Sonographic Evaluation of the Breast

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Upon completion of this activity, participants should be able to:

- Determine the indications for breast ultrasound.
- Identify structures demonstrated in sonographic evaluation of the normal breast.
- Detect abnormal structures demonstrated in sonographic evaluation of the breast.
- Distinguish benign and malignant characteristics of breast masses.

Who will benefit:

Radiologists, sonographers, physicians, physician assistants, nurses, and referring physicians interested in body imaging will benefit from the information in this educational activity and can receive Continuing Medical Education credit by completing the post-test and evaluation provided.

Breast ultrasound has become the most useful and widely available adjunctive breast imaging evaluation and guidance modality for percutaneous breast biopsy and preoperative localization. Mammography remains the gold standard screening examination, recommended yearly for all women over 40, regardless of risk assessment. Despite the proven benefits of mammography, however, there are limitations in areas of the breast where the tissue is dense or where focal changes in breast architecture appear when compared with previous mammograms. In these cases, targeted breast ultrasound can increase diagnostic accuracy. In cases of palpable lumps, breast ultrasound is always recommended.

Criteria have been established to distinguish benign from malignant characteristics in palpable and nonpalpable breast masses. The Breast Imaging Reporting and Data System for ultrasound, BI-RADS, has been instituted to standardize the criteria for interpretation and reporting.[1] These developments, along with advances in instrumentation, have made the role for breast ultrasound more important and necessary in the breast imaging evaluation. Its use allows more thorough and immediate evaluation of suspected breast abnormalities, which can speed diagnosis.

Ideally, mammographic and sonographic workup, as well as ultrasound-guided biopsy, can occur within a single patient visit. Most important, the use of ultrasound in the evaluation of suspected clinical and mammographic abnormalities can reduce the false-positive rate by demonstrating benign characteristics, thus increasing the specificity of the imaging evaluation and reducing the rate of biopsies for benign lesions.[2-4]

The utility of whole-breast bilateral screening ultrasound is currently under investigation. Several studies have already shown that ultrasound can demonstrate small, nonpalpable, invasive cancers that are not seen on mammography.[5-7] Ultrasound is less sensitive, however, than mammography or MRI in the detection of ductal carcinoma in situ.[2-4] As technology continues to improve and the common practice of breast ultrasound increases, the diagnostic capabilities of breast ultrasound will expand.

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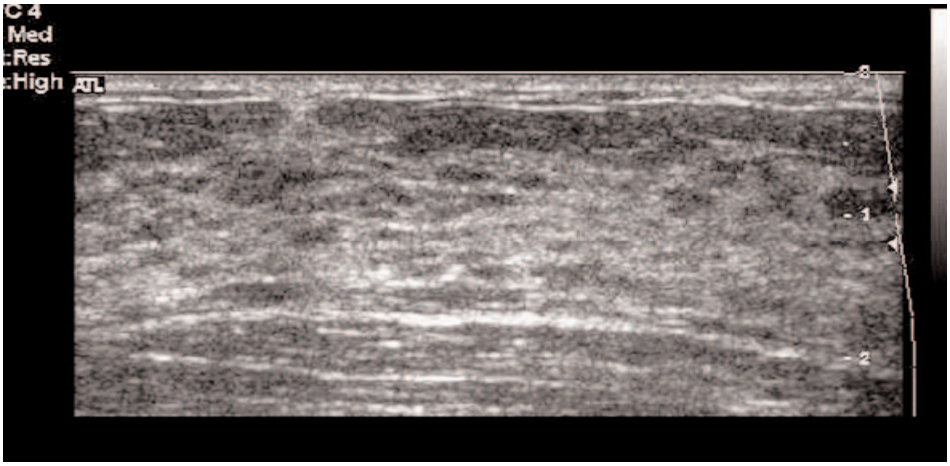

Figure 1. Normal sonographic anatomy: skin and subcutaneous fatty layer, mammary layer, retromammary fat.

Ultrasound examination of the breast currently follows several indications:

- first examination (before mammography or MRI) for the evaluation of a palpable lump in women under age 30;
- evaluation of a mass demonstrated on mammography;
- evaluation of focal asymmetry or focal change in architecture on the mammogram when compared with previous study—performed after complete mammographic workup (additional views);
- evaluation of suspicious finding requiring biopsy on MRI or a nuclear medicine study (in anticipation of ultrasound-guided biopsy);
- guidance for intraoperative or percutaneous breast biopsy and aspiration;
- evaluation of breast implants;
- adjunctive examination to evaluate nipple discharge (after mammography); and
- adjunctive examination to evaluate focal pain (after mammography).

