The sonographic appearances of benign (normal and reactive) and malignant (metastatic and lymphomatous) lymph nodes can be explained by an understanding of normal nodal anatomy and nodal pathophysiology. In this article, we review the sonographic features of benign and malignant regional (axillary, infraclavicular, internal mammary, and supraclavicular) lymph nodes. As axillary lymph nodes are those most frequently involved in patients with breast cancer, this review focuses mainly on axillary lymph nodes.

NORMAL NODAL ANATOMY

Lymph nodes are vital immunologic organs distributed widely throughout the body and linked by lymphatic vessels. Lymph nodes are usually small and bean-shaped, and range from a few millimeters to 1 to 2 cm in size. B, T, and other immune cells are stored in and circulate through these lymph nodes, which act as filters for foreign particles. Humans have approximately 500 to 600 lymph nodes, with clusters found in the axillae, groin, neck, chest, and abdomen.1

A single lymph node consists of multiple lymphoid lobules surrounded by lymph-filled sinuses and enclosed by a capsule. The smallest lymph nodes may contain only a few lobules whereas large lymph nodes contain many lobules. Lobules within the same lymph node may have different levels of immunologic stimulation and activity; therefore, the lobules will not necessarily have a uniform appearance.2 There are 3 parts to each lobule: the cortex, the paracortex, and the medulla. The cortex and the paracortex are also sometimes referred to as the superficial cortex and the deep cortex, respectively. The paracortex consists of deep cortical units (DCUs), and each DCU can in turn be anatomically and functionally divided into a central DCU and a surrounding peripheral DCU. Subcompartmentalization of the lobule creates separate areas for T and B cells to interact with their antigen-presenting cells (APCs), and to undergo clonal expansion during times of infection and/or disease.2

A single afferent lymphatic vessel delivers a constant stream of lymph to the subcapsular sinus over each lobule. Lymph spreads through the subcapsular sinus at the top of the lobule and flows down the sides of the lobule through the transverse sinuses, and into the medullary sinuses. The medullary sinuses converge at the hilum, and lymph then leaves the lymph node through a single efferent lymphatic vessel.2

The space between the lobules of a lymph node is filled with a reticular meshwork made of a delicate, porous, sponge-like tissue. This tissue forms the framework of the lobules and criss-crosses the lumens of the sinuses. The reticular meshwork

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inside the lobules, called the lobular reticular meshwork, is composed of stellate fibroblastic reticular cells (FRCs) whose processes subdivide the lobule into innumerable narrow channels that are occupied by lymphocytes, macrophages, and APCs. High-resolution ultrasonography allows for clear differentiation of the central echogenic hilum and the peripheral concentric hypoechoic cortex. The hypoechoic cortex, representing the marginal sinus, lymphoid follicles, and paracortex, is thin and has a fusiform shape with smooth edges, while the hyperechoic hilum is attributable to multiple reflective interfaces of blood vessels, fat, and the central sinus (Fig. 1).3,4

**PATHOPHYSIOLOGY**

Lymph arrives via the afferent lymphatics, and filters from the subcapsular/marginal sinus through the cortex and paracortex, via the trabecular sinuses, to the hilum. In inflammatory disease, the diffuse nature of the process is more likely to preserve the nodal shape and the echogenic hilum.3,5,6 In malignant disease, carcinoma enters the lymph node via the afferent lymphatics, penetrates the capsule, and enters the subcapsular sinus.6,7 Metastatic disease is arrested in the periphery of the nodes, causing cortical enlargement, which may be eccentric. Consequently, a cortical bulge often precedes generalized cortical enlargement and distortion or destruction of the intranodal architecture, with loss of the hilum. However, microscopic tumor deposits may not cause changes in lymph node morphology, and consequently may be invisible sonographically. In addition, some gross morphologic features seen in malignant nodes may be observed in benign hypertrophic inflammatory nodes.

Sonographic features that have been used to characterize lymph nodes as benign or malignant include size, shape, presence or absence of an echogenic hilum, cortical morphology, echogenicity, nodal border, calcification, cystic change/necrosis, and vascular patterns. There is, however, no one morphologic feature that is specific for malignancy or benignity, although there are combinations of sonographic features (lymph node patterns) that are suggestive of malignancy or benignity, and that may help in determining whether a biopsy should be performed.

