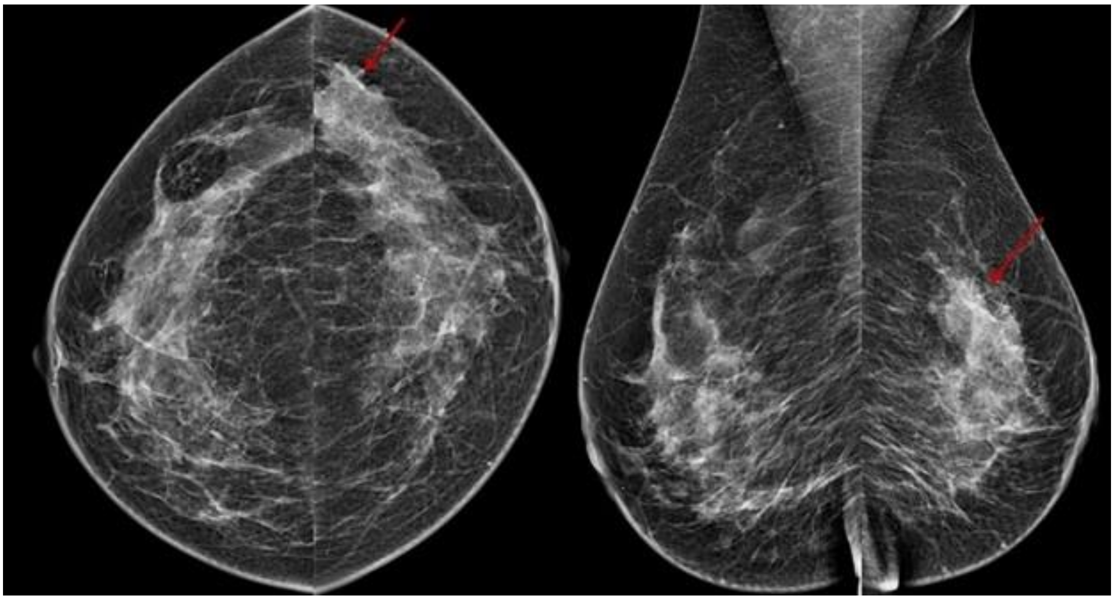


Figure 1.1 Standard mammography projection; CC (a) and MLO(b) views of right and left side of breast (Standard digital mammogram image, n.d).

Advanced mammography such as digital mammography and breast tomosynthesis is used nowadays to aid the detection of breast diseases. Digital mammography, also known as full-field digital mammography (FFDM) which use electronics or digital image receptor instead of a film that convert x-rays into images of the breast.

1.2 DIGITAL BREAST TOMOSYNTHESIS (DBT)

Digital Breast Tomosynthesis (DBT) is a new technology that is developed to overcome the limitation of conventional mammography (film screen and digital mammography). This technique uses low dose x-rays which allows volumetric reconstruction of the whole breast. DBT is also known as three-dimensional (3D) mammography as it uses series of two-dimensional images to construct three-dimensional images. It produces an image stack, where only thin slice of anatomy can be seen while the rest is blurred (Østerås *et al.*, 2018).

DBT is developed to improve the detection of breast cancer compared to digital mammography especially in women with no-fatty breast. This technique requires multiple projections for the image reconstruction which allows the visualization of the lesion without overlapping of the breast tissues. Each reconstructed slice may as thin as 0.5 mm (Helvie, 2010). The breast positioning is same as conventional mammogram, with a little pressure or compression applied. DBT can improve the detection of lesion in women with dense breast or non-fatty breast.

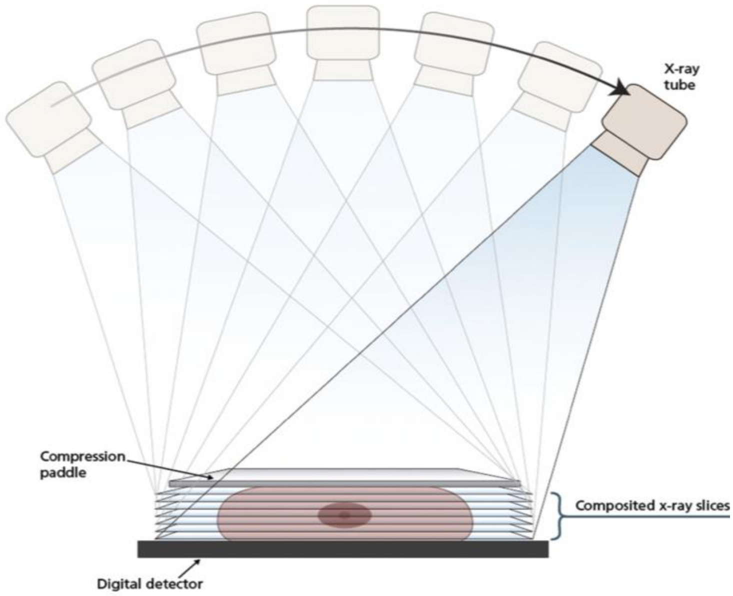


Figure 1.2 The image acquisition with multiple angle views of Digital Breast Tomosynthesis (DBT) (Takashi T.A. *et al*, 2017)

The advantage of using DBT over conventional mammography is its increase in the cancer detection rate. DBT also showed an improvement such as better detection sensitivity of the lesion than conventional mammography (Gennaro *et al.*, 2018). This study aims to evaluate the factors that affect the Average Glandular Dose (AGD) in DBT.

