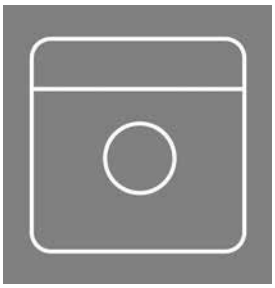

ACR BI-RADS® Ultrasound

2013

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PREFACE

Ultrasound (US) characterization of mammographic and palpable abnormalities is indicated in the evaluation and management of breast disease. However, standardization of an effective, reliable technique for whole breast examination is a work in progress. In Europe and Asia, for many years, breast screening with US has been physician performed. In the United States, practice patterns are in flux, with the majority of breast sonograms performed by sonographers, usually directed to a particular area identified on other imaging modalities or by physical examination. Because we anticipate that US screening as a supplement to mammography will become more widely practiced in the United States, we offer guidance for training and performance as was provided in ACRIN 6666.[1,2,3]

Effective use of the US lexicon is predicated on excellent sonographic technique and an understanding of breast anatomy. The descriptors comprising a lexicon for breast US are defined and exemplified in the sections that follow. Crucial to accurate assessment of masses is a method of lesion characterization achieved through analysis of multiple features rather than any single one. Some features are unique to US, such as orientation and echogenicity, and some are fundamental to interpreting breast masses with any imaging technique, such as shape and margin.

The descriptors that we recommend to designate findings are used in the illustrations throughout the second edition of the US lexicon. The legend beneath each example indicates in capital letters the primary illustrated feature. If, as is often the case, an illustration depicts more than one feature, the legend will indicate all of the features using lexicon terminology; however, the feature that the US image was chosen to illustrate will be the only term that is capitalized (e.g., "a small, oval, parallel, HYPERECHOIC mass"). Where possible, the pathology of what is described will be included.

The ACR Breast Imaging Reporting and Data System (BI-RADS®) for mammography has improved the assessment of masses, calcifications, and other mammographic findings, and the BI-RADS® final assessment phrases have been incorporated into the Mammography Quality Standards Act of 1992 (MQSA). The integration of US and mammographic findings promotes their clinical practicality.

In the late 1990s, the American College of Radiology (ACR) recognized the need for a US lexicon. Upon receipt of a grant from the Office on Women's Health of the Department of Health and Human Services in 1998, to support protocol development for research in breast US [*Contract 282-97-0076, Federal Technology Transfer Program to Advance Novel Breast Imaging Technologies, U.S. Public Health Service Office on Women's Health, U.S. Department of Health and Human Services*], the ACR convened an expert working group with national and international representation. Research topics for protocol development included breast cancer screening with US, differentiation of benign from malignant solid masses, and the possible therapeutic applications of US. The need for consistent and standardized terminology became acute, particularly in designing studies of solid mass characteristics and of screening, in which criteria for probably benign masses required strict definition. Using techniques similar to those used for BI-RADS® mammography, agreement on terminology and assessment categorization was reached by consensus of this expert working group and its subcommittee.

Several feature descriptors are frequently used in analyzing mammographic findings, with the most worrisome feature the dominant consideration in selecting a final assessment category and management recommendation. Similarly, when mammography and US reports are combined, the most abnormal features should usually determine the assessment of the lesion.

Wherever possible and appropriate, the established descriptive terms in the lexicon for mammography were utilized for US interpretation. In the important feature categories of shape and margin,

many of the descriptors work equally well for both. Since the publication of the first BI-RADS® US in 2003, there have been advances in US, such as elastography (included in Associated Features). Image quality, anatomy, the male breast, and a guidance chapter with frequently asked questions have also been added. This document will continue to change as breast US continues to evolve, with its roles for diagnostic and screening indications being further elucidated among those of other breast imaging modalities, such as mammography (including tomosynthesis), MRI, and molecular imaging.[4,5]

This illustrated fifth edition of the BI-RADS® Atlas is designed for everyday practice and should make it possible to issue meaningful and unambiguous breast imaging reports. BI-RADS® was always intended to be a dynamic and evolving document that would adapt to changes in the practice of breast imaging and be of practical use to interpreting physicians. Therefore, the Committee on BI-RADS® welcomes any comments and/or suggestions from its users and requests that these be submitted in writing or electronically to the ACR. However, prior to submitting comments or suggestions, please first visit the ACR BI-RADS® website at http://acr.org/~/media/ACR/Documents/PDF/QualitySafely/Resources/BIRADS/BIRADSFAQs.pdf, which displays committee-approved responses to suggestions already submitted.

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INTRODUCTION

The ACR BI-RADS® is a quality assurance tool designed to standardize reporting, reduce confusion in breast imaging interpretations and management recommendations, and facilitate outcomes monitoring. All interpreting physicians and referring health care providers should be aware of the benefits and limitations of breast imaging technologies.

The terminology used to describe breast US findings is still evolving, and the diversity of this terminology may cause confusion. The descriptive terms and definitions contained in the lexicon have been approved by the ACR Subcommittee on BI-RADS® Ultrasound. Employing these terms exclusively will help ensure that reports are clear, concise, and standardized. The subcommittee believes that these terms provide a reasonably complete evidence-based categorization of lesions depicted at US; however, as the field is still evolving, new terminology may be needed or existing terminology modified. If you would like to propose a substantive change, please submit it to the ACR for review by the Committee on BI-RADS®, using the contact information mentioned in the preface.

The ACR BI-RADS® — Ultrasound is divided into four sections with an appendix at the end.

SECTION I: General Considerations

SECTION II: Breast Imaging Lexicon — Ultrasound

SECTION III: Reporting System

SECTION IV: Guidance

APPENDIX: ACR BI-RADS® — Ultrasound Lexicon Classification Form

The following are brief summaries of each section.

I. General Considerations

This section discusses the anatomy of the breast, image quality issues and techniques, labeling and measurement of the images, and documenting results of the examination.

II. Breast Imaging Lexicon — Ultrasound

US is very useful for breast imaging. The lexicon offers a set of standardized terms along with copious examples of how and when to use these terms. The Subcommittee on BI-RADS® Ultrasound believes that widespread use of these descriptors will enable radiologists everywhere to communicate results clearly and efficiently to other physicians and their patients.

III. Reporting System

Just as in mammography, utilizing the reporting system will provide an organized approach to image interpretation and reporting. Using a computer-based reporting software application is not required but is strongly recommended. This will facilitate clear, concise, and standardized reporting, and further enable simultaneous data collection for the maintenance of a database for future outcomes review (audit). Regular audits enable individual interpreting physicians and breast imaging facilities to monitor their own results and appraise the accuracy of image interpretation so that they can adjust interpretive thresholds appropriately. We strongly recommended using software that requires minimal data entry. The interpreting physician's attention should be focused

on the evaluation of images not data input. The simplest input will need only a single screen for normal examinations and require limited interaction for abnormal examinations. If practical, we recommend use of a scribe to enter data.

Report Organization

Using the recommended terminology is the key to producing understandable breast imaging reports consistently. The BI-RADS® approach to reporting breast imaging examinations categorizes the overall composition of the breast and then describes masses by their shape, orientation, margin, echo patterns, and posterior features. Calcifications are described according to size and distribution. The findings are then evaluated and an assessment rendered that includes the degree of suspicion for malignancy. Finally, the report indicates the pertinent management recommendation(s). Thus, the breast US report should be divided into:

1. **INDICATION FOR EXAMINATION**
2. **STATEMENT OF SCOPE AND TECHNIQUE OF BREAST US EXAMINATION**
3. **SUCCINCT DESCRIPTION OF THE OVERALL BREAST COMPOSITION (screening only)**
4. **CLEAR DESCRIPTION OF ANY IMPORTANT FINDINGS**
5. **COMPARISON TO PREVIOUS EXAMINATION(S), INCLUDING CORRELATION WITH PHYSICAL, MAMMOGRAPHY, OR MRI FINDINGS**
6. **COMPOSITE REPORTS**
7. **ASSESSMENT**
8. **MANAGEMENT**

   Note that breast US examinations are sometimes reported separately from mammography and sometimes reported as part of a combined examination. In either case, the structure of the report should follow some general guidelines to make it clear and concise.

IV. Guidance

Through the years of continued BI-RADS® usage, the committee has received many questions and reports of problems related to the various sections that comprise BI-RADS®. To address these concerns, to introduce changes in terminology and assessments, and to explain the reasons for these changes, we offer a guidance chapter.

APPENDIX

The appendix contains a form for easily noting the findings of an US examination with the appropriate BI-RADS® terminology in a simple checklist. This form also contains the BI-RADS® assessment categories.

REVISIONS

Date	Page(s)	Section	Description of Revisions
mm/dd/yyyy			Original issue

I. GENERAL CONSIDERATIONS

A. BREAST ANATOMY

The breast is located on the chest wall between the second and the sixth ribs within layers of the superficial pectoral fascia. The fat and fibroglandular tissues of the breast are between the superficial layer of this fascia just beneath the skin and the deep fascial layer that lies just anterior to the pectoral muscle (Figure 1).

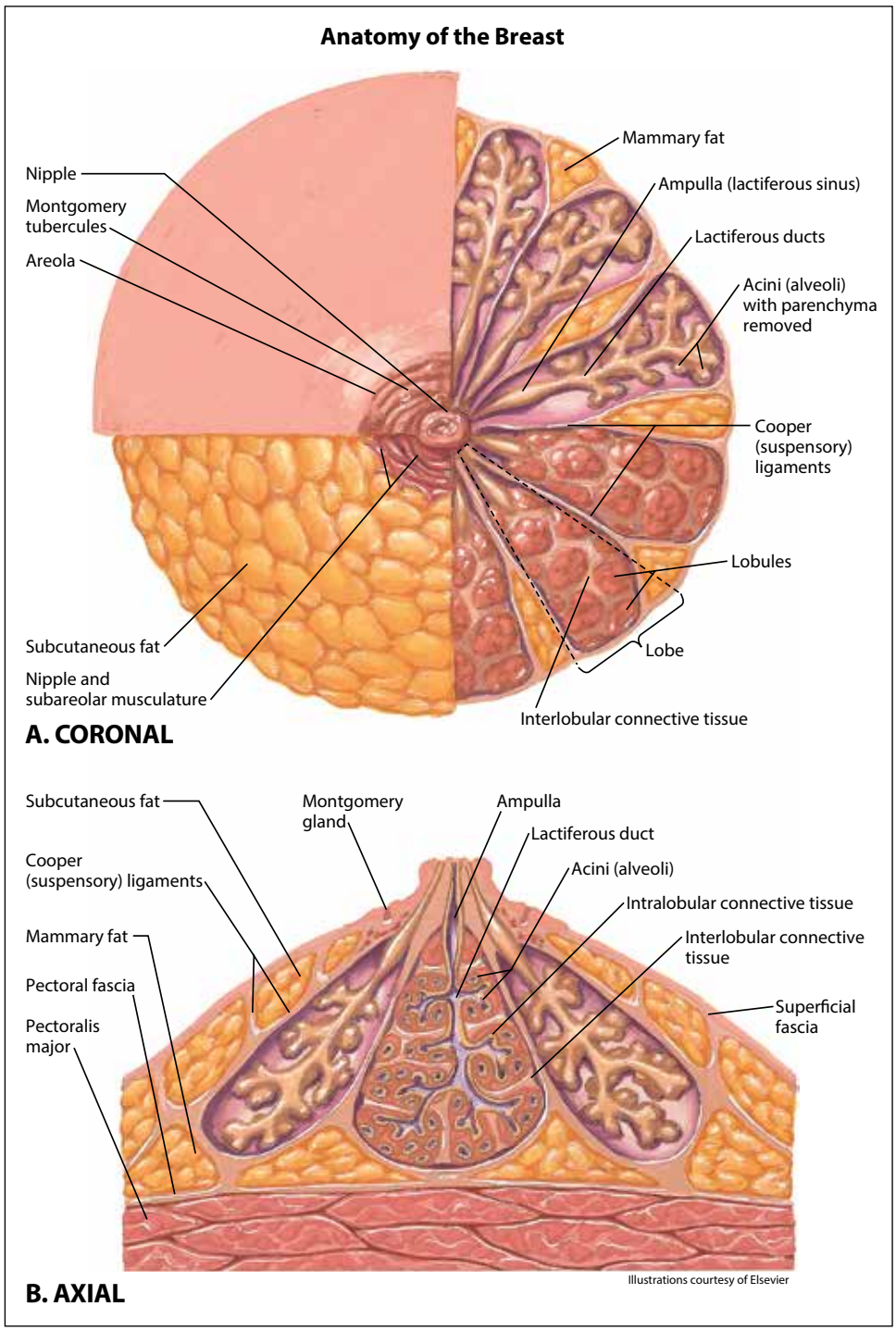


Figure 1 — NORMAL BREAST ANATOMY. Diagram of breast of woman in supine *(US)* position. Anatomy of the breast in coronal plane *(a)* and axial plane *(b)*.

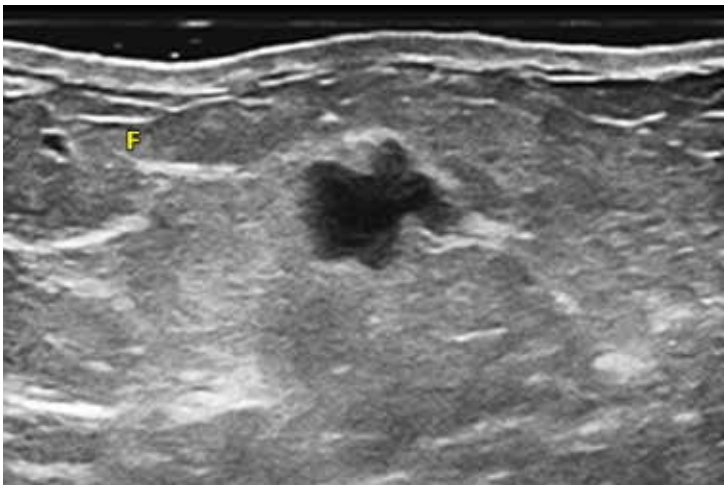


Figure 2 — ANATOMY: NORMAL SKIN COMPLEX. Two echogenic lines defining a hypoechoic layer whose total thickness is ≤ 2 mm, except in the periareolar region or inframammary fold. A gel offset enables the upper layer of skin to be seen. Make certain that the focal zone is set superficially. Beneath the normal 2 mm skin complex and superficial fat lobules (*F*) is an 8 mm microlobulated invasive ductal carcinoma (IDC).

As few as seven or eight and as many as 20 lobes, loosely associated duct segments, are the anatomic components of the breast. Each segment starts in the fine peripheral branches and ends in a large collecting duct, its punctum visible on the nipple. The most peripheral ducts, the intralobular terminal ducts, end in the terminal duct-lobular units that give rise to common malignant and benign pathologies.

The subclavian and axillary arteries and their lateral thoracic, thoracoacromial, and internal mammary branches provide arterial supply to the breast. The venous plexus lies just beneath the nipple. Over 90% of the lymphatics of the breast drain into the ipsilateral axilla, with a small percentage of drainage into the internal mammary chain. In women who have had axillary dissections or mastectomies extending into the axilla, lymphatic drainage may cross to the contralateral axilla.

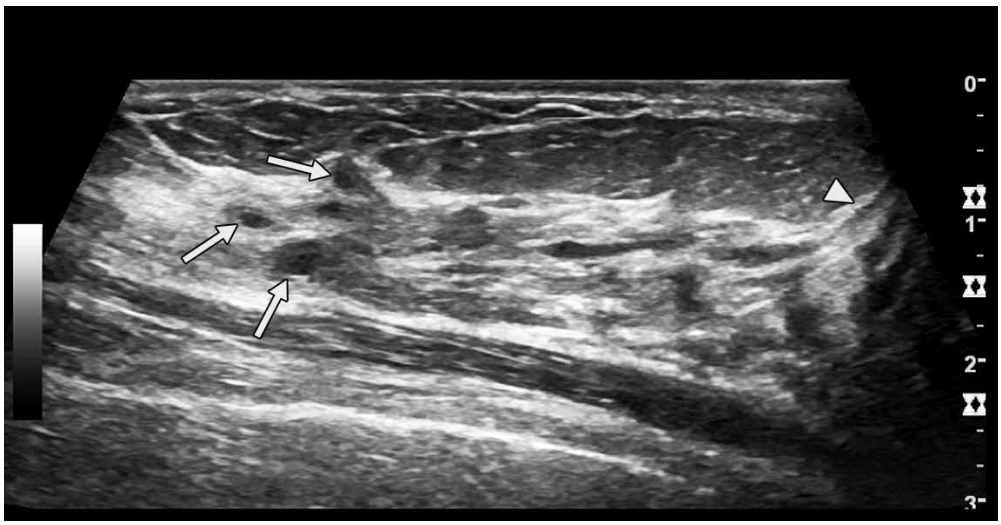
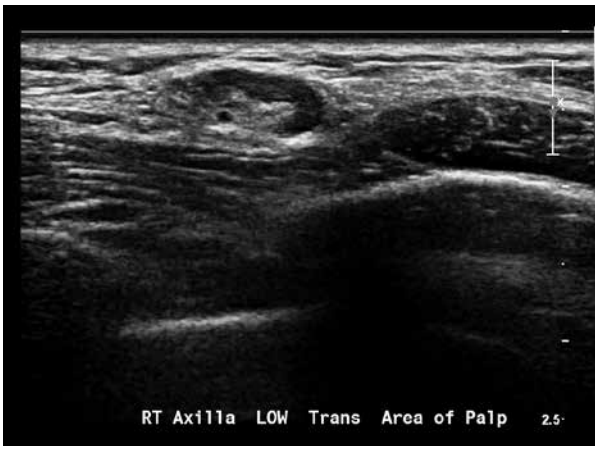


Figure 3 — IMAGE QUALITY: TRAPEZOIDAL ACQUISITION. Radial view shows the normal anatomy of a duct from its lobules *(arrows)* at the periphery, arching anteriorly *(arrowhead)* towards the nipple. The duct is within the fibroglandular zone of tissue beneath the hypoechoic fat lobules.

1. AXILLA

The axilla contains lymph nodes, the brachial plexus, and axillary artery and vein. The number and size of normal axillary lymph nodes varies widely from individual to individual. Side-to-side symmetry of size, shape, and number of nodes may help distinguish normal from abnormal. Nodes may be depicted in the axillae on mammograms; commonly two, three, or more can be identified as circumscribed oval (often reniform) masses with hilar fat and cortices of fibroglandular tissue density. With US, normal axillary or intramammary lymph nodes have echogenic fatty hila and cortices that are hypoechoic to anechoic.



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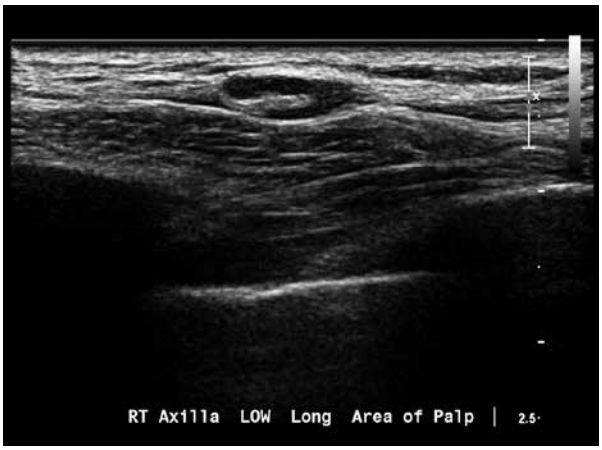

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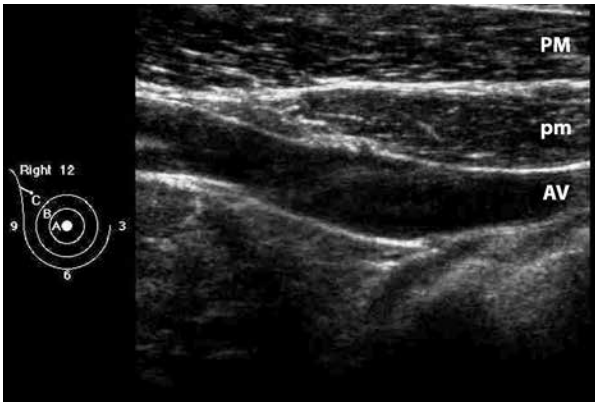


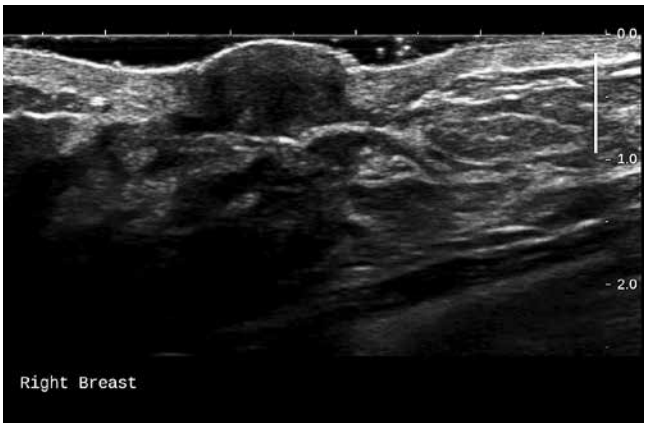
C

Figure 4 — NORMAL AXILLARY LYMPH NODE. Transverse *(a)* and longitudinal *(b)* views of a lymph node of normal size, cortical thickness, and echogenic hilus, resembling a miniature kidney. NORMAL AXILLA *(c)*. Pectoralis major *(PM)* is shown anterior to pectoralis minor *(pm)* with axillary vein *(AV)* deep to both.