**Presence of Lymph Nodes**

In early reports, the identification of axillary lymph nodes was considered to represent enlargement and therefore metastatic disease.8–10 With modern high-resolution ultrasonography, lymph nodes are identified in all patients. Women with and without breast cancer have benign axillary lymph nodes.11,12 Therefore, the mere presence of axillary lymph nodes does not indicate malignancy.

**Size**

Size cannot be used as the sole criterion in differentiating benign (normal and reactive) from malignant (metastatic or lymphomatous) lymph nodes (Fig. 2).3,13–17 Microscopic metastatic deposits in axillary lymph nodes, beyond the resolution of existing imaging technology, occur in 9% of patients11 and therefore it is unlikely that any imaging technique will have a sensitivity greater than 91%. While larger nodes have a higher incidence of malignancy (80% positive predictive value [PPV] if the long axis is >2 cm), reactive nodes can be large and malignant nodes can be small. There is a significant overlap in size between benign (Fig. 3) and malignant lymph nodes, and attempting to differentiate based solely on maximal size is unreliable. There is less overlap using short axis rather than long axis dimensions (90% PPV if short axis is >1 cm).15,18,19 Using a smaller cutoff value can

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**Fig. 1.** Normal axillary lymph node anatomy.

**Fig. 2.** Small (long axis <2 cm and short axis <1 cm) malignant axillary lymph node.
Shape

Malignant lymph nodes, including nodes involved by lymphoma, tend to be round, whereas normal and reactive nodes tend to be oval or elliptical. The degree of roundness is assessed by using the longest-to-shortest axis ratio (L/S). Reported sensitivities for malignancy using an L/S ratio <2 (ie, more rounded) are approximately 85%, with specificities varying from 61% to 85%. The reported average cancer content by volume in lymph nodes with an L/S ratio >2.0 was 26%, compared with 59.1% in lymph nodes with an L/S ratio <2.0. Malignant lymph nodes are, however, frequently oval.

Echogenic Hilum

Previously, the presence or absence of a central echogenic hilum had been proposed as a reliable indicator of benignity or malignancy. While the absence of a hilum is very suggestive of malignancy, the presence of a hilum does not necessarily imply benignity. The hilum may be absent in 14% of normal lymph nodes, and up to 30% of malignant lymph nodes may retain their hilum. As tumor infiltrates the hilum there is loss of the normal echogenicity, resulting in apparent narrowing (hilar compression), hilar displacement (the hilum, rather than lying in the center of the node, lies to one side of the node in at least one plane), and subsequent disappearance of the central hilum. In some benign lymph nodes, the node is largely replaced by a hyperechoic hilum with no visible cortex demonstrable. The lymph nodes of older patients or patients on chemotherapy may be small and have an isoechoic or a hyperechoic appearance.

Cortical Morphology

The appearances of the hilum and cortex must be interpreted together. Concurrent changes in the shape of the central echogenic hilum and the peripheral concentric hypoechoic cortex may suggest the presence of nodal disease even in the absence of nodal enlargement. The normal cortical rim measures 1 to 2 mm. Neoplastic involvement of the cortex may not affect the cortical echogenicity, but may result in concentric or eccentric cortical widening. Malignant lymph nodes may demonstrate cortical thickening with or without hilar displacement.

Fig. 3. Large (long axis >2 cm) benign axillary lymph node.

Fig. 4. Rounded and oval malignant axillary lymph nodes.

Fig. 5. Malignant axillary lymph node. A rounded (L/S ratio <2), hypoechoic (no visible hilum), 1.5-cm (short axis >1 cm) lymph node. This combination of sonographic features is highly suggestive of malignancy.
as suggestive of malignancy.\textsuperscript{13} It has also been reported that eccentric cortical widening occurs only in malignancy,\textsuperscript{3} and that focal doubling of the cortical rim thickness is specific for malignancy. Eccentric cortical widening may be due to focal nodular areas of intranodal metastatic disease.\textsuperscript{23} Other studies have used differing cortical thickness cutoff values (3 mm, 4 mm, 5 mm, and 6 mm) with the usual trade-off of decreasing specificity with increasing sensitivity and vice versa. Although a lymph node with a narrow or concentrically wide cortex is generally felt to be benign, there are reports of concentric widening in malignant lymph nodes.\textsuperscript{5}

\textbf{Echogenicity}

There have been several reports looking at the internal echo patterns in lymph nodes. Benign nodes are typically reported as being homogeneous, whereas malignant lymph nodes are typically heterogeneous and hypoechoic (Fig. 10).\textsuperscript{11,19,26,28–31} However, malignant nodes may be homogeneous\textsuperscript{17,26,28} and benign lymph nodes may be hypoechoic.\textsuperscript{19} Alterations in echogenicity in benign nodes may be due to infection or hemorrhage, and these findings may be mistaken for metastatic disease.\textsuperscript{29} Hyperechoic nodes are

\textbf{Fig. 6.} Benign axillary lymph node. A small oval lymph node (long axis <2 cm, short axis <1 cm) with a thin cortex (<3 mm) and a central hilum (no compression or displacement). This combination of sonographic features is highly suggestive of benignity.