UNDERSTANDING AND INTERPRETATION

Understanding and interpreting breast ultrasound requires a familiarity with the normal variation of the sonographic appearance of breast architecture and the ability to detect significant alterations in this appearance. Experience is therefore required, whether a radiologist or technologist performs the exam. Certain aspects of sonographic technique are unique to ultrasound examination of the breast, such as proper application of compression, transducer positioning, and image labeling. The interpretation of ultrasound artifacts can be helpful in lesion analysis. Experience and understanding are combined with knowledge of basic principles for breast ultrasound examination.

In order to stabilize, center, and thin out the breast tissue, the conventional position for breast ultrasound examination places the patient supine with the arm of the side being examined raised above the head. With larger breasts, a degree of elevation under the shoulder blade may be required in order to center the breast. This can best be accomplished with a foam wedge or roll of towels or sheets. In this position, a high-resolution linear transducer, 7.5 to 13 MHz, adequately penetrates to the chest wall. The tissue planes of the breast run horizontal to the chest wall and skin and perpendicular to the ultrasound beam.

If the patient is able to palpate the mass being examined only in an erect or semi-erect position, the exam can be initiated in this position and then continued in the conventional supine position. A 5-MHz transducer should be available for thicker breasts or, in some cases, for the evaluation of deeper surrounding tissues of breast implants, but it is rarely needed. The dynamic focus capability of most modern equipment allows for high-resolution imaging from the superficial structures to the chest wall.

For the evaluation of small lesions that are within 7 mm of the skin surface, acoustic standoff with a gel pad approximately 1 cm thick or less, or a mound of thick gel of equivalent depth, is recommended.[2] Adjustments of focal zone, overall gain, and time gain compensation curves should be a dynamic process during the examination, depending on the size and location of the region of interest.

Additional techniques, such as color Doppler and harmonic and compound imaging, can aid in lesion analysis.[8] The primary role of color Doppler is to identify blood flow within a mass. Harmonic imaging has the ability to eliminate artifact within cysts, and compound imaging better defines margins of masses. These techniques have shown proven benefits but are not widely available.

Scanning is performed with the degree of compression necessary to penetrate to the area of interest and eliminate superficial artifact. Scanning in the plane of ductal anatomy can be achieved by scanning in the radial and antiradial planes. Radial scanning is performed with the long axis of the transducer oriented along the long axis of the ductal and lobar anatomy (nipple to periphery of the breast in a branching pattern) and antiradial in the orthogonal plane (from the

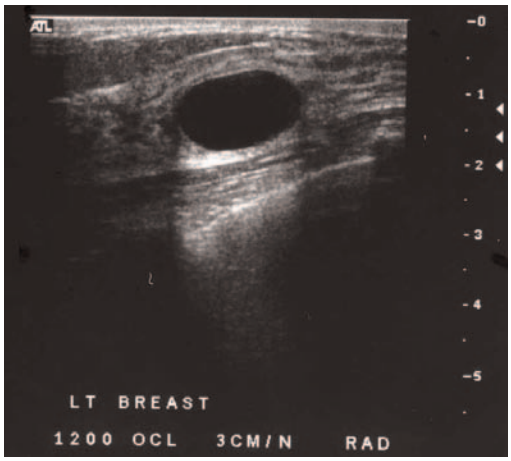

Figure 2. Simple cyst displaying classic sonographic characteristics.

periphery of the breast inward toward the nipple).

Transverse and sagittal plane scanning are acceptable in the initial survey, and if a lesion is detected, radial and antiradial scanning are recommended, as the margins and extension of the mass may be better displayed and this approach increases the potential for finding other masses within the same ductal system. A lesion should be imaged with and without calipers in two orthogonal planes. The position of the lesion should be labeled on the image according to the mammographic clock, noting distance from the nipple or areolar margin. It is important that this information be labeled on each image to ensure appropriate follow-up or localization for biopsy.