2. NIPPLE AND AREOLA

The nipple-areolar complex is quite variable, with areolar width narrow in some women or extending for 1 or 2 cm in others, making the nipple a more reliable landmark than the areola. Normal nipples can be prominent, flat, or inverted.

If an abnormality is suspected, or for interpretive confidence, look at the contralateral breast as you would for any other paired organ. The nipple's crevices and irregular surface cause posterior attenuation, and an offset pad or thick layer of gel can provide a medium for clear depiction (Figure 4a, b, and c, see page 15). The skin of the areola tapers as the areola extends to either side of the nipple. The width of normal skin over the breast is 0.2 cm except for the region of the inframammary fold and the areola, where the skin is normally a little thicker.



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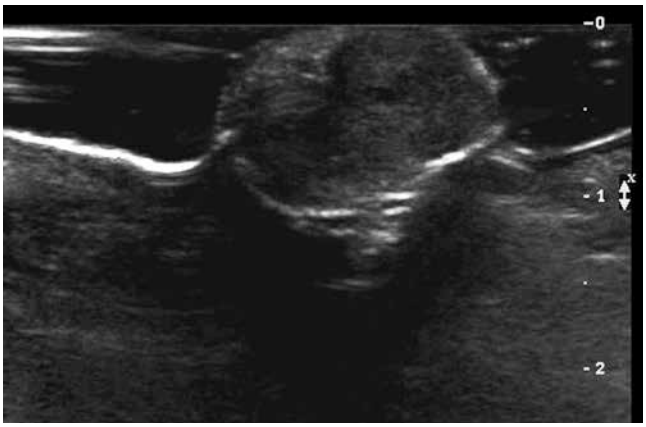

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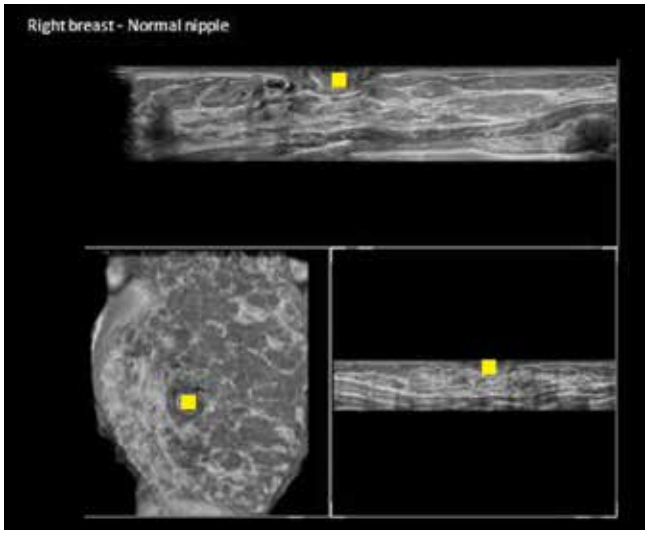

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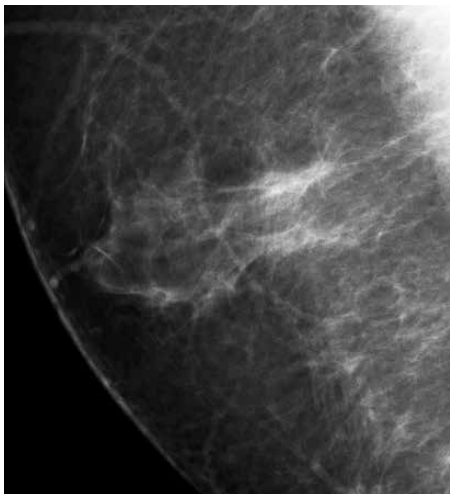
Figure 5 — ANATOMY: NIPPLE AND UNDERLYING BREAST TISSUE. Size and appearance of the nipple are variable, from retracted to flat to protuberant. A gel offset *(a* and *b)* enables the skin and superficial tissue to be seen. The nipple is normal *(a)*. If there is concern for abnormality, as with any other paired organ, comparison with the normal side is helpful in decision making. Nipple is enlarged due to mucinous carcinoma contained within it *(b)*. Automated supine whole breast scan *(c)*. Upper image is B-mode acquisition (X-plane or transverse) centered over normal nipple *(yellow square)*, with reconstructions in coronal (Z-plane) on left and sagittal (Y-plane), lower right image. The tissue beneath the nipple is not obscured by shadowing as it so often is with hand-held US.

3. GYNECOMASTIA

Hormonal effects of certain medications including anti-hypertensives, antidepressants, H2 blockers, illicit drugs, and endocrine-active tumors stimulate development of rudimentary male breast tissue. Ducts and stroma are located in the retroareolar region, typically "flame-shaped" on mammograms extending posterolaterally from the nipple, and are often asymmetric.



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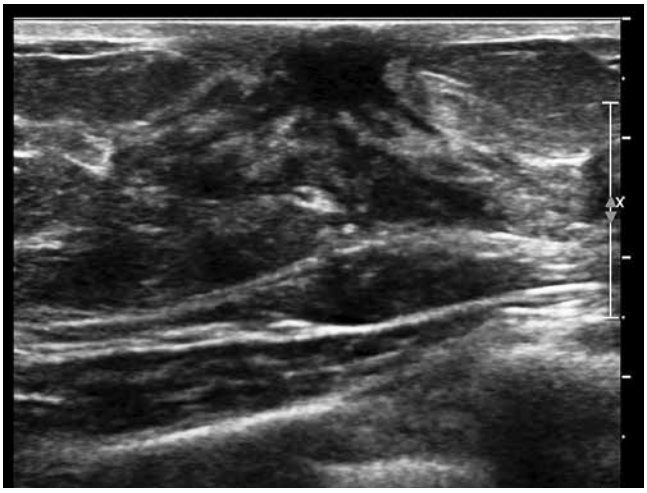

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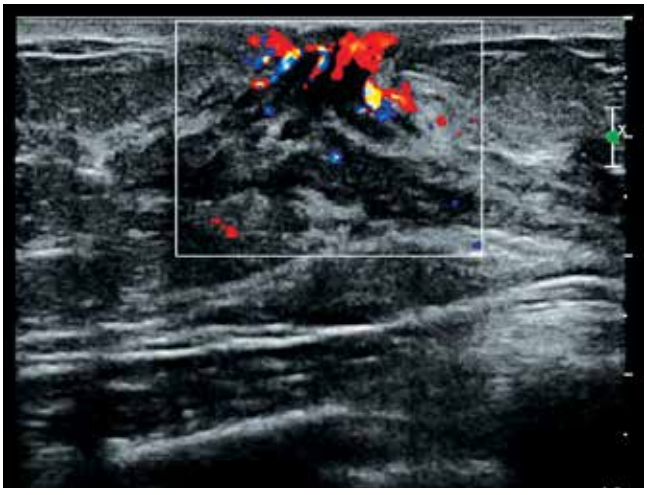

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Figure 6 — ANATOMY: GYNECOMASTIA. 71-year-old, hypertensive man with tender palpable nodule beneath the left nipple. Mediolateral oblique mammogram showing retroareolar fibroglandular tissue *(a)*; B-mode *(b)* and color Doppler *(c)* images show hypoechoic mound of breast tissue with ducts radiating and tapering posteriorly, a characteristic US appearance of gynecomastia.

B. IMAGE QUALITY

1. TRANSDUCER FREQUENCY

As with all imaging modalities, the value of US for detection and diagnosis largely depends on the quality of the images. Handheld, high-frequency breast US can be particularly prone to operator dependence if a system's many image parameters are not optimally modulated. Poor US image quality can lead to serious misinterpretations such as mistaking a cancer for a cyst. The ACR Practice Guideline for the Performance of a Breast Ultrasound Examination (2011)[4] recommends use of a broad bandwidth linear array transducer with a center frequency of at least 10 MHz. At the high-frequency end (between 12 and 18 MHz), these transducers provide high-resolution images. In their lower frequency ranges, tissue penetration of 5 cm is obtainable.

Higher frequency sound waves are more strongly attenuated by breast tissue than lower frequency waves. With proper positioning, most breasts in the supine or supine-oblique position are only a few centimeters thick, and high frequencies can provide optimal image quality for all of the breast tissue. However, when evaluating deep tissue in patients with particularly large breasts, it may be helpful to select lower frequency settings on multifrequency transducers, to use a lower frequency transducer, if available, or to apply greater compression for improvement of sound penetration and reduction of attenuation.

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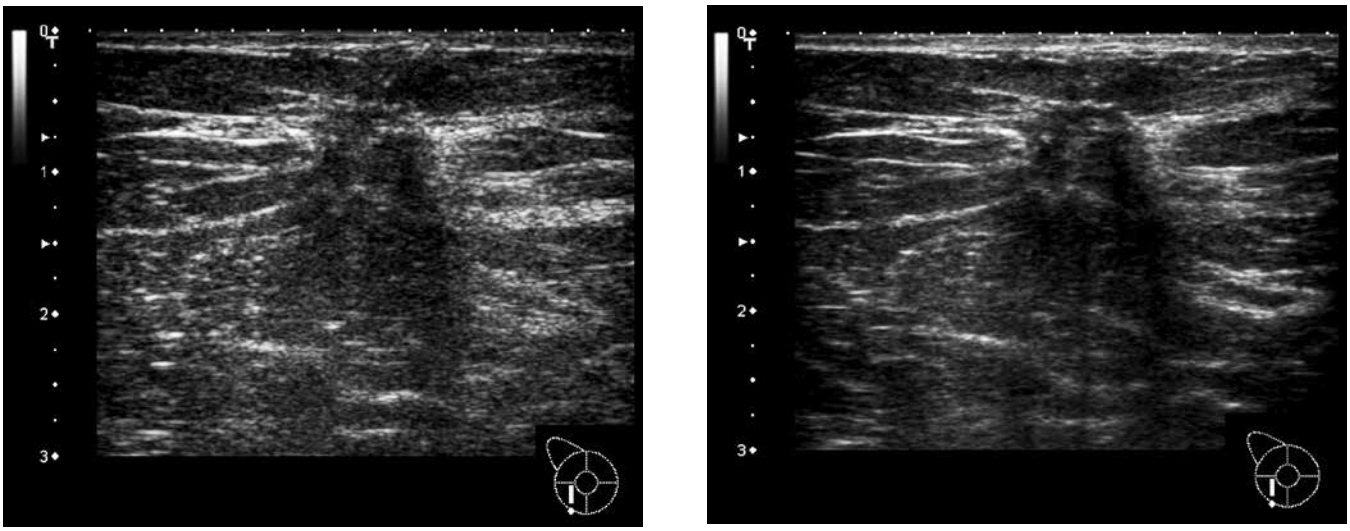
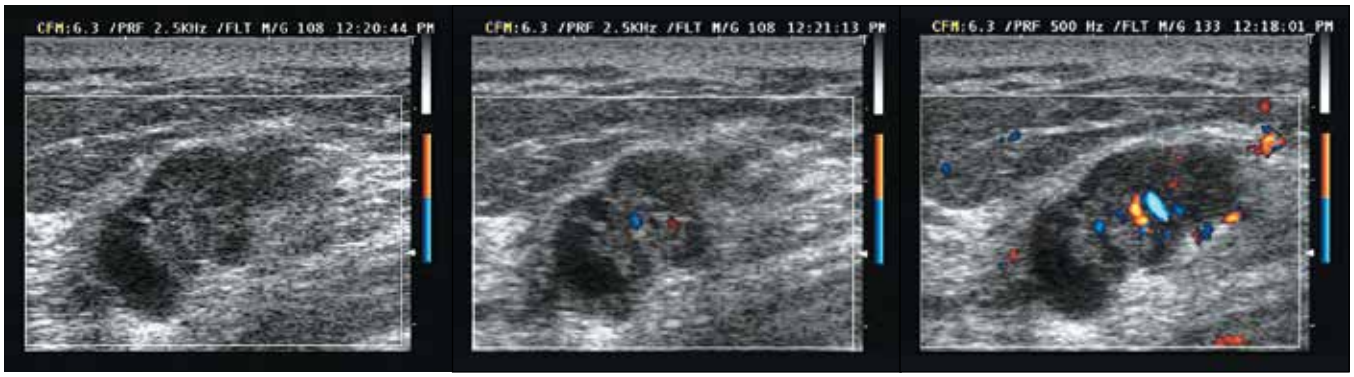


A **B**

Figure 7 — IMAGE QUALITY: TRANSDUCER FREQUENCY. Margin and surrounding architectural distortion of this irregularly shaped carcinoma (longitudinal view) with transducer operating at 7.2 MHz *(a)* is less well characterized than same mass *(b)* imaged at 14 MHz. Cicatrization of the Cooper ligaments is more conspicuous and angular and the indistinct margin of the mass more confidently characterizable due to improved resolution of the higher frequency transducer.



A **B** **C**

Figure 8 — IMAGE QUALITY: DOPPLER SETTINGS. B-mode and color flow images with too much compression *(a)* causing vessels to be occluded. Image *(b)* has scanning without compression and allows depiction of some vascularity within lesion. Image *(c)*, with the same Doppler frequency and scanning without compression shows more accurate depiction of slow flow vascular characteristics of the mass. Histopathology: invasive and intraductal carcinoma.

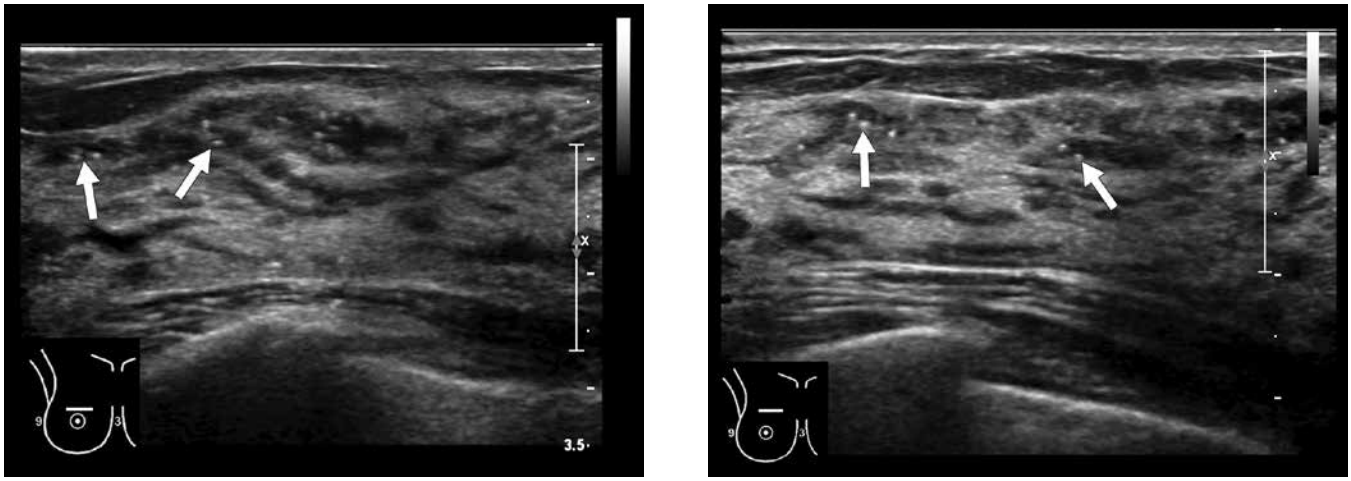


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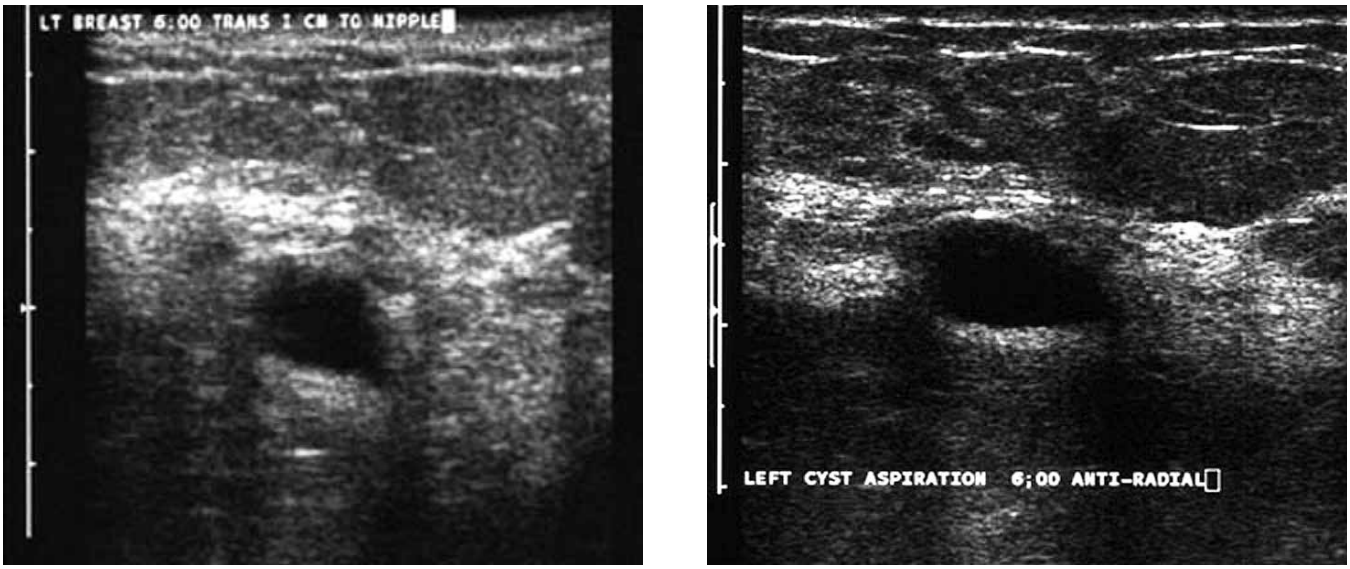
Figure 9 — IMAGE QUALITY: TRANSDUCER FREQUENCY. The image obtained with a linear transducer whose frequency range is 12–5 MHz is diagnostic *(a)* but greatly improved with a transducer whose frequency range is 17–5 MHz *(b)*. In both images, the microcalcifications present within ducts *(arrows)* in the echogenic fibroglandular zone of tissue can be seen, but resolution of these particles and the ductal anatomy is better with the higher frequency probe.



A **B**

Figure 10 — IMAGE QUALITY: TRANSDUCER FREQUENCY, RESOLUTION, AND CONTRAST SETTINGS. Confident interpretation of margin and shape of the mass is not possible in the image on the left *(a)* because of outdated technology: low transducer frequency, high contrast settings, and an inadequate gray scale. The same mass in the image on the right *(b)* appears to be better focused, and the higher resolution allows the characteristics of a simple cyst to be depicted. The BI-RADS® assessment based on image *(b)* would be benign (category 2), while in image *(a)* it might be suspicious (category 4). Annotation overlies the skin in image *(a)*; no text should overlie an image unless the image is captured with and without annotation, as is suggested for lesion measurement. Note that image *(b)* is labeled for cyst aspiration, which would not have been necessary unless the patient was symptomatic (therapeutic aspiration). Image quality for *(a)* would be unacceptable at this time.