\textbf{Fig. 7.} Malignant axillary lymph node. A small lymph node (long axis <2 cm, short axis >1 cm) with an asymmetrically thickened (>3 mm) cortex with hilar displacement (although no hilar compression). This combination of sonographic features is suggestive of malignancy.

\textbf{Fig. 8.} Malignant axillary lymph node. A small lymph node (long axis <2 cm, short axis >1 cm) with an asymmetrically thickened (>3 mm) cortex with hilar compression (although no hilar displacement). This combination of sonographic features is suggestive of malignancy.

\textbf{Fig. 9.} Malignant axillary lymph node. A small lymph node (long axis <2 cm, short axis >1 cm) with an asymmetrically thickened (>3 mm) cortex with hilar compression and hilar displacement. This combination of sonographic features is suggestive of malignancy.
typically believed to be inflammatory, although focal hyperechoic areas can be seen in malignant nodes. Lymphomatous nodes may demonstrate a pseudocystic appearance with hypoechogenicity and posterior enhancement (Fig. 11). True cystic change and/or intranodal necrosis is unusual in lymphoma except after treatment. A micronodular pattern has also been reported in lymphoma. Microcalcifications in lymph nodes have been described in the neck in the setting of papillary thyroid cancer. Calcifications in axillary nodes are less commonly reported, but these findings have been reported in treated lymphoma.

**Nodal Borders**

Benign nodes often have indistinct borders whereas malignant nodes tend to have well-defined borders, due to altered echogenicity in the replaced node compared with the surrounding tissue. However, with local infiltration, the borders of malignant lymph nodes may become indistinct. Nodal borders are therefore not reliable predictors of benignity or malignancy.

**Vascular Patterns**

Small nodes (benign or malignant) may have no demonstrable blood flow because the vessels are small, but flow is demonstrated in 90% of nodes measuring greater than 5 mm. In metastatic lymph nodes, angiogenesis factors may stimulate the growth of new vessels with thin walls, leading to high systolic and diastolic flow and abnormal vascular shunting, resulting in abnormal flow patterns and angioarchitecture.

Normal and reactive lymph nodes may be avascular or have only hilar vascularity. Mixed hilar and peripheral vascularity is associated with lymphoma, whereas pure peripheral vascularity is reportedly more suggestive of metastatic disease. Tumor deposits within a lymph node may compress the intranodal vessels, with resultant increased vascular resistance.

Yang and colleagues evaluated the reliability of unenhanced and echo-enhanced color Doppler ultrasonography in distinguishing benign breast masses and axillary lymph nodes from malignant masses and axillary lymph nodes in patients with known breast cancer. Thirty-two enlarged axillary lymph nodes in 32 patients with invasive cancer underwent power Doppler sonography with and without contrast material. Vascular features and contrast material transit times were recorded. The investigators found that the significant predictors of lymph node malignancy were an increase in peripheral vessel number after contrast material administration and duration of enhancement. Yang and colleagues also found that malignant lymph nodes were enhanced more than the corresponding primary breast cancers, whereas benign lymph nodes were enhanced less than the primary breast tumors.

**PATTERNS**

No single sonomorphological feature reliably differentiates benign, reactive, or malignant (metastatic or lymphomatous) lymph nodes. Combinations of features either as nodal patterns or as scoring systems better differentiate benign from malignant nodes.

Mills and colleagues conducted a retrospective study of 653 consecutive patients presenting with mixed histologic types of invasive breast cancer. The investigators performed 232 ultrasound-guided axillary lymph node biopsies, resulting in
a positive diagnosis in 150 cases. The morphologic criteria for metastatic involvement of lymph nodes on ultrasonography were diffuse or focal cortical thickening of more than 2 mm, replacement of the fatty hilum, and abnormal or increased peripheral blood flow. Mills and colleagues found that axillary ultrasound assessment with selected fine-needle aspiration (FNA) or core needle biopsy had a sensitivity of 59%, a specificity of 100%, a PPV of 100%, a negative predictive value (NPV) of 79%, and an accuracy of 84% in the diagnosis of axillary lymph node metastases.