1.3 AVERAGE GLANDULAR DOSE

Average glandular dose (AGD) or known as mean glandular dose (MGD) is defined as absorbed dose received by the central region of the breast which is mainly glandular tissue during mammography. Based on International Commission on Radiological Protection (ICRP), AGD is the best dose quantity used to indicate the radiation risk received by patients during mammography (Ma *et al.*, 2008). For the assessment of AGD, the breast tissues are homogeneous. The radiation energy absorbed in the adipose tissue and skin is excluded from the calculation of AGD because the risk of carcinogenic is less considered (Nigapruke *et al.*, 2010).

AGD can be calculated using conversion factors established by Monte-Carlo simulations. The calculation of AGD is usually done using Dance's method (Dance *et al.*, 2009):

$$\boldsymbol{AGD = Kgcs,}$$

where K is the incident air kerma (IAK) at the upper surface of the breast, g converts IAK to AGD for a breast with 50% glandularity, c factor which corrects for differences in glandularity other than the 50% and is given for two age groups 40 to 49 and 50 to 64 years and s is spectra dependent, it corrects for different types of spectra where s=1 for Mo/Mo anode/filter combination and changes for other combinations. g and c are dependent on HVL and CBT.

1.4 PROBLEM STATEMENT

A major consideration in the utilization of DBT is the balance between radiation dose and image quality. The concept of 'As Low as Reasonably Applicable' (ALARA) is vital and should always be practiced as the image quality tends to be directly related to radiation dose. The ALARA concept recommended that total absorbed dose received by glandular tissue should be kept as low as possible (Baptista *et al.*, 2014). Even though the dose is kept low for every projection, multiple projection images in tomosynthesis are necessary to permit the volumetric reconstruction and this unavoidably leading to dose increment (Tagliafico, Houssami, & Calabrese, 2016). However, if the uses of DBT leads to improvement of detection sensitivity, a minimally higher dose may be acceptable.

Women that undergo DBT screening were exposed to higher radiation dose than women that undergo standard mammography screening. This has raised the concern about the side effects of using tomosynthesis especially in combination with mammography on a large scale (Gennaro *et al.*, 2018).

From another perspective, there is a concern regarding the radiation doses from mammography screening and there is also concern about risk of radiation-induced breast cancer resulting from mammographic screening periodically (Baek *et al.*, 2017). Factors affecting the radiation dose in mammography should properly be evaluated and need proper modification to ensure the dose to patients is minimised. As shown in a study, breast tissues received higher dose than other tissues outside the primary x-ray field when performing mammography screening (Sechopoulos *et al.*, 2008).

1.5 JUSTIFICATION OF STUDY

When involving ionising radiation in diagnosis, we need to consider radiation the safety to staff and patients. The concept of 'As low as Reasonably Applicable', ALARA needs to be properly applied to ensure that the radiation dose received by patients does not exceed the reference dose. Unnecessary exposure can cause an increase in radiation dose and radiation-related health risks to patients. Unavoidable high radiation dose will be received by patients that performed DBT screening because of multiple projections needed for image reconstruction. However, evaluation needs to be considered to ensure patients receive more benefits than risk. So, a better understanding and awareness of dose received by patients will provide benefits to optimise the dose delivered to patients while maintaining the image quality. The dose optimisation will reduce the low dose accumulation delivered for every projection. This study will help the practitioner to avoid giving the unnecessary radiation dose to patients and increase awareness regarding the effect of unnecessary radiation dose to patients

1.6 RESEARCH OBJECTIVES

GENERAL OBJECTIVE:

This study aims to investigate the factors that affecting the glandular dose in digital breast tomosynthesis (DBT).

SPECIFIC OBJECTIVES:

1. To compare the average glandular dose (AGD) between 2D and 3D views of DBT.
2. To study the correlation between exposure settings (kVp & mAs) with the average glandular dose (AGD) in DBT.
3. To study the correlation between patient's breast characteristics (breast thickness & glandularity) with average glandular dose (AGD) in DBT.

CHAPTER 2: LITERATURE REVIEW

2.1 2D VS 3D MAMMOGRAPHY

DBT produces high radiation dose than conventional mammography as DBT needs multiple projections to construct the image than the conventional mammography that produces single image view. DBT produces 3D images of breast just like CT images. The 2D images are accumulated and summed up to produce DBT images.

Every slice of 2D images have equal amount of glandular dose and accumulated to produce total or cumulative glandular dose for DBT. For patient with non-dense breast or heterogeneously dense breast, 3D imaging mode requires more radiation than 2D imaging mode and for extremely denser breast, 3D required less radiation than 2D (Zuckerman, 2014). A study has been conducted to determine the average glandular dose in 2D imaging mode and 3D imaging mode. From the study, 3D imaging mode produced an average of 34 % higher than dose for 2D imaging mode for patients examined with the same compressed breast thickness (CBT) (Olgar *et al.,* 2012).

