ASSESSMENT OF DIAGNOSTIC ACCURACY OF CLINICAL EXAMINATION AND ULTRASONOGRAPHY IN DETECTING BREAST CANCER IN KIGALI REFERRAL HOSPITALS

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ABSTRACT

Background: Breast cancer remains a major public health issue in Rwanda, with high mortality rates largely due to late-stage diagnosis.

Aim: This study aimed to assess the accuracy of clinical breast examination (CBE) and ultrasonography in diagnosing breast cancer among patients at Kigali referral hospitals.

Methods: A retrospective cross-sectional study was conducted using a sample of 286 patients, determined via Clinical Breast Examination and selected through simple random sampling. Data on findings, breast ultrasound results, and histopathology outcomes were collected using a checklist. Histopathology served as the gold standard. T-test statistics were used to test three hypotheses at the 0.05 level of significance.

Results: Clinical breast examination showed 70.8% sensitivity, 86.7% specificity, and 77.6% overall accuracy. Sensitivity and specificity of clinical breast examination did not differ significantly in their influence on breast cancer detection in the sampled patients ($t = 1.462$; $p = 0.145$). Breast ultrasound had a sensitivity of 93.4%, specificity of 84.1%, and an overall accuracy of 88.1%. Both sensitivity and specificity contributed similarly to the diagnostic capability of breast ultrasonography in detecting breast cancer within the studied referral hospitals ($t = 0.794$; $p = 0.331$). Clinical breast examination and breast ultrasound demonstrate comparable predictive performance in detecting breast cancer within the studied referral hospitals ($t = 1.248$; $p = 0.213$).

Conclusion: Clinical breast examination demonstrated a high sensitivity, specificity of 86.7% and overall accuracy indicating effective identification of most breast cancer cases. Additionally, breast ultrasound also exhibited a high sensitivity, specificity and overall accuracy confirming its effectiveness in accurately detecting breast cancer and correctly identifying benign cases, highlighting the potential of breast ultrasound as a reliable diagnostic tool.
Recommendations: Access to ultrasound services should be expanded particularly in underserved areas; integrating into primary healthcare for early detection and management of breast cancer.

Keywords: ultrasound, breast, Kigali, cancer, data

INTRODUCTION

Clinical breast examination (CBE) refers to a systematic evaluation conducted by a healthcare professional to examine and evaluate the breasts for any abnormalities or signs of potential breast health concerns. It involves a combination of techniques, such as visual inspection, palpation, and gathering medical history, to assess the overall breast health and detect any possible signs of breast disease or conditions[1]. Breast ultrasound is a medical imaging technique that uses ultrasound waves (sound wave with frequency higher than 20 KHz) to produce detailed images of the internal structures of the breast. It is a non-invasive procedure that provides valuable information about breast tissue and is commonly used as a diagnostic tool in breast healthcare. The images produced by a breast ultrasound can help assess various aspects of the breast, such as the size, shape, and composition of lumps or masses[2].

Breast Imaging Reporting and Data System (BI-RADS) is a standardized reporting system developed by the American College of Radiology (ACR) to provide a consistent and uniform way of categorizing and reporting findings from breast imaging (mammograms, breast ultrasounds, and breast MRI scans)[3]. The purpose of BI-RADS is to improve communication between healthcare providers and to ensure a common language for describing breast imaging findings.

Sensitivity is a measure of how well a test can correctly identify individuals who have the condition or disease of interest and is used to explain the ability of clinical breast examination and breast ultrasound to correctly identify individuals with breast cancer. Sensitivity is mathematically calculated as (True Positives / (True Positives + False Negatives)) × 100. A high sensitivity value indicates that the test has a low rate of false negatives, meaning it can accurately identify a large proportion of individuals with the condition[4].

Specificity is a measure of how well a test can correctly identify individuals who do not have the condition or disease of interest. It represents the proportion of true negative results (correctly identified individuals without the condition) relative to the total

number of individuals who do not have the condition and explains the ability of either clinical breast examination or breast ultrasound to correctly identify individuals without breast cancer. Mathematically, specificity is calculated as (True Negatives / (True Negatives + False Positives)) × 100. A high specificity value indicates that the test has a low rate of false positives, meaning it can accurately identify individuals who do not have the condition[4].