Bedi and colleagues\textsuperscript{38} performed high-resolution in vitro sonography on 171 lymph nodes from 19 axillae in 18 patients with unknown axillary nodal status who underwent axillary lymph node dissection for early invasive breast cancer. Each lymph node was classified into 1 of 6 types based on the cortical morphologic features. Type 1 lymph nodes were hyperechoic with no visible cortex; type 2 had a thin (<3 mm) hypoechoic cortex; type 3 had a hypoechoic cortex thicker than 3 mm; type 4 had a generalized lobulated hypoechoic cortex; type 5 had focal, hypoechoic cortical lobulations; and type 6 had a totally hypoechoic lymph node with no hilum. Types 1 to 4 were considered benign whereas types 5 and 6 were considered metastatic. Interobserver agreement was 77% for classification of nodal morphology (types 1–6) and 88% for characterization of a lymph node as benign or malignant. The NPVs of types 1 to 4 were 100%, 100%, 93%, and 89%, respectively. The PPVs of types 5 and 6 were 29% and 58%, respectively. Sensitivity, specificity, PPV, NPV, and overall accuracy for cortical shape in the prediction of metastatic involvement of axillary lymph nodes were 77%, 80%, 36%, 96%, and 80%, respectively.

Cho and colleagues\textsuperscript{39} prospectively evaluated the role of axillary lymph node classification on sonography in 191 patients. The axillary lymph node that had the thickest cortex was prospectively classified on a scale of 1 to 6 according to the cortical thickness and then removed following sonographically guided needle localization and surgical excision. The rates of malignancy, according to the sonographic classification, were as follows: 2% for grade 1 (cortical thickness <1.5 mm), 6% for grade 2 (cortical thickness >1.5 mm and \(\leq 2.5\) mm), 40% for grade 3 (cortical thickness \(>2.5\) mm and \(\leq 3.5\) mm), 70% for grade 4

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\textbf{Fig. 12.} Lymph node patterns.
(cortical thickness >3.5 mm with an intact fatty hilum), and 90% for grade 5 (cortical thickness >3.5 mm with loss of the fatty hilum). When a cutoff point of a cortical thickness of 2.5 mm was used for determining the presence of malignancy, the sonographic classification showed a sensitivity of 85% (35/41), a specificity of 78% (117/150), an NPV of 95% (117/123), a PPV of 51% (35/68), and an accuracy of 80% (152/191) for the diagnosis of axillary lymph node metastases.

Combining sonographic features such as the presence or absence of a hilum, hilar compression, hilar displacement, smooth or lobulated borders, short axis size, and cortical thickening, it is possible to predict with reasonable accuracy those lymph nodes that are suspicious for malignancy (Fig. 13).

LYMPH NODES AFFECTED BY BREAST CANCER

Axillary, infraclavicular, internal mammary, and supraclavicular lymph nodes are located in close proximity to the breast, and these lymph nodes are the most commonly affected nodes in patients with breast cancer. In addition, intramammary nodes may be involved by breast cancer and by lymphoma.

Metastases from Breast Cancer

When cancer metastasizes, nearby lymph nodes are usually affected earlier than distant lymph nodes. Regarding breast cancer, the malignancy metastasizes first to the nearby axillary lymph nodes then to more distant axillary lymph nodes.40

Thus, metastases to lymph nodes are viewed as indicators of tumor progression. Nodal status is also considered a marker of tumor biology, with node-positive tumors having a worse prognosis than node-negative tumors.40,41 Furthermore, according to studies by Jatoi and colleagues40 and Nouh and colleagues,41 there is a correlation between the number of lymph nodes involved and the aggressiveness of the cancer. The total number of lymph nodes involved is more important than the extent to which the disease has spread within the nodes.42

As breast cancers increase in size, the likelihood of axillary lymph node involvement increases. In a study of 3747 mastectomy specimens by Nouh and colleagues,41 71.6% of T1 (<2 cm) tumors metastasized to lymph nodes, along with 75.4% of T2 (2–5 cm) tumors, and 85% of T3 (>5 cm) tumors. Multiple tumors were almost twice as likely as single tumors to result in lymph node metastases (24.1% vs 12.4%, respectively).

