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Original Article

The Best Imaging Modality for Axillary Lymph Node Status in Breast Cancer

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ABSTRACT

Objectives: To explore the diagnostic accuracy of different imaging modalities including Axillary Ultrasound (AUS), CT Scan and Contrast Enhanced Magnetic Resonance Imaging (MRI) breast in determining the axillary lymph node status in breast cancer keeping histopathology as reference standard.

Study Design: Retrospective Comparative Study.

Place and Duration of Study: The Breast Clinic, Combined Military Hospital, Rawalpindi Pakistan, from Jul 2022 to Jun 2023.

Methodology: A retrospective comparative study was conducted at a dedicated breast cancer center with 90 early breast cancer patients. Diagnostic accuracy of Axillary Ultrasound, contrast-enhanced CT, and MRI was evaluated for axillary nodal staging. Final histopathology served as the reference standard. Imaging interpretations were performed by experienced radiologists, and data were analyzed using SPSS 22.0. The following metrics were determined: accuracy, specificity, negative predictive value, sensitivity, and specificity.

Results: In total, 90 female patients mean age of 53.5±21.2 years were evaluated. N Staging displayed differences between patients who tested positive and negative for nodes. We found that MRI had the highest sensitivity of the three imaging modalities (93.34%: 95% CI, 84.34% - 98.82%) whereas CT scan had the lowest sensitivity (71.70%; 95% CI, 57.65% - 82.21). AUS had sensitivity (84.91%; 95% CI: 72.41% - 93.25) Similarly MRI had the highest Specificity of the three imaging modalities (78.38%: 95% CI, 61.79% - 90.17%) whereas CT scan had the lowest Specificity (62.96%; 95% CI, 42.37% -80.60%) and AUS had Specificity (67.57%; 95% CI: 50.21% - 1.99%).

Conclusion: MRI scan is more effective; Axillary Ultrasound shows better outcomes than CT scan in identifying metastases in lymph nodes in breast cancer.

Keywords: Cancer, Lymph node, Metastasis, MRI.

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INTRODUCTION

Breast cancer is one of the most prevalent cancers in women worldwide. It is a serious problem for global health. Genetics, lifestyle, access to healthcare, and awareness affect the incidence and prevalence of breast cancer differently, depending on the location.[1,2] Breast cancer was the most common cancer in the world in 2020, accounting for 2.3 million new cases annually and making up 12% of all cancer diagnoses worldwide.[3]

One of the most significant determinants of a patient's prognosis for breast cancer is the tumor stage. A key instrument in evaluating the course of breast cancer is the TNM staging system, which considers the tumor size, nodal stage, and the distant metastases.[4,5] Advanced stage of the disease and less favorable prognosis may result from the involvement of axillary lymph nodes. Predictive information is further refined by the degree of nodal involvement as well as the number of impacted nodes (N1, N2, or N3). Breast cancer is regarded as having reached a more advanced stage if it has spread to distant organs.[6,7] When distant metastases are present, the five-year survival percentage drops significantly to 27%. As a result, precise staging is essential for both prognosis and therapy.[8,9]

When staging and creating a treatment strategy for breast cancer, it is essential to know the condition of axillary lymph nodes.[10] Surgeons frequently evaluate the nodes using various techniques, including sentinel lymph node biopsy (SLNB) and axillary lymph node dissection (ALND). Along with other variables, such as tumor size and the existence of distant metastases, the degree of nodal involvement in the axillary lymph nodes also plays a significant role in determining breast cancer.

Patients with early-stage breast cancer are advised to undergo SLNB, especially if imaging and clinical examination indicate a low probability of axillary lymph node involvement. However, additional axillary surgery or adjuvant therapy may be required if SLNB reveals positive nodes. Although

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SLNB is the gold standard for axillary staging in early-stage breast cancer, clinical guidelines, tumor features, and individual patient considerations should be considered when deciding whether to perform SLNB or axillary lymph node dissection.

This study aimed to investigate the accurate N staging of axillary nodal status in patients by axillary sonography, MRI, and CT scan.

METHODOLOGY

A retrospective comparative study was conducted at a dedicated Breast Clinic in Combined Military Hospital, Rawalpindi from July 2022 to June 2023. Sample size was calculated using WHO sample size calculator taking confidence interval 95%, margin of error 7%, reported prevalence of early breast cancer 19.33%.[11] This study was approved by the local ethical committee (ERC NO: 503). Before enrollment, each patient signed a written informed consent form.