2.2 EXPOSURE FACTORS

Most of the digital mammographic including DBT uses AEC (Automatic Exposure Control) that automatically select the suitable x-ray tube voltage (kV) and tube current (mAs) to produce good quality of mammographic image. By modification of kV, digital mammography can modify the x-ray beam quality. Increasing the x-ray kV increases the x-ray beam penetrating power (average energy) that decreases the dose to breast. Increasing the kV resulted in a better image quality and better visualization of microcalcifications (Jousi *et al.*, 2019).

Increasing mAs resulted in high image quality, which reduced the noise in the image and the better the image spatial resolution of tumour (Jousi *et al.*, 2019). However, increasing mAs will increase the dose to patients.

The exposure factor settings are depending on the breast thickness and the breast density. Denser breast and thicker breast will require high kVp. High kVp is needed for thicker and denser breast to enable the x-rays to penetrate through the breast tissues and increases penetration (Young *et al.*, 1997). The relationship between tube current (mAs) and tube voltage (kVp) is inversely proportional, means that if kVp value is increased, mAs will decrease or vice versa. Increasing the kV from 28kV to 30kV will cause the dose reduction of 19-22% and also decrease in image contrast by 4-8% (Young *et al.*, 1997). If high mAs is used, it will cause higher of breast glandular dose as many x-ray photons are produced and absorbed by the tissue when using high mAs.

Different projection in mammography may also result in different mAs values as mAs are lower in MLO than CC view (Brnić and Hebrang, 2001).

2.3 BREAST THICKNESS

In mammography, the breast thickness is also known as the compressed breast thickness (CBT) which depends on the compression force (CF) applied. Compression force is the amount of compression applied to decrease the thickness of the breast. Compression is needed to even out the thickness of the breast and one of the important components to reduce the breast thickness. Compressions also help reducing the breast movement due to patient motion during the exposure procedure so that the blurring of the x-ray image will be minimized (Mammography, n.d). The amount of compression applied is usually between 25 to 45 pounds of pressure (Bontrager and Lampignano, 2013).

The importance of compression are to decrease the thickness of the breast and ensure it more uniform, to bring breast as close as possible to image receptor, to decrease the amount of scattered radiation dose, to decrease motion and image unsharpness, to increase the image contrast and to avoid superimposition of the breast tissues. For 42 mm of compressed breast consisting of 50% glandular and 50% adipose tissues, the AGD value must be less than 3.0 mGy as recommended by the International Atomic Energy Agency (IAEA) (Choi *et al.*, 2010).

Based on the previous study, for breast thickness <40mm, denser breast will receive higher AGD than the fatty breast. However, for breast thickness >50mm, AGD is slightly higher for fatty breast (Østerås *et al.*, 2018). The reduction of absorbed glandular dose is influenced by the reduction of breast thickness (Brnić and Hebrang, 2001). Based on other study, it has reported that increases in CBT is proportional to increament in compression force and AGD (Suliman *et al.*, 2020). A study had proved that CBT affects the AGD value with a positive correlation between AGD and CBT (Du *et al.*, 2017).

2.4 BREAST DENSITY

Breast tissues consist of three main types of tissues which are skin, subcutaneous adipose tissue and glandular tissue. Younger women usually tend to have denser glandular tissue than older women (Hogg *et al.*, 2015). American College of Radiology (ACR) has established Breast imaging Reporting and Data System (BI-RADS) to describe level of breast densities seen in mammogram. The women's breast density can be determined only by screening mammogram and is recorded by doctor in BI-RADS (Sickles, 2013).

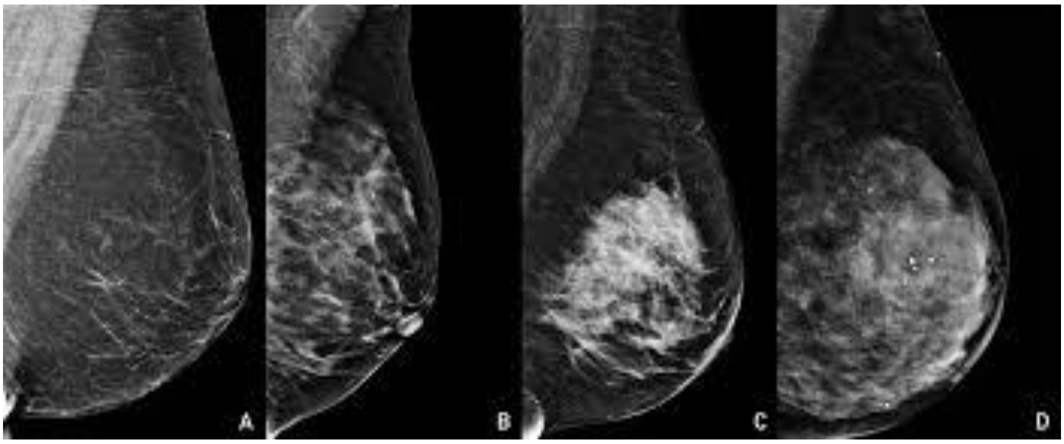


Figure 2.1 BI-RADS breast density type A (entirely fatty), B (scattered fibroglandular), C (heterogeneously dense) and D (extremely dense) (Wang A.T. *et al*, 2014).

