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Breast Ultrasound vs Mammography: Is the Former a Better Replacement for the Latter? A Comparative Study

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A B S T R A C T

Breast cancer is the most commonly occurring cancer in women. It is also the second leading cause of cancer death in women. Breast Cancer is the most common and most lethal cancer in Nigeria with an estimated 27,304 new cases in 2012 and which is estimated to increase in further years despite the lack of adequate data. Mortality rates are very high in our locality with approximately 13,960 deaths annually. Mammography is the gold standard for breast cancer screening in developed countries with some evidence showing improved survival particularly among women 50–69 years in some randomized controlled trials in developed countries where breast cancer prevalence is high. Studies gives a mammography sensitivity of (83-86%), a specificity of (48-55.5%), and a diagnostic accuracy of 56-68%. However, mammograms still pose the risk of exposing the breasts to radiation, and is also not well suited for women with dense breasts, implants, fibrocystic breasts, or those on hormone replacement therapy. Breast ultrasound has been used for many years in the characterization of breast lesions, and can also be used to help guide a biopsy needle into an area of the breast for testing. Ultrasound is relied upon significantly since mammographic facilities are few and breast magnetic resonance imaging is either too expensive or unavailable and is it also not limited by breast density. Studies show ultrasound has a sensitivity of (72.2% - 86.3%), and a specificity of (79.8-93.6%). Ultrasound is unable to screen for many types of breast cancer. It is also difficult to detect calcification in the ultrasound of the breast, and this is an early sign of breast cancer. Therefore ultrasound is mainly used in LMIC, where late presentation is most common due to lack of funds because it is cheaper and more portable and it also has a higher sensitivity in women greater than 40 years. In conclusion, this study aims to compare ultrasound and mammography if the former is a better replacement for the latter.

Introduction

Breast cancer is the most commonly occurring cancer in women. A woman's chance of developing invasive breast cancer at some time in her life is approximately 1 in 8 (12%). There were more than 2.26 million new cases of breast cancer in women in 2020 [1].

It is also the second leading cause of cancer death in women. The chance that a woman will die from breast cancer is about 1 in 39 (about 2.5%). In 2020, there were 2.3 million women diagnosed with breast cancer and 685 000 deaths globally [2].

Breast cancer death rates have been decreasing steadily since 1989, for an overall decline of 43% through 2020. The decrease in death rates is believed to be the result of finding breast cancer earlier through screening and increased awareness, as well as better treatments. However, the decline has slowed slightly in recent years [1].

Black women have the highest death rate from breast cancer. This is thought to be partially because about 1 in 5 Black women with breast cancer have triple-negative breast cancer [1].

While outcomes remain poor in most LMICs, developed nations have demonstrated remarkable improvements in breast cancer survival. In Nigeria, breast cancer five-year survival rates range from 11– 25% compared to 90% in the United States of America [3-5].

Mammography is the gold standard for breast cancer screening in developed countries with some evidence showing improved survival particularly among women 50–69 years in some randomized controlled trials in developed countries where breast cancer prevalence is high [6].

In the United States, Women with average risk of breast cancer are recommended to undergo annual screening mammography starting at age 45years up to age 54 years after which they should transition to biennial screening or continue screening annually [7].

Nigeria currently has no national breast cancer screening guideline, as such screening recommendations are made based on international guidelines. Reports from various parts of Nigeria show very low mammography screening uptake [8].

Although the University of Nigeria Teaching Hospital Enugu gave the following screening recommendation (Table 1) [11].

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AGE	RECCOMENDATION
16yr- <40yr	Clinical breast exam every 1- 3yrs Breast awareness
>40yrs -<50yrs	Annual Clinical breast exam Mammogram every 2 years Breast awareness
>50yrs- 69yrs	Annual Clinical breast exam Annual Mammogram Breast awareness
>70 – 74yrs	Annual mammogram
>75yrs	Annual mammogram until life expectancy is < 5yrs

Table 1: Showing breast cancer screening recommendation.

Black Africans have lagged behind in breast cancer survival rates (33% in 2000 and 40% in 2018) in comparison with Black Americans (76% in 2015). This is attributed primarily to limitations in early detection programs and delayed access to effective treatment. Other factors are lack of skilled manpower, functional surgical equipment, systemic therapy, and radiation facilities [9,10].

