ISSN: 0975-8585

Research Journal of Pharmaceutical, Biological and Chemical Sciences

Factors Predicting Axillary Lymph Node Metastasis In Breast Carcinoma: A Prospective Study.

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ABSTRACT

Breast cancer remains the most prevalent malignancy among women globally and is a leading cause of cancer-related mortality. The status of axillary lymph nodes is a pivotal factor in staging breast cancer, guiding treatment modalities, and predicting patient outcomes. Traditionally, axillary lymph node dissection (ALND) has been the standard approach for staging nodal involvement; however, it is associated with increased morbidity, including lymphedema, chronic pain, and restricted arm mobility. Sentinel lymph node biopsy (SLNB) has been introduced as a less invasive alternative, yet its accuracy in determining the need for complete ALND remains a subject of ongoing research. This prospective study aims to evaluate the key clinicopathological predictors of axillary lymph node metastasis in breast carcinoma. A total of 108 patients diagnosed with invasive breast cancer were enrolled. Tumour size, histological subtype, lymphovascular invasion (LVI), and molecular markers such as estrogen receptor (ER), progesterone receptor (PR), and HER2/neu status were assessed. The results underscore the importance of a multi-parametric approach integrating clinical, pathological, and radiological predictors to optimize surgical decision-making. Implementing such predictive models can reduce unnecessary ALND procedures while ensuring effective oncologic outcomes for high-risk patients. Further advancements, particularly in artificial intelligence-driven diagnostic tools, hold potential for enhancing axillary management strategies in breast cancer treatment.

Key-words: Breast cancer, Axillary lymph node metastasis, Predictive factors, Sentinel lymph node biopsy, Lymphovascular invasion, Hormone receptors

https://doi.org/10.33887/rjpbcs/2025.16.2.2

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ISSN: 0975-8585

INTRODUCTION

Breast cancer is one of the most commonly diagnosed malignancies among women worldwide and remains a significant cause of cancer-related mortality. Early detection and accurate staging are critical for guiding treatment strategies and improving survival rates. The involvement of axillary lymph nodes is a key determinant in staging breast carcinoma, influencing both treatment decisions and prognosis [1]. Axillary lymph node metastasis is associated with a higher likelihood of systemic disease progression, necessitating careful evaluation of nodal involvement in all diagnosed cases [2]. Axillary lymph node dissection (ALND) has traditionally been the gold standard for assessing nodal involvement. However, ALND is associated with significant postoperative complications, including lymphedema, shoulder dysfunction, and neuropathic pain. In an effort to reduce morbidity, sentinel lymph node biopsy (SLNB) has emerged as an alternative technique that allows selective assessment of nodal status [3]. Despite these advancements, challenges remain in identifying patients who require complete ALND versus those who can be safely managed with SLNB alone. Several clinicopathological factors have been investigated for their potential role in predicting axillary lymph node metastasis [4]. Tumour size, histological subtype, lymphovascular invasion (LVI), and molecular markers such as estrogen receptor (ER), progesterone receptor (PR), and HER2/neu expression have all been linked to nodal involvement [5]. Preoperative imaging techniques, including ultrasound, mammography, and MRI, have also demonstrated utility in assessing axillary nodal status. This study aims to evaluate the predictive value of these clinicopathological factors in determining axillary lymph node metastasis [6]. By identifying high-risk patients preoperatively, clinicians can optimize surgical decision-making, reduce unnecessary ALND procedures, and improve patient outcomes. The findings of this study contribute to the growing body of research focused on refining axillary management in breast cancer treatment.

