CHAPTER 1

INTRODUCTION

1.0 OVERVIEW

It has been reported by the World Health Organization (WHO) that stroke and cardiovascular disease (CVD) were the leading cause of death for the past 15 years, with approximately 15 million deaths occurred in years 2015 alone. Another statistics by WHO in 2014 stated that Malaysia was ranked at 33rd for death caused by coronary heart disease (CHD), with 29,363 cases (or 23.10% of total death), corresponding to a death rate of 150.11 per 100,000 of population. There are many reasons that can lead to CVD, including both modifiable and non-modifiable risk factors (Thayer, Yamamoto, & Brosschot, 2010). Apart from obesity, stress, high blood pressure, high blood cholesterol and diabetes mellitus, sedentary lifestyle and unhealthy habits such as smoking, imbalanced diet and alcohol consumption (which are directly related to human behaviour) are known as modifiable risk factors. On the other hand, age, gender and family history of cardiovascular diseases are considered as non-modifiable risk factors. (Aniza et al., 2016). In consequence, getting early diagnosis and reliability of the diagnosis has been recognized as a very crucial social issue. Many cardiac diagnostic methods for CVD that had been practiced in hospitals include cardiac ultrasound, electrocardiogram (ECG), Thallium scans or myocardial perfusion scans, cardiac Magnetic Resonance Imaging (MRI), Computed Tomography (CT) scan and Holter monitor (Antman

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et al., 2000). Interestingly, ultrasound machines had been in use as diagnostic tool for at least 60 years by sonographers to obtain images of body, non-invasively. In fact, ultrasound machines are relatively less expensive and more portable as compared to other diagnostic tools such as MRI and CT(Tyovenda, Aiyohuyin, & Akaagerger, 2013). American Heart Association (AHA) had established echocardiogram as an ultrasound diagnostic test for cardiac related illnesses. Echocardiogram utilizes high frequency sound waves to acquire the images of heart, details its structure and scrutinizes the function, through which physicians diagnose various heart related problems. Experienced sonographers attributed the largest and most complex ultrasound machines to the best image quality, and vice versa, whereas participants of related studies ranked the usability of ultrasound machines models based on design ergonomics and user interface. Thus, a purchase of an ultrasound equipment should be spearheaded by a thorough evaluation on different models and features. However, comparative data and information regarding ergonomic design, physical features, usability, quality of image produced and cost is, yet unavailable (Badano et al., 2012) . Various machines are being used for echocardiogram globally, but there are five main types that are in practical use at National Heart Institute of Malaysia including Siemens, Philips, Toshiba and Sonosite, General Electric (GE). Philips (iE33) and GE Vivid E9 are not only the pioneer machines in National Heart Institute or Institut Jantung Negara (IJN), but also worldwide. Thus, this study shall describe the evaluation process that can be conducted to choose the better cardiac ultrasound machine, between Philips (iE33) and GE Vivid E9.

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1.1 OBJECTIVES

Experimental procedures of this research shall be carried out to determine the better cardiac ultrasound machines, of Philips (iE33) and GE Vivid E9. Thus, objective(s) of the study is:

I. To study the image quality of Philips iE33 and Vivid E9 for diagnostic purposes.

II. To perform a qualitative study of image quality with doctors, medical officers and cardiovascular technologist.

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1.2 PROJECT OUTLINE

Generally, this thesis has been organized into six chapters: introduction, literature review, research methodology, results, discussion and summary. Chapter 1 shall provide an introduction to research undertaken and define the research objectives.

Chapter 2 includes the review of literature on main areas of the research, which include principle of ultrasound, details of echocardiography, diagnostic machines and their components to enhance the image quality, quantitative analysis, the bland-Altman method and image of echocardiography.

Chapter 3 describes the method of image acquisition from Philips iE33 and vivid E9 machines. The chapter also discusses the methodology for a qualitative study conducted among doctors, medical officers and cardiovascular technologist.

The results obtained from investigation of image quality and survey among medical practitioners in National Heart Institute of Malaysia are presented in graphical form in Chapter 4 of this thesis. Consequently in Chapter 5, relevant discussions on the results obtained for image quality and survey conducted are provided.

The final chapter (Chapter 6) states a summary of findings which supports the research objectives. It includes the conclusions that can be drawn from the research undertaken, besides exploring the possible areas for future research in image quality by means of quantitative work.

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CHAPTER 2

LITERATURE REVIEW

This chapter helps reader to understand the important terms and concepts of the research undertaken by providing an inclusive literature review of topics relevant to echocardiography and ultrasound machine functions. The literature review is consisting of ultrasound principles, details of echocardiography, diagnostic machines and their components to enhance image quality. Moreover, a review on quantitative analysis, the bland-Altman method and image of echocardiography is also presented.

2.1 ULTRASOUND

Ultrasound or sound wave (Figure 2.1) represents mechanical energy that propagates through a medium by vibration of molecules, through which the image of an object can be obtained. (Pesque, 1989). Ultrasound was first introduced by Dr.George at the Naval Medical Research institute in late 1940s (Pach, Legutko, & Kulig, 2012), and the earliest paper on medical ultrasonic was published in 1942 by Dr. Karl Theodore Dussik of Austria. Nevertheless, Professor Ian Donald of Scotland was the one responsible for developing the practical technology and applications of ultrasound in 1950s (Pach et al., 2012). Transducer is the vital part of an ultrasound machine that gives off sound wave at the range of 1 to 18 megahertz. Gel applied on a transducer probe helps to act as a medium for sound wave to be transmitted and reflected by internal structures of the body(Pach et al., 2012).