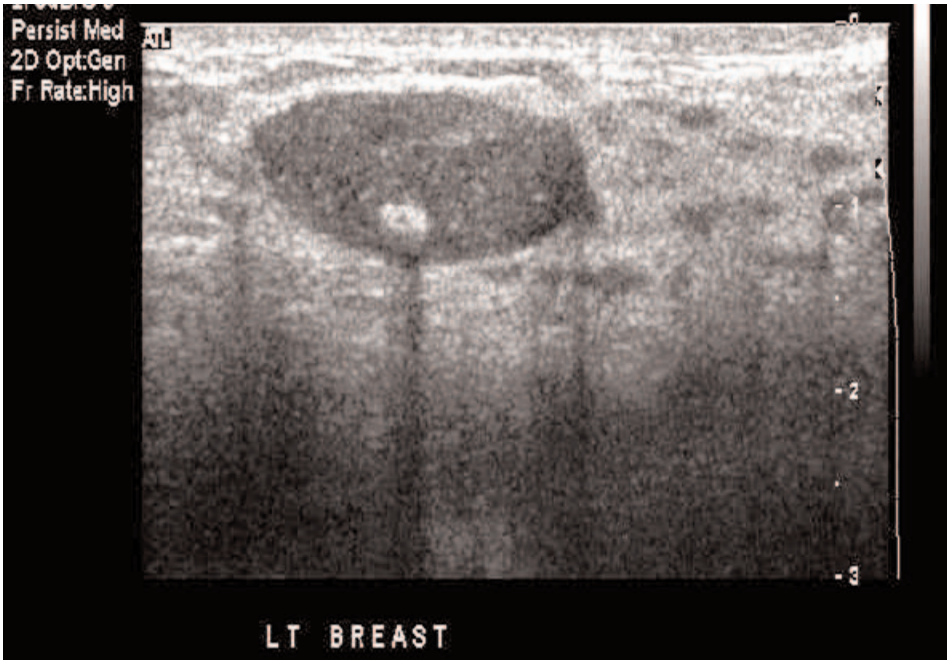

Figure 3. Fibroadenoma with shadowing calcification.

NORMAL SONOGRAPHIC ANATOMY

The breast can be divided into three layers from superficial to deep: the skin and subcutaneous fat; the mammary layer of glands, ducts, and connective tissue; and the retromammary fatty layer overlying the pectoralis muscles and chest wall. Most significant pathology arises in the mammary layer. The sonographic appearance of these layers is variable depending on the amount and distribution of fat, connective tissue, and glandular and ductal tissue. The appearance also depends on hormonal status (lactating versus postmenopausal) and can range from a clear stratification of layers to a homogeneously heterogeneous appearance (Figure 1).

Most important is the ability to recognize normal structures that are usually seen: skin, Cooper's ligaments, fat lobules, and fibrous tissue. These make up the stromal component of the breast, ducts (from which most significant pathology will arise), and chest wall structures.

• *Skin*. This brightly echogenic complex can have a trilaminar appearance and should be no more than 3 mm in thickness. Cutaneous and subcutaneous palpable lumps such as sebaceous cysts are common, and it is therefore important to image the skin layer well, with the use of standoff as necessary.

• *Cooper's ligaments.* Thin hyperechoic bands serve as supportive fibrous septae and run vertically from the skin into the mammary layer. They can produce an appearance of segmental echogenic arcs, which scallop fatty lobules in the superficial mammary layer, and can produce focal shadowing that should spread out linearly when scanned in the orthogonal plane.

• *Fat lobules.* Elliptical lobules of medium gray echogenicity contain linear and punctate echogenic foci. They should interweave on real-time imaging in a continuous braiding fashion without abrupt margination. Lobules may intermix equally with fibrous tissue, producing an overall heterogeneous appearance of the mammary layer. Medium gray echogenicity is the standard against which the echogenicity of any masses is compared.

• *Fibrous tissue.* This echogenic component of the mammary layer is composed of fibroglandular tissue. Appearance is related to hormonal status and age.

• *Ducts.* These extend radially from the nipple and course parallel to the chest wall in the supine patient position. Hypo- to isoechoic linear structures range in size but generally should be a few millimeters in diameter. Duct wall can be visible in a collapsed lumen as a thin echogenic line within the duct. Duct lumen can contain fluid. Radial and antiradial scanning allows for evaluation of ductal lumen. The terminal ductolobular unit can be identified in some patients as a globular-shaped, blunt-ending projection of the duct running in an oblique perpendicular orientation. The appearance of ducts and ductules within each breast, and even the same breast, is variable. Appearance is considered within normal limits as long as the ducts appear to taper and no areas of focal dilatation are demonstrated.

• *Chest wall.* Pectoralis muscle and underlying serratus anterior muscle overlie ribs and intercostal muscles. Muscles appear as medium gray horizontally oriented structures containing linear echogenic bands. Ribs appear as focal hypoechoic structures with posterior shadowing, which should turn into linear structures when scanning in the orthogonal plane. It is important to adjust focal zones, and sometimes patient position, to include the posterior mammary layer and chest wall.

