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Can computed tomography predict nodal metastasis in breast cancer patients?

Sherihan Fakhry[1,2*], Rasha Wessam Abdel Rahman[1,2], Hend Mahmoud Saied[1] and Safaa Ibrahim Saif El-nasr[1]

Abstract

Background: Axillary lymph node metastasis is considered one of the main prognostic factors clinically used for the evaluation of breast cancer patient. Also, an accurate diagnosis of axillary lymph node metastasis has a significant effect on the tumor staging and treatment planning. Ultrasonography is a noninvasive, available imaging modality that is capable of giving a real-time evaluation of axillary lymph nodes in breast cancer cases. On the other hand, multi-detector-row computed tomography is increasingly preferred by clinicians to preoperatively evaluate regional lymph node status in many cancers. The aim of this study was to compare the diagnostic performance of computed tomography against ultrasound in detecting axillary lymph node status in breast cancer patients.

Results: One hundred and fifty breast cancer patients were included in this prospective study. According to the final pathological results, 79/150 (52.7%) lymph nodes were metastatic, while 71/150 (47.3%) lymph nodes were benign with no evidence of metastases. Ultrasound examination has achieved a sensitivity of 76.4% and a specificity of 60.8% with overall diagnostic accuracy of 68.7%. Computed tomography (CT) examination has achieved a much higher sensitivity of 98.6%, a much lower specificity of 35.4%, and overall diagnostic accuracy of 65.3%. In our study, CT examination was superior on ultrasound in the determination of the level of lymph node affection, and this may be attributed to the dependency of ultrasound examination on the operator's experience.

Conclusions: CT is not routinely used in the assessment of nodal stage. However, if used in proper clinical setting, it may increase our confidence in excluding nodal metastasis owing to its high sensitivity. Despite its low specificity, it may act as road map for the surgeon, providing the ability to assess all groups of lymph nodes as well as the number of the suspicious lymph nodes.

Keywords: Axillary lymph nodes, Ultrasound, Computed tomography, Breast cancer

Background

Determining the pathological status of the axillary lymph nodes is crucial in staging and tailoring the management plan for breast cancer patients [1]. There is a tendency to perform less invasive and more conservative options in surgical axillary staging and management. Axillary lymph node dissection (ALND) was used as the gold standard in the evaluation of axillary lymph nodes in breast cancer patients [2, 3]. However, considering the associated potential morbidity, sentinel lymph node biopsy (SLNB) has been used as an appropriate alternative in cases with negative clinical and radiological assessments with no significant impact on the survival of breast cancer patients. The need for a second procedure with ALND, in patients with positive sentinel lymph node biopsy, has urged the need for proper and accurate preoperative evaluation, thus allowing the use of the proper surgical procedure in the appropriate clinical setting [4, 5].

Ultrasound (US) examination is the primary imaging tool in the evaluation of axillary lymph nodes in breast cancer patients. However, its diagnostic performance is variable due to its dependency on the operator's

*Correspondence: sherihan4@cu.edu.eg

[1] Radiology Department, Cairo University, Cairo, Egypt
Full list of author information is available at the end of the article

experience with subjective interpretation. This necessitates the need for an alternative noninvasive imaging tool with the aim of achieving precise and accurate preoperative knowledge of the axillary lymph node status.

Computed tomography (CT) is an informative, noninvasive imaging tool which is incorporated into the standard imaging protocol of advanced breast cancer for metastatic work-up [6]. It is not routinely used for early-stage breast cancer as the risk of distant metastasis in these cases is low [7]. CT can provide useful information about axillary lymph node involvement. It can visualize the axillary lymph node despite its depth and can accurately determine the level of the axillary nodal involvement [8, 9]. The sole assessment of the lymph node size is not reliable in the differentiation between benign and metastatic lymph nodes, yet the use of morphological criteria, being possible by the advances in CT machines, might improve the prediction of nodal metastasis [8].

The objective of this study was to compare the diagnostic performance of CT against ultrasound in detecting axillary lymph node status in breast cancer patients.

Methods

The prospective study was conducted at our institute between January 2019 and March 2022, after receiving ethics committee approval.

Patient population

This study included 150 female patients with primary breast cancer who were referred by the multi-disciplinary team for pre-management staging. They performed US examination for primary tumor and nodal staging followed by CT examination for metastatic work-up. Thus, patients with advanced breast cancer were included in this study as they underwent both imaging modalities. Exclusion criteria included patients with early-stage breast cancer who did not perform CT examination, those with previous operative interference or who received neoadjuvant chemotherapy (NACT). Patients with a lack of pathological confirmation were also excluded from this study.

