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Experimental Breast Phantom studies for Estimation of Breast Tumor Using Ultrasound and Mammography Imaging Systems.

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ABSTRACT

Mammography, the standard method for breast cancer screening, misses many cancers, especially in women with dense breast. Whole-breast ultrasonography has been advocated to supplement digital mammography to improve outcomes. The main purpose of this study was to determine early breast tumour detection by assessing the performance of breast ultrasonography compared with X-ray mammography. We compared the performance and diagnostic yield of mammography alone versus ultrasound. The main objective was to investigate is ultrasound a viable method for early breast cancer detection. Breast Elastography phantom was used in this study as a method for comparison between both imaging modalities. We examine the detection capabilities of both imaging systems through visual visulisation of tumor and measureing the full-width at half maximum (FWHM). The imaging setup were optimized for small tumors using ultrasound and X-ray mammography imaging systems. In mammography, breast compression is applied to reduce the thickness of the breast phantom. The experimental results demonstrate the validity of using high-resolution ultrasound as complementry method for both screening and diagnostic mammography. For such phantom ultrasound is a more sensitive and accurate modality compared to digital mammography.

Keywords: Mammography, US, Breast cancer; tumor detection

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INTRODUCTION

Breast cancer is the leading cause of mortality for women. By 2030, such diseases will expected to claim the lives of over 23.6 million people, according to the World Health Organization (WHO) [1]. There has pronounced geographical variation in prevalence rates, being loftiest in the advanced world and smallest in the developing countries in Asia and Africa. In 2018, data produced by the IARC (International Agency for Research on Cancer) from 185 countries reported 2.3 million new cases (11.7%) of breast cancer and a mortality rate of 6.9% [2]. Breast cancer incidence is more common in high-income countries (571/100 000) than in low-income counties (95/10 000), reflecting the association with globalization. Breast cancer is usually called a group of disease (>100) due to the presence of various biological subtypes reflecting distinct molecular profile and clinic pathological features [2]. Breast cancer accounts for a large part of the cancer burden in women worldwide and represented the most commonly diagnosed malignant disease and the leading cause of cancer-related death in 2020. Breast cancer-specific deaths accounted for 32.5% of deaths in women with diagnoses of breast cancer. The median age at diagnosis was 64 years and the median age at death was 77 years [3]. The studies show 18.1 million new cases (17.0 million excluding and 9.6 million cancer deaths (9.5 million excluding worldwide in 2018. For both sexes combined, it estimated that nearly one-half of the cases and over one-half of the cancer deaths in the world would occur in Asia. Europe accounts for 23.4% of the total cancer cases and 20.3% of the cancer deaths, although it represents only 9% of the global population, followed by the Americas' 21% of incidence and 14.4% of mortality worldwide. In contrast to other regions, the shares of cancer deaths in Asia (57.3%) and Africa (7.3%) are higher than the shares of incidence (48.4% and 5.8%, respectively) because of the different distribution of cancer types and higher case fatality rates in these regions [2]. Worldwide, about 2.1 million newly diagnosed female breast cancer cases in 2018, accounting for almost 1 in 4 cancer cases among women. The disease is the most frequently diagnosed cancer in the vast majority of the countries and is the leading cause of cancer death in over 100 countries. Breast cancer is the most common cause of death among women, accounting for ~411,000 deaths each year, which is approximately 15% of all cancer-related deaths. With the lifetime risk of developing breast cancer as high as 1 in 8 women in some Western countries and a 5-year prevalence of approximately 4.4 million cases worldwide. However, the burden is not evenly distributed worldwide due to there are large variations in the incidence, mortality, and survival between different countries, regions, and within specific regions [4]. The burden of female breast cancer in Middle East has greatly increased in the last three decades. Preventive programs should target the most important risk factors, which are high fasting plasma glucose and smoking, and should be initiated among young women [4]. Breast cancer has become a major public health issue in Gulf countries. Although the incidence rates are lower than that reported in the westernized world. Nevertheless, they are increasing rapidly concomitantly with recent changes in reproductive and lifestyle factors, coupled with low adoption of early detection practices. Long-term preventative strategies are required and should focus on issues such as tobacco cessation or avoidance, obesity reduction, increased physical activity, and effective screening programs. However, all strategies need to be tailored in a Gulf-specific way based on expert local knowledge and relevant data. Research efforts should focus on those areas where data are most deficient [5]. The Gulf Cooperation Council countries (GCC) countries share similar history, geography, culture, industrial base, and wealth. In addition, as part of apolitical union, one executive health board governs all of these countries. Therefore, it is not surprising that the same health burdens and challenges relevant to breast cancer are present in all GCC countries. Noticeable increases in breast cancer incidence in recent years reported in each GCC country. From 1998-2007, > 11,000 cases (23% of all female cancers) were reported across the GCC countries, an increase of about 20% since 1998 ($P < 0.05$)12. A further increase of 60% shown inn 2020 [5, 6].

