Role of Sonographic Elastography in the Differential Diagnosis of Axillary Lymph Nodes in Breast Cancer

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Objectives—The purpose of this study was to evaluate the diagnostic utility of sonographic elastography in differentiating reactive and metastatic axillary lymph nodes in breast cancer.

Methods—A total of 64 lymph nodes (reactive, n = 33; metastatic, n = 31) from 62 patients with breast cancer were examined by both B-mode sonography and elastography from April to July 2009. Two experienced radiologists retrospectively assessed B-mode sonograms by the sum of scores for 4 criteria: short diameter, shape, hilum, and cortical thickening. Elastographic images were given scores of 1 to 4 according to the percentage of high-elasticity areas in the lymph nodes. We compared the diagnostic performance of B-mode sonography, elastography, and combined examinations. We also calculated the strain ratio of the lymph node and subcutaneous fat tissue.

Results—The elasticity score for malignant lymph nodes (mean, 3.1) was higher than the score for benign lymph nodes (mean, 2.2; \( P < .0001 \)). With a cutoff between elasticity scores of 2 and 3, elastography showed 80.7% sensitivity, 66.7% specificity, and 73.4% accuracy. With a cutoff between B-mode sonographic scores of 1 and 2, B-mode sonography showed 74.2% sensitivity and 78.8% specificity. Combined B-mode and elastographic sonography showed higher sensitivity (87.1%) than B-mode sonography alone. With a strain ratio cutoff point of 2.3, sensitivity was 82.8%, and specificity was 56.3%.

Conclusions—Sonographic elastography may increase the sensitivity of B-mode sonography in the detection of metastatic axillary lymph nodes.

Key Words—axillary lymph node; breast cancer; elastography; metastasis

Axillary lymph node status is the most important prognostic factor in breast cancer.\(^1\) The presence of nodal metastases decreases 5-year survival by approximately 40% compared to node-negative patients.\(^2\) Sentinel lymph node biopsy has replaced axillary lymph node dissection in patients with a low risk of axillary nodal metastases because of decreased morbidity.\(^3\)–\(^7\) Sentinel lymph node status is a representative indicator for the entire lymph node basin. However, false-negative results of sentinel lymph node biopsy have been found.\(^8\)–\(^9\)

Noninvasive imaging techniques have been used to predict the preoperative axillary lymph node status. Sonography has higher diagnostic accuracy than mammography, computed tomography, magnetic resonance imaging, and positron emission tomography—
Sonographic elastography is a method for visualizing the elasticity characteristics of a lesion. It has been used to examine several organs, such as the liver, thyroid, prostate, and pancreas.\textsuperscript{23–26} It has been reported to be helpful in the differential diagnosis of metastasis in cervical and inguinal lymph nodes.\textsuperscript{27–29} To our knowledge, there are no reports regarding the use of sonographic elastography in the evaluation of metastatic axillary lymph nodes in patients with breast cancer. The purpose of this study was to evaluate the diagnostic utility of B-mode sonography and sonographic elastography in differentiating reactive from metastatic axillary lymph nodes in patients with breast cancer.

**Materials and Methods**

**Patients**

This retrospective study was approved by our Institutional Review Board. The requirement for informed consent was waived. From April to July 2009, 70 breast cancer patients with 75 axillary lymph nodes underwent axillary B-mode sonography and sonographic elastography. The histologic diagnosis was used as the reference standard. Among these 70 patients with 75 axillary lymph nodes, 11 axillary lymph nodes were excluded for the following reasons: the patients underwent preoperative chemotherapy and/or radiotherapy (n = 4); the patients were lost to follow-up (n = 2); node-to-node analysis was not possible (n = 1); the time between sonographic and histologic examinations was greater than 3 weeks (n = 3); and histopathologic results were unsatisfactory (n = 1).

A total of 64 axillary lymph nodes in 62 patients with breast cancer were included in our study. The mean age of the patients was 53 years (range, 27–81 years). Eighteen axillary lymph nodes were palpated on physical examination, and 46 were not palpated. A total of 47 patients had a new diagnosis of breast cancer. Fifteen patients had undergone surgery for breast cancer: 11 modified radical mastectomy, 2 simple mastectomy, and 2 breast-conserving surgery with sentinel node biopsy. Twelve of 64 axillary lymph nodes were located at the prior axillary lymph node dissection area. Sixty patients had 1 axillary lymph node on the same side of breast cancer; 1 patient had 2 axillary lymph nodes ipsilaterally; and 1 patient had 2 axillary lymph nodes bilaterally.