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These vibrations are then converted into an image, whose depth and strength is adjusted accordingly based on the needs. In current practice, this diagnostic tool is used to view the internal structures of human body such as organs, blood vessels, tendon and bones, apart from visualizing fetus in a pregnant woman.(Dewitte, Fierens, Stöckl, & Thienpont, 2002).

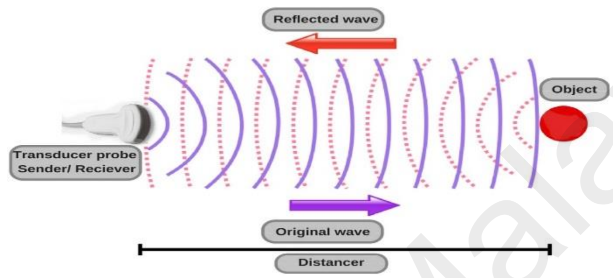

Figure 2.1: Ultrasound beam transmission from transducer to an object (Reproduced from (Nishihara & Champion, 2002)

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2.2 ECHOCARDIOGRAPHY

Echocardiography (Figure 2.2) allows medical personnel to assess the structure, function and hemodynamic of heart and its related blood vessels with aid of ultrasound. It has been used specifically in diagnosing clinical disorders of the heart, with variety of parameters for prognostic purpose (Pach et al., 2012).

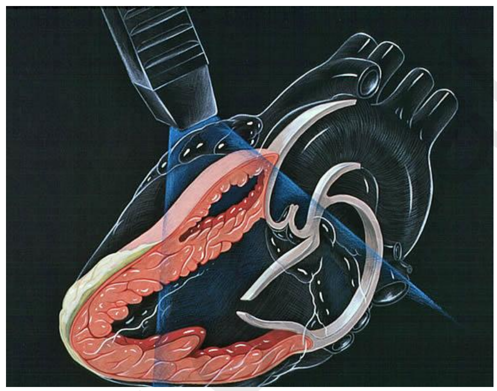

Figure 2.2: Echocardiography (Reproduced from Maul et al., 2004)

Echocardiography is only be performed by someone who has been trained in handling of the machine, with high level of knowledge and skill in both cardiovascular pathophysiology and cardiac diseases. This is due to the requirement of operating the machine and interpreting the results independently at most of the times. A fully equipped echocardiographic machine can be used to investigate morphology, characteristics and pumping function of the heart. Standard echocardiography continues to be the gold standard in detection of cardiovascular diseases (Lang et al., 2006), as physical examination was reported to miss 59% of cardiovascular abnormalities. Physician-performed echocardiography with the Hand-held ultrasound devices, on the other hand was reported to have missed 29% of cardiovascular irregularities, including 21% that can be considered as major findings. Although point-of-

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care echocardiography shows better detection of atypical cardiovascular pathology as compared to physical examination, but the efficiency of such devices is questionable due to the fact that it failed to distinguish significant percentage of findings. This could be due to inexperienced handling of echocardiography and limitations of the hand-held device. Besides, standard echocardiography produces images of better quality which helps in improved cardiac diagnostic process.

Nevertheless, it has been widely accepted that qualitative assessment of cardiac structure and function using pocket-size imaging devices results in fair diagnostic accuracy when performed by either experienced or non-experienced operators. However, the image quality of pocket-size devices is usually poorer as compared to images obtained from high-end ultrasound systems. This could be a problem while working with difficult patients, which ultimately may result in technically suboptimal images which reflect less reliable findings. Thus, pocket-size devices remain as an unpopular choice for such patients.

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2.3 PHILIPS iE33 and GE VIVID E9

A **B**

Figure 2.3: Machine Philips IE33 (A) and GE Vivid E9 (B)

Figure 2.3 (A) and 2.3 (B) represent the most commonly used machines with an ultrasound probe (as per shown by Figure 2.4) that helps to diagnose heart related diseases. Philips and Vivid are pioneer machines which had been in use since 1960s.

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Figure 2.4 Probe with bandwidth 1-5 MHz

An electrocardiography machine probes usually comes with bandwidth of 1 – 5 MHz , as per shown by figure 2.4 and are commonly used in diagnostics of adult, paediatric and congenital heart disease (Lang et al., 2006). Furthermore, ultrasound machines usually consist of imaging modes such as 2-Dimensional, steerable Pulse Wave (PW) Doppler, Continuous Wave (CW) Doppler, High Pulse Repetition Frequency (PRF), Color Doppler, Tissue Doppler, XRES and Harmonic Imaging including Left ventricular opacification (LVO) Contrast (Neelankavil et al., 2012). Ultrasound probes are consist of linear array of tiny crystals that activates a complex sequence to create a focused ultrasound beam of a few millimetres thickness which is projected into the body. The piezoelectric crystals on the face of the probe emit ultrasound waves in a focused beam and those pulses of ultrasound are emitted as the ultrasound beam with certain frequency through a 90-degree sector in order to reveal a slice of tissue at rates sufficient to capture fast motion(Jago, Collet-Billon, Chenal, Jong, & Makram-Ebeid, 2002). Each pulse must be allowed to travel to the targeted area which is then termed a “line” of information

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Figure 2.5: Probe with bandwidth 3-11 MHz

The probe shown by Figure 2.5 has bandwidth of 3 – 11 MHz and suitable to be used for vascular assessment such as carotid, arterial and venous. It is also used for cerebrovascular scanning involving the carotids, vertebral and peripheral vascular screening such as venous and arterial (Lang et al., 2006). This probe is capable of steerable pulsed Doppler, Colour Doppler, Colour Power Angio, SonoCT, XRES and Harmonic Imaging modes (Jago et al., 2002).