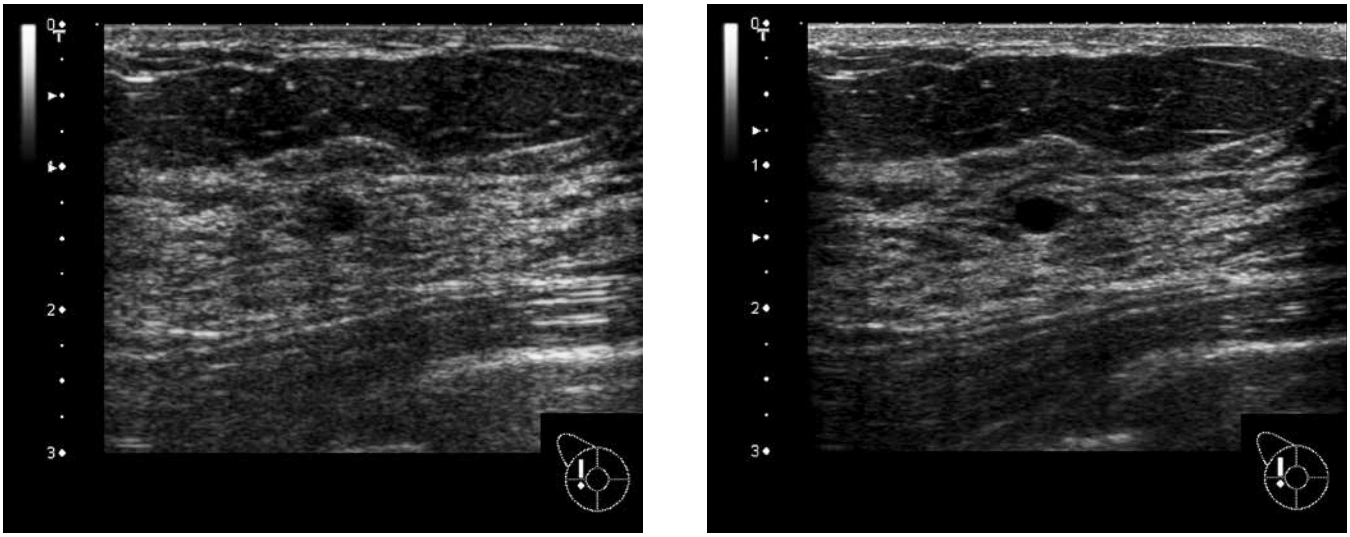


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Figure 11 — IMAGE QUALITY: EFFECTS OF HIGHER FREQUENCY AND COMPRESSION. *(a)* Oval mass in sagittal view has indistinct margins at 7.2 MHz (linear transducer, frequency range 14–7 MHz). Diagnosis of simple cyst cannot be made, and the patient would most likely have undergone aspiration. Same mass *(b)* imaged with same transducer but operating at 14 MHz is identifiable as a simple cyst. Additional compression of the tissue with the probe helps to reduce refraction shadowing that is prominent in image *(a)*. Improved image quality in *(b)* allowed BI-RADS® assessment as benign (category 2).

2. FIELD OF VIEW

The field of view (FOV) refers to the depth setting of tissue that will be displayed on the monitor. When searching for lesions, the field should be deep enough to include breast tissue and the pectoralis muscle posterior to it. The FOV should not include the pleura or lung.

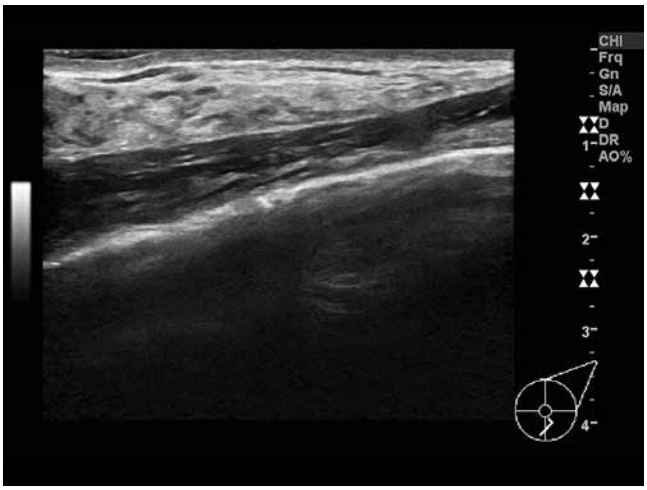


Figure 12 — IMAGE QUALITY: FOV. Single view of the left breast at 6:00 with breast tissue occupying only 50% of the FOV. From a depth of 2–4 cm, there is no information related to the breast. The focal zones (marked by ⧗ icons) are also set too deeply.

When a lesion is found, temptation is to reset the field to a shallower depth or to zoom excessively. In both of these instances, the margin of the mass may be misinterpreted as indistinct. When the FOV is set too deeply, small lesions appear minified and cannot be characterized confidently.

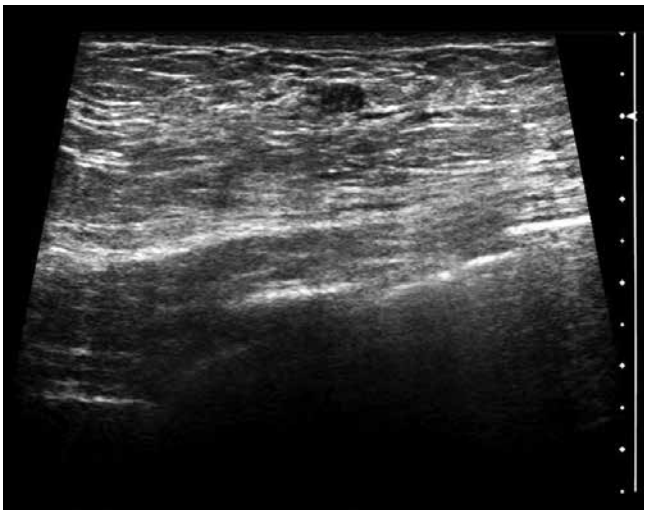


Figure 13 — IMAGE QUALITY: FOV. The lower portion of this trapezoidal image contains no information. Small, 0.4 x 0.3 cm, mass located 0.8 cm deep from the skin is poorly visualized in this sonogram set to a depth of 5.5 cm. Image appears minified.

For larger lesions, there are several methods that can be used to show the entire lesion in one image. Available with some transducers is "extended field-of-view imaging," also called "panoramic imaging," which may help to demonstrate the relationship of these lesions to surrounding the tissue. Extended FOV can also be useful to demonstrate the geographic relationship among multiple lesions or between a lesion and a structure such as the nipple. As with wide FOV automated US, freehand extended FOV is also useful for imaging multiple masses as well as large lesions.

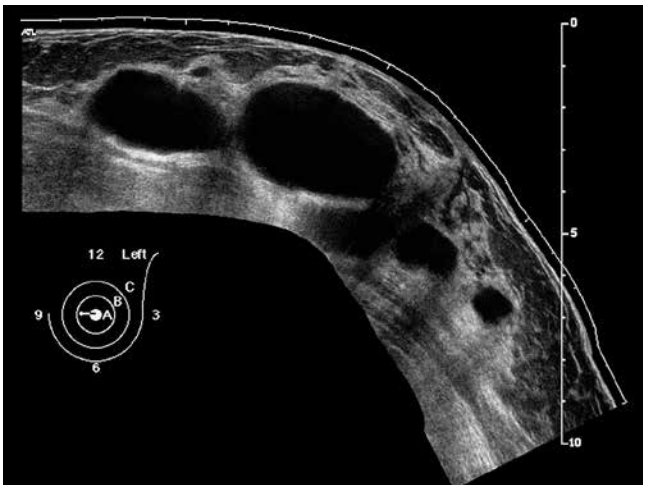


Figure 14 — IMAGE QUALITY: EXTENDED FOV. The FOV sweep shows numerous simple cysts within the fibroglandular tissue of this 46-year-old woman.

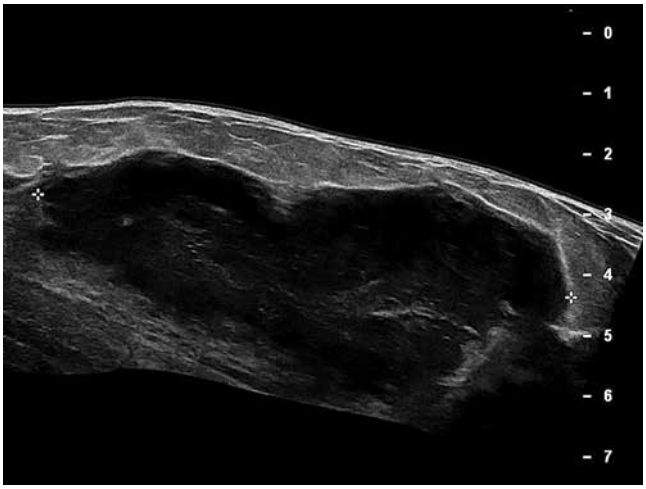


Figure 15 — IMAGE QUALITY: EXTENDED FOV. Extent of large 9 cm abscess is shown on this image using panoramic technique. On average, handheld high-resolution transducers in B-mode measure only 4–5 cm horizontally unless extended FOV functionality is used.

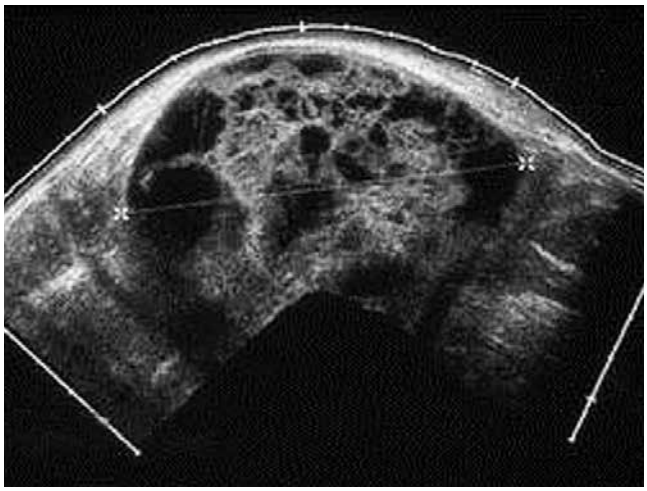
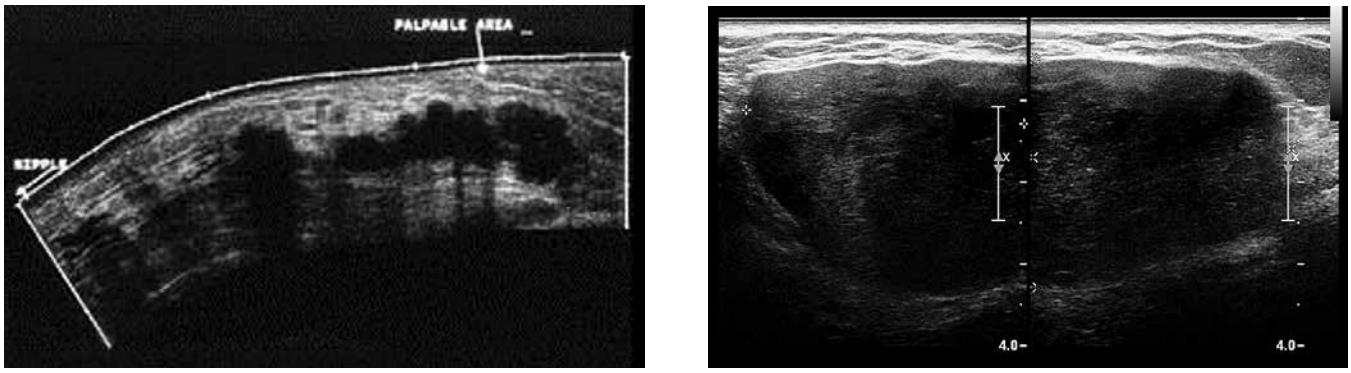


Figure 16 — IMAGE QUALITY: EXTENDED FOV. Complex cystic and solid mass shown in its entirety is a papillary ductal carcinoma in situ (DCIS).

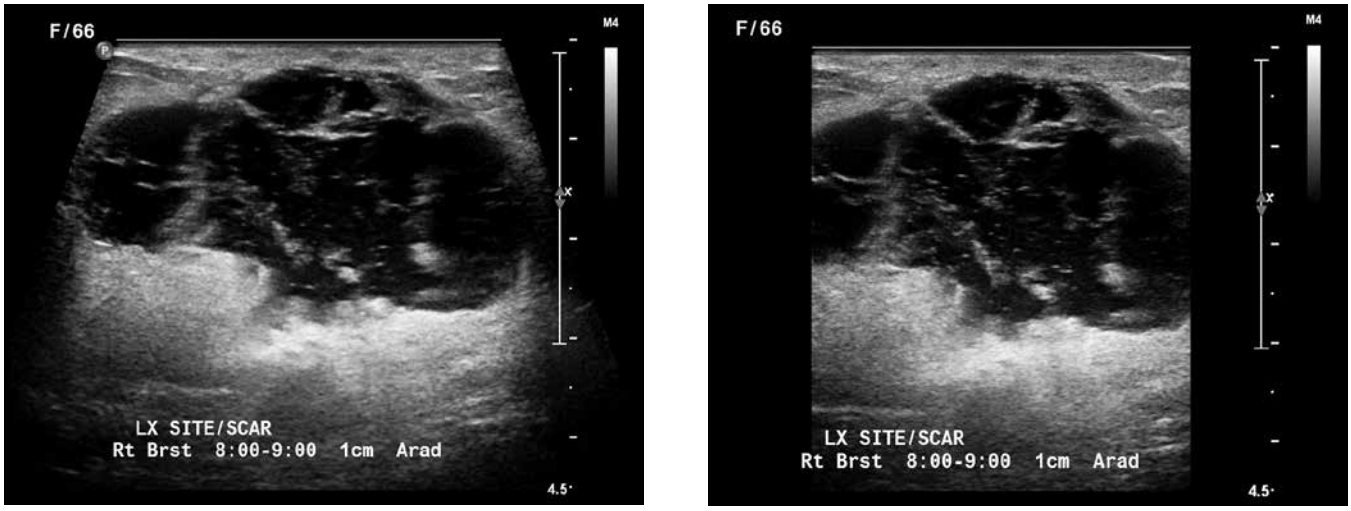


A **B**

Figure 17 — IMAGE QUALITY: EXTENDED FOV shows infiltration of invasive lobular carcinoma throughout the fibroglandular tissue *(a)*. Extended FOV imaging is useful for imaging large breast masses, for demonstrating distances between lesions, and for showing the relationship of lesions to other structures. Spliced image *(b)* of a 4 x 7 cm fibroadenoma is another method of US depiction of large abnormalities. This method is a workaround that approximates the size of the mass and shows less of the tissue surrounding it.

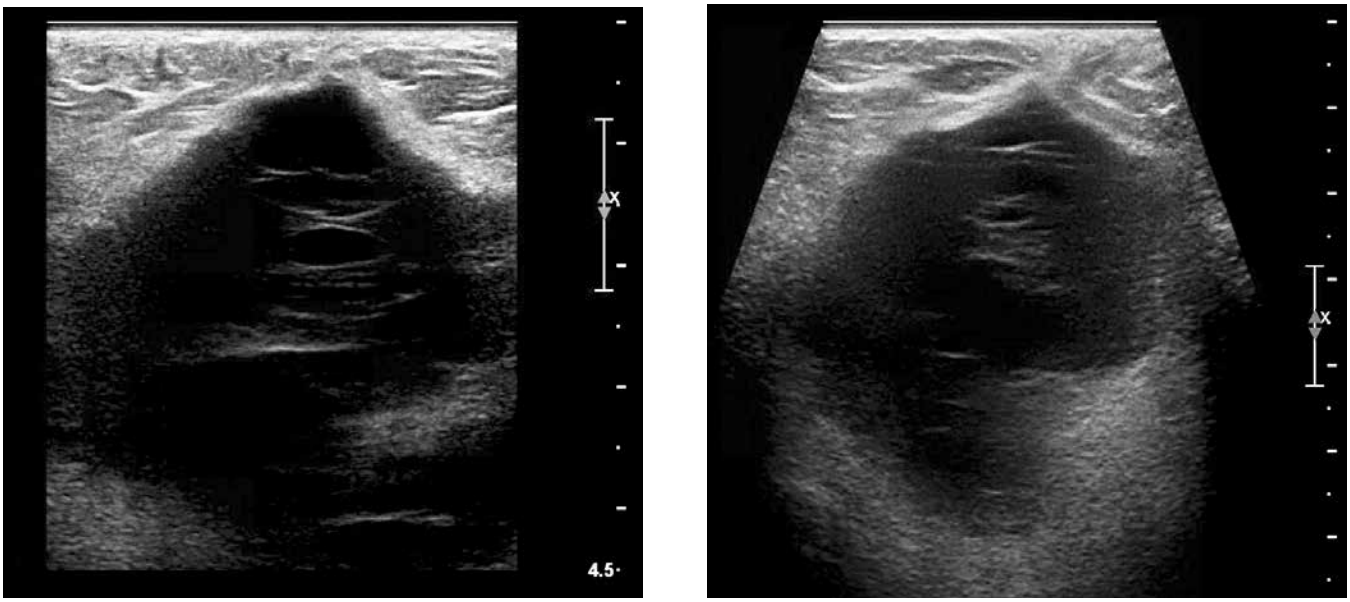
Some systems with dual screens enable image halves to be spliced. Approximately half of a large lesion or regional area of interest is captured and the image frozen; then the second image screen is activated and the other half captured. The edges of large lesions are approximated on a screen that shows both halves, and the entirety or most of the mass then is measured, albeit not precisely. Matching the anatomic landmarks provided by ducts, fat lobules, and depth from the skin facilitates accuracy. Wide FOV sweeps (panoramic displays) are more accurate and should be used whenever possible (Figure 16, see page 22).

There are additional methods as well: images produced by some linear transducers can be widened at the base of the image, which then appears trapezoidal as opposed to rectangular.



A **B**

Figure 18 — IMAGE QUALITY: TRAPEZOIDAL ACQUISITION. Postsurgical fluid accumulation following lumpectomy for an invasive ductal carcinoma. Lateral aspects of this large collection are cut off on the rectangular image *(a)* but included in the wider base of the trapezoidal acquisition *(b)*.



A B

Figure 19 — IMAGE QUALITY: TRAPEZOIDAL ACQUISITION. Compared with the rectangular image *(a)*, the posterior contour of this axillary postsurgical fluid collection is depicted better on the trapezoidal image *(b)*, wider at the base of the image.

In addition, volumetric acquisitions of linear transducers with 14–15 cm footprints enable a broad sweep of tissue to be displayed in 3-dimensional.

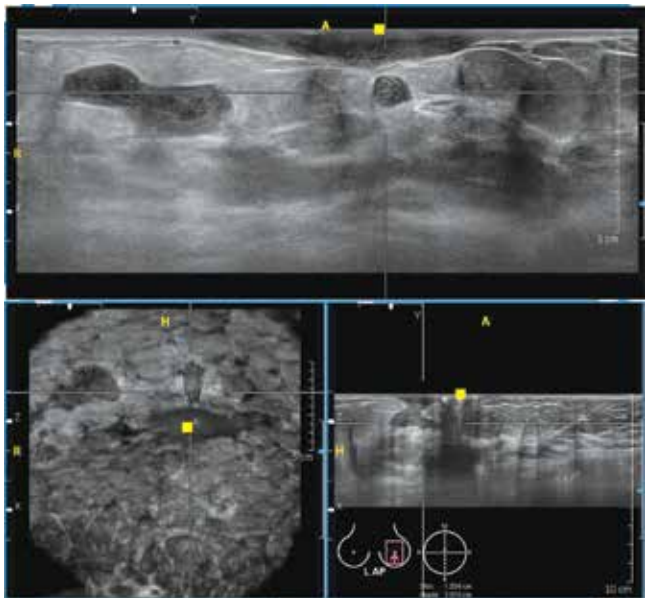


Figure 20 — IMAGE QUALITY: WIDE FOV, VOLUMETRIC ACQUISITION. Images of the right breast at 12:00 in a 29-year-old woman with chronic, sterile abscesses. Wide FOV B-mode transverse acquisition is illustrated above with coronal (lower left) and sagittal (lower right) images. The yellow square indicates location of the nipple, and the crosshairs are placed over a purulent collection shown in three orthogonal planes. Histopathology: granulomatous mastitis.