Breast Cancer is the most common and most lethal cancer in Nigeria

Breast Cancer is the most common and most lethal cancer in Nigeria with an estimated 27,304 new cases in 2012 and was projected to rise to 29,049 by 2015. This is likely a marked under-estimation since cancer registration in Nigeria as a whole, is mainly hospital-based and incomplete. Estimates from two population based cancer registries suggest even higher rates. Breast cancer is a disease for which there is effective screening and a high probability of cure when it is detected early. The greatest challenge with breast cancer management in Nigeria, as in most LMICs, is late presentation. This results in limited and more expensive treatment options often with poorer outcomes. Mortality rates are very high in our locality with approximately 13,960 deaths annually.

Current Screening Methods

Digital breast tomosynthesis (DBT) has increasingly been used for breast cancer screening and diagnosis in the past decade. In Europe and the USA, some institutions have adopted DBT as the standard method for breast cancer screening [12-15].

Clinical Breast Examination [CBE] and Breast self-examination [BSE] has been extensively studied as a low cost alternative to mammographic screening aiming to reduce mortality by early detection [16].

Mammography, which has long been considered the gold standard for screening and early detection of breast cancer, is not always feasible, especially in limited-resource settings.

Breast ultrasound, which is used in high-resource settings to supplement mammography in certain clinical scenarios, offers a potentially viable alternative for early breast cancer detection in some resource-limited areas because it is portable, lower cost than mammography, and versatile across a wider range of clinical applications [17].

MRI may be used as an adjunct to both mammography and ultrasound for breast cancer screening, increasing detection rates [14-16]. In current routine clinical practice for breast cancer management, MRI is not used for screening but is mainly used for defining tumor size and/or detecting other tumor areas. However, MRI is often used as a follow up to a high-risk diagnosis post treatment and used as an initial marker [18].

MAMMOGRAPHY

Mammography is the standard imaging technique in use, by most developed countries, for breast cancer screening in women over the age of 40 years.

A mammogram uses a low dose of radiation to take an image of the breast. The tissue is compressed between two plates in order for the best image to be taken. A mammogram can often find or detect breast cancer early, when it's small and even before a lump can be felt. This is when it's likely to be easiest to treat [1].

Prior to the emergence of mammography as a screening modality, most breast cancers were being diagnosed by palpation and often the tumors had been palpable for a variable period of time prior to clinical diagnosis. Consequently, the outcome of such cancers was poor because of the often systemic nature of the disease at the time of diagnosis [19].

American College of Radiology BIRADS™ [Breast Imaging Reporting and Data System] recommendations for mammogram interpretation and final assessment categories have helped to standardize mammographic reporting in the USA. This states that a standard mammogram report should include a description of the breast, description of significant findings such as a mass (size, morphology), calcifications' (morphology and distribution), architectural distortion and special cases (dilated ducts, intramammary lymph nodes, global and focal asymmetry) [24]

Diagnostic Indices

A study Performed in Egypt by Azzam et al which aligns with the study of Nandan et al shows a sensitivity of 83%, a specificity of 48%, a positive predictive value of 68%, a negative predictive value of 68%, and a diagnostic accuracy of 68% [30,31].

While in another study performed by Omidiji et al, mammography had reduced sensitivity as compared to ultrasound with 85.7%, a specificity of 55.4%, a positive predictive value of 42.8%, a negative predictive value of 90.9% and a diagnostic accuracy of 56% [37].

Risks

Exposure Risk: While the benefits of a mammogram may outweigh its possible harm, mammograms still pose the risk of exposing the breasts to radiation.

Women in a number of study populations have shown dose-dependent increases in the frequency of breast cancer after irradiation. The largest such population is comprised of women exposed to atomic bomb radiation at Hiroshima and Nagasaki, in whom 295 cases of breast cancer occurred between 1950 and 1987, versus the 200 cases expected in the 510,000 person-years of follow-up study [20].

It can be calculated that if 100,000 women were to receive annual mammography for 10 consecutive years beginning at age 40 with a dose of 4 mGy per examination, at most 8 breast cancer deaths might result over the lifetimes of these 100,000 women. However, if these women continued to be screened after age 50, some radiation-induced breast cancers would be detected at a curable stage at a subsequent screen [21]

Younger women's breast tissue is more susceptible to the effects of radiation versus older women because undifferentiated cells are more vulnerable to the effects of ionizing radiation. It has also been found that proliferation of these mutated cells under the influence of estrogen increases by 10%. The latent period for the development of breast cancer after low dose radiation exposure is a minimum of 10 years [22].

Rupture risk: With mammography there is a risk of rupture of the encapsulation of a cancerous tumor, as the process of taking a mammogram involves the compression of the breast tissue. Twenty-two pounds of pressure is sufficient to rupture the encapsulation around a cancerous tumor

Today's mammogram equipment uses 42 pounds of pressure. Depending on the location of the tumor, this would be sufficient force to rupture the encapsulation and potentially release malignant cells into the bloodstream [29].