Tumor grade is a measure of the amount of differentiation in the cancer cells of the tumor, with grade 1 being the most differentiated with a better prognosis, and grade 3 being the least differentiated with a worse prognosis. Node positivity showed a marked increase with an increase in tumor grade, as 49.3% of grade 1 tumors were node positive compared with 76.8% of grade 3 tumors.41 A surprising finding in the study by Nouh and colleagues41 was the effect of the laterality of breast cancer on node positivity. Left-sided breast cancer was less prone to cause metastasis to lymph nodes in comparison with right-sided breast cancer. This conclusion may be explained by the more frequent use of the right arm in the predominantly right-handed population.

LYMPHOMA

Lymphoma is the most common type of blood-related malignancy in the United States. Often the first sign of lymphoma (Fig. 14) is lymphadenopathy, or swelling of the lymph nodes. The swelling is initially painless and is usually located in the neck, the axillae, or the groin. There are two major types of lymphoma, namely Hodgkin lymphoma and non-Hodgkin lymphoma, and more than 30 subtypes. Hodgkin lymphoma develops from a specific type of abnormal B cell, whereas non-Hodgkin lymphoma may derive from abnormal B or T cells. Risk factors for lymphoma include chronic infection, immunosuppression, hereditary traits, and autoimmune disease. Autoimmune disease constantly stimulates the immune system, and thus can potentially give rise to irregular cloning of autoimmune cells.
The diagnosis of lymphoma is often based on lymph node biopsy.\textsuperscript{43} The differentiation of metastatic lymph nodes from lymphomatous nodes (Fig. 15) can be difficult. It has been suggested that within the axilla, lymphoma tends to involve all the nodes in a relatively uniform fashion, whereas with carcinoma the lymph node morphology may be different, reflecting differential nodal involvement. With advanced disease, the lymphomatous nodes often become matted together.

**SENTINEL LYMPH NODE BIOPSY**

The sentinel lymph node is the first lymph node or group of nodes that are expected to be affected by breast cancer metastases. Because the spread of cancer usually follows an orderly progression, a negative sentinel lymph node means that it is unlikely that the cancer has spread to any other, more distant nodes. To assess the sentinel lymph nodes, a sentinel lymph node biopsy is performed. Sentinel lymph node biopsy is advantageous, as it decreases the number of axillary lymph node dissections.\textsuperscript{44} Axillary lymph node dissections are more likely to cause postoperative problems such as lymphedema, pain, impaired shoulder mobility, and arm weakness.\textsuperscript{45} Furthermore, by identifying the nodes most likely to contain metastases, more attention can be paid to the specific nodes, and micrometastases will have a higher likelihood of being detected.\textsuperscript{44} In sentinel lymph node mapping, a radioisotope (usually technetium-99m sulfur colloid), a blue dye (isosulfan blue or methylene blue), or both, are injected before the biopsy is performed. These mapping agents aid in the detection of the sentinel lymph nodes. Studies have shown that the use of both mapping agents yields higher sentinel lymph node identification rates when compared with the use of a single agent.\textsuperscript{46} During the procedure, the surgeon uses a gamma probe to detect which nodes have taken up the most radioactive material. These nodes, along with the lymph nodes that have taken up the blue dye, are the sentinel lymph nodes. The pathologist then assesses the sentinel lymph nodes to determine the presence of cancer. Most sentinel lymph nodes are located in the inferior aspect of the axillary region.\textsuperscript{45}

There are also shortcomings to sentinel lymph node biopsy. There may be false-negative results. Also, cancers may drain by alternative pathways, to the internal mammary or infraclavicular lymph nodes.

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**Fig. 14.** Lymphomatous involvement of an internal mammary node. (A) Ultrasonography shows an oval hypoechoic internal mammary lymph node (arrow). (B) Computed tomography (CT) shows the suspicious internal mammary lymph node (arrow) and additional prevascular and paratracheal lymph nodes.

**Fig. 15.** Sonography demonstrates a 20-mm lymphomatous axillary node with a cortical thickness of 7 mm (arrow). The appearance is not specific for lymphoma, and these findings could also represent metastatic disease in a patient with breast cancer.
nodes rather than to the axillary lymph nodes. Increasing patient age also affects lymphatic mapping, as sentinel lymph nodes may be more difficult to identify and appear less frequently in older patients.46

ULTRASONOGRAPHY WITH CONTRAST AGENTS

Recent reports have noted that sentinel lymph nodes may be identified and localized with contrast-enhanced sonography after the injection of microbubbles. Contrast-enhanced ultrasonography is a developing technique that adds the injection of a contrast agent to traditional sonography.47 Most studies have used gas-filled microbubbles, and the contrast agent may be administered by intradermal, subareolar, or intravenous injections. Studies targeting sentinel lymph nodes have been performed with intradermal, peritumoral, and subareolar injections.48–50 The microbubbles have a high degree of echogenicity compared with normal tissue, creating increased contrast in the resulting sonographic images. Lymph node sonography is an area in which the addition of contrast agents may be beneficial, especially regarding identification of sentinel lymph nodes. Contrast-enhanced sonography has the ability to increase the specificity of ultrasound. As ultrasonography with contrast agents advances in the future, its advantages and limitations will be better understood.