MATERIALS AND METHOD

The performance of ultrasound for detecting breast cancer lesions were assed and compared with X-ray mammography. A realistic heterogeneous breast phantom used to obtain images with both imaging modalities. Such phantom based upon 3D structures as demonstrated in Figure 1. Then calculated full width at half-maximum (FWHM) and contrast for localization a digital X-ray mammography imaging system with a kVp range 20 – 30 and a compression of 40 Newton was used.

Figure 1: a Photo of the breast Electrographic phantom, model 059.

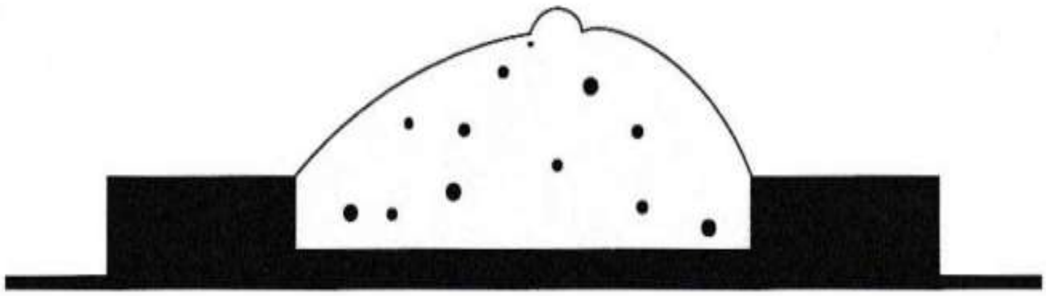

Figure 2: Demonstration of the specification of the phantom with a size dimensions of 600 cc 15cm×12cm×7cm and the material is Zerdine.

Before starting the study both imaging systems were calibrated using both quality control and specific image quality tests to evaluate the performance of both systems. The results were satisfactory and within international standards. The breast phantom that we have used contained cavities where the samples placed to study their contributions for the scattered X-ray photons. The cavities used to simulate the different type of tissues and lesions inside the breast phantom. To evaluate the scattered X-ray photons from the simulated lesions we devised three steps, we first acquired the X-ray images without the breast phantom. This is to define the field of exposure of the X-ray setup. Secondly, we acquire the X-ray images for the breast phantom containing a foreign material. The acquired images are from different position. The contribution of the "breast tumor" to the scattered X-ray photons is obtained from subtracting the third step images from the second step images. Ultrasound machine (Philips) with linear 5-9 frequency detector with jell applied to the phantom, gain 4-6 Hz and focuses 0-0 in the image center. The setup of machine we use B- mode, harmonic and electrography imaging. Imaging with different positions and different views. For X-ray mammography, we image for the phantom in cranio caudal (CC) and medio-latral oblique (MLO) positions with compression 40 Newton and kVp 20-30. The phantom used was Breast electrography phantom model 059 CIRS, the size and shape of the phantom simulate that an average patient in the supine position. A special holding tray facilitates proper hand position during the training procedure or experimental. The phantom measures approximately 15 cm long ×12 cm wide × 7 cm high with a volume of 600 cc. On such phantom12 masses approximately three times harder than the background. Also arterial and randomly positioned. These les ones have min mal contrast with convent on ultrasound (hypoechoic relative to background), but will show up readily on telautograms.