Ultrasound examination

B-mode ultrasonography (GE LOGIQ P9) was used to assess all of the patients using a high frequency (7.5–12 MHz) linear transducer. The patient was lying supine in an oblique position with her arm raised above her head. The scanning procedure includes transverse and longitudinal real-time imaging of the ipsilateral and contralateral axillary lymph nodes.

CT examination

All patients were scanned with a multi-detector CT (MDCT) scanner (a 64-detector MDCT scanner, GE Healthcare's Light Speed VCT 64) with the following settings: voltage of 120 kV, automated tube current modulation (50–70 mAs), 1.75 mm pitch, 0.625 mm slice thickness, 175 mm/s table speed, 2.5 rotation/s, and 512×512 matrix.

The examinations were performed on patients in the supine position, with both arms raised above their heads, from the level of the lower neck to the bottom of the thorax. In every case, a single breath-hold was requested during scanning. Using an automated injector, all patients received 100 ml of contrast material intravenously at a rate of 3 ml/s via an antecubital vein on the opposite side of the affected breast.

Image acquisition was started at 40 s after the start of a bolus injection of the contrast material. Axial images were reconstructed at 5 mm intervals in the coronal and sagittal planes. All three sets of images (axial, coronal, and sagittal) were evaluated using a picture archiving and communicating system.

Image analysis

Imaging analysis, including US and CT examinations, was performed by two different readers with more than 10 years of field experience, who were blinded to each other's analysis to avoid bias. In cases of disagreement, a re-assessment was done and agreement was realized in consensus. The most suspicious lymph node was evaluated by both modalities. The recorded parameters included short-axis dimension, shape (oval, round, or irregular), type and size of cortical thickening (diffuse or focal), hilar changes (preserved, symmetrical or focal indentation, displaced or lost), signs of extracapsular invasion (irregular outline on ultrasound or CT), and the level of suspicious lymph nodes.

The examined lymph nodes were then categorized into non-specific, indeterminate, and pathological lymph nodes depending on the degree of suspicion. Non-specific lymph nodes were considered if uniform cortical thickness <3 mm and preserved central fatty hila were observed. Indeterminate lymph nodes were considered if there was any of the following: diffuse cortical thickness >3 mm, focal cortical thickening (any thickness) or bulge, focal indentation or eccentric fatty hilum. Pathological lymph nodes included those with lost fatty hila, or with an irregular or spiculated nodal outline. All the results were then compared to the postoperative pathology results, which were used as the gold standard.

Statistical analysis

The statistical analysis was done with SPSS 22nd edition, and continuous variables were presented as mean and standard deviation, with paired T tests used to compare means. The Chi-square test was used to compare qualitative variables that were presented in frequency and percentages. Any *P* value less than 0.05 was deemed significant.

Results

This study included 150 female patients with primary breast cancer. Their age ranged between 26 and 83 years (mean age: 51.8 ± 11.6 SD). Among the studied cases, the most encountered malignancy was invasive duct carcinoma (103/150, 68.7%) as emphasized in Table 1. SLNB was performed in 92/150 (61.3%) cases and was followed by ALND in 17/92 (18.5%) cases. According to the final pathological results, 79/150 (52.7%) lymph nodes were metastatic, while 71/150 (47.3%) lymph nodes were benign with no evidence of malignancy.

Table 1 Distribution of pathological subtypes among the studied population

Histopathological outcome	No. of patients (*n* = 150)	%
IDC	103	68.7
Mixed IDC and ILC	13	8.7
ILC	8	5.3
Invasive tubular and cribriform carcinoma	6	4
Invasive mucinous carcinoma	5	3.3
Invasive medullary carcinoma	4	2.7
DCIS	4	2.7
Invasive micropapillary carcinoma	3	2
Invasive metaplastic carcinoma	2	1.3
Adenoid cystic carcinoma	1	0.7
Invasive neuroendocrine carcinoma	1	0.7

IDC; Invasive duct carcinoma, ILC; Invasive lobular carcinoma, DCIS; Ductal carcinoma in situ

Ultrasound examination

Based on measuring the short-axis dimension of the lymph node by US examination and in correlation with the final pathology, it was found that metastatic lymph node tends to be relatively broader with larger short-axis dimension.