• *Lymph nodes, vessels.* Lymph nodes are located throughout the breast and can be demonstrated as hypoechoic bean-shaped masses with echogenic centers. The shape, size, and appearance of normal lymph nodes are variable, and the heterogeneous echotexture can appear isoechoic with the surrounding breast tissue. Reactive and infiltrated nodes become more apparent as they become larger, rounder, and more uniformly hypoechoic. Blood vessels are identified by gray scale in the axillary region and throughout the breast with the aid of color Doppler.

SONOGRAPHIC ABNORMALITIES

The differentiation of benign from malignant solid masses has been the leading focus of research in breast ultrasound. With those criteria now well established, the many ways that this information can be used to lower the mortality from breast cancer are now being investigated. With advancing technology and an increasingly cost-conscious healthcare system, breast imaging has been challenged with not only the earlier identification of malignancy but also the reduction of the benign biopsy rate.

Guidelines for ultrasonographic characterization of breast masses have been published.[1,2] Limitations of breast ultrasonography must be recognized, however. These include the inability to visualize some solid masses owing to small size (particularly intraductal carcinomas) or isoechogenicity, overlap in ultrasonographic appearance of some benign and malignant lesions, and difficulty in identifying intraductal microcalcifications that are readily depicted on mammography in the absence of a mass. An attempt should be made to characterize solid masses and to use this information in the management plan.

• *Cysts.* Ultrasound can diagnose uncomplicated cysts with nearly 100% accuracy.[9] The diagnosis of a simple cyst can be made if there are sharp, well-circumscribed margins and no internal echoes (Figure 2). Modern equipment has become so sensitive to normal debris within cysts that as long as sharp circumscribed margins appear, enhanced through transmission, the diagnosis can be made when low-level homogeneous echoes may be present. Posterior acoustic enhancement may not be present if the mass is only a few millimeters in size or deep in location, particularly next to the chest wall.

Occasionally, cysts may contain one or two thin septations, which do not suggest significant abnormality and should not be considered cause for intervention. These are classified as complicated cysts. Most complicated cystic masses represent benign epithelial cysts. More complex cystic masses with thickened, echogenic walls, indistinct margins or evaginations into the surrounding paenchyma, heterogeneous low-level echoes, thick septations, or an intracystic solid component raise suspicion for malignancy. Intervention with aspiration or biopsy should occur in these cases.

• *Ductal abnormalities.* Ductal ectasia (periductal mastitis, plasma cell mastitis, secretory disease) is characterized by focal or segmental distention of one or multiple ducts and is associated with inflammation and periductal fibrosis.[10] This is usually present in the retroareolar region but may occur along any ductal segment. The distended ducts are partially or completely filled with thick secretions and debris. Ultrasound provides excellent visualization of distended ducts and, unlike mammography, distinguishes them clearly from the surrounding parenchyma. Typically, one or more tubular structures radiate toward the nipple and are filled with low-level echoes. No indication for intervention or follow-up has been established for mild ductal widening.[11] Irregular thickening, frondlike tissue, or masses within the duct, however, should encourage biopsy because these may represent intraductal carcinoma or papillomatosis, which carries a high risk of malignancy.[12]

• *Fibroadenomas.* These are the most common benign solid breast tumors, occurring most frequently in women in their reproductive years. Multiplicity and bilaterality are common features at all ages. Fibroadenomas are composed of fibrous stroma, proliferating ducts, and acinar tissue. The epithelial and stromal components vary in amount, accounting for some variation in the ultrasound scanning. Fibroadenomas are sharply circumscribed masses that may be encapsulated. The long axis commonly lies parallel to the skin surface.

The sharp margination of the mass is one of its most distinctive features by ultrasound and gross pathology. The typical oval or gently lobulated shape of fibroadenomas is a characteristic rarely found in malignancy. Most fibroadenomas are homogeneously hypoechoic or isoechoic to fatty tissue. Posterior acoustic enhancement is associated with some fibroadenomas, whereas those that are hyalinized or calcified can exhibit shadowing (Figure 3).

• *Phyllodes tumors.* These are usually indistinguishable from fibroadenomas on ultrasound evaluation, although they tend to be larger (4 cm or greater) or exhibit rapid growth. Phyllodes tumors are described histologically as resembling intracanalicular fibroadenomas with increased stromal cellularity but heterogeneous. They differ from fibroadenomas, showing greater cellularity and the presence of mitotic activity. Benign phyllodes tumors contain few mitoses and minimal cellular overgrowth, whereas malignant phyllodes tumors show marked hypercellularity and substantial mitotic activity.