RESULTS AND DISCUSSION

In this experiment, the goal is to know the early diagnosis of breast cancer using sound mammography, And through the use of the existing phantom to compare the early detection of breast tumor by using samples size 0.1 – 5 mm . analysis of result done by using Matlab , the result shows each tumor peak in different modality which is the same with tumor numbers . FWHM full width half maximum in Mammography (26.2 , 1.19 , 15.5 , 1.3) , In ultrasound (0.75 . 0,73) and with Elastography (6.60). This values show each modality In a distribution, full width at half maximum (FWHM) is the difference between the two values of the independent variable at which the dependent variable is equal to half of its maximum value. In other words, it is the width of a spectrum curve measured between those points on the y-axis which are half the maximum amplitude. Half width at half maximum (HWHM) is half of the FWHM if the function is symmetric. The term full duration at half maximum (FDHM) is preferred when the independent variable is time. The full width at half maximum (FWHM) is a parameter commonly used to describe the width of a "bump" on a curve or function. It is given by the distance between points on the curve at which the function reaches half its maximum value. Ultrasound images show different tumors size (0.5-5 mm) and the same for Mammography, the appearance of lesion differ from hypoechoic , anechoic and hyperechoic depend on the lesion component .

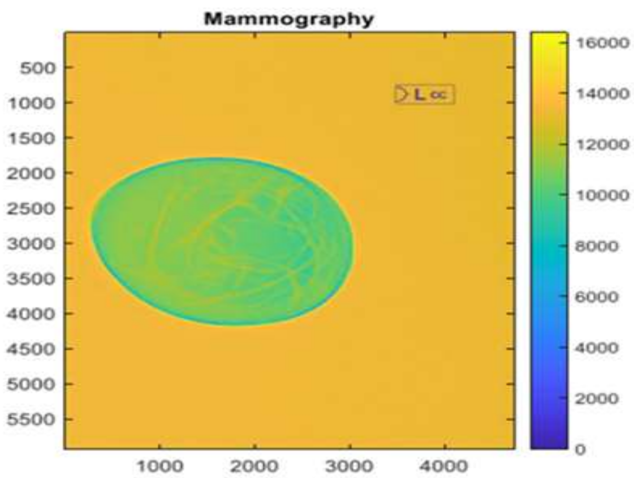

Figure 3: Mammography image in Matlab.

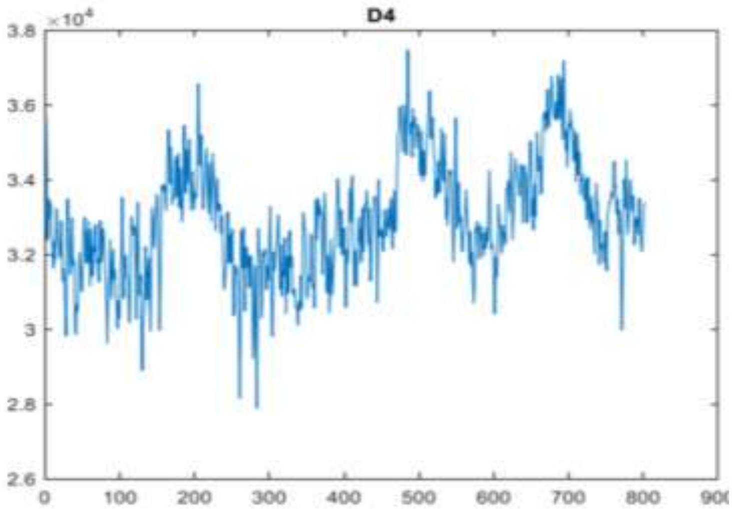

Figure 4: The 2D profiles on the mammography image shown in Fig. 3 demonstrating the peaks where legions were located 3 peaks mean 3 legions in this view.