In this study, a cortical thickening of 3 mm was considered as a cutoff value for discriminating between normal and abnormal LN. Normal cortical thickness (< 3 mm) was found in 64/150 (42.6%) lymph nodes, out of which 16/64 (25%) lymph nodes were malignant (false negative). On the other hand, thickened cortex was noted in 73/150 (48.7%) lymph nodes. Focal cortical thickness was found in 45/73 (61.6%) lymph nodes, out of which 32/45 (71.1%) lymph nodes were malignant (Fig. 1), while diffuse cortical thickness was found in 28/73 (38.4%) lymph nodes, out of which 12/28 (42.9%) lymph nodes were malignant. Total cortical infiltration emphasized by hypoechoic lymph node with lost fatty hilum was noted in 13/150 (8.7%) lymph nodes.

Based on the analysis of the morphological criteria of the examined lymph nodes and in correlation with the final pathology, we found significant correlation between metastatic lymph node infiltration and the following morphological criteria: round or irregular lymph nodes, focal cortical thickening, focal hilar indentation, and lost fatty hilum (*P* value < 0.001). Insignificant correlation was found between metastatic lymph node infiltration

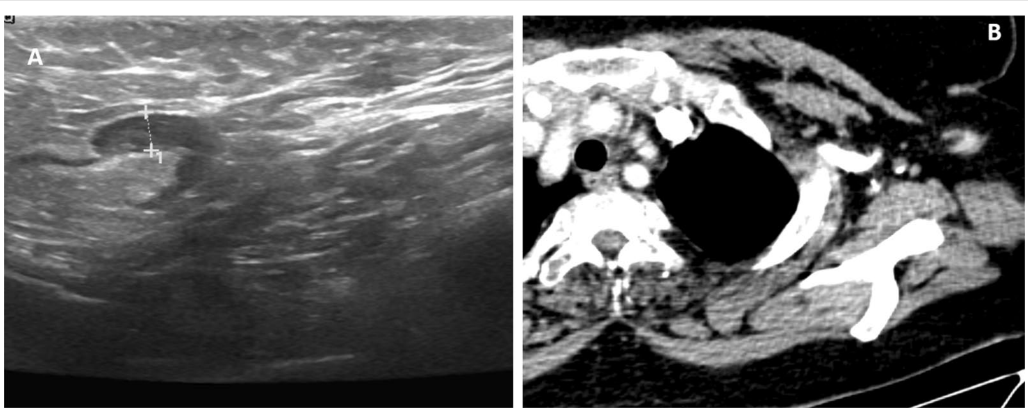

Fig. 1 A 70-year-old female with left pathologically proven metastatic axillary lymph node. **A** Axillary ultrasound image shows indeterminate LN with focal cortical thickening measuring 5 mm (true positive). **B** CT image shows an indeterminate axillary LN with focal cortical thickening measuring 11 mm (true positive). LN; Lymph node, CT; computed tomography

Table 2 Correlation between the morphological criteria of the lymph node by US and final pathology

Morphological criteria by ultrasound	Pathology			
	Negative		Positive	
	Count	%	Count	%
Shape				
Oval	77	55.8	61	44.2
Round	2	20	8	80
Irregular	0	0	2	100
Cortical thickness				
Diffuse	16	57.1	12	42.9
Focal	13	28.9	32	71.1
Normal	48	75	16	25
Fatty hilum				
Preserved	69	63.9	39	36.1
Lost	2	15.4	11	84.6
Eccentric	3	37.5	5	62.5
Focal indentation	3	16.7	15	83.3
Diffuse indentation	2	66.7	1	33.3

and the following morphological criteria: diffuse cortical thickening (P value 0.90), diffuse hilar indentation (P value 0.63), and displaced or eccentric fatty hilum (P value 0.384). Correlation between the morphological criteria, based on US examination, and final pathological results is emphasized in Table 2.

Considering the level of lymph node involvement, pathological infiltration of level I and II axillary lymph nodes was assigned in 3/150 (2%) cases, while additional involvement of level III and supraclavicular lymph nodes was found in 4/150 (2.7%) cases and 1/150 (0.7%) case, respectively.

Based on ultrasound examination, indeterminate lymph nodes were assigned in 58/150 (38.7%) lymph nodes, out of which 28/58 (48.3%) lymph nodes were benign and 30/58 (51.7%) lymph nodes were metastatic (Fig. 2), as verified by final pathology. This is shown in Table 3.

