



## Ultrasonography as a Breast Imaging Modality: A Review

P. Agbenorku<sup>1\*</sup>, V. E. Agbemor Brayn<sup>2</sup>, F. Aitpillah<sup>2</sup>, J. Akpaloo<sup>1</sup>,  
K. Aboah<sup>2</sup> and E. Agbenorku<sup>3</sup>

<sup>1</sup>Reconstructive Plastic Surgery and Burns Unit, Department of Surgery, Kwame Nkrumah University of Science and Technology, Kumasi, Ghana.

<sup>2</sup>Department of Surgery, Kwame Nkrumah University of Science and Technology, Kumasi, Ghana.

<sup>3</sup>College of Computing and Engineering, University of Salford, Media City Campus, Salford, United Kingdom.

### Authors' contributions

*This work was carried out in collaboration between all authors. Concept of the review article was from Authors PA, VEAB, KA, FA and EA managed the searching, gathering and reviewing of the literature, Authors PA and VEAB designed, and wrote the manuscript. Authors PA and JA analyzed and edited the manuscript. All authors examined and approved the final manuscript.*

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### ABSTRACT

**Introduction:** Ultrasonography and Magnetic Resonance Imaging (MRI) serves as the most prominent adjunct imaging modality to mammography. Ultrasound (US) is cheap, non-invasive and widely available in healthcare centres in Ghana but often used for obstetrics and gynaecological investigations. These including many other factors have stimulated a challenge to further investigate and optimise the use of the ultrasound equipments' availability in order to facilitate the early diagnosis and treatment of breast diseases.

**Aim:** The aim of this article is to review the role played by ultrasonography in diagnosing breast masses.

**Methods:** Google search engine was used to search for ultrasonography related articles. The

\*Corresponding author: Email: [pimagben@yahoo.com](mailto:pimagben@yahoo.com);

selected articles were reviewed to prepare this manuscript.

**Results:** It was established that though mammography is the orthodox and only modality suitable for screening and should not be replaced, ultrasound is a helpful and reliable diagnostic tool for first-line imaging (screening) especially in younger women to diagnose a palpable mass in the breast without having to necessarily perform a mammogram examination and it is also the only modality that can accurately detect a cystic mass without a biopsy. MRI has a higher sensitivity but low specificity and hence not suitable to be used as a screening tool.

**Conclusion:** Ultrasound is non-invasive, common and cost effective, however it is advisable to do this procedure when clinically necessary or deemed fit.

*Keywords: Ultrasonography; first-line imaging; cystic mass; biopsy; non-invasive.*

## 1. INTRODUCTION

Breast cancer is on the rise despite the prevalent education worldwide and it is still one of the world's leading causes of mortality. It forms 15% of all cancer and 40% of female cancers. Estimations from the World Health Organization (WHO) put the Age Standardised Incidence Ratio (ASIR) at 37/100,000 of the population, and estimates the incidence-mortality ratio of breast cancer in Ghana as 0.68, compared to 0.2 in the USA [1,2]. Approximately only 0.9% of breast abnormalities are recorded in men and therefore majority of breast imaging is performed on women [3]. Mammogram is the fundamental imaging equipment used in breast screening and diagnosis and should not be replaced with other modalities for screening the breast since it can detect non-palpable masses [4]. Ultrasound (US) and Magnetic Resonance Imaging (MRI) serve as the most prominent adjunct modality used with mammography but among these two, ultrasound is most preferred because it is not harmful to the human body and it is very affordable.

There are quite a lot more breast imaging modalities coming up in the system. Some of these include Ductogram (Galactogram), Scintimammography, Positron Emitting Tomography scan, Electrical Impedance Imaging, among others [4]. The ultrasound equipment is readily available in almost all health centres in Ghana including district health centres but mostly used for only Gynaecological and Obstetrics applications. These including many other factors have stimulated a challenge to further investigate and optimise the use of the ultrasound equipments' availability so as to facilitate the early diagnosis and treatment of breast masses. The ability of district health practitioners particularly to differentiate benign masses from malignant ones is of much essence to this goal. This article therefore seeks to

analyse and provide an overview of what an ultrasound scan of the breast entails.