Figure 2.6: Probe 2D MATRIX

Figure 2.6 shows the probe with 2D MATRIX phased array with 2,400 elements that consist of bandwidth at 1 – 3 MHz (Lang et al., 2006). The probe is used for adult and paediatric cardiology in 2D, , live 3D echo, Color Doppler with 2D, biplane and 3D and LVO modes (Jago et al., 2002)

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2.4 PHILIPS IE33 OPTIONAL TECHNOLOGY DEFINITIONS

Philips IE33 is equipped with XRES adaptive image processing which is responsible for real-time speckle reduction. It also helps in improving edge definition and real-time image enhancement by minimizing clutter artefacts, speckle and haze (Shah et al., 2008). Moreover, the iSCAN is an 'intelligent' part of the machine with an automatic one-button function that triggers global image optimization standard on Philips iE33, through AI adjustment of TGC, Doppler and receiver gain, Doppler PRF, Doppler baseline and compression curve.

2.5 BASIC IMAGE OPTIMIZATION TECHNIQUES

An even resolution and illumination represents an image of good quality. Two dimensional image can be controlled of its quality by using the 'Gain' adjustment. The 'Gain' control helps in amplification of the returning reflections commonly appearing on ultrasound images (Perez et al., 1992). Generally, the more adjustment of Gain is made, the brighter would be the image. However, this should be compensated by decreasing the Dynamic Range and Compression. This is to prevent the brightness from concealing the desired details.

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2.6 GAIN CONTROL

The weakening of image quality can be dealt by increasing 'gain' which in return amplifies the reflected signal in post processing. According to Wong et al., (1983), gain can be adjusted either during image acquisition or post processing. Nevertheless, an increase in gain would also amplify the signal and noise. Thus, it is said that the gain knob would be the most-used imaging control as it adjusts the overall brightness of the ultrasound image.

2.7 DYNAMIC RANGE, COMPRESSION AND REJECT AS CONTROLLING CONTRAST

Dynamic Range, Compression and Reject functions of an ultrasound machine are useful in acquisition of good quality image which is not too dark or grey and can produce much diagnostic information. (Inbar & Delevy, 1989), an image can be made look more greyish or white by using dynamic range adjustment, which is known to act towards weaker echoes better than stronger beam. Weaker echoes, on the other hand, are eliminated by reject enhancement. This helps to make an image appear darker. It is also useful in reducing grass appearance, which makes the image appear clearer at higher levels. Compression is also important in producing a good quality image, whereby it alters a range of echo with different intensities by squeezing them into less shades of grey. The Gain adjustment (figure 2.7) generally helps to increase or decrease the dynamic range, compression and reject in reducing effects of weak echoes. Decrease in gain is necessary to enhance the dynamic range, whereas a reduction in reject is helpful in strengthening the weak echoes.

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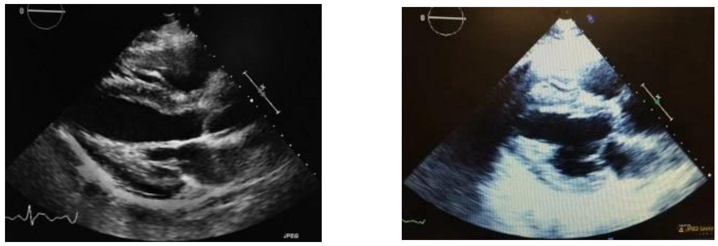

Figure 2.7 shows the left image gain adjusted well to visual the structure clearly. The right image gain adjusted too high and unable to interpret the image in detail.

2.8 TIME GAIN COMPENSATION CONTROLS (TGC)

TGC is also known as depth compensation. Most of the latest equipment is equipped with TGC to increase the gain of reflected signals from the time of pulse transmission. It utilizes an array of sliding tabs which control the gain, corresponding to specific depths and is used to compensate for the decrease in strength of the ultrasound returning from greater distances (Recchia, Miller, & Wickline, 1993). Intensification of weaker signals returning from the far field should be more than the signals returning from shallower depths, and this could be achieved by TGC. The ultimate goal of TGC is to make the entire image look evenly lit from top to bottom. Usually TGC sets as "\" shape, in which controls for near field are lower and far field is higher. Additionally, certain ultrasound units automatically compensate for the attenuation of the far field. Therefore, it requires a lower setting in both far field and near field. This setting the two units in a "bell-shape".

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2.9 LATERAL GAIN COMPENSATION (LGC)

It allows for selective modulation of the gain at lateral aspect of the image whereby more attenuation of signal occur due to increasing scatter of the ultrasound waves. Lateral gain compensation consists of the same tabular array as TGC except that it is arranged horizontally rather than vertically (Chung et al., 1996). The aim of LGC as shown in the figure 2.8 is to have control over the image brightness from side to side. It is able to adjust the brightness of areas horizontally adjacent to each other either from highly reflective areas or hypo-reflective (shadowed) areas.

Figure 2.8: LGC knob

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It is significant to set the tabs at mid-point detent which allows for brightening or darkening of image in the horizontal plane. When LGC tabs are set at minimum, there is a reduction of overall brightness of image and increased fogging of the image or noise due to the higher amplification. It is not uncommon to find a machine that has the LGC optimized for a previous patient or that has the LGC tabs slid all the way to the bottom of their track.

3.0 i- SCAN

Figure 2.9: i-Scan

This adjustment is labelled as iScan or Auto SCAN as per shown by figure 2.9 on Philips ultrasound machines, TEQ on Siemens ultrasound machines and AUTO or CTO (continuous tissue optimization) on GE machines. This adjustment is a good way to get close to the best quality image for particular conditions under selected frequency (Yang et al., 2008).