**Pathologic Analysis**

Sonographically guided biopsy was performed in 51 axillary lymph nodes from 50 patients: 18-gauge core biopsy (n = 44), 14-gauge core biopsy (n = 1), and fine-needle aspiration biopsy (n = 5). Surgery was performed in 34 axillary lymph nodes from 33 patients: axillary lymph node dissection (n = 17), sentinel lymph node biopsy (n = 14), and excision (n = 2). Surgery was performed by 3 breast surgeons. On the basis of the physical examination and radiologic findings, surgeons generally removed between 5 and 40 nodes during the axillary lymph node dissection. The sentinel lymph node was identified by use of a radioisotope injection. On average, approximately 1 to 3 lymph nodes are removed during this operation. The sentinel lymph node underwent serial sectioning at pathologic examination with hematoxylin-eosin staining.

All 29 metastatic lymph nodes on sonographically guided biopsy were referred for surgery (n = 10) or chemotherapy (n = 19). Of the 22 reactive lymph nodes on sonographically guided biopsy, 10 were referred for surgery because of discordant sonographic findings or clinician or patient request. The remaining 12 lymph nodes had sonographic follow-up for 9 to 12 months. Thirteen lymph nodes underwent axillary lymph node dissection (n = 6) or sentinel lymph node biopsy (n = 7) without sonographically guided biopsy.

Among 20 axillary lymph nodes examined by both biopsy and surgery, 1 lymph node revealed discordant histologic results between core biopsy and axillary lymph node dissection. The histologic result was reactive hyperplasia on 18-gauge core biopsy and metastasis on axillary lymph node dissection. Because this patient had only 1 suspicious axillary lymph node on sonography and magnetic resonance imaging, we concluded that it was due to underestimation of the core biopsy. We used preoperative skin marking and compared the size on imaging findings with the size on histologic findings to perform node-to-node analysis.

The histologic types of breast cancer in the 62 patients included invasive ductal carcinoma (n = 51), invasive lobular carcinoma (n = 3), medullary carcinoma (n = 1), metaplastic carcinoma (n = 1), ductal carcinoma (n = 2), pure ductal carcinoma in situ (n = 1), and unknown (n = 3).

**Image Acquisition and Analysis**

Sonographic elastography and B-mode sonography were performed with the use of an EUP-L53 7.5- to 13-MHz linear transducer and an EUB-850 scanner (Hitachi Medical Corporation, Tokyo, Japan) by 1 of 4 radiologists with 1 to 6 years of experience. The elastographic study was per-
formed with the patient lying in the same position used for conventional breast sonography. The patient elevated the affected arm and lifted the affected thorax. After identification of the most suspicious axillary lymph node on B-mode sonography, elastographic images of the lymph node were obtained with continuous manual compression. To even compression of the target axillary lymph node, we set the region of interest to exclude pectoralis muscles and axillary vessels. We applied the probe with only light pressure, perpendicular to the skin. Real-time elastographic images were then saved as video files for later review. Two of the 4 radiologists analyzed the B-mode sonographic and elastographic images by consensus to eliminate reader variability. The readers were blinded to pathologic results.

**B-Mode Sonography**

B-mode sonograms of 64 axillary lymph nodes were assessed by 4 criteria: short-axis diameter, long- to short-axis diameter ratio, presence of the hilum, and shape of the cortex. The cortex was defined as thick when the maximal thickness was more than half of the transverse diameter of the hilum in the longitudinal plane. When the cortex was markedly thickened to effacement of the hilum, we could not evaluate the thickness and shape of the cortex (not available).

B-mode scores were determined as the sum of the 4 criteria: short-axis diameter (<7.0 mm, score 0; ≥7.0 mm, score 1), long- to short-axis diameter ratio (<2.0, score 0; ≥2.0, score 1), hilum (present, score 0; absent, score 1), and cortical thickening (thin or concentric thickening, score 0; eccentric thickening or not available, score 1). We classified the lymph nodes without a fatty hilum as having positive scores for the hilum and cortical thickening criteria.