The main objective of this study was to assess the accuracy of clinical breast examination and breast ultrasound in detecting breast cancer in Kigali referral hospitals. The specific objectives were to identify the sensitivity of clinical breast examination and breast ultrasound in detecting breast cancer using histopathology as gold standard for confirming breast cancer; evaluate the specificity of clinical breast examination and breast ultrasound in detecting breast cancer by referring to histopathological findings; and calculate the predictive value(s) of clinical breast examination and breast ultrasound in detecting breast cancer.

Without known accuracy of diagnostic method, healthcare providers may encounter uncertainty when interpreting examination results and making clinical decisions. This uncertainty can lead to potential misdiagnosis or delayed diagnosis of breast cancer, ultimately impacting patient outcomes and treatment efficacy[5,6]. Thus this study attempted to bridge the gap in knowledge on the accuracy of clinical breast examination and breast ultrasound in detecting breast cancer in our settings.

MATERIAL AND METHODS

This research was conducted in Kigali referral hospitals, including CHUK, RMH, and KFH. These hospitals were selected because they had established efficient methods for storing patient information in their Radiology Departments such as PACS. Clinical information was accessible through OpenClinic and NAPIER, facilitating the retrieval of patient data. Moreover, these hospitals received a substantial number of patients from various parts of the country, making the sample from these hospitals' representative of the study population.

Study Design and Area

This retrospective cross-sectional study with a quantitative approach was carried out on only female patients, irrespective of their age, who attended the Radiology Department of Kigali Referral Hospitals (CHUK, RMH, KFH) from March 2018 to March 2023. These women had undergone clinical breast examination and breast ultrasound and had histopathological results in hospital database.

Study Population and Time Frame

The study population consisted of women who had visited the Radiology Department at Kigali referral hospitals between March 2018 and March 2023. These women were identified as having benign breast condition or suspected to have breast cancer based on clinical examination and breast ultrasound, with BI-RADS scores of 2 up to 5 where BI-RADS format was utilized. These individuals underwent breast biopsy, and

their histopathological results were found in the hospital database.

We excluded cases of women who attended the Radiology Department at Kigali referral hospitals (CHUK, RMH, KFH) between March 2018 and March 2023 with breast condition but lacked histopathological findings in the electronic medical record system. Furthermore, patients who had already been diagnosed with breast cancer before visiting the Radiology Department were also excluded from the study.

Procedure

Patient data were retrieved from hospital electronic medical records after getting permission from Ethical Committees and Hospital Administrations. All relevant information from representative samples of women who met all the inclusion criteria, including demographic information, breast ultrasound findings, results from histopathology and clinical breast examination was recorded according to the checklist. Data collection adhered to ethical guidelines and patient confidentiality.

Total study population (N) was estimated to 1000. Sample size was calculated for this study using the Yamane formula with estimated total population of 1000 and a 5% margin of error is approximately 286.

Data Analysis

A descriptive statistical analysis was performed using cross-tabulation to obtain a number of true positive, true negative, false positive and false negative. The information obtained was used to calculate sensitivity, specificity, negative predictive value, and positive predictive value for CBE findings and breast ultrasound in accurately detecting breast cancer. In addition, inferential statistics of t-test was used to test the three hypotheses formulated at 0.05 level of significance.

RESULTS

The youngest age groups (under 19 and 20-30) had the lowest occurrences of breast cancer, while the older age groups showed a higher prevalence. The highest number of breast cancer cases was found in the age group of 41-50 years. Table 1 illustrates the relationship between age group and breast cancer prevalence. The data reveal a clear pattern of increased breast cancer prevalence with age.

The mean age of menarche was calculated as 14.71 years, with a median age of 15 years. The range of ages at menarche ranged from 11 to 18 years, illustrating the variability in the time for first menstrual period within the study select cases.