• *Papillomas.* These are single formations of epithelial fronds supported by a fibrovascular stroma. They are most frequently located in the subareloar region within major ducts but also occur peripherally.[12] Serous or serosanguineous nipple discharge is commonly present, and the involved duct is distended and occasionally cystic. Papillomas generally appear hypoechoic to fibroglandular tissue. They may be a discrete, well-marginated, gently lobulated or microlobulated mass,

or they may conform to the shape of a duct and can be outlined by fluid if lying within a cyst or distended duct.

• *Hamartomas.* These differ from fibroadenomas largely because of the presence of fat and thus are more easily recognized mammographically. They appear as partially demarcated heterogeneous regions on ultrasound examination, containing variable amounts of hypoechoic tissue (representing fat) and echogenic fibroglandular elements. It is best to correlate a suspected hamartoma on ultrasound with mammography.

Other lesions containing fat include fat necrosis and lipomas. These have a variable appearance of homogeneous poorly demarcated regions within fatty tissue to heterogeneous masses. It is best to correlate with the mammogram and use diagnostic criteria to guide management.

• *Stromal fibrosis.* This is a frequent mimicker of both benign and malignant breast masses. Its ultrasonographic appearance ranges from ill-defined hyperechoic tissue to a well-defined hypoechoic mass.

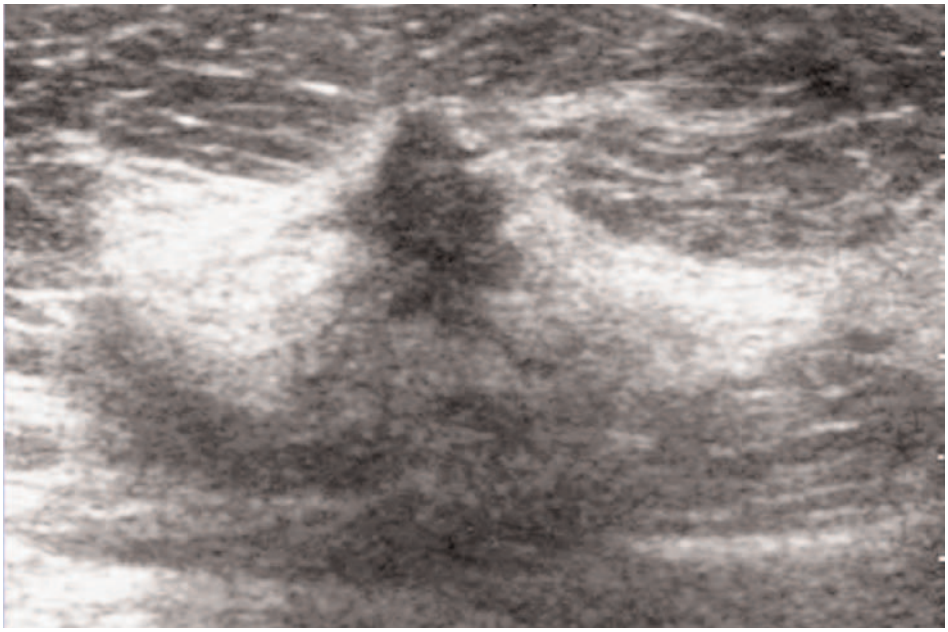

Figure 4. Invasive ductal carcinoma with malignant sonographic characteristics.

MALIGNANT MASSES

Although mammography is the primary imaging modality for the early detection of breast cancer, ultrasound, used in conjunction with mammography, can further increase the cancer detection rate.[2] The most common breast malignancies are of ductal epithelial origin and are either confined to the duct (in situ or intraductal) or infiltrative (invasive). Lobular and stromal cancers and metastases are less common.

The different histologic characteristics account for some variability in ultrasound appearance. Most invasive ductal carcinomas exhibit irregular or ill-defined margins related to infiltrative and fibrotic components (Figure 4). Carcinomas of uniform cell type or types that do not invade aggressively may appear as well-circumscribed masses.

Stavros et al[2] reported a 98.4% sensitivity for diagnosis of malignant masses using ultrasonographic criteria for malignancy, including spiculation, nonparallel orientation, angular margins, marked hypoechogenicity (relative to fat), shadowing, calcification, duct extension and branching pattern, and microlobulation. These results reflect the high resolution of state-of-the-art equipment and expanding skills of the radiologist. Suspicious masses identified on ultrasound should always be correlated with mammography, which can depict extent and other sites of malignancy or reveal benign characteristics of the lesion in question, thus precluding unnecessary intervention.