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3.1 ULTRASOUND FOCUSING

The phased-array transducers used for echocardiography are capable of adjusting the narrowest point in the ultrasound beam anywhere along its length. This is called the focal zone and it is within this 2-4 cm portion of the ultrasound beam that the highest resolution is achieved resulting in the best quality images(Chung et al., 1996). It may be necessary to focus the ultrasound beam at various depths in order to see individual structures with the greatest clarity. Ultrasound machines automatically adjust the focal zone when the zoom function is used, when colour Doppler is activated, and when the image depth is changed upon end of use of these features. However, it is a good practice to make sure that the focal zone is re-positioned to the new area of focus interest, (shown by figure 2.10) as the machine will not always reset it.

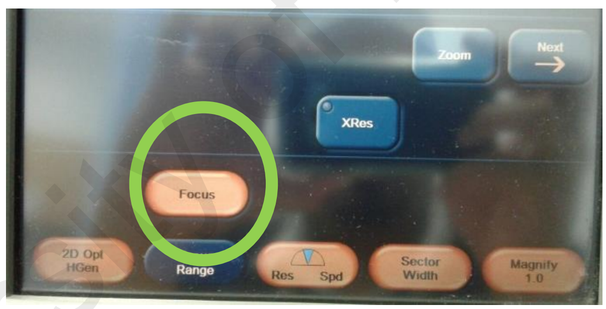

Figure 2.10: Focus

The new ultrasound machines are able to effectively focus in multiple areas along the ultrasound beam. However, this can affect other factors such as frame rate since more than one scan or pulse is necessary to build the image.

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3.2 TISSUE HARMONICS, SPECKLE REDUCTION AND COMPOUND IMAGING

Tissue Harmonics Imaging (Figure 2.11 and 2.12), Compound Imaging, and Speckle Reduction Imaging are the most influential technologies introduced within the last two decades in the field of ultrasound image acquisition. The advancement was proven to be very much helpful for sonographers in obtaining good quality images out of an ultrasound machine. It was reported by Oktar et al.,2003 that Harmonics imaging allows improved identification of body tissue and also exclusion of image artefacts. This is achieved when an ultrasound probe sends and receives signals at two distinct frequencies. For instance, using Harmonics imaging function, a probe can be set to work at both 2MHz and 4MHz; in which the probe may send signal frequency of 2MHHz but only receives signal frequency of 4MHz. This practice helps to produce a clearer image and better display of body tissue.

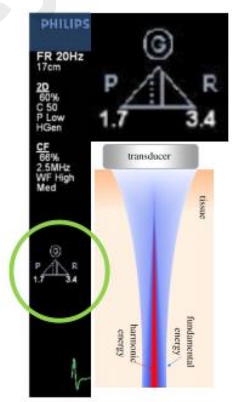

Figure 2.11: Harmonic

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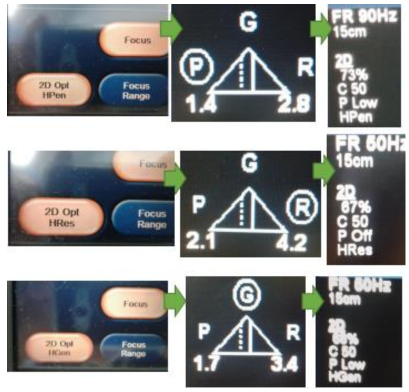

Figure 2.12: Harmonic range

With Harmonics imaging, frequency display will be continuously changing its frequency range (in MHz) to Low, Mid, and High or Pen, Gen, and Res. “Low” and “Pen” are used in deep tissue imaging whilst superficial imaging make use of the “High” and “Res” rage.

3.3 ULTRASOUND SECTOR IMAGE WIDTH

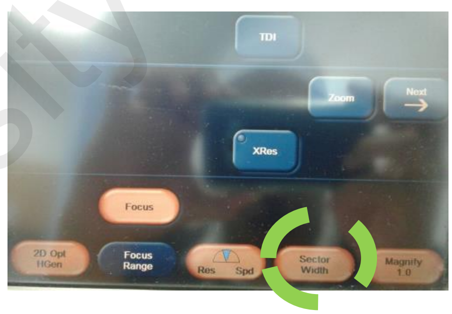

Figure 2.13: Sector

Sector width or ‘swept’ (Figure 2.13) is used to enhance lateral or temporal resolution in ultrasound image acquisition. Temporal resolution, particularly refers to speed of images updating. This process is usually done by decreasing the number of ultrasound lines in each frame. Sector width can be considered as an adjustment that regulates the extent to which an ultrasound ray can be swept during image acquisition. Frame rate refers to number of complete sweep of sector per second. Frame rate is abruptly reduced when two-dimensional

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imaging is shared with other features such as the colour doppler (Hein & O'brien, 1993). It had been a practice in echocardiography whereby frame rates of colour doppler is maintained in range of 20-30 Hz, preferably at 17 Hz. A decrease in depth, width and size of colour doppler box in 2-D image is important in maintenance of frame rate. This is due to reduction of distance for ultrasound pulse movement and also time taken to complete a sector sweep.