Inclusion Criteria: Patients with histopathological diagnosis of carcinoma breast with T1-T3 tumor size, clinically negative axilla, no prior history of cancer, aged 30 to 75 years, hormone positive tumors, her 2 neu positive tumors and triple negative tumors were included.

Exclusion Criteria: Clinically T4 tumors, N2-N3 nodal status, breast feeding, pregnancy, malignancy during the last 5 years and patient with any contra indication to MRI were in the excluded.

A total of Ninety (n=90) patients were included in the study. Patients having early breast cancer were studied and diagnostic accuracy of different imaging modalities was evaluated for detection of axillary lymph node metastasis. The results were compared with final histopathology results. The three imaging modalities included Axillary Ultrasound (AUS), Contrast Enhanced CT Scan Chest (CT) and Contrast Enhanced MRI (MRI) bilateral breasts for Axillary Nodal Staging. All imaging modalities were interpreted by classified consultant radiologists. The radiologist involved had 5 years of experience in both breast and axillary ultrasonography performed axillary sonography. Three systems with linear array transducers operating at 5–12 MHz were used: Acuson S2000 (Siemens Healthcare GmbH), Super Sonic Imagine Aixplorer (Toshiba Medical Systems GmbH), and Aplio MX SSA 780A (Toshiba Medical Systems GmbH). When the node was lobulated, the hilum was diminished or nonexistent, or when the cortical thickness was >3mm, lymph nodes were considered suggestive, usually with a biopsy indication. Two radiologists with minimum 5 year experience of hybrid imaging, along with a nuclear medicine specialist, independently analyzed the images using an OsiriX Workstation (Pixmeo SARL). Patient's histopathology report was used as a benchmark to assess nodal status (nodal-positive vs. nodal-negative).

Data was analyzed by using Statistical Package for Social Sciences (SPSS) 22.00. Mean and SD was calculated for quantitative data. Frequency and Percentages were calculated for qualitative data. 2x2 contingency table was made for diagnosis's parameters.

RESULTS

The mean age of study participants was 53.5±21.2 years. Patient demographics and primary tumor characteristics are presented in Table-I. Out of 90 patients, 53(58.9%) patients had nodal-negative and 37(41.1%) had positive nodes based on reference standard. In every patient, breast MRI, axillary sonography and CT scan was carried out. 50 Patients had true positive results on MRI followed by AUS (n=45) and (n=38) on CT scan. (Table-II). N Staging displayed differences between patients who tested positive and negative for nodes. We found that MRI had the highest sensitivity of the three imaging modalities (93.34%: 95% CI, 84.34% - 98.82%) whereas CT scan had the lowest sensitivity (71.70%; 95% CI, 57.65% - 82.21). AUS had sensitivity (84.91%; 95% CI: 72.41% - 93.25). Similar MRI had the highest Specificity of the three imaging modalities (78.38%: 95% CI, 61.79% - 90.17%) whereas CT scan had the lowest Specificity (62.96%; 95% CI, 42.37% - 80.60%) and AUS had Specificity (67.57%; 95% CI: 50.21% - 1.99%) Shown in Table-III. Breast CT scan by itself had the lowest AUC of all the imaging modalities examined, at 0.778 (95% CI 0.679 – 0.859). MRI had the highest AUC, measuring 0.877 (95% CI: 0.791 – 0.937), whereas the axillary sonography exhibited 0.778 (95% CI, 0.722-0.899), see in Table-IV. Figure Shows the axillary lymph node metastasis on MRI, CT scan, and axillary sonography (AUS).

DISCUSSION

This study demonstrates that MRI is the most effective imaging modality among those evaluated for detecting axillary lymph node (ALN) metastases in breast cancer patients, followed by axillary ultrasound (AUS), with CT scan performing least effectively. In clinical settings, combining MRI with AUS may enhance diagnostic accuracy, particularly in staging

lymph node involvement, which is crucial for treatment planning.