LIMITATION

Breast density: Mammography is not well suited for women with dense breasts, implants, fibrocystic breasts, or those on hormone replacement therapy. [22]

Dense (fibrous and glandular) breast tissue looks white on a mammogram. Breast masses and cancers can also look white, so the dense tissue can make it harder to see them. In contrast, fatty tissue looks almost black on a mammogram, so it's easier to see a tumor that looks white if most of the breast is fat tissue. [1]

In a study reported on by the American Cancer Society, the density of breast tissue was graded into 4 categories. Grade 1 represented the least dense breast tissue and grade 4 the densest. Mammogram detection rates were found to be 83% for grade 2, 68% for grade 3, and 55% for grade 4 [23].

Black women had statistically significantly higher absolute breast area density (40.1cm ^{2}) than white women (33.1cm ^{2}) Black women have been shown to have statistically significantly higher volumetric density (263.1 cm^3) than white women (181.6 cm^3) [25].

In women older than 45 years, black women have a lower incidence of breast cancer but a higher mortality and yet Black women also are more likely than white women to be diagnosed with an advanced-stage tumor [25].

Unawareness: According to a study performed in ILE-IFE, Nigeria it was concluded that other factors aside cost contribute significantly to poor mammography uptake given that other forms of inexpensive or free screening similarly demonstrate poor uptake. It was interesting to note that despite mammography service availability in Ife Central, 88.2% of the respondents were unaware of its existence [26] Only about 20% of the women had ever had a clinical breast examination, the majority not in the last one year. Only 2.3% of women reported ever having had a mammogram [5,26].

Cost effectiveness: Low and middle income countries face numerous barriers to quality health care including lack of facilities and resources [27].

In LMICs, like Nigeria where majority of the patients pay out of pocket, mainly by sourcing for funds from relations, friends, and nongovernmental organizations They would rather opt for cheaper breast screening techniques.

A story in the PUNCH newspaper stated; "right from the registration procedure after diagnosis, to the treatment proper, fighting breast cancer is expensive and resource draining" [28].

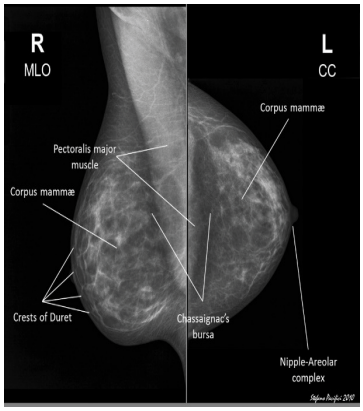

Figure 1: A normal mammogram (https://radiopaedia.org/cases/labelled-normal-mammograms)

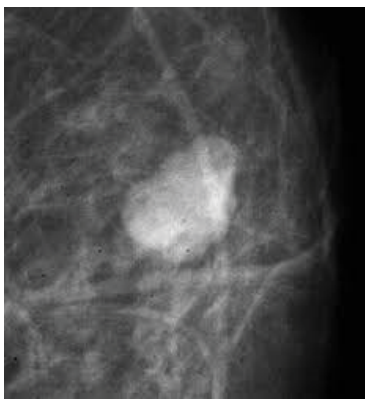

Figure 2: Coned view of a mammogram showing a benign lesion (Fibroadenoma) (https://radiopaedia.org/cases/labelled-normal-mammograms

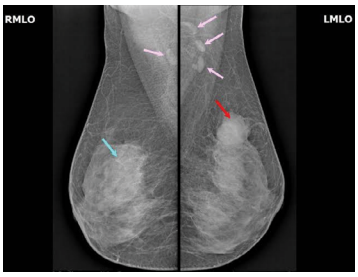

Figure 3: Mammography showing bilateral spiculated and infiltrating masses (carcinoma)

ULTRASOUND

An ultrasound uses high-frequency sound waves and converts them to an image with no risk of radiation. The soundwaves are sent through a wand called a transducer to make computer pictures of the insides of the breast. It can show certain breast changes, like fluid-filled cysts, that can be harder to see on mammograms. No plates are involved and the breasts are not flattened as in the case of mammography. Breast ultrasound has been used for many years in the characterization of breast lesions. Ultrasounds can also be used to help guide a biopsy needle into an area of the breast so that cells can be taken out and tested for cancer. This can also be done in swollen lymph nodes under the arm [1].