Table 3 Correlation between indeterminate lymph node by ultrasound and final pathology

	Operative Findings			
	Negative		Positive	
	Count	Column N %	Count	Column N %
Indeterminate lymph nodes by Ultrasound	28	48.3	30	51.7

CT examination

Based on measuring the short-axis dimensions of the examined lymph nodes and in correlation with final pathology, it was found that metastatic lymph nodes were associated with broader range of size (5–46) mm with a higher maximum value of 46 mm as compared to benign lymph nodes that showed a range of sizes of (5–27) mm with maximum value of 27 mm.

In this study, thickened cortex was noted in 103/150 (68.7%) lymph nodes. Focal cortical thickness was found in 45/103 (43.7%) lymph nodes, out of which 29/45 (64.4%) lymph nodes were malignant, while diffuse cortical thickness was found in 58/103 (56.3%) lymph

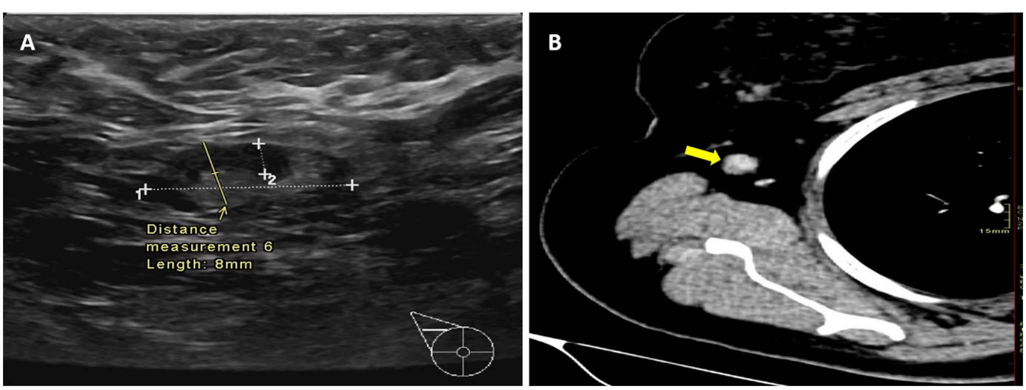

Fig. 2 A 57-year-old female with right pathologically proven metastatic axillary lymph node. **A** Axillary ultrasound image shows indeterminate axillary LN with focal cortical thickness and preserved central fatty hilum (true positive). **B** CT image shows a pathologically enlarged lymph node with globular shape and eccentric fatty hilum (true positive). LN; Lymph node, CT; computed tomography

nodes, out of which 24/58 (41.4%) lymph nodes were malignant. Total cortical infiltration emphasized by lost hypodense fatty hilum was noted in 18/150 (12%) lymph nodes.

Based on the analysis of the morphological criteria of the examined lymph nodes and in correlation with the final pathology, we found significant correlation between metastatic lymph node infiltration and the following morphological criteria: irregular or amalgamated lymph nodes, focal cortical thickening, focal hilar indentation, or lost fatty hilum (P value < 0.001). On the other hand, insignificant correlation was found between metastatic lymph node infiltration and the following morphological criteria: round lymph nodes (P value 0.4), diffuse cortical thickening (P value 0.90), diffuse hilar indentation (P value 0.18), and displaced or eccentric fatty hilum (P value 0.46). Correlation between the morphological criteria, based on CT examination, and final pathological results is emphasized in Table 4.

Table 4 Correlation between the morphological criteria of the lymph node by CT and final pathology

Morphological criteria by CT	Pathology			
	Negative		Positive	
	Count	%	Count	%
Shape				
Oval	75	56.4	58	43.6
Round	4	40	4	60
Irregular	0	0	2	100
Amalgamated	0	0	2	100
Cortical thickness				
Diffuse	34	58.6	24	41.4
Focal	16	35.6	29	64.4
Normal	27	93.1	2	6.9
Fatty hilum				
Preserved	65	65.7	34	34.3
Lost	1	5.6	17	94.4
Eccentric	11	47.8	12	52.2
Focal indentation	0	0.0	8	100
Diffuse indentation	2	100	0	0.0

In 11/150 (7.3%) cases, pathological infiltration of level I, II axillary lymph nodes was assigned, while additional involvement of level III and supraclavicular lymph nodes was found in 9/150 (6%) and 1/150 (0.7%) cases, respectively.