Table-I: Demographic characteristics of Study Participant (n=90)

Variables		Frequency/ Mean±SD
Age in Years		53.5±21.2 years
Menopause stage	Pre	25(28.0%)
	Post	65(72.0%)
HER 2 neu receptor	0	33(37.0%)
	1+	22(24.0%)
	2+	15(17.0%)
	3+	20(22.0%)
Progesterone	Positive	15(16.7%)
	Negative	75(83.3%)
Estrogen	Positive	79(87.8%)
	Negative	11(12.2%)
Ki-67	Positive i-e ki>14%	81(90.0%)
	Negative i-e ki< 14%	9(10.0%)
Tumor grade	G1	17(18.9%)
	G2	40(44.4%)
	G3	33(36.7%)
Histopathology	Lobular invasive	5(5.5%)
	NST	60(66.7%)
	Other	25(27.8%)
T-stage	T1	41(45.5%)
	T2	29(32.2%)
	T3	15(16.7%)
	T4	5(5.6%)
N-stage	N0	53(58.9%)
	N1	27(30.0%)
	N2	8(8.9%)
	N3	2(2.2%)
M-stage	M0	85(94.4%)
	M1	5(5.6%)

Table-II: Diagnostic Accuracy Metrics for three Modalities (n=90)

Modalities	Histopathology		*p*-value
	Positive (n=53)	Negative (n=37)	
MRI			
Positive	50(94.3%)	8(21.6%)	<0.001
Negative	3(5.7%)	29(78.4%)	
AUS			
Positive	45(84.9%)	12(32.4%)	<0.001
Negative	8(15.1%)	25(67.6%)	
CT scan			
Positive	38(71.7%)	10(27.0%)	<0.001
Negative	15(28.3%)	27(73.0%)	

Table-IV: Area Under Curve for the three Modalities (n=90)

	AUC	95 CI
MRI	0.878	0.791 – 0.937
AUS	0.778	0.679 – 0.859
CT SCAN	0.705	0.591 – 0.803

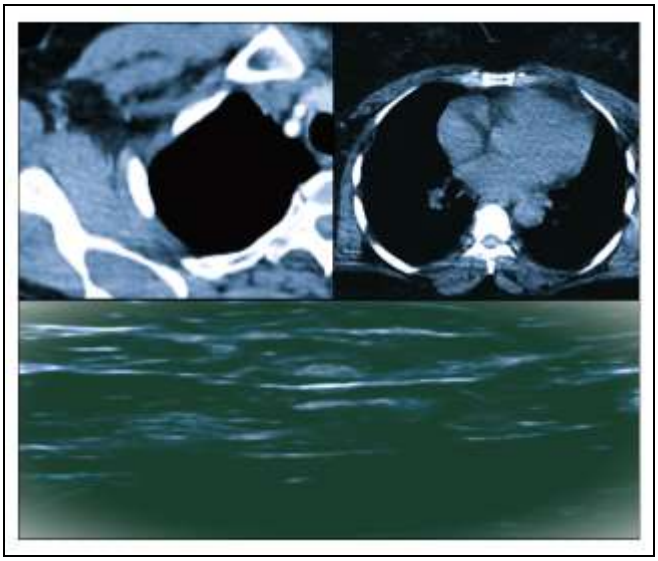

Figure-1(A-C): Shown Axillary Lymph Node Metastasis. (A): MRI Image. (B): CT Scan Image. (C): On Axillary Sonography (AUS), this Lymph Node was Classified as False-Negative

Accurate axillary staging is essential in patients with newly diagnosed breast cancer, as it informs decisions regarding neoadjuvant chemotherapy (NAC), surgical planning, and overall prognosis. Imaging modalities such as MRI, CT scan, and AUS are frequently employed alongside sentinel lymph node biopsy or axillary lymph node dissection. Each modality has distinct advantages and limitations in detecting ALN metastases, which can be influenced by the size of the lymph node, technical settings, and the experience of the interpreting clinician.[12]

In our study cohort (n=90), ALN was staged radiologically using MRI, CT, and AUS. Among these, AUS remains widely utilized due to its noninvasive nature, low cost, absence of radiation, and ease of use. However, the diagnostic accuracy of AUS is operator-dependent and subject to variability. Reported

Table-III: Diagnostic Accuracy Comparison for Lymph Node Metastasis among the Three Imaging Modalities (n=90)