## 2. METHODS

Google search engine was used to search for several imaging articles. The key words for the search included: 'Imaging Modalities', 'Breast Imaging Modalities' 'Ultrasonography', 'Breast ultrasound', 'Benign and Malignant' and 'Breast Tumor Diagnosis'. Manual searches were also conducted using references cited in relevant articles published in peer-reviewed journals. These articles were sorted out and ultrasound breast imaging related ones were selected. All articles commenting on the role played by ultrasound in diagnosing breast masses were included in this review paper. In all 58 articles were gathered and 24 applicable ones were reviewed to prepare this manuscript.

## 3. RESULTS AND DISCUSSION

### 3.1 Breast Imaging Modalities

Screening and diagnostic mammography has been the known efficient breast screening and diagnostic tool for a very long time now [4]. It makes use of about a 0.4 mS low dose radiation [5] to generate internal images of the breast. It is useful in detecting non-palpable masses but not very efficient in completely diagnosing breast lesions due to false-positives and false-negatives results which are very common in younger women and patients with dense breasts, family history of cancer, biopsied breasts and those who take in oestrogen rich diets [5]. It is therefore expedient to make use of ultrasound and MRI adjunctive to the mammography. The MRI makes use of magnetic field, aligning the hydrogen atoms in the body to this field. A radio frequency electromagnetic field is for a short time switched on, alternating the hydrogen atoms' magnetization field. A receiver picks up signals in

the process of these hydrogen atoms realigning to their equilibrium state (at different rates) when the field is switched off to generate an image. It therefore does not make use of radiation, but it is very expensive and uncommon. MRI is normally recommended for high risk patients and those who have already been diagnosed with cancer; to detect the volume of tissue affected [5,6]. Though it is highly sensitive, it has a low specificity and therefore not a recommended screening tool for average to low risk women due to false positives which will intend call for unnecessary biopsies [5]. Ultrasound on the other hand makes use of high frequency sound to generate internal life images (sonogram) which can be printed out. By hand-held transducers, high frequency sound beyond the human hearing is sent into the body and the echoes again picked up by same transducer and processed into live images. Since live images are generated, this technique is able to guide needle aspirations and biopsies [7,8,9]. The US examination spans a few minutes and also the quality of image generated is dependent on operators' expertise and equipment resolution [10]. Successful use of the ultrasound to effectively diagnose breast abnormalities is altogether dependent on operators' lesion characterization know-how, patient positioning, experience in ultrasound-guided techniques for accurate lesion localization and high-quality imaging [3,11]. By far it is the only modality used to clearly detect if a mass is a cyst without having to perform a needle aspiration [5-10]. Ultrasonography has been established to enhance the differentiation between benign and malignant lesions by reason of the technological advancement in transducer modelling, electronics and signal processing [4]. It helps to conduct interventional proceedings such as needle aspirations, core-needle biopsies, and pre-biopsy needle localizations [7,8,9]. It is very convenient in determining tumor location, volume and borders [6]. It is cheaper and common besides there are no known side effects.

### **3.2 Comparing Mammography, MRI and Ultrasonography**

The mammography examination may result in a long term effect on patients due to the use of ionizing radiation whiles the MRI and ultrasound are not known to have any such effect on patients. Mammography takes about 30 minutes but the MRI may span from several minutes to a couple of hours whiles ultrasound, depending on equipment resolution and operators expertise

may also take 30 minutes on the average to complete [12-13]. Compared to mammography and the MRI, ultrasound equipment is widely available in health centres; though mainly used for gynaecological and obstetrics procedures in Ghana, cost-effective, non-invasive and offer patient's comfortability [9]. The ultra-modern advancement in ultrasonography such as Power Doppler imaging that detects the vascularity in tumors and surrounding tissue, Elastography that uses colours to mark out cancers, automated 3-D systems which produce a 3-dimensional volume of the entire breast; visualising cancers with Computer Aided Detection (CAD) [10] among others have made the ultrasound equipment the preferred choice, though researches are still ongoing to prove their feasibility. Compared to the mammography and MRI, ultrasonography is the most convenient tool to be used for a pregnant or a lactating mother and women with implants [14].