Based on BI-RADS, the breast density is categorised into four groups; type A (breast is almost entirely fatty), type B (there are scattered area of fibroglandular tissues), type C (the breasts are heterogeneously dense) and type D (the breasts are extremely dense) (Hogg *et al.*, 2015). Group A and B are considered as non-dense breast and group C and B are considered as dense breast.

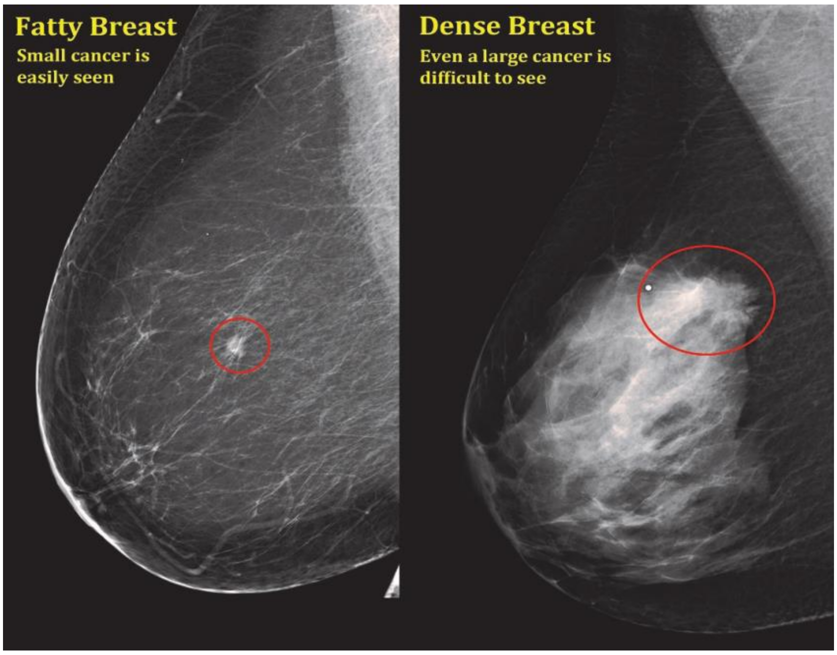


Figure 2.2 Difference between fatty breast and dense breast on mammogram (The American Society of Breast Surgeons Foundation, 2019.)

The radiation beam for each mammography machine must be calibrated so that it can delivers specific and accurate absorbed dose to the average breast thickness. Age is negatively associated with AGD per view (Baek *et al.*, 2017). However, mAs, setting and compressed breast thickness are positively associated with AGD per view. The 'dense breast' group or patients with denser breast had significantly higher AGD than the 'non-dense breast' group or patients with less dense breast.

Patients with denser breast tends to have higher AGD and shown their breast images are more frequently showed higher doses which are above the diagnostic level than the patients with less dense breast (Baek *et al.*, 2017). This means that patients with denser breast will absorb more radiation dose, thus high in glandular dose than patients with less dense. The mean dose is higher for denser breast as compared to fatty breast (Østerås *et al,*(2018).

2.5 DBT PROJECTION

The base of the breast is the portion near the chest wall, and the area near the nipple which is known as the apex. All mammographic procedures including DBT used two types of projection which are craniocaudal (CC) view and mediolateral oblique (MLO) view. In both CC and MLO projections the base of the breast is much thicker and contains denser tissues (less fibroglandular tissues) than the breast tissues at the apex (Bontrager and Lampignano, 2013). Besides, there are also added projections to view the breast tissues including left craniocaudal (LCC), right craniocaudal (RCC), left mediolateral oblique (LMLO) and right mediolateral oblique (RMLO).

Comparison between 2D imaging and 3D imaging mode of DBT, AGD value is higher in DBT for all views than the conventional mammography. Comparison of AGD values between CC and MLO views in DBT showed that AGD of MLO view is slightly higher than the CC view. However, there was no statistically different of AGD between left and right side of the breasts for both CC and MLO views (Gennaro *et al.*, 2018).

Each mammographic projection in DBT has different mammographic angle. AGD is reduced by 25% when 60° angle is used instead of 45° angle for MLO view in mammography (Brnić and Hebrang, 2001).

CHAPTER 3: METHODOLOGY

This study involved a total of 224 patient's data of female adult (aged > 18 years old) underwent breast examination using digital breast tomosynthesis (DBT) at Imaging Unit in Advanced Medical and Dental Institute (AMDI) USM, Penang. All the patients that underwent DBT examination were exposing using the same mammography unit. Only the CC view and MLO view were included in this study. Patient's identification such as age was recorded. The inclusion and exclusion criteria for patient selection were discussed in detail as below.

3.1 INCLUSION CRITERIA

1. Patients glandular dose data of patients underwent DBT examination in the period from June 2019 until October 2019
2. Related patients' information including patients age, compressed breast thickness (CBT), and exposure setting (kV, mAs) were recorded.
3. Patients glandular dose data of patients that performed both DBT and 2D mammography.
4. Glandular dose data of patients that performed mammographic screening in AMDI, USM.