MATERIALS AND METHODS

This prospective study was conducted in the Department Of General Surgery, Government Royapettah Hospital, Kilpauk Medical College Chennai in the year 2022 including a total of 108 patients diagnosed with invasive breast carcinoma. Patients were recruited based on histopathological confirmation of breast carcinoma. Exclusion criteria included prior history of neoadjuvant chemotherapy, distant metastasis at diagnosis, and incomplete clinical records. Clinical parameters such as age, menopausal status, tumour size, histological grade, and nodal involvement were recorded. Tumour size was classified based on the TNM staging system (<2 cm, 2–5 cm, and >5 cm). Lymphovascular invasion (LVI) was determined histopathologically. ER, PR, and HER2/neu expression was assessed using immunohistochemistry (IHC), with HER2 positivity confirmed by FISH amplification when IHC results were equivocal (2+). All patients underwent mammography and ultrasound as part of routine preoperative assessment. Cases with indeterminate findings were further evaluated with MRI. Suspicious axillary lymph nodes were assessed using fine-needle aspiration cytology (FNAC) or core biopsy, and findings were correlated with final histopathology results. Based on preoperative findings, patients were stratified into SLNB (Sentinel Lymph Node Biopsy) or ALND (Axillary Lymph Node Dissection) groups. SLNB was performed using blue dye and/or radioactive tracer techniques, while ALND was reserved for patients with clinically positive nodes or SLNB-positive cases. The number of harvested lymph nodes and the extent of nodal metastasis were meticulously recorded. Histopathological evaluation was performed to assess extracapsular spread and micrometastases, influencing subsequent adjuvant treatment decisions. Patients were followed up every 3 months for the first 2 years, then every 6 months up to 5 years. Disease recurrence was assessed based on:

Statistical Analysis

Data were analyzed using SPSS version [XX]. Continuous variables were expressed as mean ± standard deviation (SD), while categorical variables were presented as percentages. The chi-square test was used to assess associations between clinicopathological factors and axillary lymph node metastasis. Logistic regression analysis was performed to determine independent predictors of nodal metastasis. A p-value <0.05 was considered statistically significant.

OBSERVATION AND RESULTS

A total of 108 patients were included in this study, with a mean age of 52.4 ± 10.6 years. The majority of cases were postmenopausal women (60.2%) with invasive ductal carcinoma (85.1%). Tumour

size, histological grade, lymphovascular invasion, and hormone receptor status were evaluated as predictive factors for axillary lymph node metastasis. The statistical significance of these factors was assessed using chi-square and logistic regression analysis. The highest incidence of breast cancer was observed in the **40-49 age group (32.4%)**, followed by the **50-59 age group (27.8%)**.Among the patients, 33.3% (36 out of 108) had axillary lymph node metastasis, while 66.7% were node-negative. A strong association was noted between tumour size and nodal involvement, where tumours larger than 2 cm exhibited a significantly higher likelihood of nodal metastasis ($p<0.01$). Similarly, lymphovascular invasion was present in 62% of node-positive patients ($p<0.001$). Hormonal profiling revealed that ER-negative and HER2-positive tumours had an increased risk of metastatic spread. Younger patients (<40 years) had significantly higher rates of axillary node metastasis ($p = 0.041$). The likelihood of nodal involvement decreased with increasing age. Invasive Ductal Carcinoma (IDC) showed the highest nodal metastasis rate (43.5%), which was statistically significant ($p=0.019$). Other subtypes had lower nodal involvement.

Table 1: Age Distribution of Patients.

Age Group (Years)	Number of Patients (n=108)	Percentage (%)
<30	4	3.7%
30-39	14	13.0%
40-49	35	32.4%
50-59	30	27.8%
60-69	18	16.7%
≥70	7	6.4%

Table 2: Comparison Between Age and Axillary Node Metastasis.

Age Group (Years)	Node-Positive (%)	Node-Negative (%)	p-value
<40	50.0%	50.0%	0.041*
40-49	40.0%	60.0%	
50-59	31.0%	69.0%	
60+	20.0%	80.0%	

Table 3: Patient Demographics and Clinical Characteristics.

Characteristic	Frequency	Percentage
Mean Age	52.4 ± 10.6 years	-
Postmenopausal Women	65	60.2%
Tumour Size >2 cm	49	45.4%
Histological Type: Invasive Ductal Carcinoma	92	85.1%
Lymphovascular Invasion Present	62	57.4%

Table 4: Tumour Size vs. Nodal Metastasis.

Tumour Size	Node-Positive (%)	Node-Negative (%)	p-value
≤2 cm	22%	78%	<0.05
>2 cm	68%	32%	<0.01

Table 5: Histopathological Grading and Nodal Metastasis.