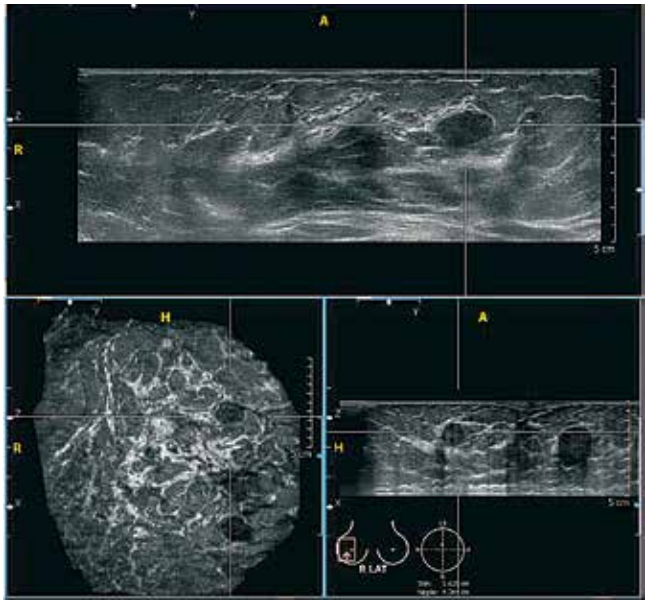
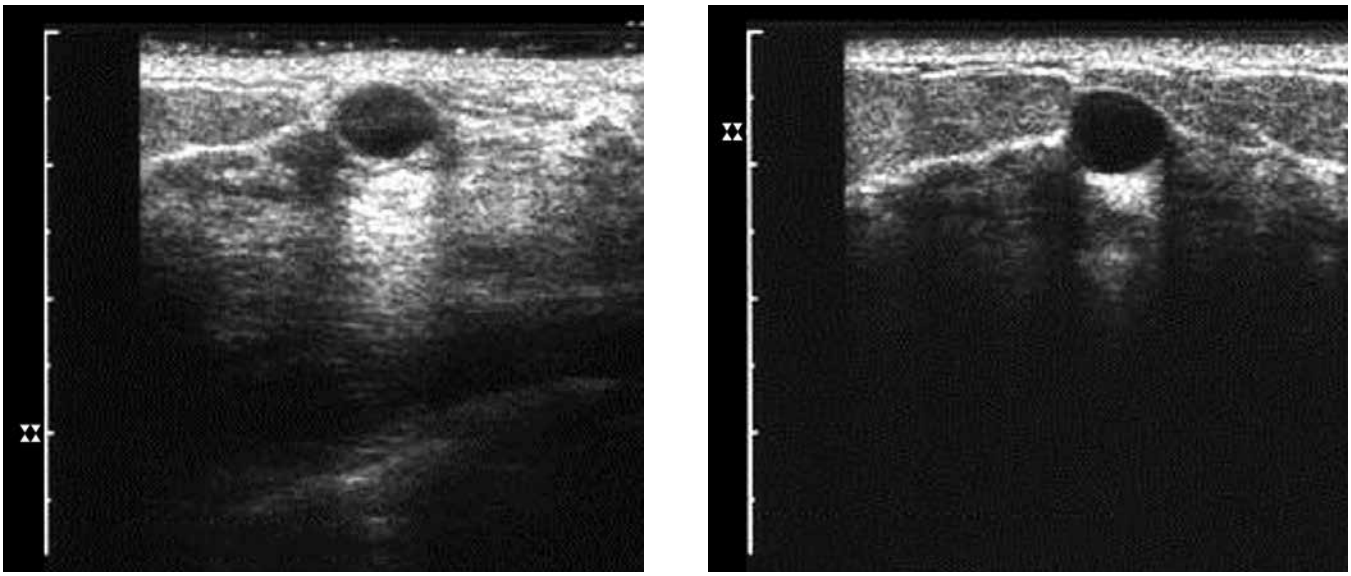


Figure 21 — IMAGE QUALITY: WIDE FOV, VOLUMETRIC ACQUISITION. Extended FOV, supine automated US examination, lateral view, of two of several benign masses in right breast of 42-year-old patient. Crosshairs intersect on a circumscribed, oval, parallel mass at 12:00. Top image is transverse, B-mode acquisition; lower left is coronal reconstruction with fibroglandular tissue white and fat darker gray; lower right, sagittal reconstruction. Wider acquisition fields allow more of the local anatomy to be depicted along with effect, if any, on the surrounding tissue (here, none). The volumetric acquisition also depicts the lesion in three orthogonal planes and can show distances between and relationships among multiple masses.

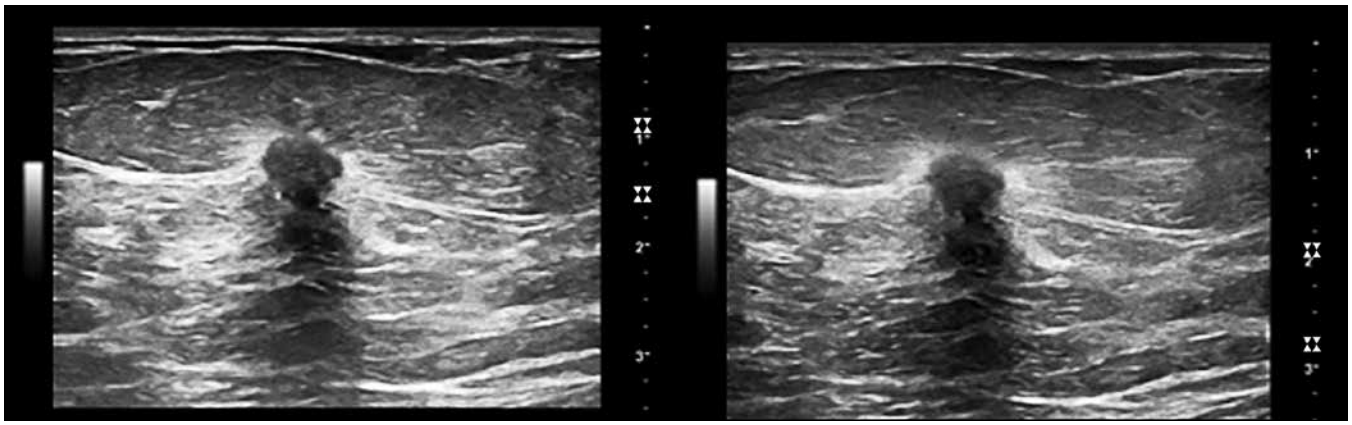
3. FOCAL ZONE

Variable focusing is available in many transducers. The focal zone(s) should be placed in the anterior-to-middle third of the region of interest between the skin and chest wall. When evaluating a lesion, the focal zone is optimally placed in the center of the lesion. Two to three focal zones or a single focal zone that has variable range will increase the resolution of the tissue imaged within that zone. However, in many systems, if more than three focal zones are used, the frame rate will be slowed significantly, losing the benefits of real-time scanning. Many systems have transducers that can be used with broad focal zone ranges that facilitate the rapidity of scanning large areas of the breast. If targeted scans are being done, a single zone or narrow range can be set at the midlevel of the mass or area of interest. Artifacts and blur caused by poor placement of the focal zones can cause misinterpretation of breast lesions.

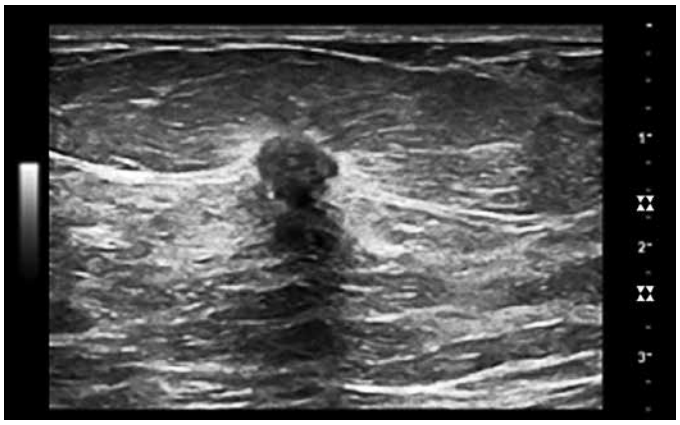


A **B**

Figure 22 — IMAGE QUALITY: EFFECT OF FOCAL ZONE SETTINGS: Focal zone (marked by ⧗ icons) inappropriately positioned below the mass causing echoes to appear within its anterior half *(a)*; with focal zone set properly in the midportion of the mass *(b)*, its anechogenicity is unquestioned. The echoes seen in *(a)* are confirmed as artifactual.



A **B**



C

Figure 23 — IMAGE QUALITY: FOCAL ZONE PLACEMENT can affect conspicuity and clarity of lesion depiction. Three US images of a carcinoma that was readily visible at mammography (not shown) were performed with focal zone settings (marked by a pair of ⧓ icons) at different levels. Although the small IDC is clearly identifiable on these three images, marginal features are best depicted when the focal zones are set at the depth of the lesion *(a)*. When the focal zones are adjacent to the pectoral muscle *(b)*, or set at the posterior aspect of the lesion *(c)*, while the shadowing remains intense, marginal features are less distinct.

4. GRAY SCALE GAIN

US waves are absorbed by tissue; the deeper the tissue, the greater the absorption, with less of the beam available to create an image. Increasing the gain may help compensate for this by increasing the brightness of the image, but penetration of tissue for adequate depiction also depends on transducer frequency (greater penetration inversely proportional to frequency), focal zone settings, power increase, and the appropriate selection of FOV. Gray scale gain should be set so normal breast parenchyma varies in echogenicity using much of the gray scale range. The gain may be set too high if the tissue appears as varying shades of white, which can obscure some lesions and make some cysts appear solid. The gain may be set too low if the parenchyma appears dark gray to black, causing some very hypoechoic solid lesions to appear anechoic and be mistaken for simple cysts. As a reference setting for the gray scale, subcutaneous fat lobules should appear medium gray, never black.

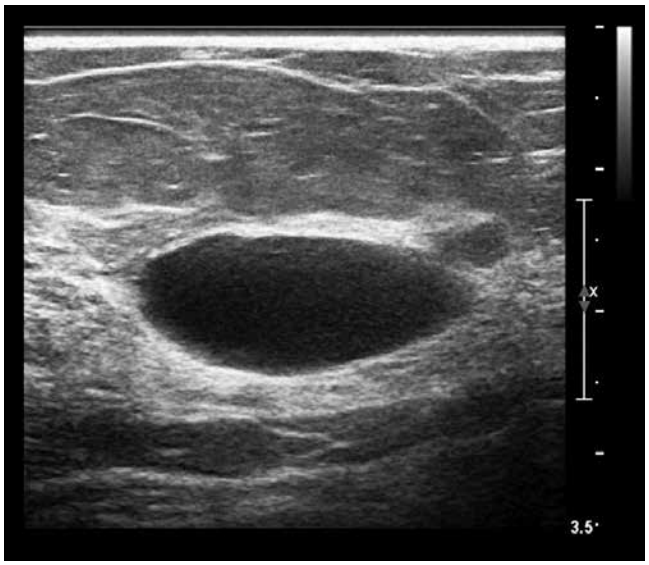
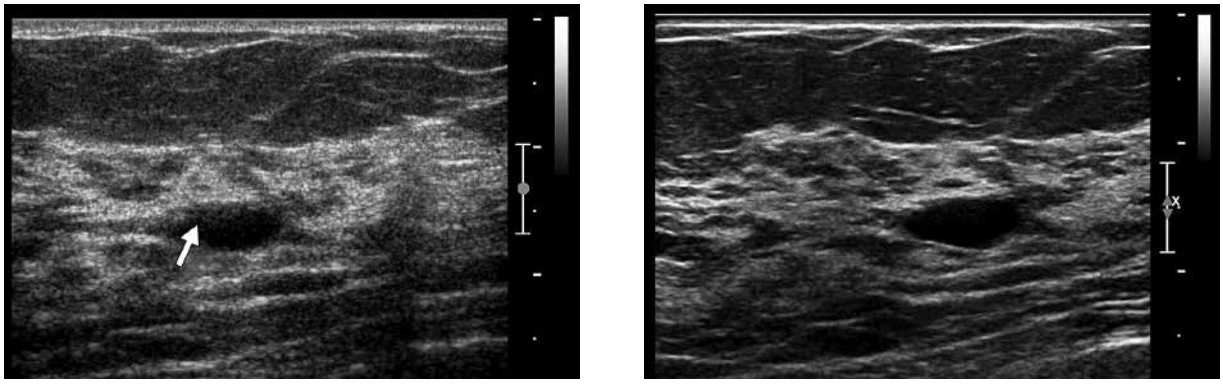


Figure 24 — IMAGE QUALITY: GRAY SCALE GAIN. Mass imaged with appropriate gain settings allows criteria for simple cyst to be applied. The center of the cyst appears anechoic, and surrounding fat and parenchyma are distinguished by the different shades of gray in this well-modulated image. A small complicated cyst is seen at the right margin of and anterior to the larger simple cyst.

5. COMPOUND IMAGING

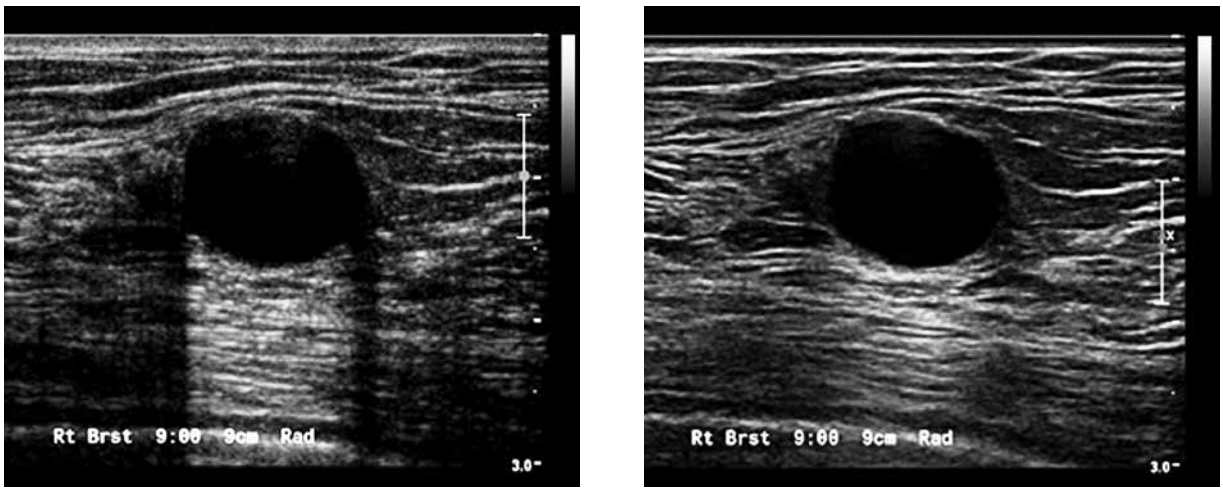
Real-time spatial compound imaging creates a single US frame by averaging several overlapping US images obtained at slightly different angles of insonation. The different angles are obtained by electronically steering the transducer array. The process can be repeated so rapidly that imaging occurs in real time, but the frame rate will slow as an increasing number of overlapping images is selected. Compound imaging reduces noise (speckle) and improves resolution in the center of the image. Architectural alterations may be easier to appreciate with compound imaging.

When masses are centered in an image obtained with spatial compounding, the margins are more confidently interpreted. The posterior features, shadowing and enhancement, may be less apparent but still discernible with spatial compounding, and enhancement may appear conical, reflecting the pattern of intersecting beam angles.



A **B**

Figure 25 — IMAGE QUALITY: SPATIAL COMPOUNDING. US image in native mode *(a)* demonstrates reverberation artifact in anterior, nondependent wall of cyst *(arrow)*. Spatial compounding technique *(b)* eliminates artifacts, making the cyst appear anechoic. In both of these images, the focal zone is set correctly.



A **B**

Figure 26 — IMAGE QUALITY: SPATIAL COMPOUNDING. The tissue posterior to this simple cyst enhances brightly in a column in this image obtained in native mode *(a)* but refraction shadowing at the lateral margins of the cyst obscures the adjacent tissue. At the left anterior margin, the definition is not as sharp as it is in *(b)*, obtained with spatial compounding. In *(b)* also, the lateral refraction shadows are nearly imperceptible, and the tissue lateral to the cyst is depicted clearly. Posterior enhancement is unmistakable; it is not as bright as that in *(a)* and is a more conical shape.

C. LABELING AND MEASUREMENT

1. LABELING

Breast US images should include the following labeling as described in the ACR Practice Guidelines for the Performance of Breast Ultrasound Examination and the ACR Practice Guidelines for the Performance of Ultrasound-Guided Percutaneous Breast Interventional Procedures.[4,6]

1. Facility name and location
2. Examination date
3. Patient's first and last name
4. Identifying number and/or date of birth
5. Designation of right or left breast
6. Anatomic location using clock-face notation (to the nearest hour) or a labeled diagram of the breast
7. Transducer orientation (e.g., radial, antiradial, oblique, transverse, sagittal)
8. Distance from the nipple to the abnormality or the area being scanned in centimeters (measure from the nipple as a standard reference point, not the edge of the very variable areola)
9. Sonographer's and/or physician's identification number, initials, or other symbol

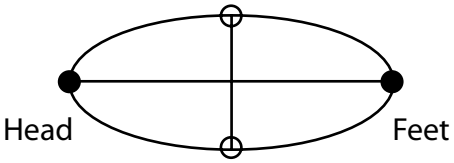
2. MEASUREMENT

How To Measure

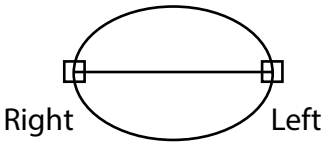
The sonologist or sonographer should seek the longest axis of a lesion, similar to what would be done for measuring a kidney or an ovary, and then obtain an orthogonal image with a measurement in the plane not present on the initial image. A common error is to use the rectangular frame of an image as the reference standard for measuring lesions (Figure 27, see page 31). Often, a mass is not oriented horizontally or vertically but obliquely within the image. For solid or complex cystic and solid lesions, an image with color or power Doppler is also desirable. Although real-time scanning is optimal, video clips of the study may also contribute some interpretive confidence when the interpreter of the exam is not the performer, ***but video clips should not be a substitute for direct interpreter scanning if questions persist.***

1. Record measurements to the nearest ***millimeter*** or ***centimeter*** (be consistent with the use of distance units throughout the report). For example, 0.45 cm–0.49 cm should be rounded up to 0.5 cm, and 0.11–0.14 cm should be rounded down to 0.1 cm.
2. When possible, three measurements of a lesion should be given. The largest measurement should represent the longest axis of a lesion if there is one. The next measurement should be the one perpendicular to the first. The third measurement should be taken from a view orthogonal to the first image, and it should represent a plane different from the first two. For example, see diagram below.