### **3.3 Is Breast Ultrasonography Suitable as a Screening Tool?**

Ultrasound is the only modality that can clearly differentiate cystic from solid masses [8,9]. It is convenient in differentiating benign and malignant lesions. Studies have shown a higher sensitivity and specificity compared to the mammogram [15]. It is good at detecting invasive carcinomas [16,17] and also capable of visualising ductal carcinoma in-situ (DCIS) presenting as a palpable lump without microcalcification [18,19]; however, DCIS lumps with microcalcifications can barely be detected by the ultrasound making the mammogram a better screening tool in terms of breast cancer diagnosis [10]. No longer is the ultrasound only used in the visualisation of palpable masses or differentiating a mass seen by a mammogram but current researches have shown that ultrasonography is a valuable screening and diagnostic modality to be used in asymptomatic younger women (less than 30 years) and patients with dense breast [9,10,11,15].

### **3.4 The Ultrasound Equipment and Its Operation**

The ultrasound equipment makes use of sound to generate the internal image of the body. Before the examination is conducted a thorough review of the patients' clinical history needs to be made and a physical examination is also necessary. To perform the test, the patient is

made to lie on her back in the supine position with her hand positioned above the head. This position causes the breast to flatten across the pectoralis muscle. A wedge-like cushion is placed beneath the shoulder of the breast to be examined so as to hold the breast in place to avoid movements during the examination. A reasonable amount of acoustic gel is applied on the breast to reduce friction and prevent the distortion of the sound waves as it passes through the skin. The transducer set at a frequency of 7-15 MHz is then gently pressed on [9]. The scan could be done longitudinally or in a transverse manner. Radial and anti-radial scanning can be employed when a lesion is detected. Scanning in clockwise direction is efficient in detecting ductal carcinomas. The breast may also be divided into four quadrants and examined one after the other or based on the position of a detected tumor by physical examination or mammography. The erected nipple can sometimes result in posterior acoustic shadowing. In this case more gel and pressure could be applied. It is also advisable to make the patient lie on the side and with a folded towel in between the breasts; the examination could then be performed from the side [9]. The transducer emits high frequency sound waves and receives back the echoes. The echoes are electronically used to generate internal live images (sonogram) of the breast which can as well be printed out.

Indications for a US is when a palpable mass is detected, breast examination in pregnant and lactating women, differentiating a mass found on the mammogram, checking up on a known mass and other infections of the breast, nipple

discharges and the need to guide needle biopsies [9,15].

### 3.5 The Normal Breast Anatomy as Seen by the US

The normal breast as observed with the US presents the skin line, the fibroglandular tissue (also known as the mammary gland) and the pectoralis muscle as hyperechoic (maximum sound reflection and little sound transmission) and the subcutaneous fat and retromammary fat are visualised as hypoechoic, that is to say they bounce back little amount of sound and allow maximum transmission through them as shown in Fig.1. Most tumours occur in the fibroglandular tissue (mammary gland) of the breast.

### 3.6 Differences between Benign and Malignant Lesions

There are some factors that characterise diagnosis of breast masses using ultrasound. These include: tumor margin, shape, orientation, echotexture, echogenicity and posterior acoustic attenuation pattern or shadowing [9].