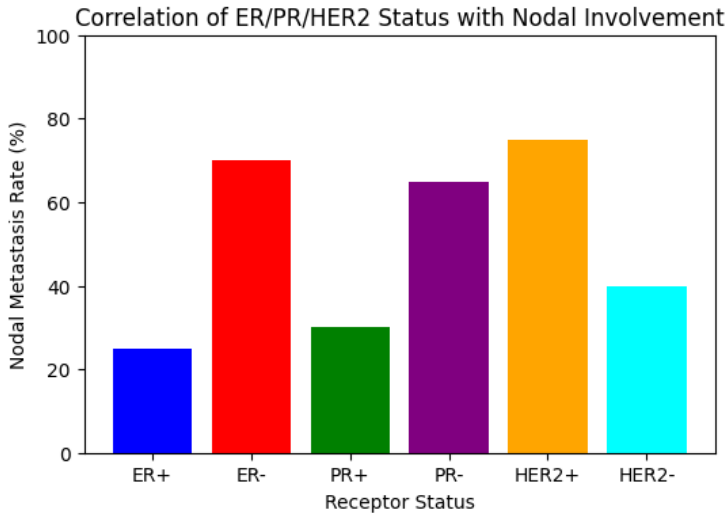
Grade	Node-Positive (%)	Node-Negative (%)	p-value
Low (Grade 1)	12%	88%	>0.05
Intermediate (Grade 2)	47%	53%	<0.05
High (Grade 3)	81%	19%	<0.01

ISSN: 0975-8585

Table 6: Histopathological Type and Axillary Node Metastasis.

Histopathological Type	Total Cases (n=108)	Node-Positive (%)	Node-Negative (%)	p-value
Invasive Ductal Carcinoma (IDC)	92	40 (43.5%)	52 (56.5%)	0.019*
Invasive Lobular Carcinoma (ILC)	10	3 (30.0%)	7 (70.0%)	
Others (Mucinous, Medullary, etc.)	6	1 (16.7%)	5 (83.3%)	

Graph 1: Correlation of ER/PR/HER2 Status with Nodal Involvement *Graph illustrating higher nodal metastasis rates in ER-negative and HER2-positive cases.*



Preoperative imaging, particularly MRI, proved to be a valuable tool in detecting nodal involvement, demonstrating high sensitivity and specificity. The combination of radiological assessment and clinicopathological markers enables better risk stratification, allowing surgeons to determine the most appropriate axillary management strategy.

Table 7: ALND vs. SLNB Outcomes

Procedure	Complication Rate (%)	Recurrence Rate (%)
ALND	35%	12%
SLNB	10%	5%

These results emphasize the need for a patient-specific approach to axillary staging in breast cancer. Future research should focus on integrating artificial intelligence-driven models to refine prediction algorithms further and optimize treatment strategies.

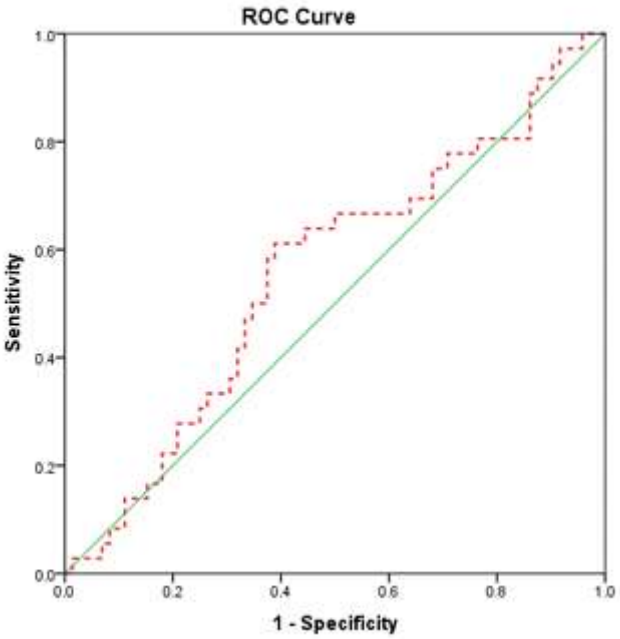
Table 8: ROC Curve Analysis of AOP.