A. Initial image of lesion



B. Orthogonal view (turned 90º)

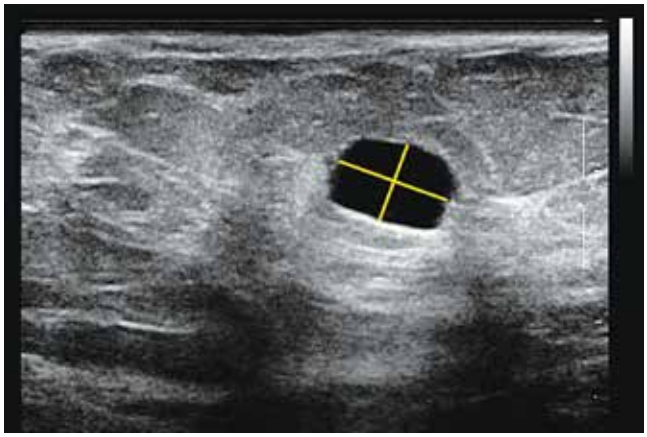


● Superior to Inferior

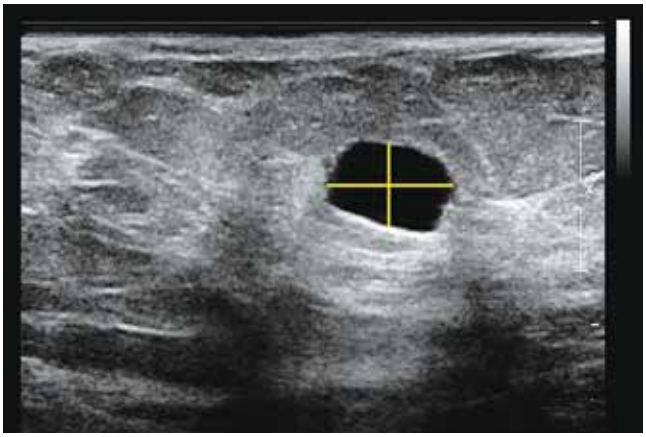
○ Anterior to Posterior

☐ Lateral to Medial

If it is necessary, the volume of a mass can be computed and reported by using a 3-D transducer (for 2-D US, two perpendicular images will allow three measurements to be made). If posterior shadowing is intense, the posterior margin of the mass may be obscured, and the anterior-posterior dimension may not be measurable.



A



B

Figure 27 — LABELING AND MEASUREMENT. This simple cyst and other obliquely situated masses should be measured as in *(a)*, first finding the longest axis of the mass and then a measurement perpendicular to it. The measurements shown in *(b)* are incorrect; the rectangular image frame should not be the reference for measuring.

D. DOCUMENTATION

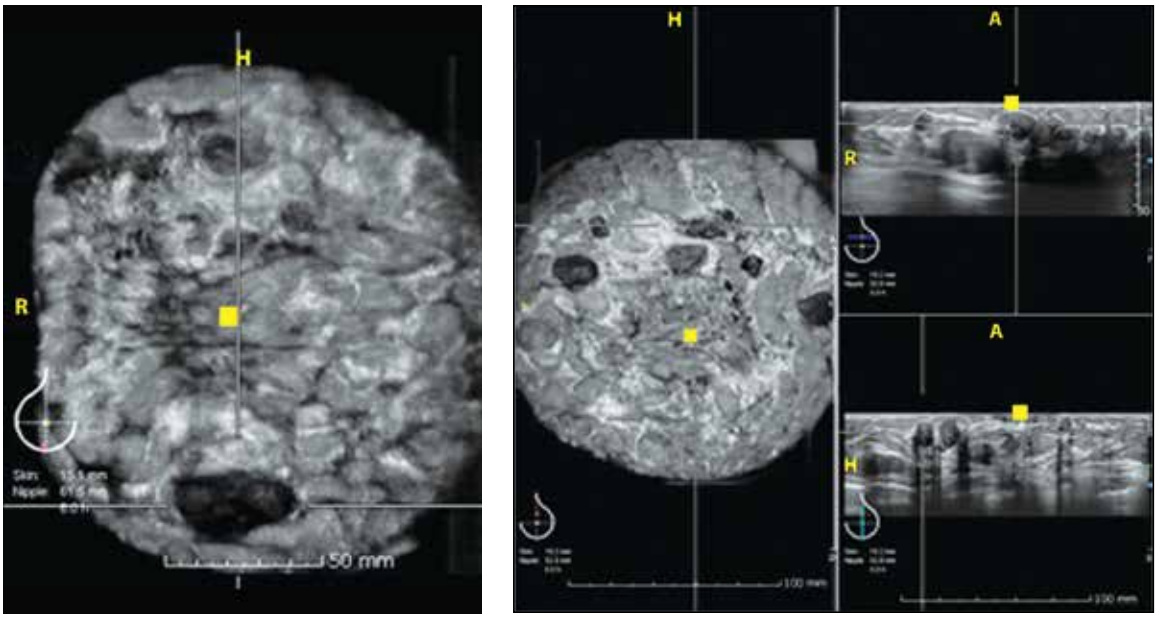
Cysts, Intramammary Lymph Nodes, and Multiple Benign Masses

When there are multiple cysts, representative images suffice. When several cysts are present, it is not necessary to document every cyst in two views; measuring the largest in each breast along only its longest axis is sufficient.[7] If the US examination is directed to a mammographic abnormality(ies) or if the cyst corresponds to an area of clinical concern to the patient, physician, or other health care provider, its measurements should be recorded as previously discussed. However, if a solitary asymptomatic simple cyst is identified at screening US, it should be fully evaluated by the operator at real-time scanning to establish its characteristically benign features, but it does not require complete documentation. One image along the longest axis of the cyst would be sufficient if the cyst is described in the report (benign assessment). No documentation is required if the cyst is not described in the report (negative assessment).

Although cysts can occur high in the axillary tail location or in accessory breast tissue within the axilla, such a location should suggest other etiologies, such as metastatic lymph nodes. Color or power Doppler and some elastographic methods can offer confirmation of the circumscribed, anechoic mass as a simple cyst.

Similar guidance is pertinent for the documentation of intramammary lymph node(s). If the US examination is directed to a mammographic abnormality(ies) or if the node corresponds to an area of clinical concern to the patient, physician, or other health care provider, full documentation of the lesion is appropriate. However, an asymptomatic, characteristically benign, intramammary lymph node, fully evaluated at real-time scanning or observed incidentally, does not require complete or even any documentation.

For US, as for mammography, benign (category 2) is the appropriate assessment for multiple bilateral solid masses, as long as all the masses are similar in appearance.[7] If the interpreter prefers to document all masses rather than the largest in each quadrant or in each breast, reporting should be in the form of a list including clock-face locations of the masses, distance from the nipple, and three orthogonal measurements. When there are numerous masses in the same area, reporting the depth from the skin to the anterior aspect of a lesion also helps to differentiate it from others. (Follow-Up and Outcome Monitoring section, (see FOM, page 61) regarding the effect that documenting nonstandard images has on the audit of screening examinations.)



A **B**

Figure 28 — DOCUMENTATION: MULTIPLE MASSES. Coronal views of the right *(a)* and left *(b)* breasts obtained with automated US show numerous circumscribed masses bilaterally. The transverse or axial acquisition is shown at the top right of *(b)* with the sagittal reconstruction at the lower right. Crosshairs correlate with lesion location on the three views. Diagrams and annotation at the lower corners of the coronal views indicate distance from the nipple, clock-face notation, and depth from the skin to the center of the crosshairs. DOCUMENTATION in a list is efficient and clear.

REFERENCES

1. American College of Radiology Imaging Network. Protocol 6666, screening breast ultrasound in high-risk women. (http://www.acrin.org/TabID/153/Default.aspx). Accessed November 4, 2013.
2. Berg WA, Blume JD, Cormack JB, et al. Combined screening with ultrasound and mammography vs mammography alone in women at elevated risk of breast cancer. *JAMA* 2008; 299:2151–2163.
3. Berg WA, Zhang Z, Lehrer D, et al. Detection of breast cancer with addition of annual screening ultrasound or a single screening MRI to mammography in women with elevated breast cancer risk. *JAMA* 2012; 307:1394–1404.
4. American College of Radiology. ACR practice guideline for the performance of breast ultrasound examination. (http://www.acr.org/~/media/ACR/Documents/PGTS/guidelines/US_Breast.pdf). Accessed November 4, 2013.
5. American College of Radiology. ACR practice guideline for the performance of screening mammography. (http://www.acr.org/~/media/ACR/Documents/PGTS/guidelines/Screening_Mammography.pdf) Accessed November 4, 2013.
6. American College of Radiology. ACR practice guideline for the performance of ultrasound-guided percutaneous breast interventional procedures. (http://www.acr.org/~/media/ACR/Documents/PGTS/guidelines/US_Guided_Breast.pdf). Accessed November 4, 2013.
7. Berg WA, Zhang Z, Cormack J, Mendelson E, Multiple bilateral circumscribed masses at screen breast US: consider annual follow-up. *Radiology* 2013; 268(3):673–683.

II. BREAST IMAGING LEXICON — ULTRASOUND

Table 1. BI-RADS® Ultrasound Lexicon Overview

Breast Tissue	Terms	
A. Tissue composition (screening only)	1. a. Homogeneous background echotexture – fat	
	2. b. Homogeneous background echotexture – fibroglandular	
	3. c. Heterogeneous background echotexture	
Findings	**Terms**	
B. Masses	1. Shape	a. Oval b. Round c. Irregular
	2. Orientation	a. Parallel b. Not parallel
	3. Margin	a. Circumscribed b. Not circumscribed i. Indistinct ii. Angular iii. Microlobulated iv. Spiculated
	4. Echo pattern	a. Anechoic b. Hyperechoic c. Complex cystic and solid d. Hypoechoic e. Isoechoic f. Heterogeneous
	5. Posterior features	a. No posterior features b. Enhancement c. Shadowing d. Combined pattern
C. Calcifications	1. Calcifications in a mass	
	2. Calcifications outside of a mass	
	3. Intraductal calcifications	
D. Associated features	1. Architectural distortion	
	2. Duct changes	
	3. Skin changes	a. Skin thickening b. Skin retraction
	4. Edema	
	5. Vascularity	a. Absent b. Internal vascularity c. Vessels in rim
	6. Elasticity assessment	a. Soft b. Intermediate c. Hard
E. Special cases	1. Simple cyst	
	2. Clustered microcysts	
	3. Complicated cyst	
	4. Mass in or on skin	
	5. Foreign body including implants	
	6. Lymph nodes – intramammary	
	7. Lymph nodes – axillary	
	8. Vascular abnormalities	a. AVMs (arteriovenous malformations/pseudoaneurysms) b. Mondor disease
	9. Postsurgical fluid collection	
	10. Fat necrosis	

A. TISSUE COMPOSITION

The wide normal variability in tissue composition seen on mammograms can also be observed on US images. Just as increasing breast density diminishes the sensitivity of mammography in the detection of small masses, heterogeneous background echotexture of the breast may affect the sensitivity of breast sonograms for lesion detection.

1. a. HOMOGENEOUS BACKGROUND ECHOTEXTURE — FAT

   Fat lobules and uniformly echogenic bands of supporting structures comprise the bulk of breast tissue.

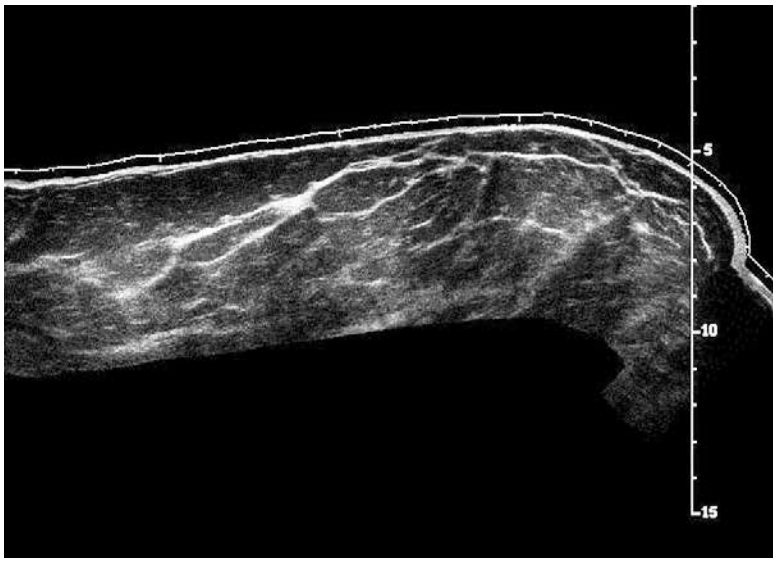


Figure 29—HOMOGENEOUS BACKGROUND ECHOTEXTURE — FAT. Homogeneously fatty tissue in a 59-year-old patient is easily characterized and compared with mammography using extended FOV or other US techniques that widen the field. The patient's head would be at the left and feet at the right.

A. TISSUE COMPOSITION

2. b. HOMOGENEOUS BACKGROUND ECHOTEXTURE — FIBROGLANDULAR

A thick zone of homogeneously echogenic fibroglandular parenchyma is present beneath the thin hypoechoic layer of fat lobules. Many lesions, cancers, and fibroadenomas, for example, are found within the fibroglandular zone or at its junction with the layer of fat.

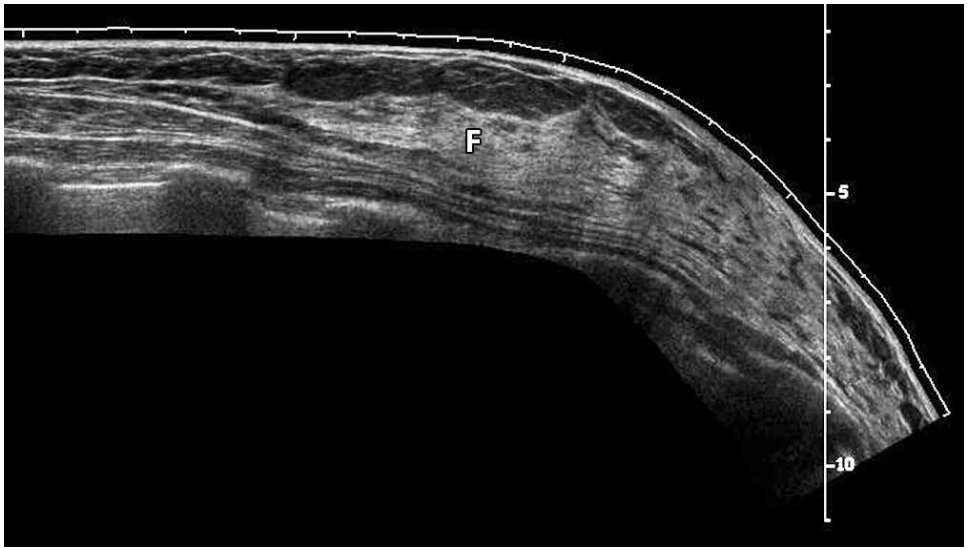


Figure 30 — HOMOGENEOUS BACKGROUND ECHOTEXTURE — FIBROGLANDULAR. The subcutaneous layer of fat is distinct from the more echogenic fibroglandular zone *(F)* that lies between it and the pectoral fascia and muscle beneath it.

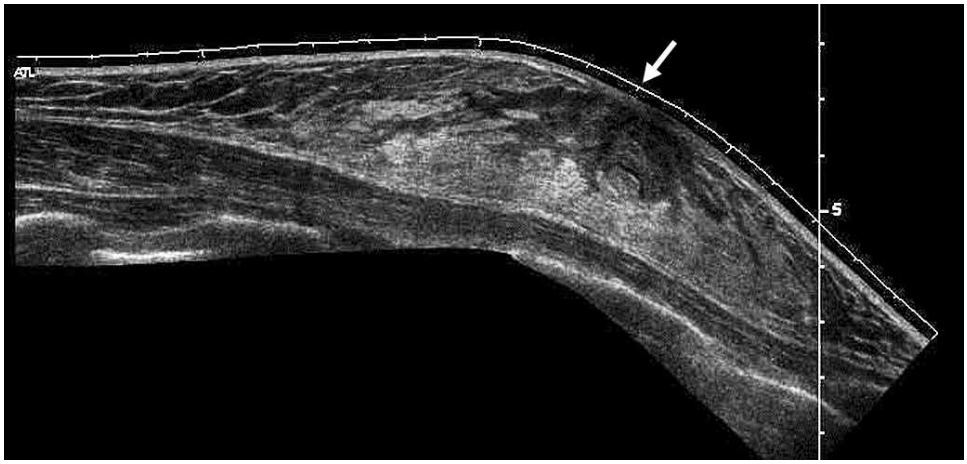


Figure 31 — HOMOGENEOUS BACKGROUND ECHOTEXTURE — FIBROGLANDULAR. The breast at puberty resembles gynecomastia with hypoechoic tissue immediately posterior to the nipple *(arrow)*. Because these young patients ordinarily do not undergo mammography, it is important not to misinterpret the hypoechoic retroareolar breast bud as an abnormality requiring biopsy. This area should be recognized as normal for this age group; if it is removed surgically, the breast will not develop.

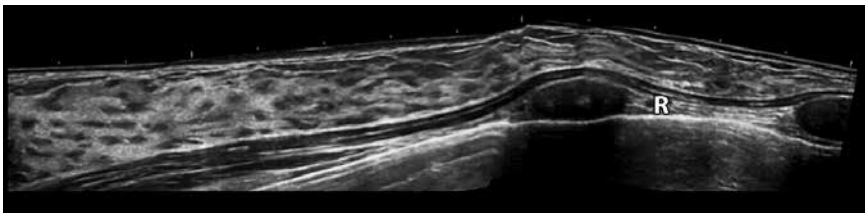


Figure 32 — HOMOGENEOUS BACKGROUND ECHOTEXTURE — FIBROGLANDULAR. Echogenic fibroglandular tissue with hypoechoic ducts beneath a layer of subcutaneous fat that is extremely thin. Rib *(R)*.

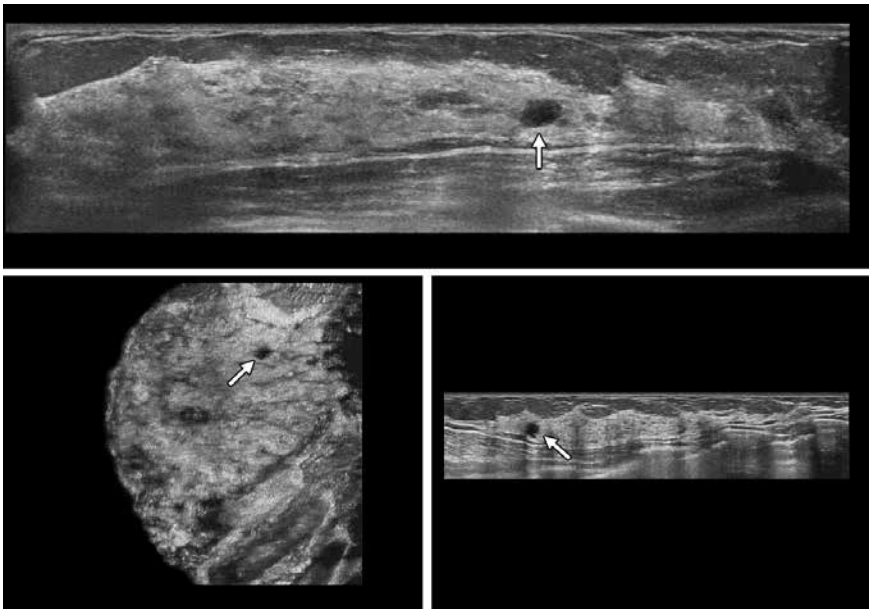


Figure 33 — HOMOGENEOUS BACKGROUND ECHOTEXTURE — FIBROGLANDULAR. Automated US image (lateral view) of the left breast showing a small cyst *(arrows)* within the homogeneous echogenic fibroglandular zone on each view, the 14–5 MHz linear acquisition,14.5 cm wide, at the top, with the coronal (left) and vertical (right) reconstructions below. A thin layer of subcutaneous fat overlies the fibroglandular zone.