Simple cystic masses are utterly anechoic since transmissions through them are very much enhanced. They possess thin-edged shadows with very thin encapsulations and smooth margins [9]. Complex cysts on the other hand possess intracystic echoes, substantial encapsulations, and may be visualised in clusters, of which a considerable number of them, particularly those with a solid intracystic mass, happens to be malignant [20-21].

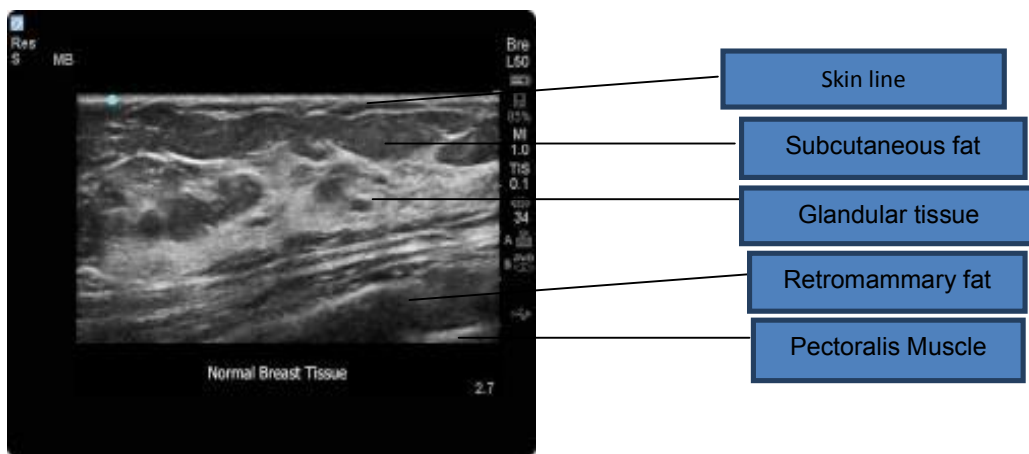


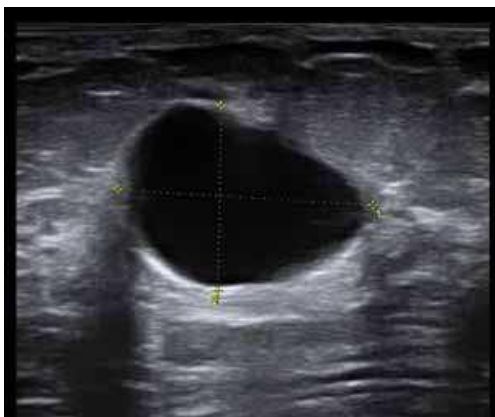
Fig. 1. An ultrasound image of the normal breast [22]



Fig. 2A. An US benign tumor [10]



Fig. 2B. An US malignant tumor [9]



A



B

Fig. 3. A - US simple breast cyst: completely anechoic with smooth and distinct margin [9] and B - US complex breast cyst with smooth margins, non-uniform internal echoes and three gentle macro-lobulations [9]

### 3.7 Understanding the Ultrasound Breast Imaging Records and Data Systems (BIRADS-US) Report Categories

The BIRADS-US Classification form was developed in 2003 by the American College of Radiology to provide harmony and consistency among radiologists in the data recording of breast imaging and diagnoses [23]. The assessment categorizations are in the range of 0 - 6. Below is a Table 2 that describes these ranges and the necessary action that must be taken.

### 3.8 Advantages and Disadvantages of US-Guided Breast Diagnosis

#### 3.8.1 Advantages

1. The US examination is painless and non-invasive [9].
2. Real-time US can in effect check the treatment response using grayscale transformations or contrast-enhanced US [6].
3. It is the only modality that is known to detect a cystic mass without performing biopsies [5,10].
4. It is efficient in directing a needle aspiration and core-needle biopsies since it generates real-time images [7,8,9].
5. High frequency diagnostic US is much sensitive to identify precisely the periphery of breast tumor, which aids in the complete destruction of breast tumors using effective and safe High-Intensity Focused Ultrasound (HIFU) therapy [6].