3.4 QUANTITATIVE ANALYSIS

Image enhancement is the basics for improving image quality for better diagnosis in the field of healthcare. The parameters involved in quality of image are contrast, brightness and sharpness. Enhancement of contrast is one of the significant tool in image processing(Thanigaraj et al., 2001). Contrast deficiency may be due to poor illumination, less dynamic range and wrong setting of lens during acquiring of image. The main function of contrast is to enhance the dynamic range of image pixels and visual quality of image. Brightness refers to intensity of image pixels, which is represented by a histogram. An image is brighter when the histogram is at the higher end of the histogram. Conversely, the image is darker when the histogram falls to the lower end. Sharpness, on the other hand, refers to image with no motion blur, out of focus or irreversible compression that affects its quality.

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3.5 THE BLAND–ALTMAN METHOD

Bland-Altman plot indicates significant differences between two selected methods or measurements (Myles & Cui, 2007). It is mainly used to find the mean difference in two methods of measurement with 95% agreement limit. In comparing two methods using Bland-Altman plot, all available data is to be used, including the repeated ones. Although the original method was not suitable for repeated data, a little modification had allowed for use of repeated data, especially when the repeated data were collected over a period of time.

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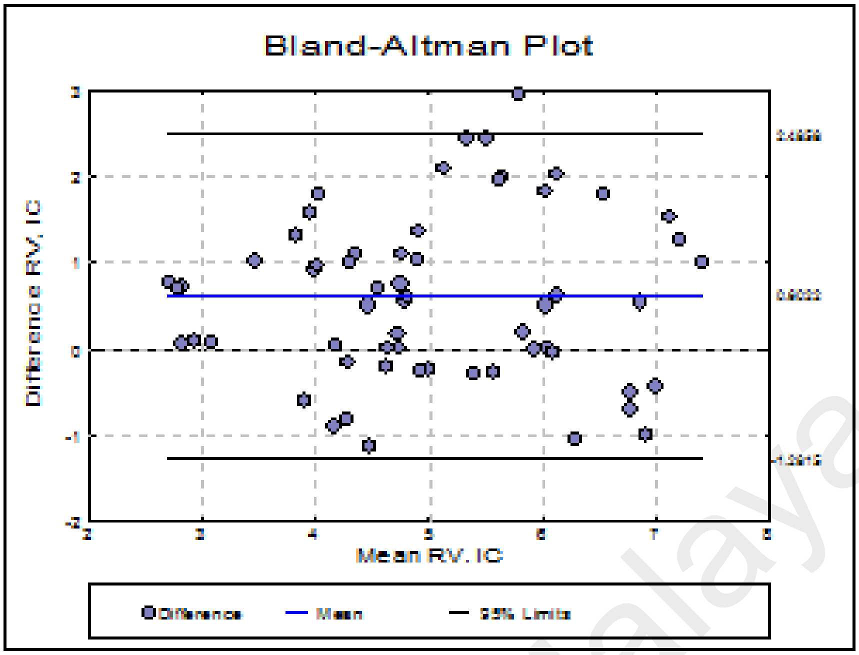

Figure 2.14: The Bland-Altman plot also known as Difference Plot or Tukey Mean Difference Plot (Reproduced from Unistat Software 1984- 20017).

The Bland and Altman plot shown by Figure 2.14 represents the standard deviation (SD) of difference between the means of repeated measurements (Dewitte et al., 2002). Since the Bland–Altman plot is aimed at exhibiting the difference between means in a single measurement, any variation in the original measurement will be undervalued. This can result in measurement error. Therefore, some form of statistical tool is required to assess the effects of such measurement errors when plotting the Bland and Altman plot.

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3.6 IMAGE OF ECHOCARDIOGRAPHY

It is recommended by American Society of Echocardiography (ASE) that a 16- segment model of the Left Ventricular (LV) is used to detect the regional wall motion abnormalities. The 16-segments are obtained from Parasternal Short axis (PSAX), Parasternal Long axis (PLAX), Apical 2 chamber view (A2C) and Apical 4 chamber view (A4C), as shown by Figure 2.15. It is for myocardial perfusion evaluation which helps to identify on the coronary diseases (Dewitte et al., 2002).

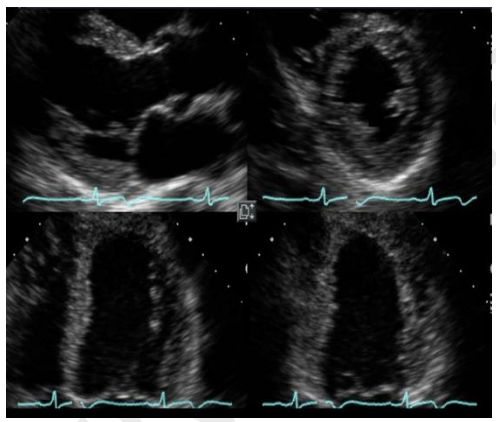

Figure 2.15: Basic echocardiography image (Reproduced from Underwood SR *et al* 2004)

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CHAPTER 3

METHODOLOGY

This chapter describes image acquisition from Philips iE33 and Vivid E9 machines at the same depth and frequency of probe, from five consented volunteers. It also explains the methodology of a qualitative study that was conducted among doctors, medical officers and cardiovascular technologist to indicate their preference for the machines, based on quality of the acquired image(s).

3.1 IMAGE ACQUISITION

Five volunteers were selected upon obtaining official consent to be subjected to image acquisition by both machines (Philips iE33 and Vivid E9) with same depth and frequency of probe. The volunteers were requested to lay down on bed on his/her left side for image acquisition (Figure 17) of the heart, which is located just behind and slightly left of the breastbone. A total of 4 basic images of echocardiogram were captured for each volunteer, including parasternal long axis (PLAX), parasternal short axis (PSAX), Apical 4 chamber view (A4C) and Apical 2 chamber view (A2C) as shown in Figure 16.