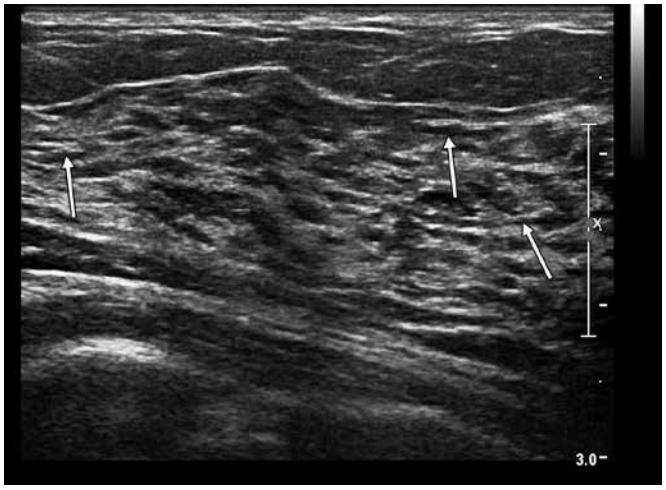
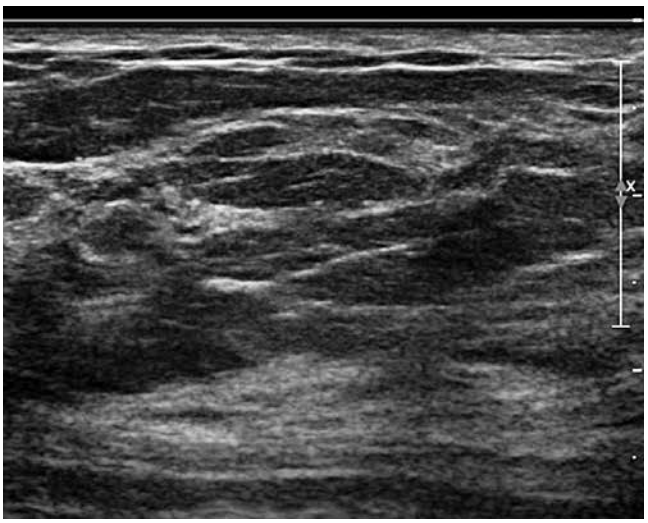


Figure 34 — HOMOGENEOUS BACKGROUND ECHOTEXTURE — FIBROGLANDULAR. Handheld image (linear transducer 17–5 MHz) with similar findings, but in greater detail, than the automated image above. The linear hypoechoic threadlike ducts *(arrows)* are seen throughout the fibroglandular tissue in the axillary tail of the right breast.

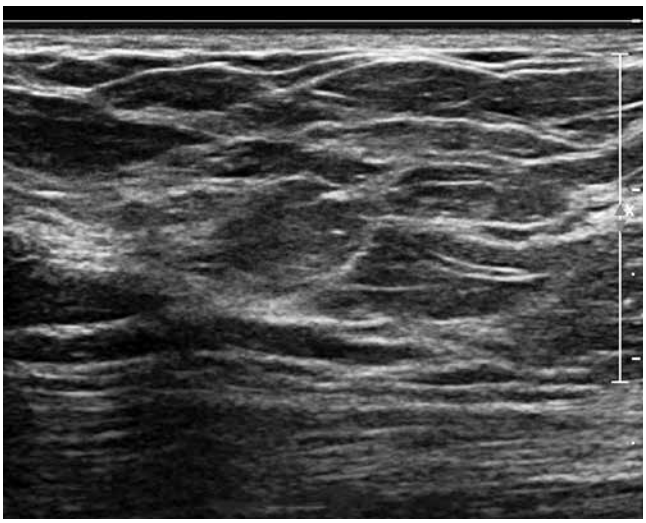
A. TISSUE COMPOSITION

3. c. HETEROGENEOUS BACKGROUND ECHOTEXTURE

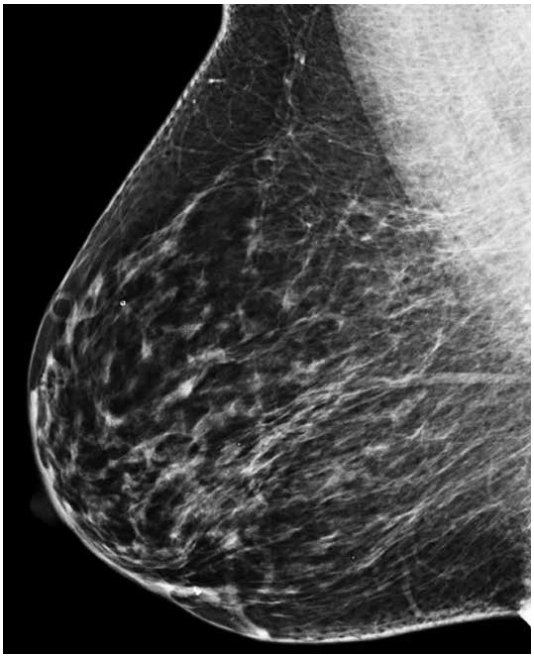
Heterogeneity can be either focal or diffuse. The breast echotexture is characterized by multiple small areas of increased and decreased echogenicity. Shadowing may occur at the interfaces of fat lobules and parenchyma. This pattern occurs in younger breasts and those with heterogeneously dense parenchyma depicted mammographically. Whether and how this pattern affects the sensitivity of sonography merits study, but clinical experience suggests that the detection of small and subtle lesions may be confounded by heterogeneous background echotexture. Technical maneuvers may help resolve interpretive dilemmas that occasionally result in unnecessary biopsy.



A



B



C

Figure 35 — HETEROGENEOUS BACKGROUND ECHOTEXTURE. Two images, one at 10:00 in the right breast *(a)* and the other at 12:00 in the left breast *(b)*, show an admixture of fat and fibroglandular tissue, not in separate homogeneous tissue layers as in the preceding images (Figs. 30–34). The mammographic correlate *(c)* is seen on a mediolateral oblique image of this 57-year-old woman's breast, described as scattered areas of fibroglandular density.

B. MASSES

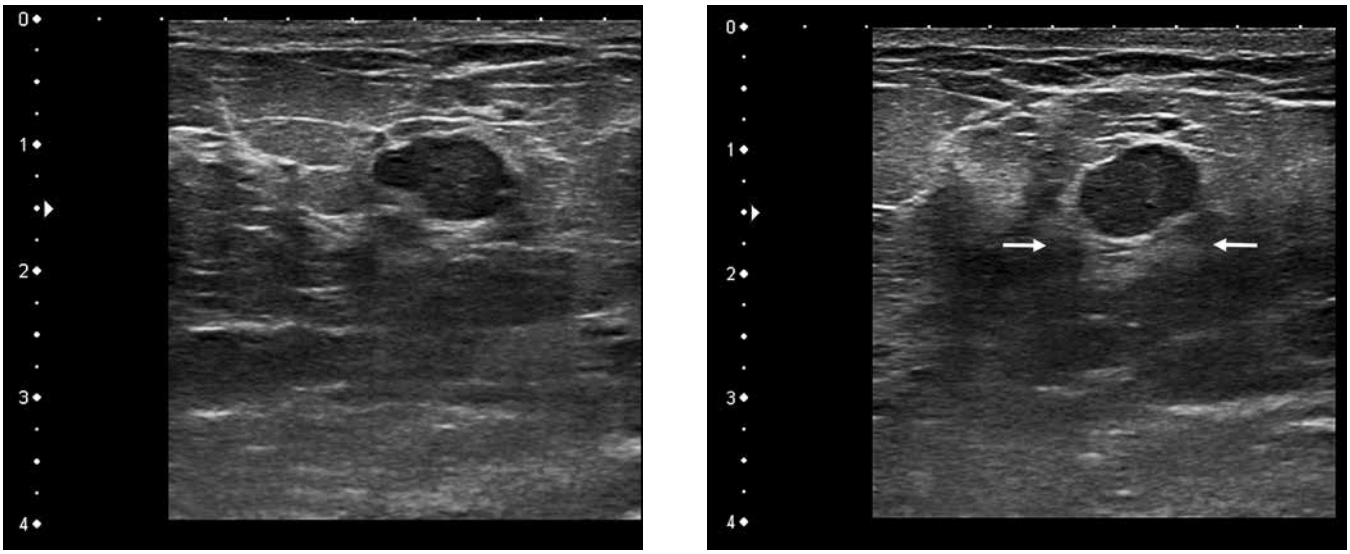
A mass is 3-D and occupies space. With 2-D US it should be seen in two different planes; with volumetric acquisitions it should be seen in three planes. Masses can be distinguished from normal anatomic structures, such as ribs or fat lobules, using two or more projections and real-time scanning.

B. MASSES

1. SHAPE

   a. Oval

   A mass that is elliptical or egg-shaped (may include two or three undulations, i.e., gently lobulated or macrolobulated).



A B

Figure 36 — SHAPE: OVAL. Radial *(a)* and antiradial *(b)* images of an OVAL mass in a 32-year-old woman. Margin is circumscribed, and orientation (longest axis of mass) is parallel to the skin. Refractive edge shadowing is present at the edges of curved surfaces *(arrows)*, particularly noticeable in *(b)*. Applying increased probe pressure or slight alteration in patient's position or probe angle can minimize this effect. Combined features suggest benign etiology. Patient requested US-guided biopsy. Concordant histopathology was fibroadenomatous change, sclerosing adenosis, and calcifications.

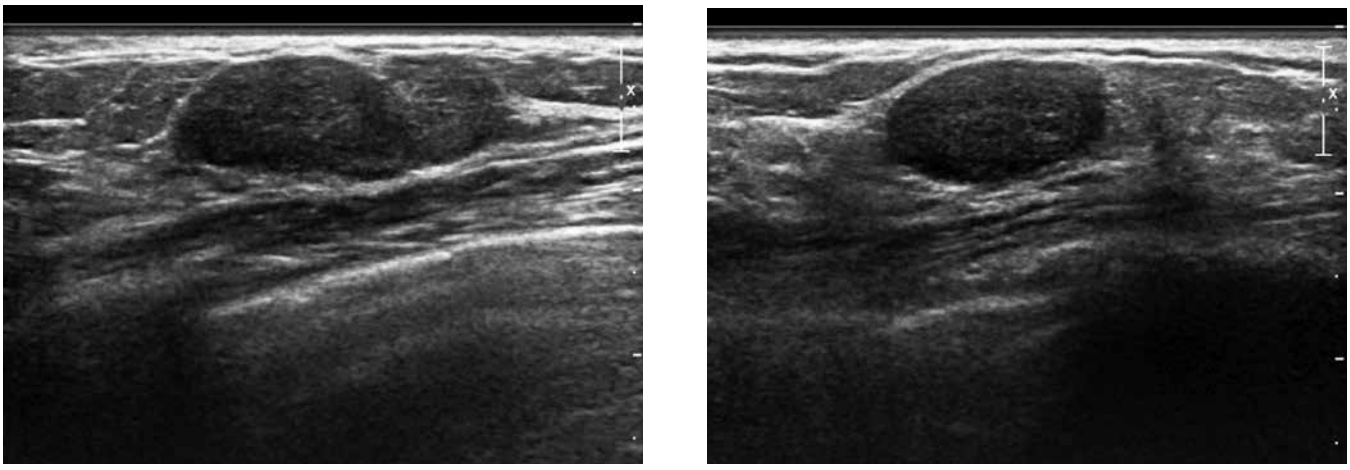
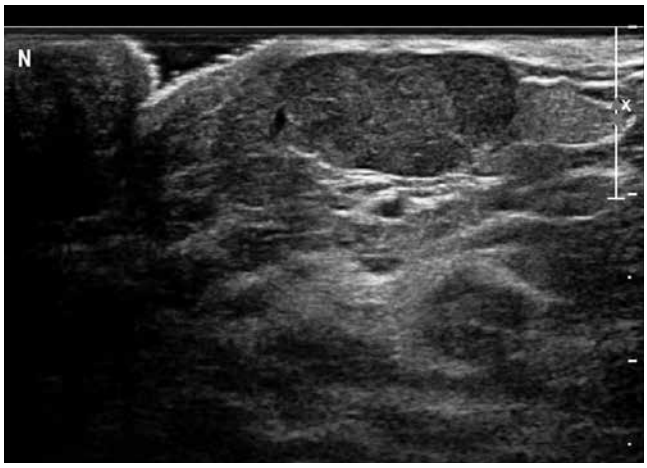
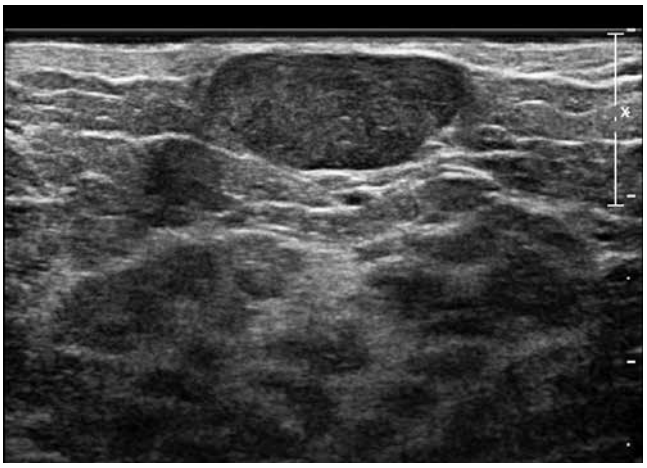


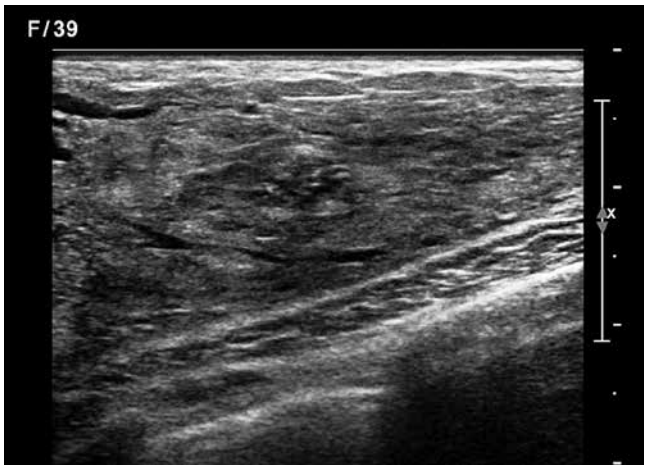
Figure 37 — SHAPE: OVAL. Orthogonal views of two adjacent, contiguous masses, each OVAL in shape, circumscribed, and parallel to the skin. Histopathology: fibroadenoma.



A



B



C

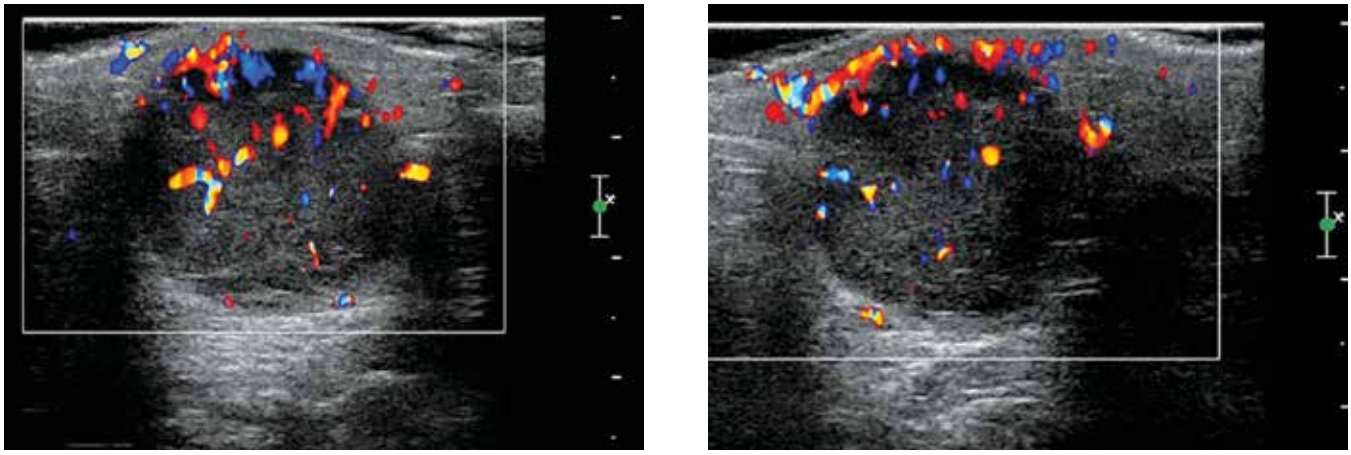
Figure 38 — SHAPE: OVAL. 28-year-old woman in third trimester of pregnancy with orthogonal views of a palpable mass *(a* and *b)* with features similar to those of the benign mass shown in Figure 26. US image *(c)* obtained 6 months after completion of lactation showed disappearance of the mass. Histopathology: lactating adenoma or lobular hyperplasia of pregnancy.

B. MASSES

1. SHAPE

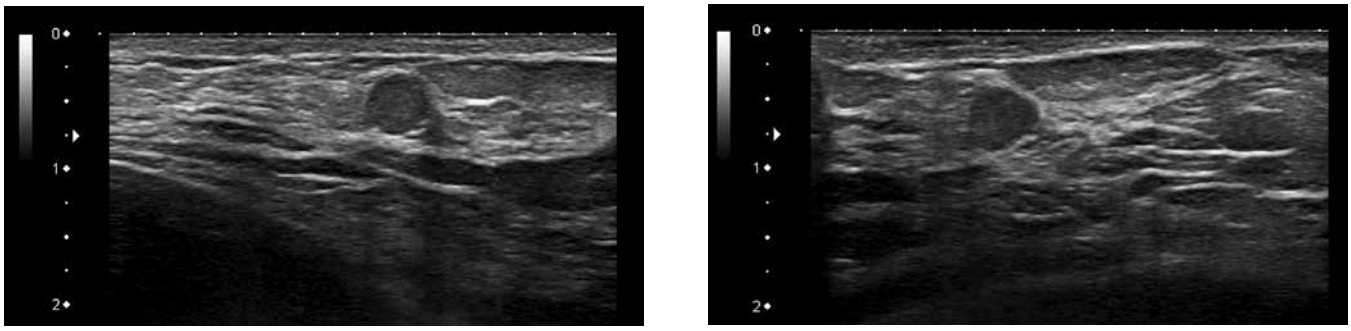
b. Round

A round mass is one that is spherical, ball-shaped, circular, or globular. It has an antero-posterior diameter equal to its transverse diameter; to qualify as a round mass, it must be circular in perpendicular projections. Masses with a round shape are not commonly seen at breast US.



A B

Figure 39 — SHAPE: ROUND. Axillary lymph node metastasis from esophageal carcinoma. Orthogonal, color flow images *(a* and *b)* in a woman who also has breast cancer. The mass is ROUND, is circumscribed, and enhances posteriorly. Vascularity is seen internally throughout the node and at its anterior rim. This lymph node, completely replaced by metastasis, has lost its reniform shape and hilar fat.



A B

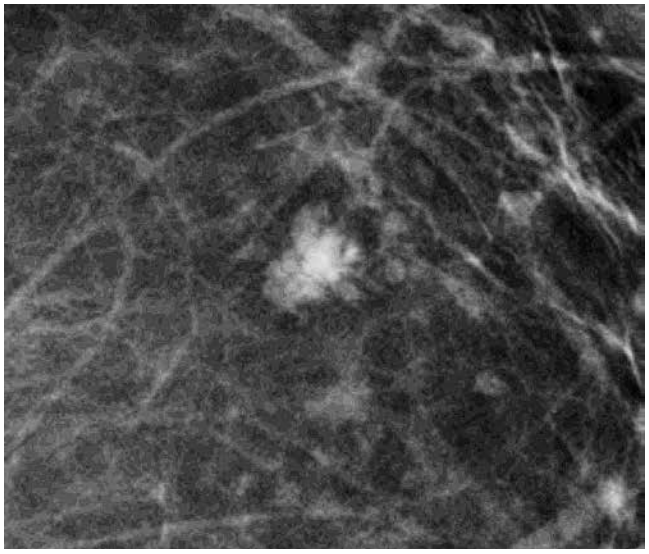
Figure 40 — SHAPE: ROUND. 37-year-old with pathogenic BRCA2 mutation and breast implants. Contrast-enhanced screening MRI depicted a suspicious mass. MRI-directed US also depicts this mass, as small, round, and circumscribed: *(a)* antiradial image; *(b)* radial image. Histopathology: intraductal papilloma.