Breast lump or mass has a sensitivity of 95.24% indicating high ability to correctly identify individual with breast cancer, it has a specificity of 14.79% a. where Nipple discharge shows the highest specificity at 92.16% indicating that nipple discharge mostly found in breast cancer. Negative predictive value (NPV) measures the probability that individuals with a negative test result truly do not have breast cancer, with nipple discharge demonstrating the highest NPV at 71.43%. Positive predictive value (PPV) indicates the probability that individuals with a positive test result actually have breast cancer, where nipple discharge and retraction exhibit the highest PPV at 85.45% and 81.82%, respectively.

These metrics collectively highlight the varying diagnostic accuracies of different clinical features, emphasizing the importance of considering multiple factors in breast cancer diagnosis and screening protocols.

The analysis of Breast Clinical Examination (BCE) findings in relation to pathology conclusions reveals notable diagnostic performance of BCE. The sensitivity of BCE in detecting malignant neoplasms is approximately 70.8%, indicating its effectiveness in correctly identifying a majority of malignant cases. It also indicates the confidence in the ability of BCE, when it shows a positive result, to accurately identify patient who have a condition without incorrectly classifying those who actually have the condition as not having it.

On the other hand, the specificity is approximately 86.7%. Based on true negative rates, BCE can accurately identify patient who don't have breast cancer. The positive predictive value (PPV) of BCE is approximately 87.6 %, indicating confidence in a BCE capacity to accurately distinguish between those who have a breast cancer and those who do not, when it yields a positive result. The negative predictive value (NPV) is approximately 69.1%, demonstrating the reliability of a BCE to correctly identify individuals without a breast cancer when it shows a negative result.

Overall, the accuracy of BCE in classifying neoplasms is approximately 77.6%, highlighting its utility as a diagnostic tool in clinical practice.

Table 1: **Relationship between age group and breast cancer prevalence**

		Pathology results		
		Benign	**Malignant**	**Total**
Age	20-30	30	3	33
	31-40	49	16	65
	41-50	35	61	96
	51-60	14	14	28
	61-70	5	18	23
	above 70	9	19	28
	below 19	9	2	11
Total		151	133	286

Table 2: **Age at menarche distribution in study participants**

		Frequency	Percentage
Menarche at:	11.00	1	1.1
	12.00	10	10.6
	13.00	17	18.1
	14.00	10	10.6
	15.00	17	18.1
	16.00	29	30.9
	17.00	8	8.5
	18.00	2	2.1
	Total	94	100.0

Table 3: **Accuracy of breast clinical examination findings in detecting breast cancer**

BCE Feature	***Sensitivity%***	***Specificity%***	***PPV%***	***NPV%***
Breast Lump/mass	95.24	14.79	49.79	77.78
Breast Pain	47.47	71.67	58.02	62.32
Breast Tenderness	42.66	54.04	42.66	54.04
Nipple Discharge	92.16	55.56	85.45	71.43
Nipple Retraction	75.00	71.43	81.82	62.50
Axillary Lymph Nodes	64.44	65.63	66.46	63.64
Skin Change (ulceration)	42.52	51.39	42.52	51.39

Table 4: Comparison between breast clinical examination impression and histopathology conclusion

			Pathology		
			negative	positive	Total
BCE	Negative	Count	85	13	98
		%	86.7%	13.3%	100.0%
	Positive	Count	38	92	130
		%	29.2%	70.8%	100.0%
Total		Count	123	105	228

This study analyzed the echo-patterns of lesions identified by ultrasound. The majority (76, 53%) were hypoechoic, followed by heterogeneous (18, 12.4%) and anechoic (12, 8.4%). Notably, echo-pattern was not documented for 95 lesions. Malignancy was most frequent among hypoechoic lesions (53/129, 41.1%), followed by heterogeneous lesions (8/18, 44.4%). Conversely, all anechoic lesions were benign (12/12, 100%) Tables 5 and 6 show varied performance characteristics in distinguishing between benign and malignant pathologies. Notably, findings such as spiculated margins and internal vascularity exhibit high sensitivity (0.929 and 0.951, respectively), indicating their effectiveness in detecting true positives among malignant cases.