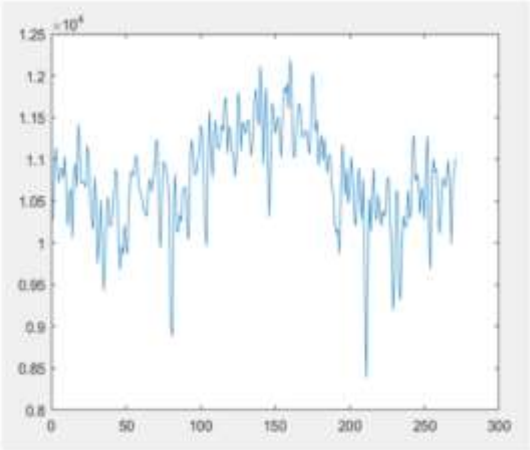

Figure 5: The 2D profiles demonstrating the peaks where legions were located 5 peaks mean 5 legions in this view.

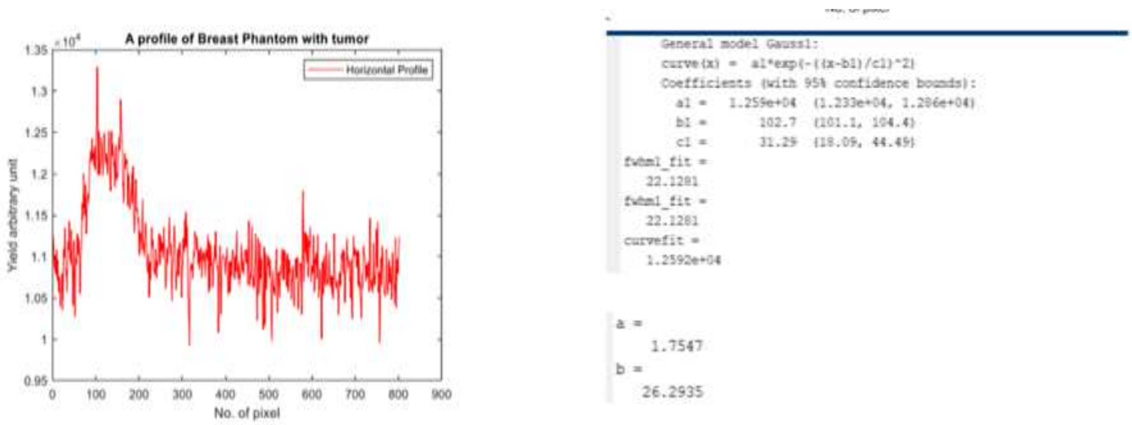

Figure 6: The FWHM demonstrating the legion visibility & Diameter but the value here need to be fist multiplied by the digital mammography pixel size.

The full width at half maximum (FWHM) is a parameter commonly used to describe the width of a "bump" on a curve or function. It is given by the distance between points on the curve at which the function reaches half its maximum value. Ultrasound images show different tumors size (0.5-5 mm) and the same for Mammography, the appearance of lesion differ from hypoechoic, anechoic and hyperechoic depend on the lesion component. We compared the FWHM, appearance of tumor and accuracy of detection, for diagnostic performance tests within different modalities and phantoms. We found that the sensitivity of mammography increased with age, possibly because the density of the breast decreases with age, thus making mammography more sensitive, suggesting that older women may be more suitable for mammography. The specificity of ultrasound sharply decreases in more obese women, which may be due to the increased tissue thickness and fat attenuation reducing the quality of ultrasound-guided images. This seems to be echoed in the trend of ultrasound accuracy being negatively correlated with BMI. However, we found that different breast densities do not seem to have a significant effect on the sensitivity and specificity of ultrasound.