B. MASSES

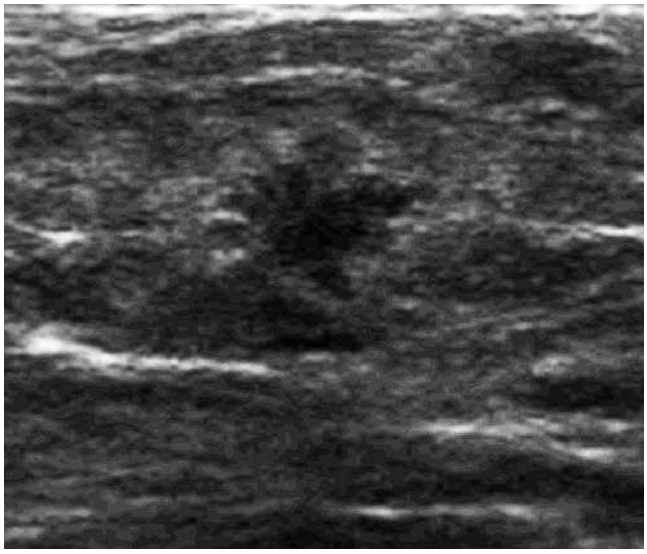
1. SHAPE

    c. Irregular

    The lesion shape is neither round nor oval.



A



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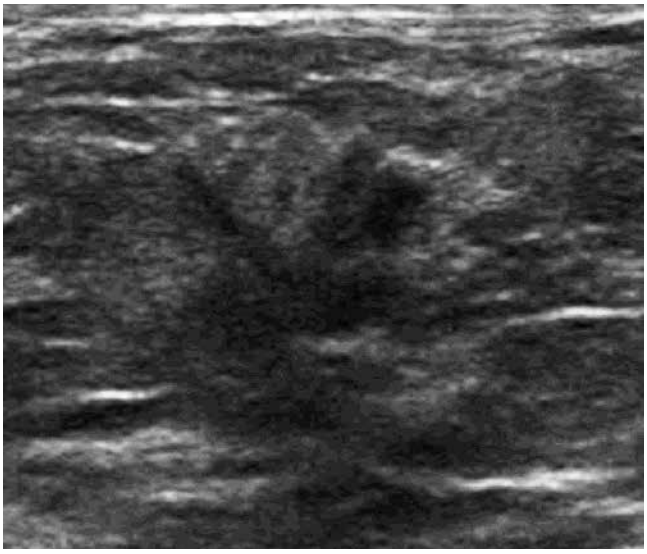
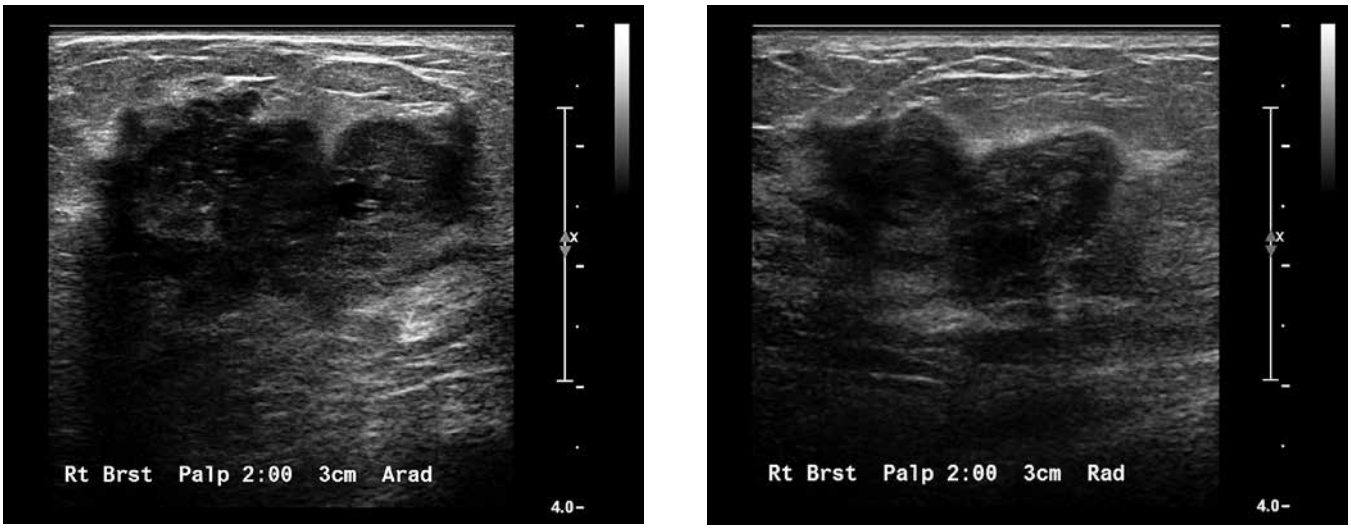


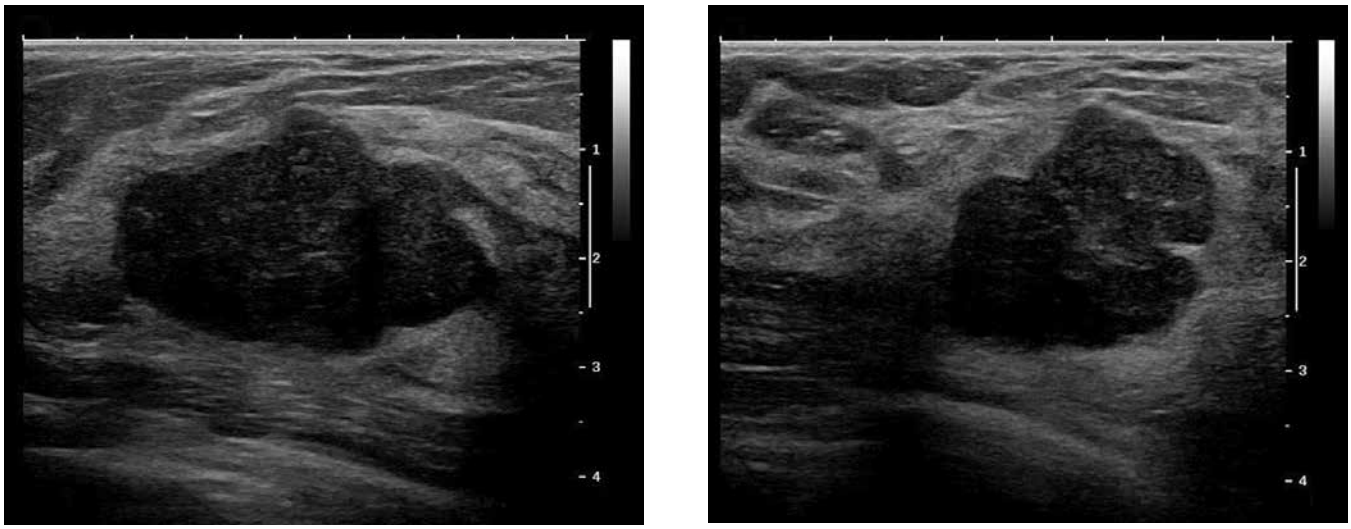
C

Figure 41 — SHAPE: IRREGULAR. Spot compression mammographic view of a mass with IRREGULAR shape *(a)* and perpendicular views of its sonographic correlate (*b* and *c*). The key findings are that the mass has an IRREGULAR shape, its margin is not circumscribed, and its orientation is not parallel. Histopathology is benign, high risk: complex sclerosing lesion, not upgraded at excision.



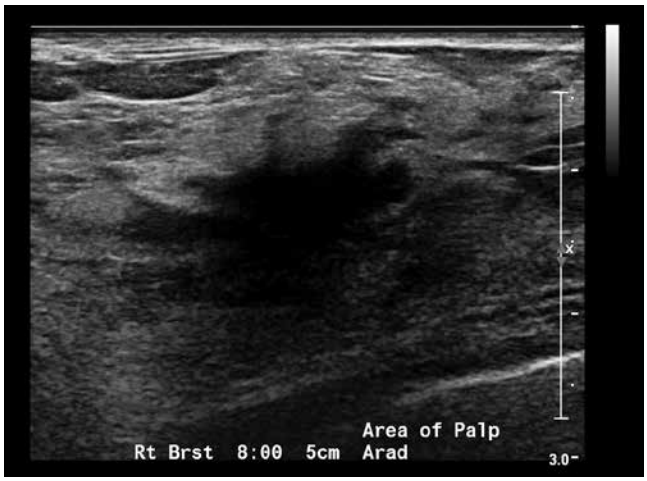
A **B**

Figure 42 — SHAPE: IRREGULAR. This large mass in a 49-year-old woman is 4 cm in its longest dimension. Its shape is IRREGULAR, its margin is not circumscribed, and its orientation is parallel to the skin *(a* and *b)*. Histopathology: invasive ductal carcinoma, grade 3.

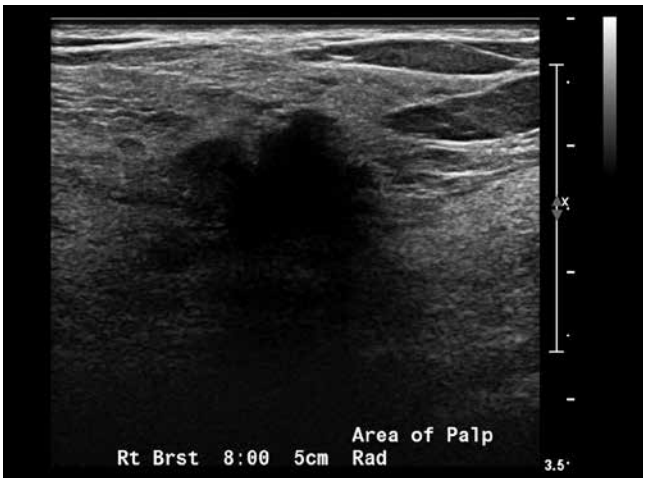


A **B**

Figure 43 — SHAPE: IRREGULAR. A 42-year-old woman has a mass with an IRREGULAR shape and microcalcifications within; the margin is not circumscribed, and a long axis is parallel to the skin *(a)*. Not uncommon in high-grade tumors is enhancement of the tissue posterior to the mass, well seen on *(b)*. Histopathology: invasive ductal carcinoma, grade 3.



A



B

Figure 44 — SHAPE: IRREGULAR. Spiculated hypoechoic mass in a 35-year-old woman with type 1 diabetes has an IRREGULAR shape and is oriented parallel to the skin in the antiradial scan *(a)*. The margin is not circumscribed *(b)*. BI-RADS® assessment is category 4C— high suspicion for malignancy. As in this case, even if the patient is an insulin-dependent diabetic with juvenile onset, tissue sampling ***must*** be performed. Histopathology: diabetic mastopathy.

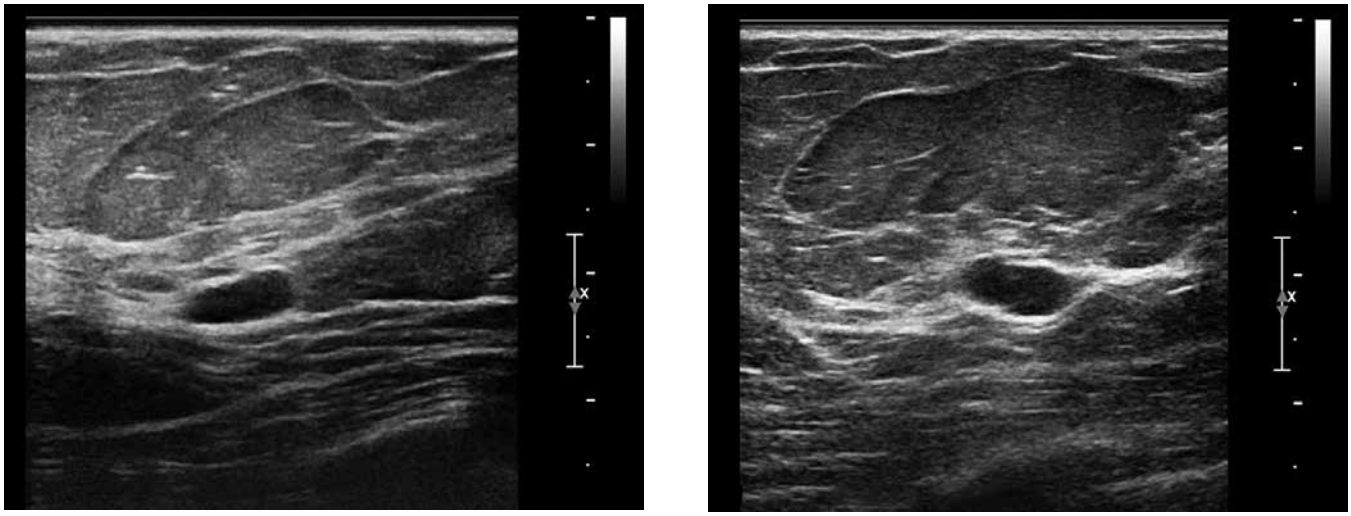
B. MASSES

2. ORIENTATION

This feature of masses is unique to US imaging. Orientation is defined with reference to the skin line. Obliquely situated masses may follow a radial pattern, and their long axes will help determine their classification as parallel or not parallel. Parallel or "wider-than-tall" orientation is a property of most benign masses, notably fibroadenomas; however, many carcinomas have this orientation as well. Orientation alone should not be used as the sole feature in assessing a mass for its likelihood of malignancy.

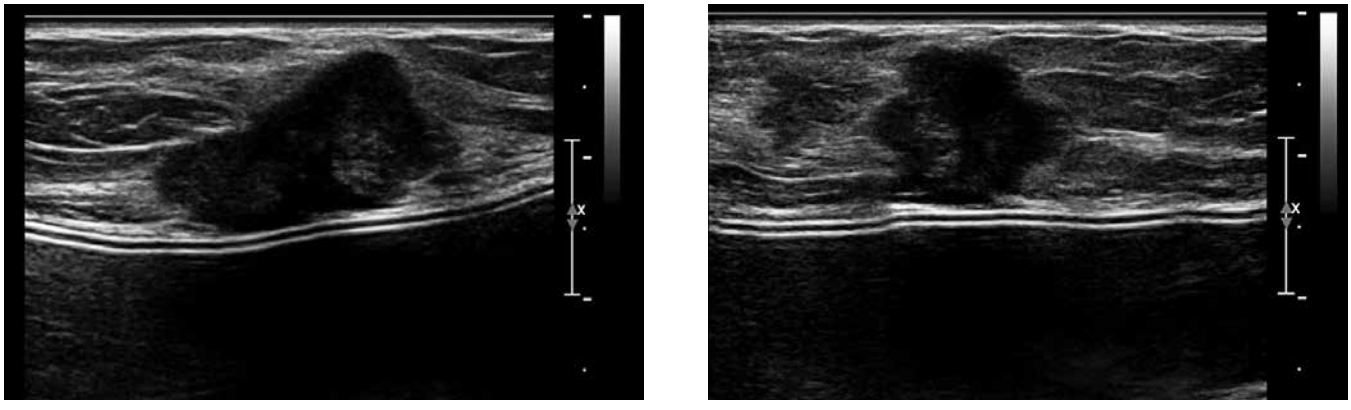
a. Parallel (historically, "wider-than-tall" or "horizontal")

The long axis of the mass parallels the skin line. Masses that are only slightly obiquely oriented might be considered parallel.



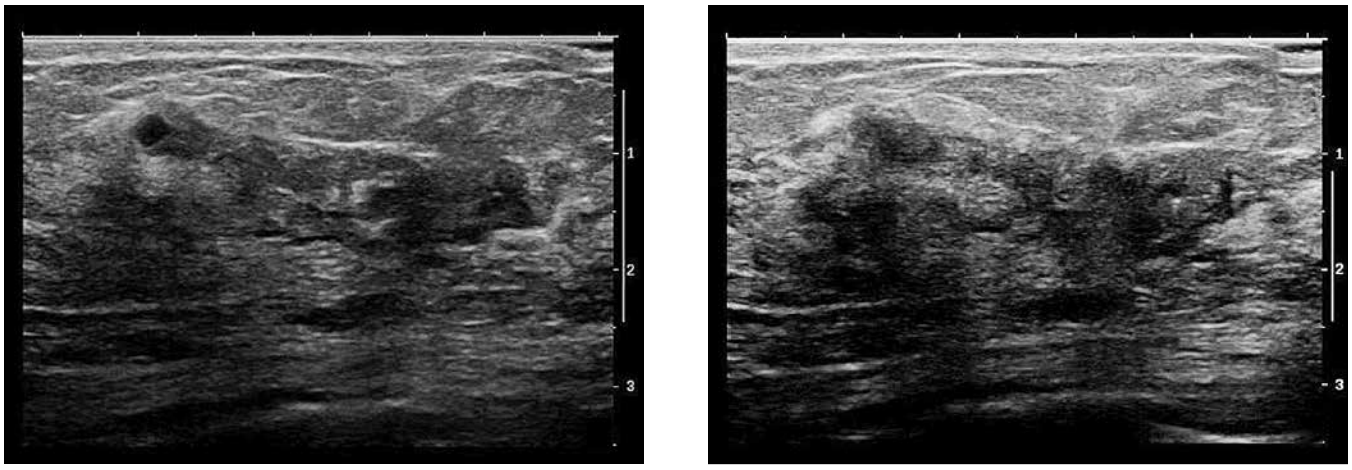
A B

Figure 45 — ORIENTATION: PARALLEL. Radial *(a)* and antiradial *(b)* views of a PARALLEL mass, oval and circumscribed, benign features taken together, situated within a thin layer of echogenic fibroglandular tissue in a predominantly fatty breast. Histopathology: fibroadenoma in a 39-year-old patient.



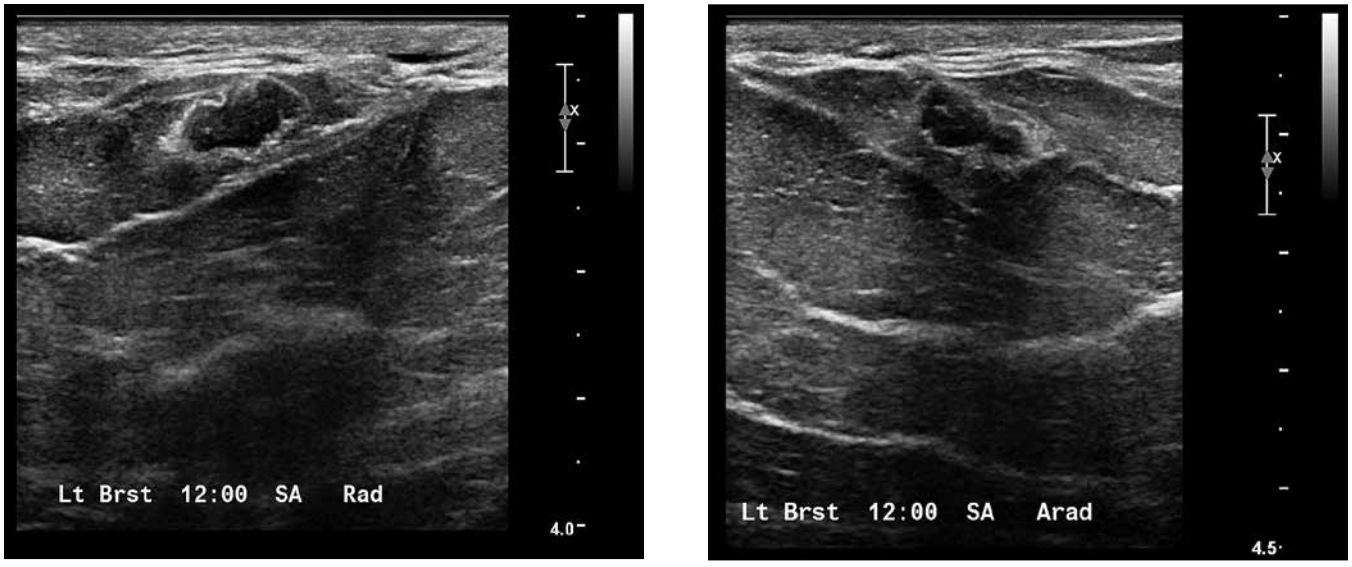
A B

Figure 46 — ORIENTATION: PARALLEL. Longest axis of mass is parallel to the skin *(a)*. Apparently nonparallel orientation is shown in the short axis view *(b)* of this mass in a 46-year-old woman with saline implants. When characterizing orientation, it should be from the view that depicts the longest axis of the lesion. The mass has an irregular shape, has a margin that is not circumscribed, and is located just anterior to the fibrous capsule of the implant. Echogenic flecks clumped within the mass are calcifications. Histopathology: invasive ductal carcinoma, grade 2.