Based on CT examination, indeterminate lymph nodes were assigned in 77/150 (51.3%) lymph nodes, out of which 41/77 (53.2%) lymph nodes were benign (Fig. 3) and 36/77 (46.8%) lymph nodes were metastatic, as verified by final pathology, as shown in Table 5.

Overall diagnostic performance of US and CT examinations

Based on the combined US morphological findings of the studied axillary lymph nodes, 65/150 (43.3%) lymph nodes were considered non-specific, 58/150 (38.7%) lymph nodes were considered indeterminate, and 27/150 (18%) lymph nodes were considered pathological. Among the assigned non-specific lymph nodes by ultrasound,

Table 5 Correlation between indeterminate lymph node by CT and final pathology

	Operative findings			
	Negative		Positive	
	Count	Column N %	Count	Column N %
Indeterminate lymph node by CT	41	53.2	36	46.8

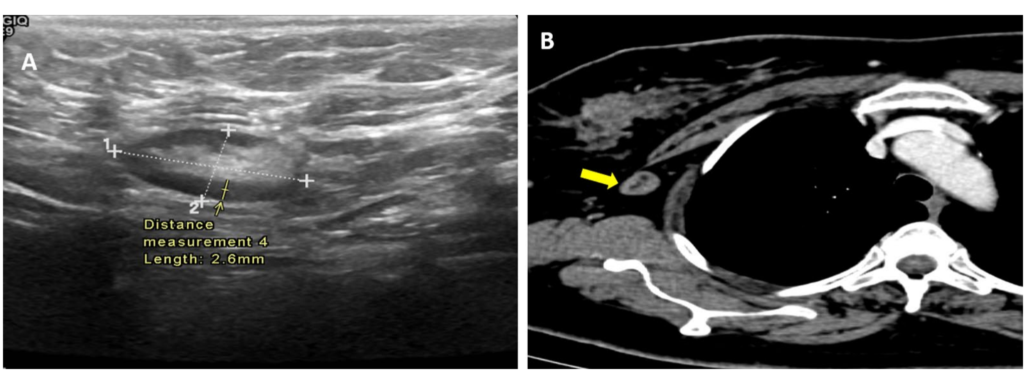

Fig. 3 A 51-year-old female with right pathologically proven non-metastatic axillary lymph node. **A** Axillary ultrasound image shows a non-specific LN with average cortical thickness and preserved fatty hilum (true negative). **B** CT image shows an indeterminate LN with diffuse cortical thickness and central fatty hilum (false positive). LN; Lymph node, CT; computed tomography

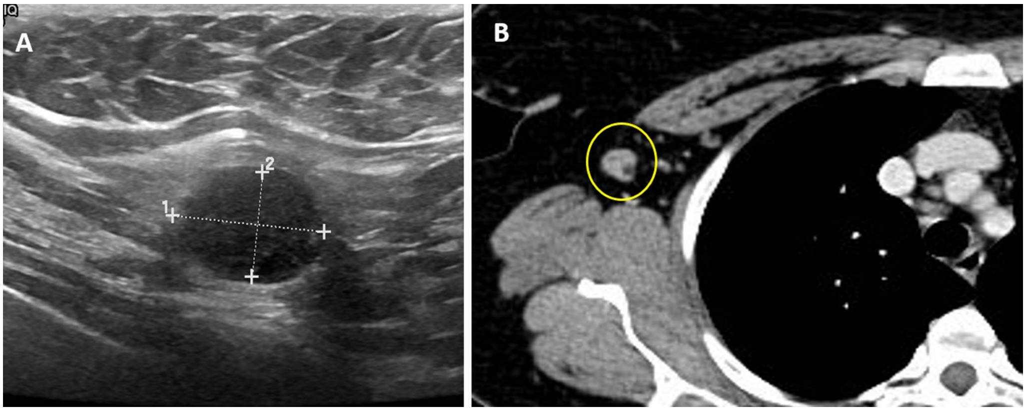

Fig. 4 A 72-year-old female with pathologically proven non-metastatic axillary lymph node. **A** Axillary ultrasound image shows pathological axillary LN with globular shape and lost fatty hilum (false positive). **B** CT image shows pathological axillary lymph node with globular shape and eccentric fatty hilum (false positive). LN; Lymph node, CT; computed tomography

Table 6 Correlation between the lymph node diagnosis by ultrasound and final pathology