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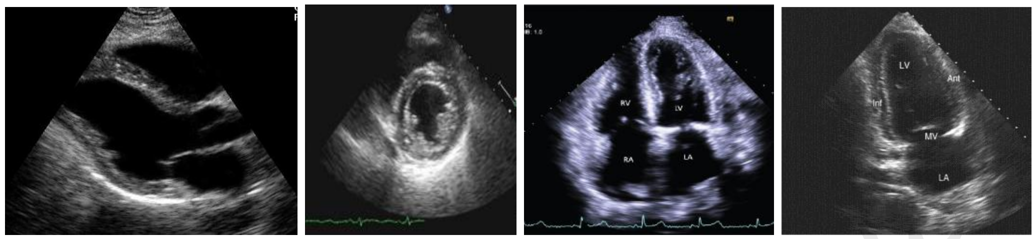

PLAX **PSAX** **A4C** **A2C**

Figure 3.1 shows the basic view of echocardiogram

Figure 3.2 shows the position of subject and sonographer

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3.2 QUALITATIVE STUDY

A qualitative study was conducted following the image acquisition. A total of 50 questionnaires were prepared and distributed to randomly selected respondents consisting of doctors, medical officers and cardiovascular technologists to investigate their preference for the machines, based on quality of the acquired images. The survey was carried out in a room of doctors and during meeting of cardiovascular technologists (Figure 3.3) after the respondents were explained of its purpose.

Figure 3.3: Survey has carried out in their respective room and also in meeting room

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CHAPTER 4

RESULT

Results obtained for investigation of image quality and also major findings of the survey conducted among medical practitioners of National Heart Institute of Malaysia are presented in this chapter of the thesis. Comparison between the images acquired by Philips iE33 and Vivid E9 were reported, besides graphical interpretation of the survey outcome.

4.1 IMAGE ACQUISITION

Echocardiography basic images (PLAX, PSAX, A4C and A2C) were acquired for the five volunteers from both Philips iE33 and Vivid E9 machines at same depth and probe frequency, as indicated by Table 4.1 and Table 4.2. It was shown that the image quality changes according to subject (volunteer) and machines. The '12 cm' depth is used for PLAX and PSAX, whereas '16 cm' depth was used for A4C and A2C. A frequency of 17 Hz was used for all the images. Nevertheless, brightness was adjusted according to needs of the operator to enhance viewing of image, without altering depth and probe frequency.

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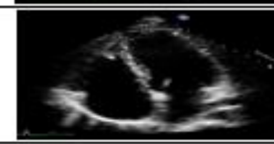
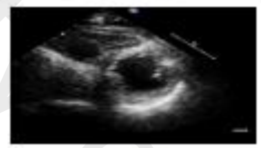
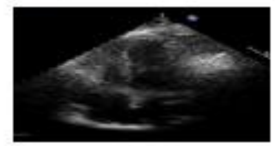
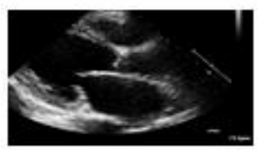
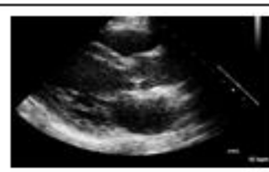
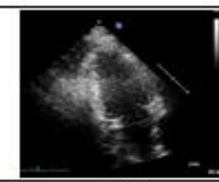
MACHINE	PHILIPS iE33			
IMAGE	PLAX	PSAX	A4C	A2C
SUBJECT 1				
SUBJECT 2				
SUBJECT 3				
SUBJECT 4				
SUBJECT 5				
DEPTH (cm)	12	12	16	16
FREQUENCY (Hz)	17	17	17	17

Table 4.1 shows the echocardiography images acquired from machine Philips iE33

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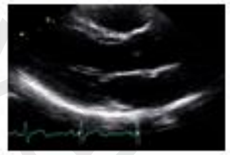
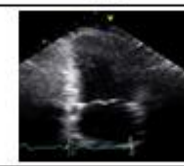
MACHINE	VIVID E9			
IMAGE	PLAX	PSAX	A4C	A2C
SUBJECT 1				
SUBJECT 2				
SUBJECT 3				
SUBJECT 4				
SUBJECT 5				
DEPTH (cm)	12	12	16	16
FREQUENCY (Hz)	17	17	17	17

Table 4.2 shows the echocardiography images acquired from machine Vivid E9

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4.2 QUALITATIVE STUDY

Table 4.3, Table 4.4 and Graph 4.1 represent the data on machine preference of the 50 respondents, based on quality of images produced by both Philips iE33 and Vivid E9 machines.

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SURVEY	CARDIOLOGIST	MEDICAL OFFICERS	CARDIOVASCULAR TECHNOLOGIST	WORKING EXPERIENCE	PREFERENCE OF MACHINE	
					Philips iE33	**Vivid E9**
1			√	2-5 years	√	
2			√	2-5 years	√	
3			√	More than 5 years	√	
4			√	Less than 1 year	√	
5			√	Less than 1 year	√	
6			√	More than 5 years	√	
7			√	Less than 1 year		√
8			√	2-5 years	√	
9	√			More than 5 years		√
10		√		Less than 1 year		√
11	√			More than 5 years	√	
12		√		2-5 years		√
13		√		Less than 1 year	√	
14			√	2-5 years	√	
15	√			More than 5 years		√
16			√	Less than 1 year	√	
17			√	More than 5 years		√
18			√	Less than 1 year	√	
19			√	More than 5 years		√
20			√	2-5 years		√
21			√	More than 5 years		√
22			√	More than 5 years	√	
23		√		More than 5 years	√	
24			√	2-5 years	√	
25	√			More than 5 years	√	
26			√	More than 5 years	√	
27		√		Less than 1 year	√	
28			√	More than 5 years		√
29			√	2-5 years		√
30	√			Less than 1 year		√
31		√		2-5 years		√
32			√	Less than 1 year	√	
33		√		More than 5 years	√	
34	√			2-5 years	√	
35			√	More than 5 years		√
36			√	More than 5 years	√	
37			√	2-5 years	√	
38	√			More than 5 years	√	
39	√			2-5 years	√	
40	√			Less than 1 year	√	
41			√	2-5 years		√
42		√		More than 5 years	√	
43			√	More than 5 years		√
44		√		2-5 years	√	
45			√	More than 5 years	√	
46	√			Less than 1 year	√	
47		√		2-5 years		√
48			√	2-5 years	√	
49			√	More than 5 years	√	
50		√			√	