Diagnostic Parameters	MRI		AUS		CT scan	
	Values	95 % CI	Values	95 % CI	Values	95 % CI
Sensitivity	93.34%	84.34% - 98.82%	84.91%	72.41% - 93.25	71.70%	57.65% - 82.21%
Specificity	78.38%	61.79% - 90.17%	67.57%	50.21% - 1.99%	62.96%	42.37% - 80.60%
Positive Predictive Value	86.21%	77.13% - 92.05%	78.95%	69.91% -85.82%	79.17%	69.32% - 86.47%
Negative Predictive Value	90.62%	76.07% - 96.71%	75.76%	61.37% - 86.01%	53.12%	40.33% - 65.52%

sensitivity and specificity rates range from 56–75% and 70–90%, respectively. In our data, false-negative AUS results were associated with a smaller average metastatic diameter (mean: 3.73mm), consistent with findings that AUS may miss small or micrometastatic disease. While AUS-guided fine needle aspiration cytology (FNAC) can enhance accuracy, AUS alone demonstrated low positive predictive value and limited sensitivity in morphological assessments. The findings of our study are in line with the study performed by Diessnar *et al.*, which also showed that AUS might miss smaller diameter lymph nodes.[13]

MRI, by contrast, provided superior imaging detail, particularly in evaluating the breast and axilla. These findings of our study are in harmony with the existing literature.[14-16] MRI was more accurate in identifying the clinical N stage in cases with positive findings and demonstrated better sensitivity compared to AUS and CT. Although MRI is also radiation-free, its cost and limited availability may restrict its routine use. Nonetheless, its high soft-tissue contrast and ability to detect lesions not visible on mammography or AUS make it a valuable tool, especially for patients with dense breast tissue or equivocal findings on other modalities.[17,18]

In our study CT scan, while useful in detecting distant metastases, exhibited the lowest sensitivity, accuracy, and AUC for identifying locoregional lymph node metastases in our study. It also produced a higher rate of false-positive results, particularly in inflammatory conditions. This is in line with the study conducted by James *et al.*, the primary advantage of CT lies in its ability to perform functional imaging, allowing earlier detection of distant metastases.[19] However, the exposure to ionizing radiation raises concerns about long-term risk, particularly in younger patients or those requiring repeated imaging.[20] Additionally, CT scan lacks the specificity needed for detailed nodal staging compared to MRI or AUS.

Importantly, our data revealed that false-negative findings across all modalities were associated with smaller nodal metastases, reaffirming the challenges of detecting low-volume disease through imaging alone. MRI was more accurate than AUS in predicting nodal burden, which has significant prognostic implications and may guide the choice between surgical management and NAC.[21,22] For example, nodal staging accuracy differed between modalities, with patients classified as pN2 or pN3 based on imaging findings later confirmed intraoperatively.

Taken together, these findings support the growing body of evidence suggesting that MRI offers superior anatomical resolution and diagnostic confidence, especially when combined with AUS or AUS-guided FNAC. Given its sensitivity, MRI can be particularly helpful in preoperative planning and in identifying patients who may benefit from more extensive axillary surgery or systemic therapy. While CT continues to play a role in systemic staging, its utility in regional nodal assessment appears limited by both sensitivity and radiation risk.

In clinical practice, imaging approaches that avoid ionizing radiation, such as MRI and AUS, should be prioritized for routine nodal staging in breast cancer, especially in early-stage disease. Future studies with larger cohorts and standardized imaging protocols may further refine the role of each modality and support the integration of multimodal imaging strategies to optimize patient outcomes.

LIMITATION OF STUDY

In our study the imaging was performed by a plethora of radiologists and the sample size was small. To further standardize it, a larger and more dicerse sample size should be considered.

CONCLUSION

MRI scan is more effective and axillary US is shown better outcomes then CT scan in identifying metastases from lymph nodes in breast cancer. In a clinical setting, MRI in conjunction with axillary sonography (AUS) may be able to diagnose patients even more accurately. Compared to traditional imaging, MRI, axillary US may be more sensitive in detecting metastases.

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Authors' Contribution

Following authors have made substantial contributions to the manuscript as under:

SG & ZA: Data acquisition, data analysis, drafting the manuscript, critical review, approval of the final version to be published.

MMJ & MT: Study design, data interpretation, drafting the manuscript, critical review, approval of the final version to be published.

AS & SRQN: Conception, data acquisition, drafting the manuscript, approval of the final version to be published.

Authors agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity

of any part of the work are appropriately investigated and resolved.

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