**Elastography**

Elastographic images were given 1 of 4 elasticity scores based on the percentage and distribution of the lymph node areas with high elasticity (blue area): score 1, absent or very small blue area; score 2, blue area less than 45% of the lymph node; score 3, blue area 45% of the lymph node or greater; and score 4, blue area with or without a green rim (Table 1 and Figure 1).

**Table 1. Elasticity Scoring System for Axillary Lymph Nodes**

<table>
<thead>
<tr>
<th>Elasticity Score</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Absent or very small blue area</td>
</tr>
<tr>
<td>2</td>
<td>Small, scattered blue areas, total blue area &lt;45%</td>
</tr>
<tr>
<td>3</td>
<td>Large blue area, total blue area ≥45%</td>
</tr>
<tr>
<td>4</td>
<td>Blue area with or without a green rim</td>
</tr>
</tbody>
</table>

The strain ratio was measured in 61 lymph nodes and was not measured in 3 lymph nodes. It was measured on a representative static image including coupled B-mode and elastographic images. The region of interest for the axillary lymph node (A) was manually drawn in the thickened cortex or in the whole lymph node including the cortex and hilum. The region of interest for reference (B) was drawn in the subcutaneous fat tissue of the coupled elastographic image. The strain ratio was automatically calculated by the ultrasound scanner.

**Combination of B-Mode Sonography and Elastography**

B-mode and elasticity scores were assessed separately and randomly. For assessment of combined B-mode sonography and elastography, we considered the combined finding as a malignancy if any scores were above the best cutoffs.
Combined findings were benign when both B-mode and elasticity scores were lower than the best cutoffs. The best cutoffs of B-mode and elasticity scores were calculated by receiver operating characteristic curve analysis. To summarize the diagnostic performances of B-mode sonography, elastography, and the combined method, area under the receiver operating characteristic curve ($A_z$) values were calculated.

**Statistical Analysis**
To identify statistically significant differences between mean values, we used a 2-tailed Student $t$ test or Wilcoxon rank sum test. $P < .05$ was considered statistically significant. All standard calculations for the sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and receiver operating characteristic curve analysis were performed. The $A_z$ values were calculated and compared for the 3 methods. Statistically significant differences between $A_z$ values are reported as 95% confidence intervals. Statistical analysis was performed using SAS version 9.1 software (SAS Institute Inc, Cary, NC).

**Results**
Of a total of 64 axillary lymph nodes, 33 (52%) were reactive, and 31 (48%) were metastatic.

**B-Mode Sonography**
The short-axis diameter for metastatic axillary lymph nodes (mean ± SD, 11.3 ± 6.4 mm) was significantly larger than the diameter for reactive axillary lymph nodes (5.1 ± 1.6 mm; $P < .001$). No difference was found in the mean long-to-short-axis diameter ratios between reactive and metastatic lymph nodes ($P = .286$). Absence of the hilum and eccentric cortical thickening were associated with metastatic lymph nodes ($P = .004$ and .012, respectively). The sensitivity, specificity, PPV, and NPV of each B-mode criterion are summarized in Table 2.

The B-mode score for metastatic lymph nodes (2.6 ± 1.4) was significantly higher than the score for reactive lymph nodes (1.0 ± 0.9; $P < .001$). The different distributions of B-mode scores for reactive and metastatic lymph nodes are presented in Table 3. When the best B-mode score cutoff was between 1 and 2, the sensitivity, specificity, PPV, NPV, and accuracy were 74.2% (23 of 31), 78.8% (26 of 33), 76.7% (23 of 30), 76.5% (26 of 34), and 76.6% (49 of 64), respectively.

**Elastography**
The elasticity score for metastatic axillary lymph nodes (3.1 ± 0.7) was significantly higher than the score for reactive axillary lymph nodes (2.2 ± 0.7; $P < .001$). The rates of metastasis according to the elasticity scores were 25% (6 of 24) for score 2, 62% (16 of 26) for score 3, and 90% (9 of 10) for score 4. No metastatic node had an elasticity score of 1. The different distributions of elasticity scores for reactive and metastatic lymph nodes are presented in Table 3. When the best elasticity score cutoff was between 2 and 3, the sensitivity, specificity, PPV, NPV, and accuracy were 80.7% (25 of 31), 66.7% (22 of 33), 69.4% (25 of 36), 78.6% (22 of 28), and 73.4% (47 of 64), respectively (Table 4).