Table 4.3 shows the machine preference based on image quality among medical practitioners

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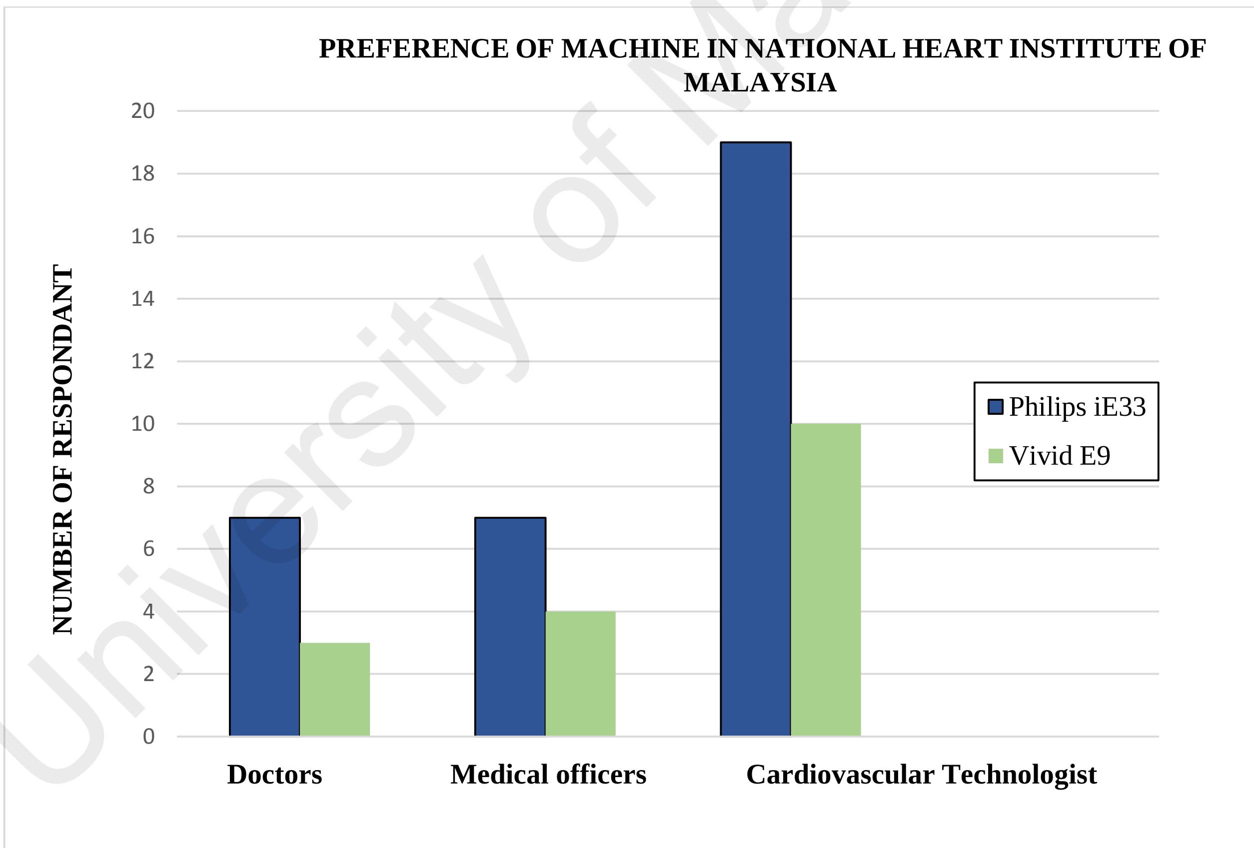
CARDIOLOGIST		MEDICAL OFFICERS		CARDIOVASCULAR TECHNOLOGIST	
Philips iE33	Vivid E9	Philips iE33	Vivid E9	Philips iE33	Vivid E9
7	3	7	4	19	10

Table 4.4 shows the summary of machine preference among medical practitioners



Graph 4.1 shows the graphical interpretation of machine preference among medical practitioners in National Heart Institute of Malaysia

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CHAPTER 5

DISCUSSION

This section of the thesis elaborates on the results obtained for image quality and preference of machines by survey respondents.

A comparison on quality of images acquired from Philips iE33 and vivid E9 machines showed that images obtained from Philips iE33 had less contrast effect as compared to image acquired from Vivid E9. Taking PLAX and PSAX images of Subject 1 as evidence, it had been revealed that clearer images were produced by Philips iE33. Vivid E9, on the other hand was observed to produce images with more contrast effect, thus of a lower quality.