3.2 EXCLUSION CRITERIA

1. Glandular dose data of patients aged below 18 years old.
2. Glandular dose data of incomplete mammographic screening.

3.3 SAMPLING METHOD

Simple random sampling method was used for this study where the patient's glandular dose data were selected randomly from the Picture Archiving and Communication System (PACS). This means that patient's glandular dose data, which meet the stated inclusion criteria, were acquired and collected. Based on the calculation of sample size, a total of 224 dose data were included in this study (57 samples for RCC, 55 samples for LCC, 57 samples for LMLO, and 55 samples for LMLO projections). The total number of samples were also based on the availability of the patient's data underwent Digital Breast Tomosynthesis (DBT) imaging.

3.4 SUBJECT RECRUITMENT

For subject recruitments, dose data of the patients were selected based on these criteria:

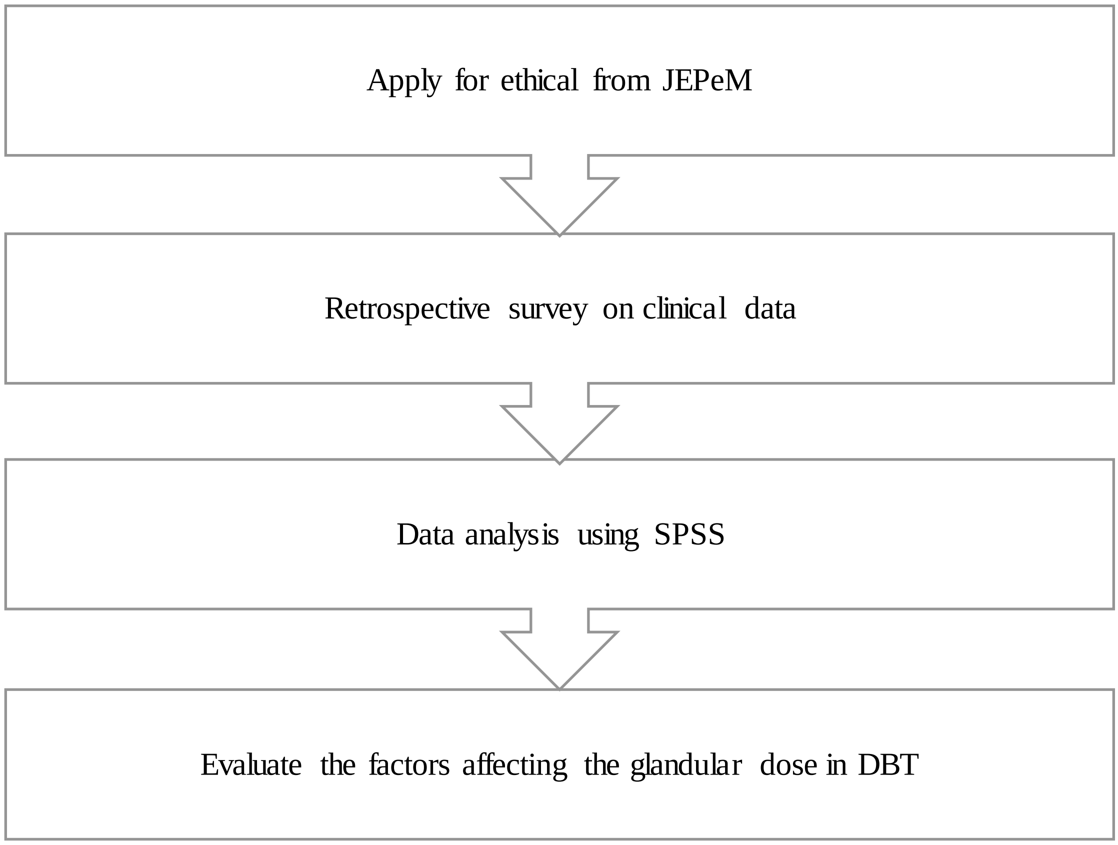
1. Glandular dose data received from DBT and 2D mammography and images of few selected patients.
2. Glandular dose data of adults' patient (above 18 years old).
3. Glandular dose data performed by female patients of all races.

3.5 RESEARCH TOOLS

In this study, all DBT examinations were performed using the same mammographic unit which is Siemens MAMMOMAT Revelation unit (Siemens Healthineer, German) at Imaging Unit, Advanced Medical and Dental Institute (AMDI), USM, Penang (as shown in Figure 3.1). This mammographic system used a combination of Tungsten target with Rhodium filter (W/Rh). The DBT unit permits the acquisition of both mammography images (2D) and tomosynthesis image series (3D).

Figure 3.1 Mammography unit (MAMMOMAT Revelation) used in AMDI

3.6 RESEARCH METHODOLOGY



3.6.1 ETHICAL CONSIDERATION

Upon starting the data collection that involved a retrospective survey on the clinical data of patient's dose, an ethical approval form was submitted to Human Research Ethics Committee of Universiti Sains Malaysia (USM) known as JEPeM (Jawatankuasa Etika dan Penyelidikan Manusia). Human ethical approval from JEPeM should be applied before starting the retrospective study. It involved patient's data and to protect the patients' privacy and confidentiality in research.