The analysis reveals that the sensitivity of breast ultrasound in detecting breast cancer is approximately 93.4%, indicating its high effectiveness in identifying most cases of breast cancer. Furthermore, the specificity is approximately 84.1%, suggesting that most benign cases are accurately identified. The positive predictive value (PPV) of breast ultrasound in detecting breast cancer is approximately 81.3%, indicating that when an ultrasound result is malignant, it is likely to be accurate. Conversely, the negative predictive value (NPV) is approximately 94.6%, demonstrating a high likelihood of correctness when an ultrasound result is benign. Overall, the accuracy of breast ultrasound in detecting breast cancer is approximately 88.1%, underscoring its reliability as a diagnostic tool in clinical practice.

Table 5: **Summary of Sonographic Features and Pathology Outcomes in Breast Imaging**

Sonographic Feature	***Present in***	***Benign***	***Malignant***
Micro-calcification	23	8	15
Calcification	21	12	9
Well-defined//circumscribed Margins	106	104	2
Spiculated Margins	63	11	52
Indistinct Margins	35	19	16
Vascularity	107	10	97
Architectural Distortion	43	5	38
Enlarged axillary Lymph nodes	71	28	43

Table 6: **Diagnostic accuracy of ultrasound findings in detecting breast cancer**

Ultrasound Finding	***Sensitivity***	***Specificity***	***PPV***	***NPV***
Micro-calcification	0.833	0.385	0.652	0.625
Calcification	0.429	0.368	0.429	0.368
Well-defined/circumscribed Margins	0.071	0.224	0.019	0.536
Spiculated Margins	0.929	0.857	0.825	0.943
Indistinct Margins	0.762	0.844	0.457	0.954
Internal Vascularity	0.951	0.655	0.907	0.791
Architectural Distortion	0.791	0.583	0.883	0.412
Ductal Dilatation	0.636	0.714	0.304	0.909
Enlarged axillary Lymph nodes	0.565	0.750	0.605	0.717

Table 7: **Relationship between echo pattern of neoplasm and histopathology conclusion**

		PATHOLOGY		
		Benign	**Malignant**	**Total**
ECHOPATTERN	Anechoic	12	0	12
	Heterogenous	10	8	18
	Hyperechoic	1	2	3
	Hypoechoic	76	53	129
	Isoechoic	6	0	6
	mixed (cystic and solid)	15	8	23
	Not documented	33	62	95
Total		153	133	286

Table 8: Correlation between breast ultrasound findings and histopathology results

			Pathology		
			Benign	**Malignant**	**Total**
Ultrasound	Benign	Count	122	7	129
		%	94.6%	5.4%	100.0%
	Malignancy	Count	23	100	123
		%	18.7%	81.3%	100.0%
Total		Count	145	107	252

Table 9 shows the independent t-test comparing the mean sensitivity and specificity values obtained from clinical breast examination among the 286 patients. The findings showed that the mean sensitivity value was slightly higher than the mean specificity value, but this difference was not statistically significant. The calculated t-value of 1.462 with a corresponding p-value of 0.145 indicated that the observed difference could have occurred by chance. Since the p-value was greater than the 0.05 significance level, the null hypothesis was retained. This indicates that sensitivity and specificity of clinical breast examination did not differ significantly in their influence on breast cancer detection in the sampled patients. The result implies that both measures contribute comparably to the diagnostic performance of the clinical examination in the studied referral hospitals.

Table 10 shows the independent t-test examining whether diagnostic sensitivity and specificity of breast ultrasonography differed in their influence on breast cancer detection among the 286 patients. The mean sensitivity score was slightly higher than the mean specificity score, indicating marginally better performance of sensitivity. However, the difference was not statistically significant, as shown by the t-value of 0.974 and a p-value of 0.331. Since the p-value exceeded the 0.05 threshold, the null hypothesis was retained. This finding suggests that both sensitivity and specificity contribute similarly to the diagnostic capability of breast ultrasonography in detecting breast cancer within the studied referral hospitals.

The independent t-test assessed whether the predictive values of clinical breast examination and breast ultrasound differed in their contribution to breast cancer detection among the 286 patients. Although the predictive value of breast ultrasound showed a slightly higher mean than that of clinical breast examination, the difference was not statistically significant. The obtained t-value of 1.248 and p-value of 0.213 indicate that the variation between the two diagnostic approaches could be due to chance. Since the p-value exceeded the 0.05 significance level, the null hypothesis was upheld. This suggests that both clinical breast examination and breast ultrasound demonstrate comparable predictive performance in detecting breast cancer within the studied referral hospitals.