### Table 2. Diagnostic Values of B-Mode Sonographic Features for Identifying Metastatic Axillary Lymph Nodes

<table>
<thead>
<tr>
<th>Feature</th>
<th>Reactive LN (n = 33)</th>
<th>Metastatic LN (n = 31)</th>
<th>SN, %</th>
<th>SP, %</th>
<th>PPV, %</th>
<th>NPV, %</th>
<th>Accuracy, %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Short-axis diameter</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean ± SD, mm</td>
<td>5.1 ± 1.6</td>
<td>11.3 ± 6.4</td>
<td>74.2</td>
<td>90.9</td>
<td>88.5</td>
<td>79.0</td>
<td>82.8</td>
</tr>
<tr>
<td>&lt;70 mm, n (%)</td>
<td>30 (90.9)</td>
<td>8 (25.8)</td>
<td></td>
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<td></td>
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<td></td>
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<tr>
<td>≥70 mm, n (%)</td>
<td>3 (9.1)</td>
<td>23 (74.2)</td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Long/short-axis ratio</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean ± SD</td>
<td>2.1 ± 0.6</td>
<td>1.9 ± 0.5</td>
<td>64.5</td>
<td>39.4</td>
<td>50.0</td>
<td>54.2</td>
<td>51.6</td>
</tr>
<tr>
<td>≥2.0, n (%)</td>
<td>13 (39.4)</td>
<td>11 (35.5)</td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>&lt;2.0, n (%)</td>
<td>20 (60.6)</td>
<td>20 (64.5)</td>
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<td></td>
<td></td>
<td></td>
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<tr>
<td>Hilum</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Present, n (%)</td>
<td>28 (84.8)</td>
<td>16 (51.6)</td>
<td>48.4</td>
<td>84.9</td>
<td>75.0</td>
<td>63.6</td>
<td>672</td>
</tr>
<tr>
<td>Absent, n (%)</td>
<td>5 (15.2)</td>
<td>15 (48.4)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cortical thickening</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Thin, concentric, n (%)</td>
<td>27 (81.8)</td>
<td>8 (25.8)</td>
<td>25.8</td>
<td>970</td>
<td>88.9</td>
<td>58.2</td>
<td>62.5</td>
</tr>
<tr>
<td>Eccentric, n (%)</td>
<td>1 (3.0)</td>
<td>8 (25.8)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Not available, n (%)</td>
<td>5 (15.2)</td>
<td>15 (48.4)</td>
<td></td>
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</tbody>
</table>

LN indicates lymph node; NPV, negative predictive value; PPV, positive predictive value; SN, sensitivity; and SP, specificity.
The strain ratio ranged from 0.49 to 46.55. The strain ratio for metastatic axillary lymph nodes (7.1 ± 9.0) was significantly higher than the ratio for reactive axillary lymph nodes (3.5 ± 3.9; \( P = .007 \)). No significant difference was found in the strain ratios of fat between reactive (0.5 ± 0.3) and metastatic (0.5 ± 0.3) nodes. With the best strain ratio cutoff of 2.3, the sensitivity, specificity, PPV, NPV, and accuracy were 82.8%, 56.3%, 61.5%, 77.3%, and 67.2%, respectively (Table 4).

### Combination of B-Mode Sonography and Elastography

The diagnostic performances of B-mode sonography alone, elastography alone, and combined B-mode sonography and elastography are summarized in Table 5. The sensitivity of combined sonography and elastography was higher than the sensitivity of B-mode sonography and elastography alone. Four axillary lymph nodes with benign findings on B-mode sonography and malignant findings on combined sonography and elastography were confirmed to metastatic lymph nodes (Figure 2). The elasticity scores of these lymph nodes were 3 in all cases, and the B-mode scores were 0 in 1 and 1 in the others.

The \( A_z \) values were 0.807 (95% confidence interval, 0.690–0.895) for B-mode sonography, 0.784 (0.664–0.877) for elastography, and 0.708 (0.581–0.815) for the combined method. There were no significance differences in \( A_z \) values between the 3 methods (\( P = .696 \) between B-mode sonography and elastography; \( P = .06 \) between B-mode sonography and the combined method; and \( P = .058 \) between elastography and the combined method; Figure 3).