Ultrasound Diagnosis	Operative findings			
	Negative		Positive	
	Count	%	Count	%
Non-specific	48	73.8	17	26.2
Indeterminate	28	48.3	30	51.7
Pathological	2	7.4	25	92.6

Table 7 Correlation between the lymph node diagnosis by CT and final pathology

CT Diagnosis	Operative findings			
	Negative		Positive	
	Count	%	Count	%
Non-specific	28	73.8	1	26.2
Indeterminate	41	48.3	36	51.7
Pathological	10	7.4	34	92.6

17/65 (26.2%) lymph nodes were metastatic (false negative), while 48/65 (73.8%) were benign (true negative), as verified by final pathology. Conversely, among the assigned pathological lymph nodes, 2/27 (7.4%) lymph nodes by were benign (false positive) (Fig. 4), while 25/27 (92.6%) lymph nodes were malignant (true positive). That is emphasized in Table 6.

Based on the combined CT morphological findings of the studied axillary lymph nodes, 29/150 (19.3%) lymph nodes were considered non-specific, 77/150 (51.3%) lymph nodes were considered indeterminate, and 44/150 (29.3%) lymph nodes were considered pathological. Among the assigned non-specific lymph nodes by CT, only 1/29 (3.4%) lymph nodes were metastatic (false negative), while 28/29 (96.6%) were benign (true negative), as verified by final pathology. Conversely, among the assigned pathological lymph nodes, 10/44 (22.7%) lymph nodes were benign (false positive) (Fig. 4), while 34/44 (77.3%) lymph nodes were malignant (true positive). That is emphasized in Table 7.

In the current study, in order to calculate the diagnostic performance of US and CT, we considered indeterminate axillary lymph nodes as suspicious. The accuracy measures and diagnostic indices of ultrasound and CT examinations were calculated individually, as shown in Table 8.

Table 8 Diagnostic indices of ultrasound examination compared to CT examination in the detection of metastatic lymph nodes

Diagnostic indices	Ultrasound (95% CI)	CT (95% CI)
Sensitivity	76.4% (64.91–85.60%)	98.6% (92.40–99.96%)
Specificity	60.8% (49.83–72.34%)	35.4% (25.00–47.01%)
Positive predictive value	64.71% (57.38–71.40%)	57.9% (53.77–61.83%)
Negative predictive value	73.9% (64.27–81.59%)	96.6% (79.63–99.50%)
Accuracy	68.7% (60.59–75.98%)	65.3% (57.14–72.91%)

Discussion

The prediction of axillary lymph node status remains an important issue in the preoperative assessment of breast cancer patients. SLNB is the standard option for women who are staged with a negative nodal status [10]. Nevertheless, if axillary metastases are suspected, the success of SLNB may be impaired, and these patients should still receive ALND [11]. The procedure of radical ALND implies a significant increase in morbidity, such as lymphedema or paresthesia of the arm [12].

Ultrasound is readily available and is employed in a wide range of diagnostic applications. It is the initial method of investigation used in the evaluation of axillary lymph nodes with the advantage of being cost-effective, noninvasive, and can guide interventional procedures [13]. On the other hand, though CT examination of the chest is not a routine recommendation in early-stage breast cancer, it is recommended for the pre-management metastatic work-up of stage III–IV breast cancer. It may also be used in early-stage breast cancer if associated pulmonary symptoms or other indications are present [14].

In this study, we discussed the reliability of the CT examination, when used in a proper clinical setting, as compared to the US examination, in the prediction of the metastatic involvement of axillary lymph nodes in breast cancer patients. The morphologic criteria of the examined lymph nodes were carefully analyzed, and then, the overall diagnostic performance of both modalities was assessed. The results were compared with the final pathology results.

We included a total of 150 patients who were first assessed clinically and then referred for breast sonography, followed by a CT chest examination. Patients showed a mean age of 51.8 ± 11.6 years (ranging from 26 to 83 years). SLNB was performed in cases with assigned non-specific or indeterminate lymph nodes based on imaging findings in which fine needle aspiration cytology (FNAC) yielded negative lymph node infiltration. Accordingly, SLNB was performed in 92/150 (61.3%) cases and was followed by ALND in 17/92 (18.5%) cases.