Ultrasound is relied upon significantly since mammographic facilities are few and breast magnetic resonance imaging is either too expensive or unavailable.

A study done by Okello, et al. showed that ultrasonography detected 27% more mass lesions that would have been otherwise missed by mammography. In this study the missed malignant lesions were about 10 mm or less in size, the most likely reason for them being missed were due to dense breast tissues obscuring visualization on mammography. But they were detected using ultrasound as it's not limited by breast density. The study concluded by saying that breast ultrasound scan resulted in significant incremental breast cancer detection rate (of 27%) among symptomatic women with mammographically dense breast tissue [32].

It was found that sensitivity of mammography declines with decreasing tumor size and increasing breast density, while ultrasound remained effective regardless of tumor size. However, the sensitivity of ultrasound declines in detecting non-palpable tumors such as microcalifications. The overall accuracy of ultra-sound has been found to depend on three factors: quality of the tools, expertise of the physician in conducting the procedure and in interpreting the image, and the use of a multi-disciplinary approach for breast cancer detection [34,35].

Diagnostic Indices

Using ultrasound as a first line diagnostic tool was studied by S.R.C. Benson et al. There were 796 patients with confirmed breast cancer in this study. The specificity in this case was not significant as positive, on ultrasound was 710 (89%) and on mammography 706 (89%). There were 537 symptomatic patients, ultrasound positives were 497 (93%) and mammography 465 (87%). The study determined that ultrasound is significantly better than mammography for detecting invasive breast cancer (92% patients). There was a 9% increase of detection with the combination [30].

Another study by Azzam et al showed that breast ultrasound had a sensitivity of 97%, a specificity of 85%, a positive predictive value of 90%, a negative predictive value of 96%, and a diagnostic accuracy of 92% [31].

A systematic review and meta-analysis by Sood et al showed that ultrasound had an overall pooled sensitivity and specificity (95% CI) of 80.1% (72.2% to 86.3%) and 88.4% (79.8% to 93.6%), respectively [36]

Limitation

The main disadvantage of ultrasound is that it is unable to screen for many types of breast cancer. It is also difficult to detect calcification in the ultrasound of the breast, and this is an early sign of breast cancer [33].

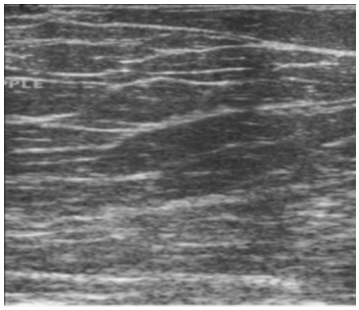

Figure 4: Ultrasound showing normal breast sonographic findings (https://sciencedirect.com)

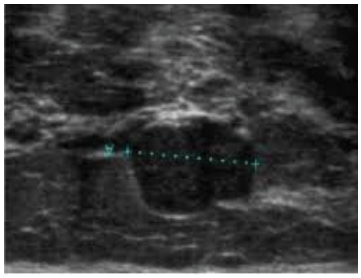

Figure 5: Ultrasound showing benign breast lesion (fibroadenoma). (https://sciencedirect.com)

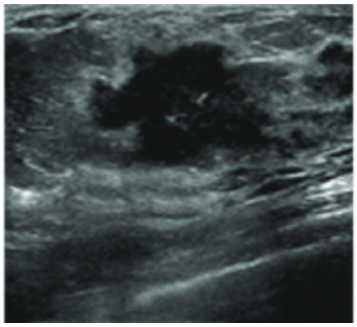

Figure 6: Ultrasound showing bilateral spiculated and infiltrating masses (carcinoma) (https://sciencedirect.com)

CONCLUSION

Mammography and ultrasound are the standard imaging techniques for detection and evaluation of breast cancer. However, in women 40 years or younger, ultrasound has a significantly greater sensitivity than mammography. Ultrasound is also cheaper and safer than other imaging modality for screening and diagnosis.

Ultrasound is widely available, easy to maintain, economical, durable, and easily portable. Given the increasing global burden of breast cancer and lack of access to timely detection with imaging, especially in LMICs, ultrasound may be an effective primary detection tool and triage method for breast lesions, particularly in low-resource settings where mammography is not available.

Ultrasound is relied upon significantly since mammographic facilities are few and breast magnetic resonance imaging is either too expensive or unavailable. In LMIC like Nigeria where it is it difficult to access full health care due to reasons such as inaccessibility, cost effectiveness leading to breast cancer discovery at a late stage, it might be better to opt for a screening that better suits their predicament.

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