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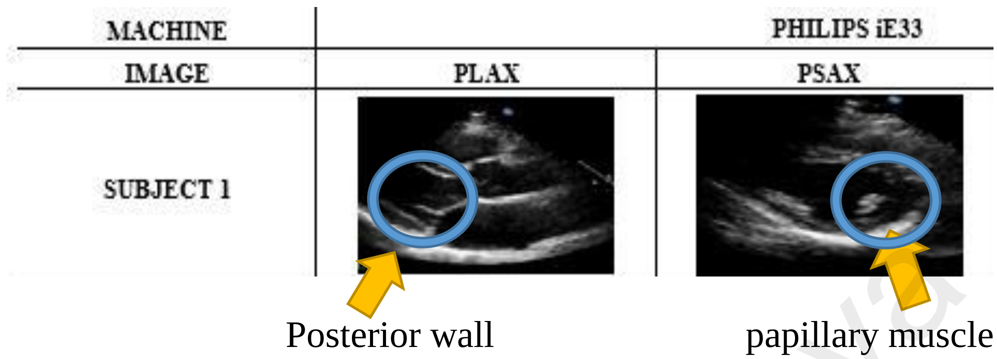

Figure 5.1: PLAX and PSAX image of subject 1 from machine Philips iE33

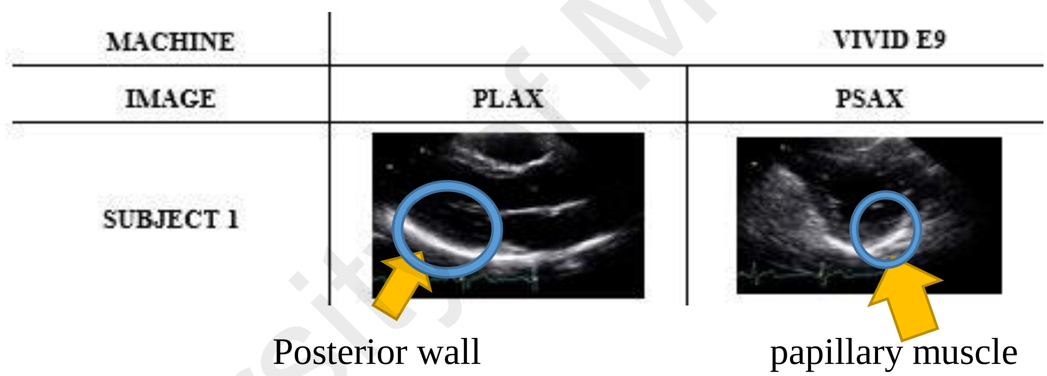

Figure 5.2: PLAX and PSAX image of subject 1 from machine vivid E9

As shown by Figure 5.1, the image PLAX and PSAX of posterior wall and papillary muscle appeared to be clearer as compared to similar image obtained from vivid E9 (as per shown by Figure 5.2). This could be due to capacity of Philips Ie33 on adjusting the gain control and i-scan, which was missing in Vivid E9 (Dewitte et al., 2002). Moreover, the compressor unit of Philips machine could have resulted in a better range of echo intensities by compressing them into fewer shades of grey.

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The qualitative study (survey) conducted among doctors, medical officers and cardiovascular technologist in National Heart Institute of Malaysia (IJN) revealed that 7 out of 10 doctors, 7 out of 11 medical officers and 19 out of 29 preferred the image acquisition by Philips iE33. This is may be due to the image of Philips machine produced less artefacts and contrast which easily to diagnose compare to Vivid E9. Moreover, the sharpness and brightness is very optimal compare to the Vivid E9 that assist the physicians made the decision quickly. In additional, Machine Philips could be attributed to a few factors pertaining to the machine itself such as its user-friendly nature, easy accessibility and frequency of being in use during on call duties. Thus, Vivid E9 which had been used mostly for outpatients in National Heart Institute of Malaysia was not preferred by the respondents. Although the same number of Vivid E9 and Philips iE33 are available in IJN facility, the improvised technology of Philips iE33 in terms of ease to move and portability might have caused the preference of users towards Philips iE33 to Vivid E9. Moreover, frequent workshops organized by vendor of Philips machine iE33 might have provided the opportunity for physicians and technologist to improve their knowledge and skills in handling the machine, thus accounting for their preference on the model.

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CONCLUSION

Cardiovascular disease is a leading cause of death among Malaysians, regardless of age, gender and race. Thus, an accurate diagnosis is essential to determine the options of treatment for a patient. Echocardiography is one of the crucial diagnostics to detect cardiovascular diseases at an early stage, in which images produced by the ultrasound machine help medical experts to rule out any abnormalities in structure and function of the heart. Thus, it is of great importance that quality of the images is not compromised at any circumstances.

The following conclusions had been drawn for objectives of the research, accordingly:

I. To study the image quality of Philips iE33 and Vivid E9 for diagnostic purposes.

The research outcome showed that Philips iE33 produced better quality of cardiac images as compared to Vivid E9. The images produced by the machine had less contrast effect and less artifacts as compare to the images acquired from Vivid E9. Thus, the image quality of Philips iE33 was more easily diagnosed than Vivid E9.

II. To perform a qualitative study of image quality among doctors, medical officers and cardiovascular technologist.

The physicians and technologist preferred Philips iE33 over Vivid E9. They associated the preference to frequent education given to them on handling of the machine and also its user-friendly nature, as compared to Vivid E9.

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FUTURE DIRECTION

A medical practitioner should evaluate the models of ultrasound machines meticulously before considering to purchase one. It is important to ensure that features of the machine match his/her own clinical practice requirements. However, a quantitative study is recommended to justify the machines and image quality in term of contract, sharpness and brightness as Bland-Altman.

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