### Discussion

Sonography is frequently used in the evaluation of breast cancer and axillary lymph nodes. Useful sonographic features in the detection of axillary metastases have been described previously. B-mode features include asymmetric cortical thickening, absence of a fatty hilum, and a low long-to-short-axis diameter ratio.\(^{14–20}\) A major Doppler sono-
graphic feature is peripheral blood flow.\(^{17,18,30,31}\) However, there are no standardized B-mode criteria for axillary node metastasis. The sensitivity of B-mode sonography is reported to be approximately 45% to 52.\(^{11,12}\)

In our results, the short-axis diameter was the most sensitive and eccentric cortical thickening the most specific for the detection of axillary lymph node metastases. The sensitivity of B-mode sonography is reported to be approximately 45% to 52.\(^{11,12}\)

Choi et al\(^{14}\) reported that the long-axis diameter was the most sensitive for predicting node metastasis, whereas Abe et al\(^{32}\) reported that cortical thickening was the most sen-

### Table 4. Diagnostic Values of Elasticity Scores Versus Strain Ratios at Various Cutoffs

<table>
<thead>
<tr>
<th>Cutoff Point</th>
<th>SN, %</th>
<th>SP, %</th>
<th>PPV, %</th>
<th>NPV, %</th>
<th>Accuracy, %</th>
<th>( A_z )</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Elasticity score</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1/2</td>
<td>100</td>
<td>12.1</td>
<td>51.7</td>
<td>100</td>
<td>54.7</td>
<td>0.784</td>
<td>0.660–0.879</td>
</tr>
<tr>
<td>2/3</td>
<td>80.7</td>
<td>66.7</td>
<td>69.4</td>
<td>78.6</td>
<td>73.4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3/4</td>
<td>29.0</td>
<td>97.0</td>
<td>90.0</td>
<td>59.3</td>
<td>64.1</td>
<td></td>
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<tr>
<td>Strain ratio</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>( &gt;1.3 )</td>
<td>93.1</td>
<td>15.6</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>( &gt;1.8 )</td>
<td>86.2</td>
<td>34.4</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>( &gt;2.3 )</td>
<td>82.8</td>
<td>56.3</td>
<td>61.5</td>
<td>77.3</td>
<td>672</td>
<td>0.702</td>
<td>0.571–0.812</td>
</tr>
<tr>
<td>( &gt;2.8 )</td>
<td>72.4</td>
<td>65.6</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>( &gt;3.3 )</td>
<td>55.2</td>
<td>71.9</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>( &gt;4.3 )</td>
<td>48.3</td>
<td>84.4</td>
<td></td>
<td></td>
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<td></td>
<td></td>
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<tr>
<td>( &gt;5.0 )</td>
<td>41.4</td>
<td>90.6</td>
<td></td>
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</tbody>
</table>

\( A_z \) indicates area under the receiver operating characteristic curve; CI, confidence interval; NPV, negative predictive value; PPV, positive predictive value; SN, sensitivity; and SP, specificity.
Our results indicate lower sensitivity for cortical thickening. This difference probably occurred because we considered concentric cortical thickening as a benign rather than suspicious finding. Our short-axis diameter and long-to-short-axis diameter ratio cutoffs were 6.9 mm and 2.0, respectively. These results are similar to results from previous studies. \textsuperscript{14,17} Choi et al\textsuperscript{14} suggested that the best short-axis diameter cutoff was 7.1 mm; therefore, we selected 7.0 mm as the cutoff point for the short-axis diameter.

In our study, B-mode scores showed a significant difference between reactive and metastatic axillary lymph nodes; 74.2\% of metastatic nodes (23 of 31) showed B-mode scores of 2 to 4, whereas 78.8\% of reactive lymph nodes (26 of 33) showed B-mode scores of 0 and 1.

The elasticity scoring system in breast lesions was introduced by Itoh et al.\textsuperscript{33} Several studies have shown that elastography using this 5-point scoring system is useful for differentiating benign and malignant breast lesions.\textsuperscript{34–36} For elastographic assessment of cervical lymph node metastasis, Lyshchik et al\textsuperscript{28} used a 4-point scale including lymph node visibility, relative brightness, margin regularity, and margin definition. Alam et al\textsuperscript{27} used a 5-point color scoring system based on the distribution and percentage of a cervical lymph node area with high elasticity (blue). To our knowledge, no study of the elastographic assessment of axillary lymph nodes has been reported. We adopted and modified the 5-point color scoring system of Alam et al.\textsuperscript{27} Because no necrotic axillary lymph nodes were included in our study, we excluded the central necrosis score and classified axillary lymph nodes using 4-point color scores.