Though IDC was the commonest encountered malignancy in this study, we found that certain subtypes are less commonly associated with metastatic axillary lymph nodes. Lymph node infiltration was excluded in 4/4 (100%) cases with medullary carcinoma, 4/5 (80%) cases with mucinous carcinoma, and in 4/6 (66.7%) cases with tubular and cribriform carcinoma as verified by final pathology. That was in accordance with Stelmach et al. [15], who stated that typical medullary carcinoma is associated with lower frequency of axillary LN metastases as compared to IDC. Also, Diab et al. [16] stated that mucinous and tubular carcinoma were associated with less nodal involvement with overall favorable prognosis.

In the current study, ultrasound examination has achieved a sensitivity of 76.4% and a specificity of 60.8% with overall diagnostic accuracy of 68.7%. Riedel et al. [17] reported a lower sensitivity of 53.3% and a much higher specificity of 93.6% with overall diagnostic accuracy of 79.7%. Also, Futamura et al. [18], and An et al. [19], reported a comparable sensitivity of 72 and 78%, yet a higher specificity 77% and 78%, respectively.

While interpreting the CT examination, we relied upon the same morphological criteria used by ultrasound examination in discriminating benign from metastatic axillary lymph nodes, not only the routine use of the size of the lymph nodes whether by measuring the short-axis dimension or the ratio between the major/minor axis dimension as used in previous studies. The multi-planner capabilities of CT nowadays with thin sections and possible reconstruction in sagittal, coronal, and axial planes allowed proper assessment of the cortical abnormalities and hilar changes through analyzing changes to the central hypodense fatty hilum.

CT examination has achieved a much higher sensitivity of 98.6%, a much lower specificity of 35.4%, and overall diagnostic accuracy of 65.3%. Chun et al. [14] reported a lower sensitivity of 85.3% and a higher specificity of 87.4%, as compared to our results. Also, Shein et al. [20] reported lower sensitivity of 78% and a higher specificity of 75%.

The achieved high sensitivity of CT examination in our study may be attributed to the use of detailed hilar changes for assessment. We considered focal or diffuse hilar indentation as well as eccentric fatty hilum as descriptors of indeterminate lymph nodes, while other studies considered just the absence of fatty hilum as suspicious descriptor. Accordingly, there was only 1/150 (0.7%) false-negative case in our study with resultant high sensitivity, yet at the cost of low specificity (51/150, 34%) false-positive cases.

Our low specificity achieved by both ultrasound and CT examination may be related to the grouping of the indeterminate and the pathological lymph nodes and considering them as suspicious. More indeterminate lymph nodes were assigned on CT examination (n:77) than on US examination (n:58), with larger nodal size and cortical thickness noted on CT examination. Based on US findings, 28/58 (48.3%) indeterminate lymph nodes were benign (false positive) and 30/58 (51.7%) indeterminate lymph nodes were malignant (true positive), as verified by final pathology. Based on CT examination, 41/77 (53.2%) indeterminate lymph nodes were benign (false positive) and 36/77 (46.8%) indeterminate lymph nodes were malignant (true positive), as verified by final pathology.

In this study, we underwent analysis of the size and morphological criteria of the axillary lymph nodes including the shape, cortical thickness (size and extent), and hilar changes (preserved, focal or diffuse indentation, eccentric or lost). We did not consider the size as a reliable criterion differentiating benign from metastatic axillary lymph nodes though standard interpretation of CT examination relied mainly on the assessment of nodal size based on the literature and previous studies.

Though we noticed that the metastatic lymph nodes tended to be larger along their short-axis dimension, the same size may be found in both benign and metastatic lymph nodes. That was in agreement with Bedi et al. [21], who concluded that cortical morphological findings and hypoechoic cortex were more important than the lymph node size in the discrimination between benign and metastatic lymph nodes.

By analysis of both CT and US examination findings, we found that the shape of lymph node is not a reliable criterion for exclusion of metastatic nodal involvement. Insignificant correlation between the oval shape and benign lymph nodes was found (*P* value 0.035 in US, *P* value 0.011 in CT). Based on US examination, there was significant correlation between round lymph nodes with metastatic lymph node infiltration. This is not the case with CT examination in which round lymph nodes were found in 4/10 cases of which their primary pathological subtype was medullary carcinoma. Irregular lymph nodes as depicted by US or CT examination were significantly associated with metastatic lymph node infiltration (*P* value < 0.001).