There are few considerations for the human ethical approval such as below:

1. **Subject vulnerability**

   Not applicable

2. **Declaration of absence of conflict of interest**

   I hereby declare that I do not have any personal conflict of interest.

3. **Privacy and confidentiality**

   All the mammographic dose data and images are anonymous and were entered into the SPSS software. Only research team members can access the data. Data were presented as grouped data and will not identify the subjects individually.

4. **Community sensitivities**

   Not applicable

5. **Community benefits**

   From this study, we will be able to determine the factors that affecting the glandular dose in DBT. Thus, it can help professionals to plan the dose reduction strategies in patients undergoing DBT examination.

6. **Honorarium and incentives**

   Not applicable

7. **Other ethical review board approval [if applicable]:**

   Not applicable

The ethical approval for this retrospective study was obtained on May 2020 from the Human Research Ethics Committee of USM (study protocol code: USM/JEPeM/19120866), and the need to obtain the informed consent was waived.

3.6.2 RETROSPECTIVE SURVEY ON DOSE DATA

A retrospective survey was performed on the selected patient data. All the related data were retrieved and collected from the Picture Archiving and Communication System (PACS) that contains patient's information and dose data from the DBT examination which have been performed at AMDI, USM. The data includes the images of patient's image mammographic screening that display the AGD values (in mGy). The images of male patients were also excluded from the study and only female patients were included. Bilateral mammography with craniocaudal (CC) and mediolateral oblique (MLO) views of each patient were also included.

Data obtained from the mammographic images in the PACS were analysed and all the factors affecting the glandular dose in Digital Breast Tomosynthesis were evaluated. DBT images were also analysed together with the related parameters that affecting glandular dose such as breast density, compressed breast thickness or the thickness of the breast (in mm). Besides, acquisition factors such as kVp and mAs setting, and different projections; CC and MLO views were also acquired and analysed. The difference on the glandular dose between 2D and 3D images were also analysed.

3.6.3 DATA ANALYSIS

Data analysis were performed using statistical software (SPSS 25.0 for windows; SPSS Inc., Chicago, IL, USA). Descriptive statistical analysis was used to summarise the socio-demographic of the patient such as age group and breast glandularity.

For statistical analysis, a parametric test (independent t-test) was used to compare the glandular dose between 2D and 3D images, and glandular dose for different projection views (CC and MLO) was also compared. The comparison of the glandular dose between 2D image and 3D image were evaluated separately for CC and MLO views. The radiation dose management system on the DBT image monitor shows the average glandular dose

(AGD) per side of the breast (in mGy) for both left and right sides of the breast according to the “L” or “R” value in the image from PACS. The dose between MLO and CC were also compared and the dose for each projection (CC or MLO) were also compared for each side (left and right sides)

Meanwhile, a multiple regression and correlation analysis were used to study the correlation between the related factors such as the exposure settings (kVp and mAs) with glandular dose. The exposure factors such as kilovoltage peak (kVp) and tube current (mAs) affect the MGD values and are displayed on the images. Multiple regression and correlation were also used to determine the correlation between patient’s breast characteristics (breast thickness and glandularity) with glandular dose. The scatter plot graphs were plotted to see the relationship between breast thickness and exposure factors.