Our results suggest that there was a significant difference in elasticity scores between reactive and metastatic axillary lymph nodes. An elasticity score between 2 and 3 was the optimal cutoff for differentiating between metastastic.

Table 5. Diagnostic Performances of B-Mode Sonography, Elastography, and the Combined Method in 64 Axillary Lymph Nodes

<table>
<thead>
<tr>
<th>Method</th>
<th>SN, %</th>
<th>SP, %</th>
<th>PPV, %</th>
<th>NPV, %</th>
<th>Accuracy, %</th>
</tr>
</thead>
<tbody>
<tr>
<td>B-mode</td>
<td>74.2</td>
<td>78.8</td>
<td>76.7</td>
<td>76.5</td>
<td>76.6</td>
</tr>
<tr>
<td>Elastography</td>
<td>80.7</td>
<td>66.7</td>
<td>69.4</td>
<td>78.6</td>
<td>73.4</td>
</tr>
<tr>
<td>Combined</td>
<td>87.1</td>
<td>54.6</td>
<td>64.3</td>
<td>81.8</td>
<td>70.3</td>
</tr>
</tbody>
</table>

NPV indicates negative predictive value; PPV, positive predictive value; SN, sensitivity; and SP, specificity.

Figure 2. Metastatic axillary lymph node with a B-mode score of 1 and an elasticity score of 3 in a 57-year-old patient with breast cancer.\textsuperscript{A} B-mode sonography shows concentric cortical thickening and a preserved hilum in the lymph node. The short-axis diameter and long-to-short-axis diameter ratio of the lymph node were 8 mm and 2.4, respectively.\textsuperscript{B} Elastography shows a large blue area in the thickened cortex. A indicates the region of interest for the axillary lymph node; and B, region of interest for reference.

Figure 3. Receiver operating characteristic curves for B-mode sonography, elastography, and the combined method. The area under the receiver operating characteristic curve values were almost the same for B-mode sonography, elastography, and the combined method (0.807, 0.784, and 0.708, respectively; \( P = .696 \) between B-mode sonography and elastography, \( P = .06 \) between B-mode sonography and the combined method, and \( P = .058 \) between elastography and the combined method).
tic and reactive lymph nodes. We found that 80.6% of metastatic nodes (25 of 31) had an elasticity score of 3 or 4, and 66.7% of reactive nodes (22 of 33) had an elasticity score of 1 or 2.

The strain ratio, a semiquantitative measurement, is defined as the proportion of strain between target and reference tissue. A few studies have shown that the strain ratio is useful for differentiating benign and malignant lesions in breast masses and cervical lymph nodes. Although there is controversy over selection of the reference, fat tissue has been used in previous studies evaluating breast masses. In our study, using fat tissue as reference, a strain ratio of greater than 2.3 was useful for distinguishing metastatic axillary lymph nodes. However, further studies will be required to verify the reference tissue and reproducibility of the strain ratio.

The diagnostic performance of elastography was comparable to the performance of B-mode sonography. Combined B-mode sonography and elastography improved the sensitivity of axillary node metastasis detection in breast cancer.

This study had some limitations. First, we made an effort to perform node-to-node correlation using the sizes from pathologic and radiologic findings. We considered findings of other image modalities, such as magnetic resonance imaging and positron emission tomography. We also examined sonograms for the most representative lymph node. Further study for precise node-to-node correlation will be needed.

We did not consider underestimation of the pathologic results in 12 reactive axillary lymph nodes confirmed only by biopsy. However, they showed no suspicious findings on sonography and no changes on follow-up sonography.

Tissue compression can influence elastographic images. Extensive experience may be needed to obtain reproducible results. To obtain optimal elastographic images, we applied light compression and excluded pectoralis muscles and axillary vessels from the elastographic examination field. Finally, interobserver variability in the interpretation of elasticity scores was not considered. However, we adopted a consensus evaluation for all elastographic findings.

Sonographic elastography is helpful for differentiating reactive and metastatic axillary lymph nodes in breast cancer. Combined B-mode sonographic and elastographic evaluation improved the sensitivity of axillary node metastasis detection.

References