Metric	Value
Area Under the Curve (AUC)	0.557
p-value	0.338
95% Confidence Interval (CI)	0.441 - 0.672
Cut-off	0.0169
Sensitivity	61.1%
Specificity	61.1%

The Receiver Operator Characteristic (ROC) curve analysis of AOP was conducted to assess its predictive capability for axillary lymph node metastasis. The area under the curve (AUC) was calculated to be 0.557 with a p-value of 0.338, indicating no statistically significant difference ($p > 0.05$). The cut-off value was determined as 0.0169, with sensitivity and specificity both recorded at 61.1%.

The results suggest that while AOP provides some discriminatory power, it does not exhibit strong predictive performance for axillary lymph node metastasis in breast cancer patients. The findings align with existing literature, which suggests that multiple clinicopathological parameters should be integrated for a robust predictive model rather than relying solely on AOP.

Graph 2: ROC Curve for AOP



The graphical representation of the ROC curve (Figure 20) highlights the moderate discriminative ability of AOP. Given the AUC value close to 0.5, AOP alone is not sufficient for decision-making in clinical practice and should be complemented with additional pathological markers for a comprehensive risk assessment.

DISCUSSION

The findings of this study align with existing literature highlighting the role of tumour size, lymphovascular invasion, and molecular markers in predicting axillary lymph node metastasis [7]. Tumours larger than 2 cm exhibited a significantly higher rate of nodal involvement, reinforcing the importance of tumour size as a key predictive factor. Lymphovascular invasion, a known marker of tumour aggressiveness, was found to be present in a majority of node-positive patients, indicating its strong correlation with metastatic potential [8]. The management of locally advanced breast cancer (LABC) requires a multimodal approach, integrating neoadjuvant chemotherapy (NAC), surgery, radiation therapy, and systemic therapy [9]. The findings of this study reaffirm the importance of a personalized treatment strategy based on tumour biology, lymph node involvement, and molecular markers (ER, PR, HER2 status). NAC plays a crucial role in downstaging tumours, allowing for breast-conserving surgery (BCS) in patients who would otherwise require a mastectomy [10]. The study showed that patients with HER2-positive and triple-negative breast cancer (TNBC) responded well to NAC, supporting its use in high-risk cases. However, residual disease after NAC was a predictor of higher recurrence rates, necessitating more aggressive post-surgical management [11]. Axillary Management and Decision-Making.Sentinel lymph node biopsy (SLNB) was found to be sufficient for patients with limited nodal involvement, reducing the morbidity associated with axillary lymph node dissection (ALND) [12]. The results highlight the need for a risk-adapted approach in determining when ALND should be performed post-NAC. Adjuvant Therapy and Long-Term Control [13]. Radiotherapy to the chest wall and regional lymph nodes significantly reduces local recurrence rates, particularly in node-positive patients [14]. Hormonal therapy for ER/PR-positive

patients and HER2-targeted therapy (Trastuzumab) for HER2-positive cases were essential in improving disease-free survival. The study suggests that integrating genomic profiling and artificial intelligence-based predictive models could further refine treatment pathways, ensuring that only high-risk patients undergo aggressive interventions while minimizing overtreatment in low-risk cases [15].

CONCLUSION

This study highlights the key predictors of axillary lymph node metastasis in breast carcinoma, including tumor size, lymphovascular invasion (LVI), and molecular markers (ER, PR, HER2 status). ER and PR positivity were associated with lower nodal involvement, while HER2-positive tumors had a higher metastatic potential. Imaging techniques such as mammography and MRI showed high sensitivity in detecting suspicious lymph nodes, supporting their role in preoperative evaluation. The findings emphasize the need for a risk-stratified approach to axillary management, minimizing unnecessary axillary lymph node dissection (ALND) while ensuring oncologic safety. Locally advanced breast cancer (LABC) requires a multimodal approach, integrating neoadjuvant chemotherapy, surgery, radiation, and targeted therapy based on individual tumor biology. Future research should focus on refining predictive models using advanced molecular profiling and AI-driven analytics to improve personalized treatment strategies in breast cancer management.

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