CHAPTER 4: RESULTS

4.1 DESCRIPTIVE ANALYSIS OF PATIENT DEMOGRAPHIC DATA

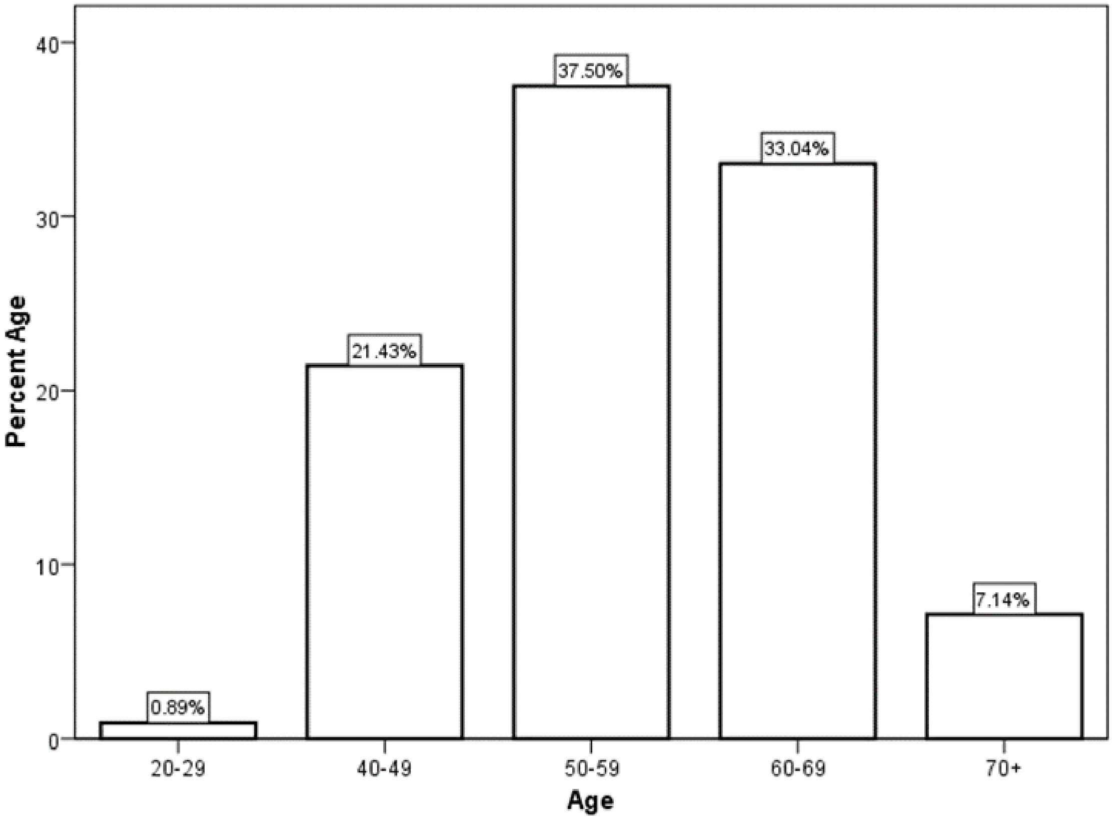


Figure 4.1.1 The patient demographic plot based on the patient's age

Based on figure 4.1.1, the patients aged 50-59 years old showed a higher percentage of 37% followed by age 60-69 (33.04%), 40-49 (21.43%), age over 70 (7.14%) and the lowest age group was 20-29 years old (0.89%).

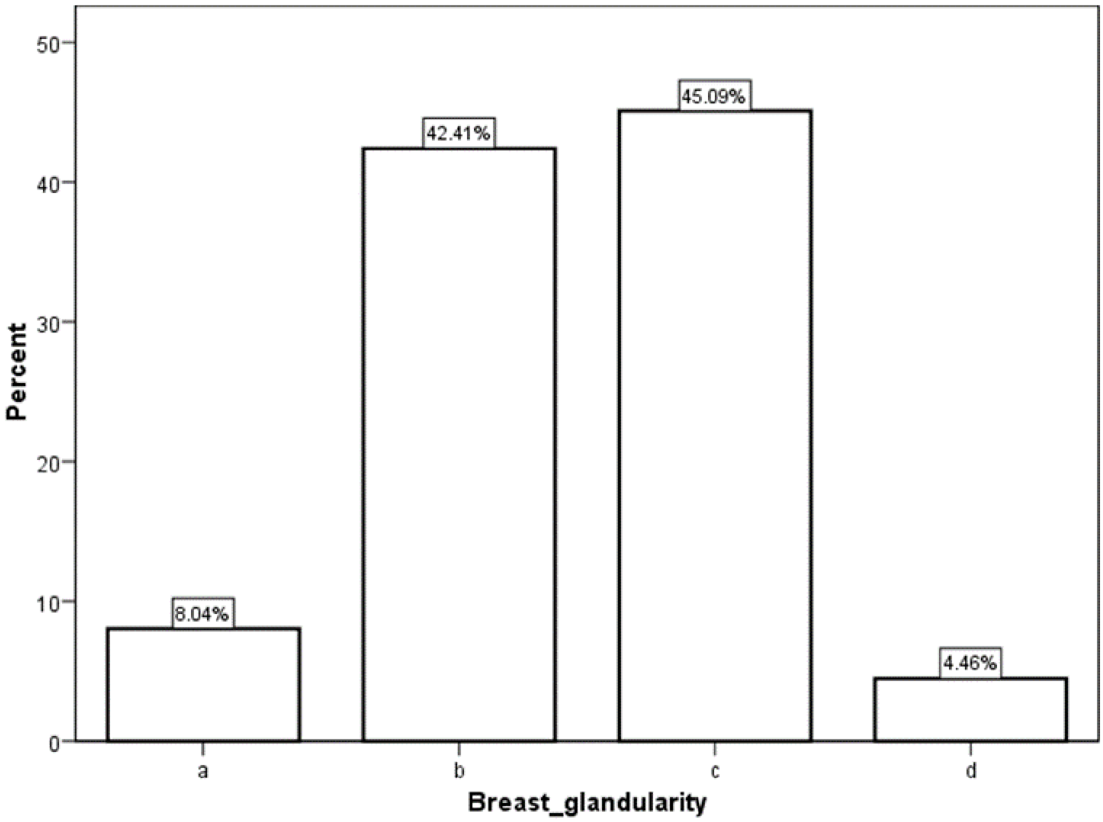


Figure 4.1.2 The patient demographic plot based on the patients' breast glandularity

The patients with breast glandularity type C (heterogeneously dense breasts) showed the highest percentage (45.09%), which the highest among the other breast glandularity types as shown in figure 4.1.2. The breast glandularity type B (scattered areas of fibroglandular density breasts) showed the second highest percentage with 42.41% of total patients followed by breast glandularity type A (entirely fatty breasts) is 8.04% and type D (extremely dense breast) is 4.46%.