RUPTURED SILICONE GEL IMPLANT

Although MRI has been shown to be more accurate than ultrasound for evaluation of silicone gel implant integrity,[13,14] ultrasound can be used as the initial evaluation. Several ultrasonographic signs of implant rupture have been described in the literature.[15-17] The finding of multiple echogenic parallel lines ("stepladder" sign) within the implant lumen is highly suggestive of a broken and collapsed implant shell.[17] Echogenic noise ("snowstorm" appearance) within the breast tissue correlates strongly with extraluminal or extracapsular silicone.[14] Areas of moderate to marked homogeneous low-level echogenicity within the implant may be the most sensitive sign of rupture, but this sign is not highly specific.[17]

CONCLUSION

The establishment of standardized diagnostic criteria and the widespread use of the BI-RADS lexicon should help to demystify the practice and application of breast ultrasound. Taking all clinical and imaging information into consideration, most masses meeting benign criteria can be followed clinically or with short-term interval ultrasound follow-up. Masses meeting criteria for complex cysts or solid masses with malignant characteristics should be aspirated or biopsied, most readily by ultrasound-guided core biopsy. When used regularly along with the mammogram, for the appropriate indications and with proper technique, breast ultrasound should prove to lower breast cancer mortality and decrease the benign biopsy rate. ■

References

1. American College of Radiology. *Illustrated breast imaging reporting and data system (BI-RADS): ultrasound.* Reston, VA: American College of Radiology, 2003.
2. Stavros AT, Thickman D, Rapp CL, et al. Solid breast nodules: use of sonography to distinguish benign from malignant lesions. Radiology 1995:196:123-124.
3. Berg, WA, Gutierrez L, NessAiver MS, et al. Diagnostic accu-

racy of mammography, clinical examination, US, and MR imaging in preoperative assessment of breast cancer. Radiology 2004: 233:830 -849
4. Kolb TM, Lichy J, Newhouse JH. Comparison of the performance of screening mammography, physical examination, and breast US and evaluation of the factors that influence them: an anaylsis of 27,825 patient evaluations. Radiology 2002:225:165-175.
5. Berg WA, Gilbreath PL. Multicientric and multifocal cancer: whole breast US in preoperative evaluation. Radiology 2000:214:59-66.
6. Kaplan SS. Clinical utility of whole breast US in the evaluation of women with dense breast tissue. Radiology 2001:221:641-649.
7. Berg WA. Operator dependence of physician performed whole breast us: lesion detection and characterization: Radiology 2006;214:355-365.
8. Mesurolle B, Helou T, EI-Khoury M, et al. Tissue harmonic imaging, frequency compound imaging, and conventional imaging: use and benefit in breast sonography. J Am Inst Ultrasound Med 2007:26:1041-1051.
9. Jackson VP. The role of US in breast imaging. Radiology 1990:177:305.
10. Page DL, Simpson JF. Benign, high-risk, and premalignant lesions. In: Bland KI, Copeland EM, eds. *The breast: comprehensive management of benign and malignant diseases.* Philadelphia: WB Saunders, 1991:113.
11. Teboul M, Halliwell M. Ductal echography: the correct ultrasonic approach to the breast. In: Teboul M, Halliwell M, eds. *Atlas of ultrasound and ductal echography of the breast.* Oxford: Blackwell Scientific, 1995:83.
12. Tavassoli FA. Papillary lesions. In: Tavassoli FA, ed. *Pathology of the breast.* Norwalk, CT: Appleton & Lange, 1992:193
13. Gorczyca DP, DeBruhl ND, Ahn CY, et al. Silicone breast implant ruptures in an animal model: comparison of mammography, MR imaging, US and CT. Radiology 1994;190:227.
14. Berg WA, Caskey CI, Hamper UM, et al. Single- and double-lumen silicone breast implant integrity: prospective evaluation of MR and US criteria. Radiology 1995;197:45.
15. Debruhl ND, Gorczyca DP, Ahn CY, et al. Sonographic evaluation of silicone breast implants. Radiology 1993;189:95.
16. Harris KM, Ganott MA, Shestak KC, et al. Silicone implant rupture detection with US. Radiology 1993;187:761.
17. Caskey CI, Berg WA, Anderson N, et al. Breast implant rupture: diagnosis with ultrasonography. Radiology 1994;190:819.

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