**Table 1. Comparison between benign and malignant masses [4,9,23]**

<b>Benign</b>	<b>Malignant</b>
<b>Physical observation</b>	
Soft to firm	Hard
Mobile	Immobile and fixed to surrounding tissue
Causes no skin change	Results in skin change
<b>US observation</b>	
<b>Margin</b>	
Regular or well defined margins	Irregular/angular margins or finger-like projections
<b>Shape</b>	
Mostly spherical or ellipsoid or oval in shape (mostly wider than tall) sometimes with three or less gentle macro-lobulations	Variable and irregular shapes (mostly taller than wider) with micro-lobulations
<b>Orientation</b>	
Grows parallel to tissue plane (horizontal)	Develops and invades across tissue planes
<b>Echotexture</b>	
Homogenous echotexture i.e. uniform internal echoes	Heterogeneous with varieties of echotexture echoes
<b>Echogenicity</b>	
Of equal or lower echogenicity compared to surrounding tissues	Mostly hypoechoic
<b>Acoustic attenuation (Sound absorption)</b>	
Have minimal through transmission	May absorb sound beam resulting in black and scattered echoes posterior to location

**Table 2. The BIRADS-US assessment categorizations [18,20,24]**

<b>Assessment category</b>	<b>Description</b>	<b>Action to be taken</b>
0	Incomplete	Additional imaging evaluation needed before final assessment
1	Negative	No lesion found (routine follow-up)
2	Definitely benign	Routine follow-up for aged, clinical management
3	Probably benign	Initial short interval follow-up
4	Suspicious abnormality	Biopsy should be considered
5	Highly indicative of malignancy	Appropriate action should be taken
6	Known cancer	Biopsy proven malignancy, prior to institution of therapy

**3.8.2 Disadvantages**

1. Implants in apparent regions affect the detection of tumors in deeper regions since the quality of US imaging is affected by the ultrasonic frequency, the tumor location, the state of the skin, and the operator's experience.
2. Identification of masses with equal echogenicity as surrounding tissue is difficult to view using US imaging.
3. Quality of image outcome and efficiency of diagnosis is totally dependent on equipment technology and operator's expertise.

4. It does not produce a one-time image of the whole breast for examination.

The ultra-modern automated 3- D system may eliminate these short comings in the future [10]. Combining ultrasound with other imaging modalities may help surmount the specific disadvantages and inconveniences [6].

**4. CONCLUSION**

Ultrasonography is not only suitable as an adjunct to mammography but also useful and efficient as a screening tool and to diagnose a palpable mass in the breast without having to

necessarily perform mammography. It is able to accurately distinguish between masses and as well determine their specific location and volume in the breast tissue. It is therefore recommended that the use of ultrasound in the diagnosis of breast lesions should be maximised in all health centres but not to be used only for obstetrics and gynaecological procedures to aid the early detection and treatment of breast masses. In this way, the workload on tertiary health centres in Ghana would have been reduced by a significant value and much attention could be directed towards patients with malignancies to commence and deliver early disease management. MRI has a higher sensitivity but not recommended as a screening tool except for patients at a higher risk. Ultrasound is safe with no known side effects; however it is recommended that the procedure be done when clinically deemed fit. Current technological advancement in ultrasonography is making the equipment more complex to use but yet more efficient in diagnosis, hence more trained personnels are required.

## CONSENT

It is not applicable.

## ETHICAL APPROVAL

It is not applicable.

## COMPETING INTERESTS

Authors have declared that no competing interests exist.