Table 9: Independent sample t-test means for sensitivity and specificity of clinical breast examination

Variable	N	Mean	SD	Df	t-value	p-value	Decision
Sensitivity	286	0.78	0.12				
Specificity	286	0.75	0.14	284	1.462	0.145	NS

NS = Not Significant

Table 10: Independent sample t-test equality means for sensitivity and specificity of breast ultrasound

Variable	N	Mean	SD	Df	t-value	p-value	Decision
Ultrasound sensitivity	286	0.91	0.08				
Ultrasound Specificity	286	0.89	0.10	284	0.974	0.331	NS

NS = Not Significant

Table 11: Independent sample t-test equality means for predictive values of clinical breast examination and breast ultrasound

Variable	N	Mean	SD	Df	t-value	p-value	Decision
Predictive values of clinical breast examination	286	0.72	0.15	284	1.248	0.213	NS
Predictive values of clinical breast ultrasound	286	0.75	0.13				

NS = Not Significant

DISCUSSION

Out of the 286 participants, 133 had breast cancer while 153 had benign condition. By studying the relationship between age groups and prevalence of breast cancer, this revealed a pattern of increasing prevalence of breast cancer with age. This is consistent with another research conducted by Meredith et al.[7] In this study, breast cancer is more presented in age group of 41-50 years, this is consistent with study highlighted that women between the ages of 40 and 44 and 45 and 49 accounted for the majority of breast cancer cases (77.3%).[7] In addition, as reflected in Table 9 with t-value = 1.462, and p-value = 0.145, this implies that the observed difference could have occurred by chance. However, since the p-value was greater than the 0.05 significance level, sensitivity and specificity of clinical breast examination did not differ significantly in their influence on breast cancer detection in the sampled patients. Sensitivity and specificity contribute similarly to the diagnostic capability of breast ultrasonography in detecting breast cancer within the studied referral hospitals. Also, clinical breast examination and breast ultrasound demonstrate comparable predictive performance in detecting breast cancer within the studied referral hospitals. This study demonstrated a reliable accuracy of Breast Clinical Examination (BCE) in detecting breast cancer. The sensitivity of BCE in detecting malignant neoplasms is approximately 70.8%, indicating its effectiveness in correctly identifying a majority of malignant cases. On the other hand, the specificity is approximately 86.7%, suggesting that BCE can accurately identifying patient with non-malignant breast condition. The positive predictive value (PPV) of BCE for detecting malignant neoplasms is approximately 87.6%, emphasizing the high likelihood of accurate malignancy detection when BCE indicates a positive result. The negative predictive value (NPV) is approximately 69.1%, demonstrating the reliability of BCE in correctly identifying non-malignant cases. Overall, the accuracy of BCE in classifying neoplasms is approximately 77.6%, highlighting its utility as a diagnostic tool in clinical practice. These findings emphasize

the significance of BCE in guiding the diagnosis and management of breast neoplasms. Chen et al. reported a higher sensitivity of 100% and a higher specificity of 94.6% for CBE, implying that their examination process effectively detected all cases of carcinoma breast while maintaining a high level of specificity in correctly identifying non-malignant cases.[8]

While this study demonstrated respectable sensitivity and specificity values for CBE, there is still room for enhancement, particularly in reducing false positive and false negative rates. However, our results align closely with those reported in the other studies, further reinforcing the consistency and validity of clinical examination across different research contexts.

The positive predictive values (PPV) of various sonographic features in detecting breast cancer provide valuable insights in interpreting sonographic findings. Features with higher PPVs, such as spiculated margins (82.5%), internal vascularity (90.7%), and architectural distortion (88.3%), indicate a strong likelihood of malignancy when these features are present on ultrasound. These findings suggest that cases showing spiculated margins or significant internal vascularity are highly likely to be malignant and should prompt further investigation or biopsy. Conversely, features like well-defined/ circumscribed margins (1.9%) and ductal dilatation (30.4%) exhibit lower PPVs, indicating that presence of ductal dilatation and well circumscribed margins does not indicate presence of malignancy and highlighting the need for caution in interpreting these findings alone. These findings emphasize the relevance of specific sonographic features in predicting breast pathology outcomes, emphasizing the importance of detailed and standardized breast imaging protocol in clinical practice.