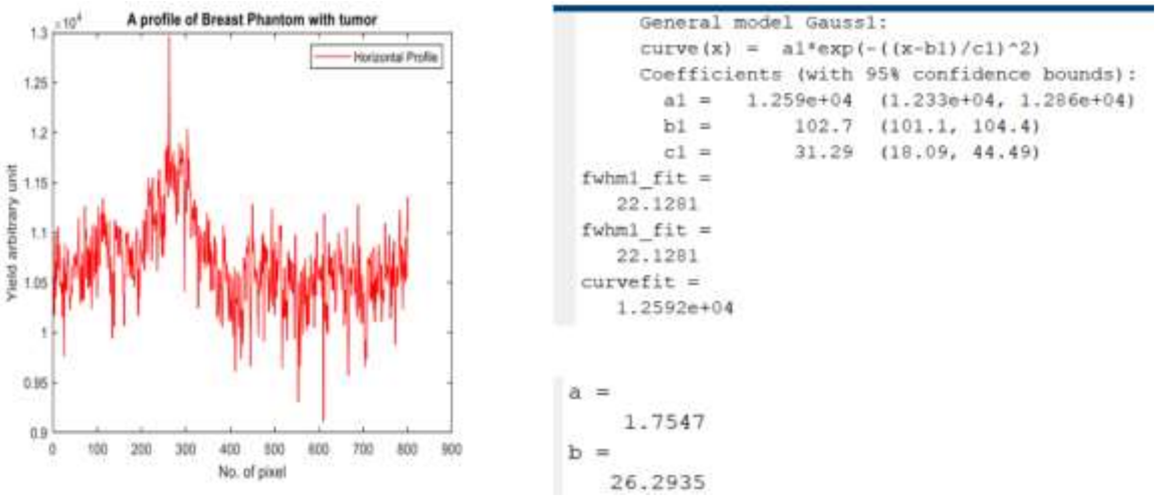

Figure 7: The FWHM demonstrating the legion visibility & Diameter in pixel for the digital mammography.

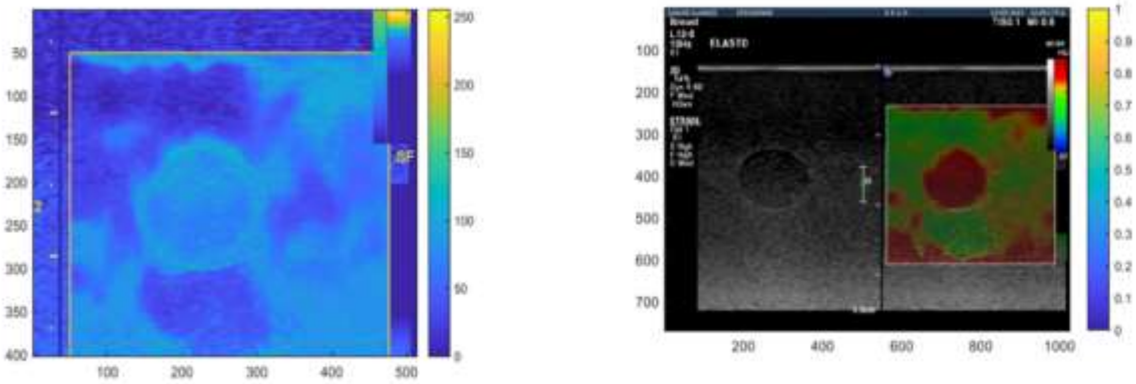

Figure 8: the Ultrasound images on the left side obtained through matlab and the on the right side obtained from the scanner.