## REFERENCES

1. The Ministry of Health and the Ghana Health Service. National Strategy for Cancer Control in Ghana; 2011.
2. Global Cancer Facts & Figures, 2<sup>nd</sup> Edition. American Cancer Society, Atlanta, Georgia; 2011. No. 861811.
3. National Breast Cancer Center. Breast imaging: A guide for practice; 2002.
4. Sachin PN, Houserkova D. The role of various modalities in breast imaging. Biomed Pap Med Fac Univ Palacky Olomouc Czech Repub. 2007;151(2):209-218.
5. Mammograms and other breast imaging tests. American Cancer Society; 2014.
6. Magnetic resonance imaging- Guided versus ultrasound- guided high- intensity focused ultrasound in the treatment of breast cancer. Chin J Cancer. 2013; 32(8):441-452.
7. Hong AS, Rosen EL, Soo MS, Baker JA. BI-RADS for Sonography: Positive and negative predictive values of sonographic features. American Journal of Roentgenology. 2005;184:1260-1265.
8. Eun-Kyung K, Kyung HK, Ki KO, Jin YK, Jai KY, Min JK, et al. Clinical application of the bi-rads final assessment to breast sonography in conjunction with mammography. American Journal of Roentgenology. 2008;190:1209-1215.
9. Amy ML. Guide to sonography of the breast. Philip Medical Systems; 2006.
10. Heino H. Advances in breast ultrasound, sonography. Kerry Thoires (Ed.), ISBN: 978-953-307-947-9. In Tech; 2012. Available:<http://www.intechopen.com/book/s/sonography/advances-in-breast-ultrasound>.
11. Susan G. Breast imaging modalities. Komen for the Cure. (Assessed: 01/2015).
12. Available:<http://www.womenscollegehospital.ca/programs-and-services/medical-imaging/breast-imaging/> (Assessed: 05/2015).
13. Breast MRI (Magnetic Resonance Imaging). Massachusetts General Hospital; 2015.
14. Vashi R, Hooley R, Butler R, Geisel J, Philpotts L. Breast imaging of the pregnant and lactating patient imaging modalities and pregnancy-associated breast cancer. American Journal of Roentgenology. 2013; 200(2):321-328.
15. Steinkeler J, Lieberman G. Breast ultrasound: Benign vs. Malignant Lesions. Tufts University, school of medical sciences IV; 2004.
16. Benson SR, Blue J, Judd K, Harman JE. Ultrasound is now better than mammography in detection of invasive breast cancer. American Journal of Surgery. 2004;188:381-385.
17. Berg WA, Blume JD, Cormack JB, Mendelson EB, Lehrer D, Böhm-Vélez M, et al. Combined screening with ultrasound and mammography vs. mammography alone in women at elevated risk of breast cancer. Journal of the American Medical Association. 2008;299:2151-2163.
18. Yang WT, Tse GMK. Sonographic, mammographic and histopathologic correlation of symptomatic ductal carcinoma in situ. American Journal of Roentgenology. 2004;182:101-110.

19. Berg WA, Gutierrez L, Ness Aiver MS, Carter WB, Bhargavan M, Lewis RS, et al. Diagnostic accuracy of mammography, clinical examination, US, and MR imaging in preoperative assessment of breast cancer. *Radiology*. 2004;233:830-849.
20. Shah G, Jankharia B. Pictorial essay: Breast USG. *Indian J Radiol Imaging*. 2010;20(2):98–104.
21. Berg WA, Campassi CI, Ioffe OB. Cystic lesions of the breast: Sonographic-pathologic correlation. *Radiology*. 2003; 227:183–91.
22. Available:[http://www.sonosite.com/sites/default/files/imagecache/sonosite-stories-video-thumbnail-260x195-image/clinicalimages/hfl50\\_normal\\_breast\\_tissue.jpg](http://www.sonosite.com/sites/default/files/imagecache/sonosite-stories-video-thumbnail-260x195-image/clinicalimages/hfl50_normal_breast_tissue.jpg)
23. BIRADS-US Classification form. American College of Radiology; 2003.
24. Breast Ultrasound Reporting System. American College of Radiology; 2013.

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