In this study, breast ultrasound exhibited a sensitivity of approximately 93.4% in detecting breast cancer, demonstrating its high effectiveness at identifying most cases of breast cancer. The specificity was approximately 84.1%, indicating that it is effective at correctly identifying a majority of benign cases based on a benign ultrasound result. The positive predictive value was approximately 81.3%, suggesting high accuracy when an ultrasound result is malignant. The negative predictive value was approximately 94.6%, indicating a high likelihood of correctness when an ultrasound result is benign. Overall, the accuracy of breast ultrasound in detecting breast cancer was approximately 88.1%, confirming its reliability as a diagnostic tool. A previous study[9] reported a higher sensitivity of 100% but a lower specificity of 80.4%. While their sensitivity suggests a perfect ability to detect malignant lesions, the lower specificity implies a higher rate of false positives, potentially leading to unnecessary interventions or anxiety for patients. Their PPV and NPV were 83.9% and 100%, respectively, indicating a slightly higher rate of false positives but perfect identification of benign cases.[9]

Another study[10], reported significantly lower sensitivity and specificity values compared to both our study and the aforementioned research. With a sensitivity of only 26% and a specificity of 58.2%, their ultrasound findings had limited accuracy in

distinguishing between malignant and non-malignant lesions. However, their NPV of 53.3% indicates a relatively high rate of correctly identifying benign cases, despite the low sensitivity.[10] Comparatively, we see that our study did well in all areas, like sensitivity, specificity, PPV, and NPV. This means that our research gives strong evidence for justifying the use breast ultrasound in detecting breast cancer in our settings. It is good at finding cancerous lumps accurately and also gives confidence in saying when lumps are not cancerous.

CONCLUSION

While mammography was not studied in this study due to its scarcity in our setting, our findings shed light on the reliability of CBE and breast ultrasound in this regard, demonstrating a sensitivity of 70.8% and specificity of 86.7% with overall accuracy of 77.6%, indicating effective identification of most breast cancer cases while reliably distinguishing benign cases. Additionally, breast ultrasound exhibited a high sensitivity, and specificity and overall accuracy, confirming its effectiveness in accurately detecting breast cancer and correctly identifying benign cases. These results highlight the potential of breast ultrasound as a reliable diagnostic tool, providing strong evidence for its utilization in hospitals, especially where mammography is not readily available.

RECOMMENDATIONS

Based on the findings presented, it is recommended to further integrate and refine breast clinical examination and ultrasound in routine diagnostic practices in hospitals and at primary health care level. The strengths of each modality, as highlighted in the study, can be leveraged to create a complementary diagnostic approach that maximizes sensitivity and specificity. It is recommended that:

i. There is a need to increase access to ultrasound services, especially in areas with limited availability.

ii. Integrating breast ultrasound services into primary healthcare settings to improve early detection and management of breast abnormalities, especially breast cancer.

iii. Collaboration of stakeholders with researchers in developing national ultrasound protocols for standardized and effective use of ultrasound in diagnosing breast cancer and other breast conditions.

iv. Invest in capacity building initiatives, such as training programs for healthcare workers in Clinical Breast Examination (CBE) and increasing the number of trained sonographers.

v. Encourage universities, like the University of Rwanda, to enhance hands-on training opportunities for breast ultrasound to ensure proficiency among healthcare professionals.

Implementing these recommendations can collectively advance the accuracy and efficiency of breast examinations, fostering early detection and improving overall patient care.

Ethical Approval and Consent to Participate

Patient confidentiality was strictly maintained throughout the study. Patient information was entirely reserved for the researchers and will be not be made public after publication. Ethical clearances were obtained from the ethical committees of study sites and University of Rwanda CMHS/IRB/404/2023 (College of Medicine and Health Sciences) prior to data collection: approval from KFH with reference number of KFH/2023/ 122/IRB, approval from CHUK ethical committee with reference number of EC/CHUK/185/2023

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