4.2 COMPARISON OF MEAN AGD WITH DIFFERENT MAMMOGRAPHY MODES

The independent t-test was used to find the significant difference between mean AGD with different mammography modes; 2D mammography and 3D mammography. The AGD were also compared separately for right and left breast.

4.2.1 Comparison of mean AGD between 2D and 3D modes of right breast

Variable	Mean AGD (mGy)		Mean diff.	T statistic	*p* value
	2D	3D	(95% CI)	(df)	
AGD	1.96 (0.74)	4.36(1.64)	0.17 (-2.731, -2.065)	-14.195 (226)	0.000

Table 4.2.1 The Comparison of Mean AGD between 2D and 3D of Right Breast

Table 4.2.1 shows the result of mean different of AGD between 2D and 3D mammography modes for right breast. The P value obtained is less than 0.05 ($p < 0.05$), so there is statistically significant difference between 2D and 3D modes of right breast. The mean AGD for 3D is four times higher than 2D with the mean difference of 0.17%.

4.2.2 Comparison of mean AGD between 2D and 3D modes of left breast

Table 4.2.2 The comparison of mean AGD between 2D and 3D modes of left breast

Variable	Mean (SD) AGD (mGy)		Mean diff.	T statistic	*p* value
	2D	3D	(95% CI)	(df)	
AGD	2.07 (0.96)	4.37(1.92)	0.20 (-2.705, -1.90)	-11.224 (218)	0.000

Significant different p<0.05; statistical test independent t-test

Based on Table 4.2.2, it shows the results from the comparative study of AGD between 2D and 3D modes. The p-value obtained is 0.00 ($p < 0.05$), thus there is a statistically difference between 2D and 3D modes of left breast. The mean AGD of 3D is higher than 2D with mean difference of 0.2%.

For the comparison of AGD left and right for 2D and 3D, the left side of breast showed slightly higher AGD value for both 2D (2.07 mGy) and 3D (4.36 mGy) than the right side of breast for both 2D (1.96 mGy) and 3D (4.36 mGy).

4.3 RELATIONSHIP BETWEEN AGD AND EXPOSURE FACTORS

A multiple regression and correlation test were performed to see the relationship and correlate between AGD with the exposure factors such as kV and mAs setting. The linear scatter plot graphs were plotted to see the linear relationship between AGD and the evaluated exposure factors. The data were analysed differently for left and right sides of the breast.

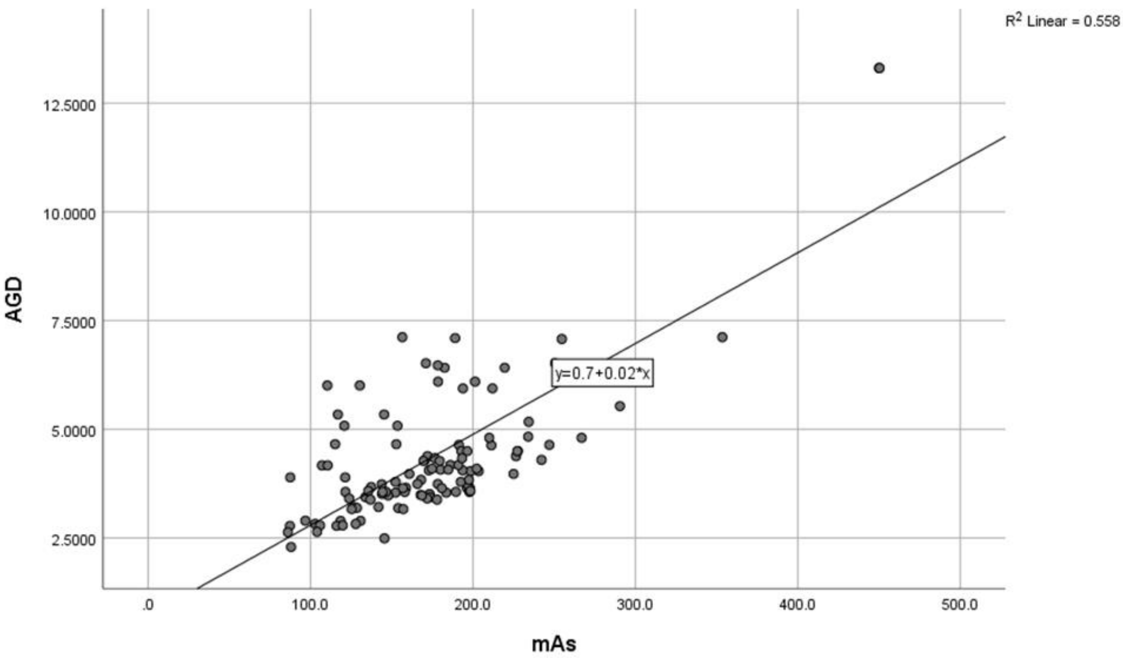


Figure 4.3.1 Linear relationship between AGD and mAs of right breast

Based on the scatter plot graph of AGD against mAs above, it shows that there is a positive linear relationship between AGD and mAs of right breast with the regression value of R^2=0.558.