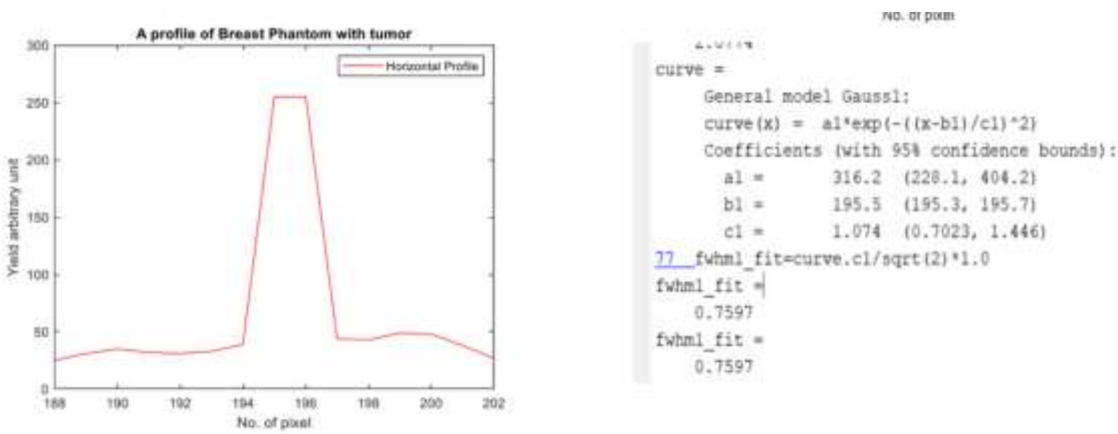

Figure 9: shows one peak this mean only one lesion in this view in both images demonstrated in Figure 8.

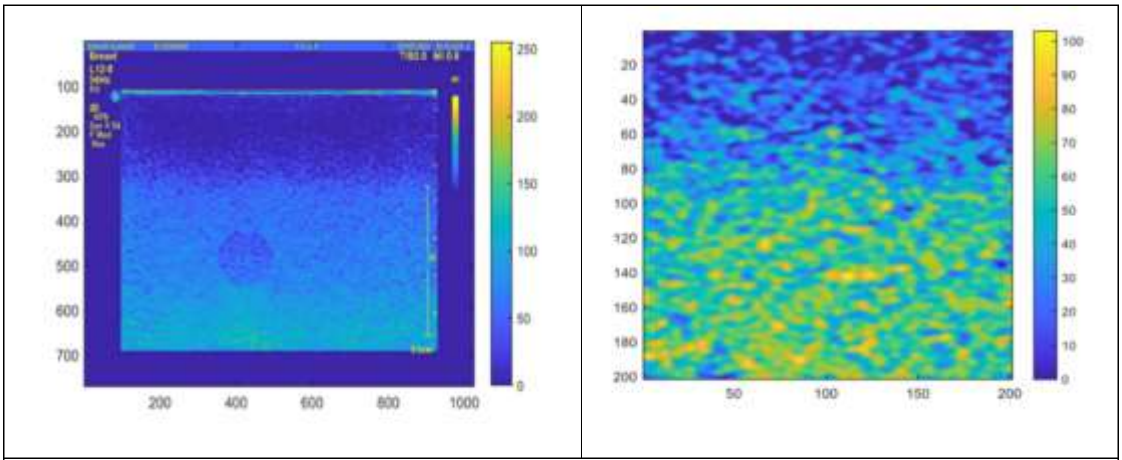

Figure 10: Shows elastography images visulized in Matlab.

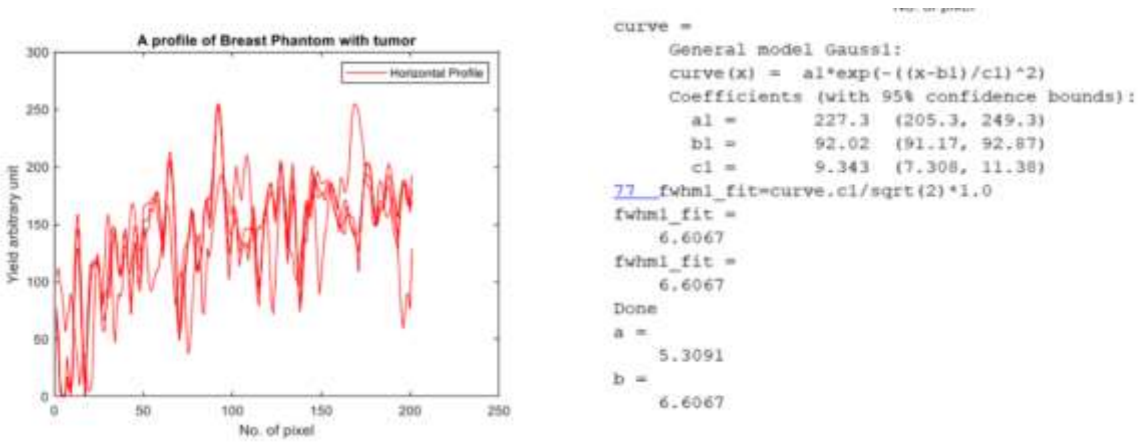

Figure 11: The FWHM demonstrating the legion visibility & Diameter but the value here need to be fist multiplied by the digital mammography pixel size and peaks in this image 5 this equal 5 lesions.