PERCUTANEOUS BIOPSY PROCEDURES

In addition to its role in identifying normal and abnormal lymph nodes, sonography plays a major role in guiding biopsies of suspicious lymph nodes. Nearly all biopsies of the regional (axillary, infraclavicular, supraclavicular, and internal mammary) lymph nodes are performed with sonographic guidance. Ultrasound-guided FNA may be performed when adequate cytology support is available. If appropriate cytology support is unavailable, core needle biopsy is suggested. Percutaneous axillary lymph node biopsy determines whether the patient proceeds to sentinel lymph node biopsy or to axillary dissection. Patients with negative ultrasonograms and/or negative ultrasound-guided axillary lymph node biopsies proceed to sentinel lymph node biopsy, while those with metastatic disease documented by percutaneous biopsy will undergo axillary dissection. In addition, patients with proven axillary lymph node involvement will usually be treated with neoadjuvant or adjuvant chemotherapy.

Fine-Needle Aspiration

FNA employs a thin needle (18–25 gauge) to biopsy breast masses and regional lymph nodes. Ultrasonography is used to detect the lymph node in question, and the needle is then inserted into the node and moved in a back-and-forth motion to obtain cellular material under sonoographic guidance. Once the cells are extracted, they are stained and evaluated by a cytologist.

In a study by Kuenen-Boumeester and colleagues,51 ultrasonography combined with ultrasound-guided FNA identified evidence of metastatic disease in 44% (37 of 85) of histologically node-positive patients and in 20% of the patients evaluated in the study. In these cases, cytology identified metastases in the lymph nodes, sparing the patient sentinel lymph node biopsy. In addition, FNA can document extensive metastatic involvement, which may be associated with false-negative sentinel lymph node biopsies.

There is a risk of false-negative axillary lymph node FNAs because the sampling size is small, potentially allowing tumor cells to be missed. Also, FNA may sometimes fail to identify any lymph tissue and instead demonstrate only blood, making the diagnosis inconclusive. In cases where no lymph tissue is obtained, the physician should perform additional passes to retrieve lymphocytes. FNA is particularly useful for sampling deep lymph nodes in the axillary and infraclavicular regions (Fig. 16). FNA is a minimally invasive procedure with a low cost and high specificity. When adequate cytology support is available, FNA is a reliable preoperative staging procedure that can eliminate unnecessary sentinel lymph node biopsies.51

Core Needle Biopsy

Core needle biopsy removes cores of tissue. Core needle biopsy samples are larger than the samples obtained with FNA. The larger samples allow pathologists to evaluate abnormal cells in the context of the surrounding environment. Ultrasound-guided core needle biopsy is considered to be minimally invasive and safe. In a study by Topal and colleagues52 of 39 patients who underwent ultrasonic-guided axillary lymph node biopsy, the sensitivity and the specificity of ultrasound-guided core needle biopsy of axillary lymph nodes were 90% and 100%, respectively. No significant complications were noted in this study other than pain, which responded to analgesics.

Core needle biopsy is considered a good alternative to FNA when adequate cytology support is lacking. FNA is more dependent on operator expertise than is core needle biopsy. Core needle
biopsy, like FNA, can be used to document metastatic disease and to avoid sentinel lymph node biopsy. Core needle biopsy has a higher reproducible success rate in comparison with FNA.45

SUMMARY

In the future, there will be increased emphasis on sonography of the regional lymph nodes in patients with breast cancer. Gray-scale sonography is an efficient, reliable tool in classifying regional lymph nodes. In addition, ultrasound-guided FNA and ultrasound-guided core needle biopsy are safe, quick, reliable, low-cost procedures that can be used to document metastatic involvement. Contrast-enhanced ultrasonography will likely improve clinicians’ ability to classify regional lymph nodes. In addition, contrast-enhanced ultrasonography has the potential to transform sentinel lymph node biopsy into a less invasive procedure.

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