A significant association between the extent of cortical thickening and metastatic infiltration of LN was found in our study based on both US and CT examination findings. That was in accordance with Mainiero et al. [22], who stated that a cortical thickness measurement of ≥ 3 mm is an indication for ultrasound-guided FNAC, and was 88% sensitive and 75% specific in predicting a positive ultrasound-guided FNAC result. A study conducted by Choe et al. [23] revealed that cortical thickness greater than 3 mm was the most accurate indicator, with 4.14 times increased risk of the presence of an axillary lymph node metastasis as compared to cortical thickness less than 3 mm.

Diffuse cortical thickening per se is not a reliable predictor of metastatic lymph node infiltration as it may occur in reactive lymph nodes as well. In our study, diffuse cortical thickening was depicted in 28/150 (18.7%) cases by US examination, out of which 16/28 (57.1%) lymph nodes were benign, as verified by final pathology. By analysis of CT examination, it was depicted in 58/150 (38.7%) cases, out of which 34/58 (58.6%) lymph nodes were benign, as verified by final pathology. These findings are in agreement with Abe et al. [2], Ecanow et al. [7] and Neal et al. [24], who stated that diffuse cortical thickening can be seen with metastasis, but this finding is even more non-specific, often being associated with a reactive node.

Focal cortical thickening whatever its size was significantly associated with metastatic LN infiltration (*P* value < 0.001). These findings are consistent with a recent study conducted by Imai et al. [25], who concluded that the presence of focal cortical thickening in three or more axillary lymph node had 72% sensitivity in detection of positive LN infiltration by pathology.

In the current study, lost fatty hilum and focal indentation by US and CT were more commonly associated with positive lymph node infiltration (*P* value < 0.001). These findings are in accordance with Moore et al. [26], who reported high probabilities of extensive axillary involvement in the presence of morphological changes such as absence of hilum and/or extracapsular extension. Some studies revealed that absence of the hilum, making the lymph node completely hypoechogenic, is the most specific alteration for prediction of metastatic disease [21, 23].

In our study, CT examination was superior on ultrasound in the determination of the level of lymph node affection and thus changes the nodal staging. Level III and supraclavicular lymph nodes were depicted in 10/150 (6.7%) cases by CT examination compared to 5/150 (3.3%) cases depicted by ultrasound examination, and this may be attributed to the dependency of ultrasound on operator experience. This was in agreement with what stated by Groheux et al. [27] regarding the superiority of CT in detecting supraclavicular LN infiltration.

There are few limitations in this study. First, the small sample size, as we included only those who performed both imaging modalities and excluded those who received neoadjuvant therapy. Second, the different level of operator expertise performing the ultrasound examination which might affect the interpretation despite being analyzed by an experienced reader. Third, the consideration of indeterminate and pathological lymph node as one group with resultant low specificity despite the subtle abnormalities that may be associated with indeterminate lymph nodes category.

Conclusions

We concluded in this study that the depiction of irregular lymph node shape, focal cortical thickening, focal indentation, or loss of the fatty hilum by both modalities were independent predicting factors of nodal metastasis in breast cancer patients. Ultrasound is a valuable tool in assessing positive LN infiltration among breast cancer patients. However, the relative low specificity still necessitates histopathological correlation. CT, if used in proper clinical setting, may increase our confidence in excluding nodal metastasis owing to its high sensitivity. Despite its low specificity, it may act as road map for the surgeon, providing the ability to assess all groups of lymph nodes as well as the number of the suspicious lymph nodes.

Abbreviations
ALND: Axillary lymph node dissection; SLNB: Sentinel lymph node biopsy; US: Ultrasound; CT: Computed tomography; NACT: Neoadjuvant chemotherapy; MDCT: Multi-detector CT; IDC: Invasive duct carcinoma.; ILC: Invasive lobular carcinoma.; DCIS: Ductal carcinoma in situ; FNAC: Fine needle aspiration cytology.

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None.

Author contributions
RWA designed the work. SF wrote the manuscript and was responsible for correspondence to journal. HMS helped in writing the manuscript and worked with SIS on data collection and interpretation. RWA and SF contributed in reviewing the manuscript and interpretation. All authors have read and approved the final manuscript.

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Availability of data and materials
All are available with the authors upon request.

Declarations

Ethics approval and consent to participate
The protocol was reviewed and approved by the Ethics Committee of Cairo University.

Consent for publication
A written consent for publication was obtained for these cases.

Competing interests
The authors declare that they have no competing interests.

Author details
[1]Radiology Department, Cairo University, Cairo, Egypt. [2]Baheya Center for Early Detection and Treatment of Breast Cancer, Giza, Egypt.

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