We compared the FWHM, appearance of tumor and accuracy of detection, for diagnostic performance tests within different modalities and phantoms . We found that the sensitivity of mammography increased with age, possibly because the density of the breast decreases with age, thus making mammography more sensitive, suggesting that older women may be more suitable for mammography. The specificity of ultrasound sharply decreases in more obese women, which may be due to the increased tissue thickness and fat attenuation reducing the quality of ultrasound-guided images. This seems to be echoed in the trend of ultrasound accuracy being negatively correlated with BMI. However, we found that different breast densities do not seem to have a significant effect on the sensitivity and specificity of ultrasound.

Modality	No. of Lesion Visualized
X-ray Mammography	8
Ultrasonography	12
Electrography	12

CONCLUSIONS

women with dense breasts have an increased risk of developing breast cancer while mammography has a lower sensitivity. Screening ultrasound, both handheld and automated, is effective in detecting mammographically occult cancer in women with dense tissue. In conclusion, breast cancer early detection in ultrasound and mammography complement each other. However for this particular breast ultrasound phantom ultrasound showed a more sensitivity than mammography. Authors believe that a breast ultrasound is most often done to find out if a problem found by a mammogram or physical exam of the breast may be a cyst filled with fluid or a solid tumor. Breast ultrasound is not usually done to screen for breast cancer. This is because it may miss some early signs of cancer.

REFERENCES

1. DeSantis CE, Bray F, Ferlay J, Lortet-Tieulent J, Anderson BO, Jemal A. International Variation in Female Breast Cancer Incidence and Mortality Rates. Cancer Epidemiol Biomarkers Prev. 2015; 24(10): 1495-506. http://www.ncbi.nlm.nih.gov/pubmed/26359465
2. D. Kashyap, D. Pal, R. Sharma, V. K. Garg, N. Goel, D. Koundal, A. Zaguia, S. Koundal, and A. Belay, "Global increase in breast cancer incidence: Risk factors and preventive measures," BioMed Research International, 18-Apr-2022. [Online]. Available: https://www.hindawi.com/journals/bmri/2022/9605439/.
3. L. Ilic, G. Haidinger, J. Simon, M. Hackl, E. Schernhammer, and K. Papantoniou, "Trends in female breast cancer incidence, mortality, and survival in Austria, with focus on age, stage, and birth cohorts (1983–2017)," Nature News, 29-Apr-2022. [Online]. Available: https://www.nature.com/articles/s41598-022-10560-x.
4. S. Safiri, M. Noori, S. A. Nejadghaderi, M. J. M. Sullman, N. L. Bragazzi, A. Almasi-Hashiani, M. A. Mansournia, and A.-A. Kolahi, "Burden of female breast cancer in the Middle East and North Africa region, 1990–2019 - Archives of Public Health," SpringerLink, 11-Jul-2022. [Online]. Available: https://link.springer.com/article/10.1186/s13690-022-00918-y.
5. Albeshan SM; Mackey MG; Hossain SZ; Alfuraih AA; Brennan PC;, "Breast Cancer Epidemiology in Gulf Cooperation Council countries: A Regional and international comparison," Clinical breast cancer. [Online]. Available: https://pubmed.ncbi.nlm.nih.gov/28781021/.
6. L. T. A. Tanner and K. L. Cheung, "Correlation between breast cancer and lifestyle within the Gulf Cooperation Council Countries: A systematic review," World journal

of clinical oncology, 24-Apr-2020. [Online]. Available: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7186238/.