A **B**

Figure 47 — ORIENTATION: PARALLEL. 52-year-old woman with a PARALLEL mass that has an irregular shape and not circumscribed (indistinct) margin on perpendicular views *(a)* and *(b)*. The tumor extends through the fibroglandular zone of breast tissue. Portions of the mass show posterior shadowing; in other areas, there is no change in posterior features. Histopathology: invasive carcinoma (ductal and lobular features).



A **B**

Figure 48 — ORIENTATION: PARALLEL. Two views *(a* and *b)* show obliquity in orientation, but the long axis is more PARALLEL than not. Obliquity may be due to proximity to the nipple and apex of the breast cone. Mass, surrounded by an echogenic rim, contains calcifications. Margin is not circumscribed (microlobulated), and assessment in this case is suspicious (category 4). Surrounding tissue is fatty, and there is posterior shadowing. Histopathology: nodular sclerosing adenosis.

B. MASSES

2. ORIENTATION

b. Not Parallel

The long axis of the mass is not parallel to the skin line. The anterior-posterior or vertical dimension is greater than the transverse or horizontal dimension. These masses can also be obliquely oriented to the skin line. Round masses are not parallel in their orientation.

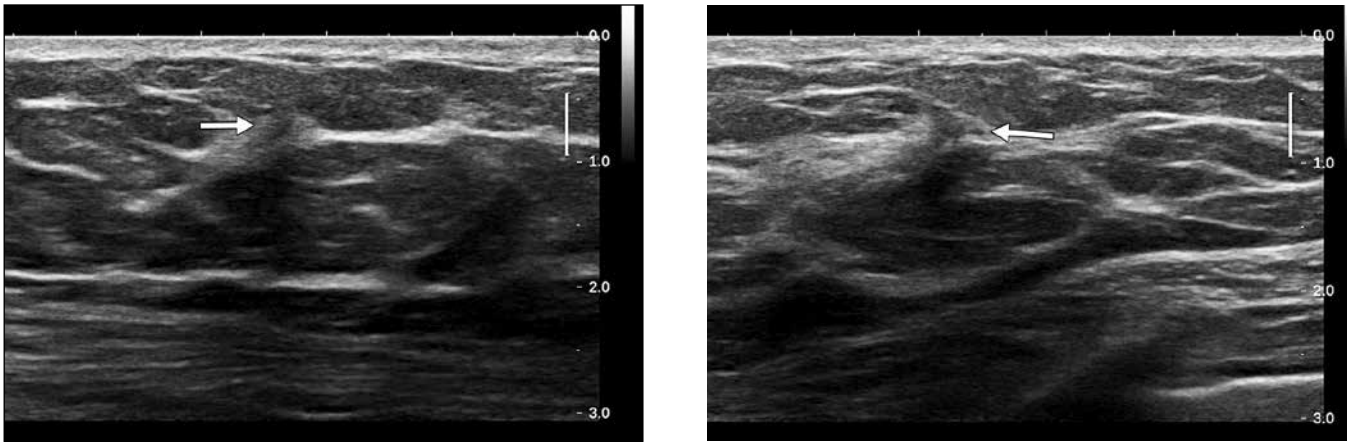
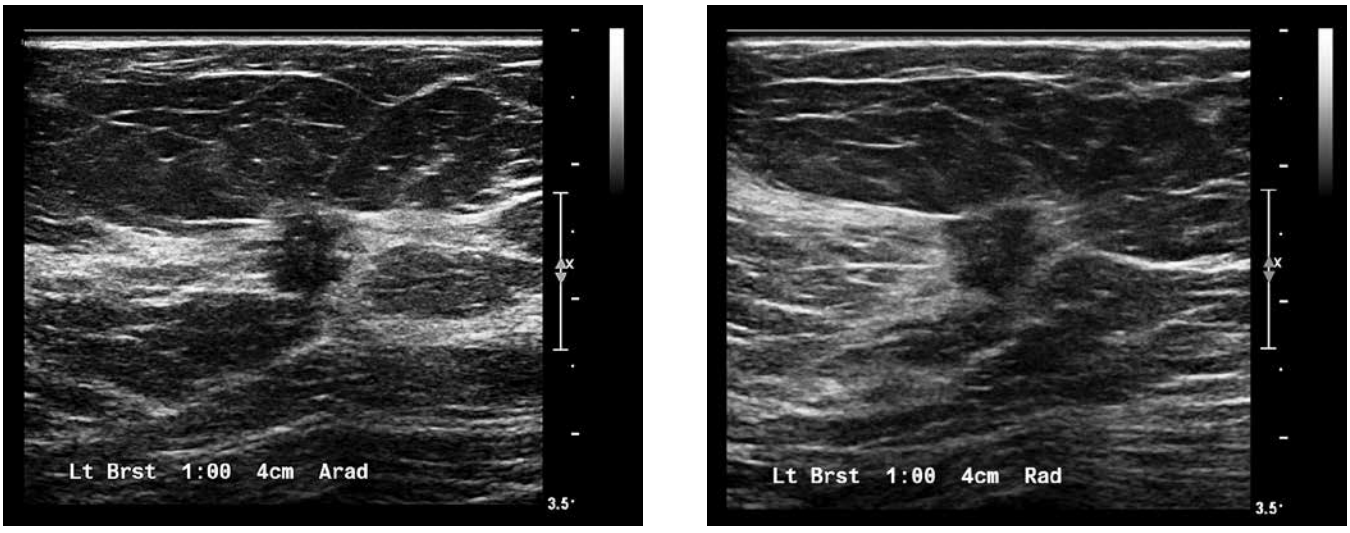


Figure 49 — ORIENTATION: NOT PARALLEL. Invasive ductal carcinoma *(arrows)* within the fibroglandular zone of a breast of predominantly fatty tissue composition is oriented NOT PARALLEL to the skin.



A **B**

Figure 50 — ORIENTATION: NOT PARALLEL. The long axis of this isoechonic mass on the antiradial view *(a)* is NOT PARALLEL to the skin surface, whereas in *(b)* the long and short axes are equal: the mass is NOT PARALLEL. Invasive ductal carcinoma, grade 2, occupies nearly the entire thickness of the fibroglandular zone on orthogonal images.

B. MASSES

3. MARGIN

The margin is the edge or border of the lesion. The descriptors of margin, like the descriptors of shape, are important predictors of whether a mass is benign or malignant.

a. Circumscribed (historically, "well-defined" or "sharply defined")

A circumscribed margin is one that is well defined, with an abrupt transition between the lesion and the surrounding tissue. For a mass to be described as circumscribed at US, its entire margin must be sharply defined. Most circumscribed lesions have round or oval shapes.

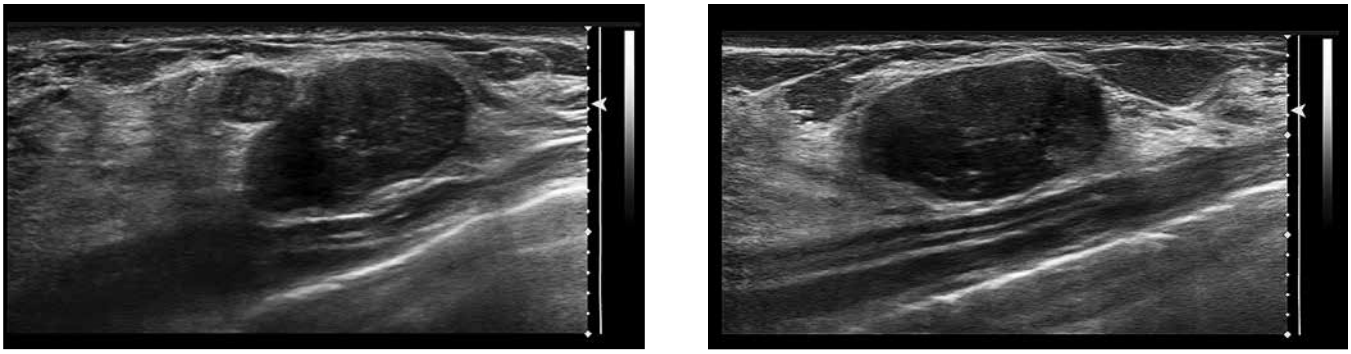


Figure 51 — MARGIN: CIRCUMSCRIBED. Two oval, parallel, CIRCUMSCRIBED masses, one much smaller and superficial, within the fibroglandular layer of tissue in a 32-year-old woman. Tissue composition is homogeneous background echotexture. Histopathology: fibroadenoma.

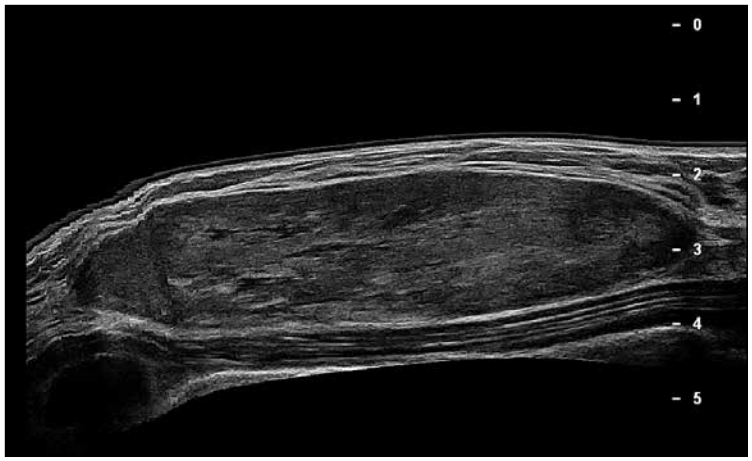


Figure 52 — MARGIN: CIRCUMSCRIBED. Oval, parallel, benign mass in a 28-year-old woman is a giant fibroadenoma. Giant fibroadenoma is defined as being ≥ 5 cm in its longest dimension. Extended FOV scan depicts the entire extent of the mass, here more than 9 cm on this medial-to-lateral image.

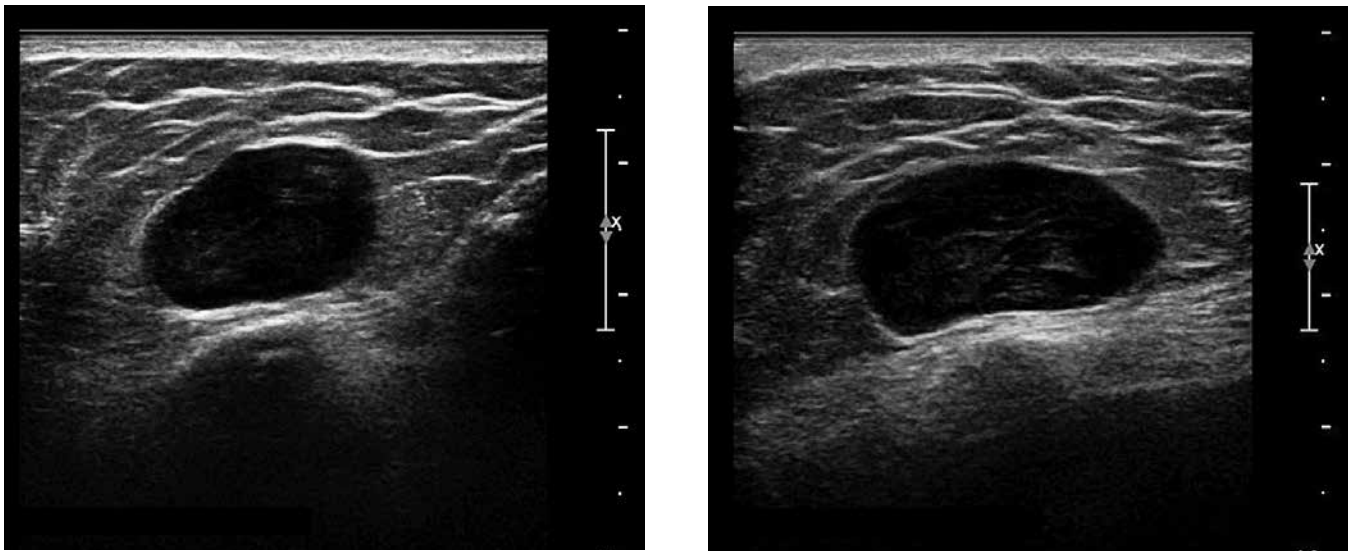


Figure 53 — MARGIN: CIRCUMSCRIBED. Oval, parallel, CIRCUMSCRIBED mass is metastatic leiomyosarcoma. Clinical history is essential in determining management of benign-appearing masses that require biopsy.

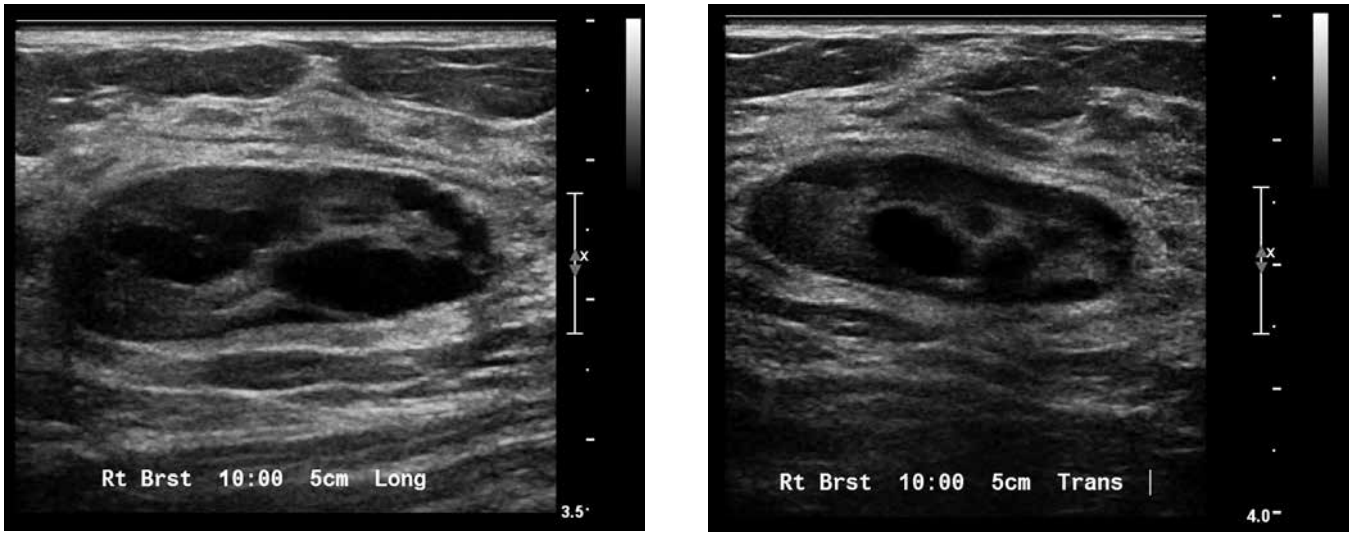


Figure 54 — MARGIN: CIRCUMSCRIBED. A complex cystic and solid mass palpable in a 39-year-old woman with extremely dense fibroglandular tissue. BI-RADS® assessment was suspicious — low suspicion (category 4A), likelihood of malignancy 2%–10%. Histopathology: pseudoangiomatous stromal hyperplasia (PASH), portions of cyst wall lined by benign epithelial hyperplasia and apocrine metaplasia. A complex fibroadenoma that contains cysts may also have this appearance.

B. MASSES

3. MARGIN

b. Not Circumscribed

If *any* portion of the margin is not circumscribed, the mass should be characterized as not circumscribed. A mass that is not circumscribed may further be described as having ***indistinct, angular, microlobulated, or spiculated margins,*** or any combination of these. "Irregular" is not used to group these marginal attributes because irregular describes the shape of a mass.

i. Indistinct

There is no clear demarcation of the entire margin or any portion of the margin from the surrounding tissue. The boundary is poorly defined, and the significant feature is that the mass is not circumscribed. The descriptor "indistinct" includes echogenic rim (historically, "echogenic halo") because one may not be able to distinguish between an indistinct margin and one that displays an echogenic rim.

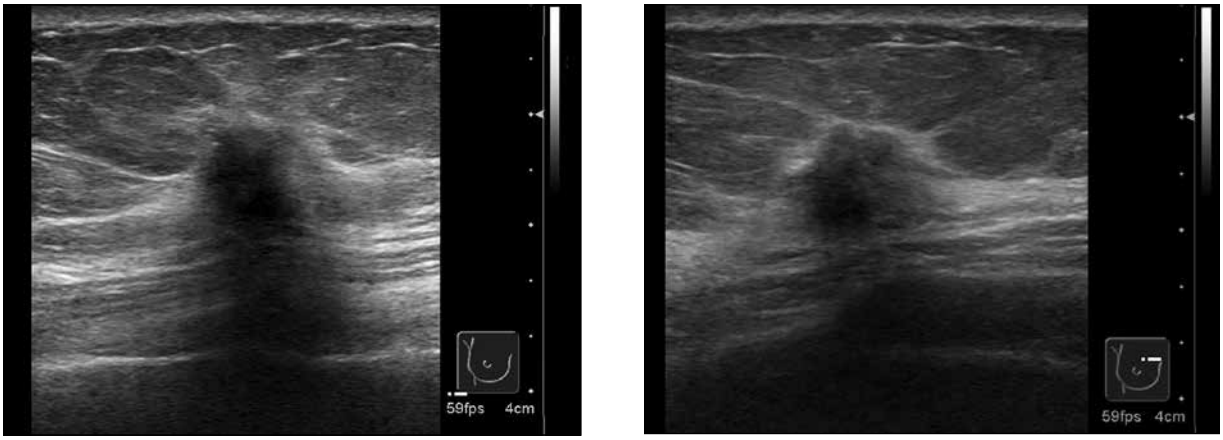


Figure 55 — MARGIN: NOT CIRCUMSCRIBED, INDISTINCT. The interface between the mass and the surrounding tissue is not circumscribed, with a predominantly INDISTINCT margin that also is partially angular and spiculated. Invasive ductal carcinoma, grade 2, that is hypoechoic, irregular in shape and not parallel to the skin.

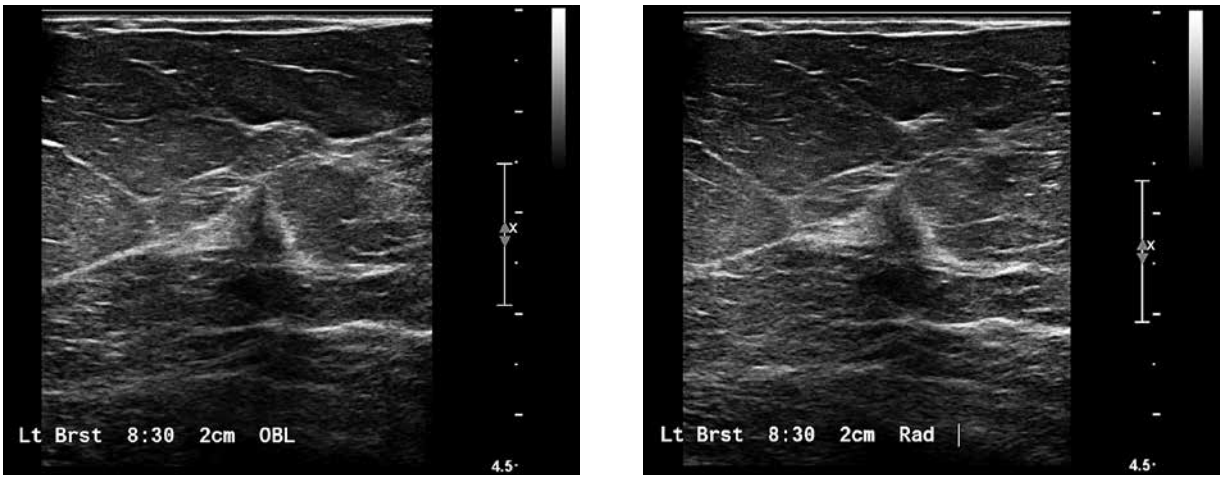


Figure 56 — MARGIN: NOT CIRCUMSCRIBED, INDISTINCT. Orthogonal views of an irregular mass in a 65-year-old woman, not parallel, with INDISTINCT margin. Histopathology: invasive ductal carcinoma and ductal carcinoma in situ, grade 2.

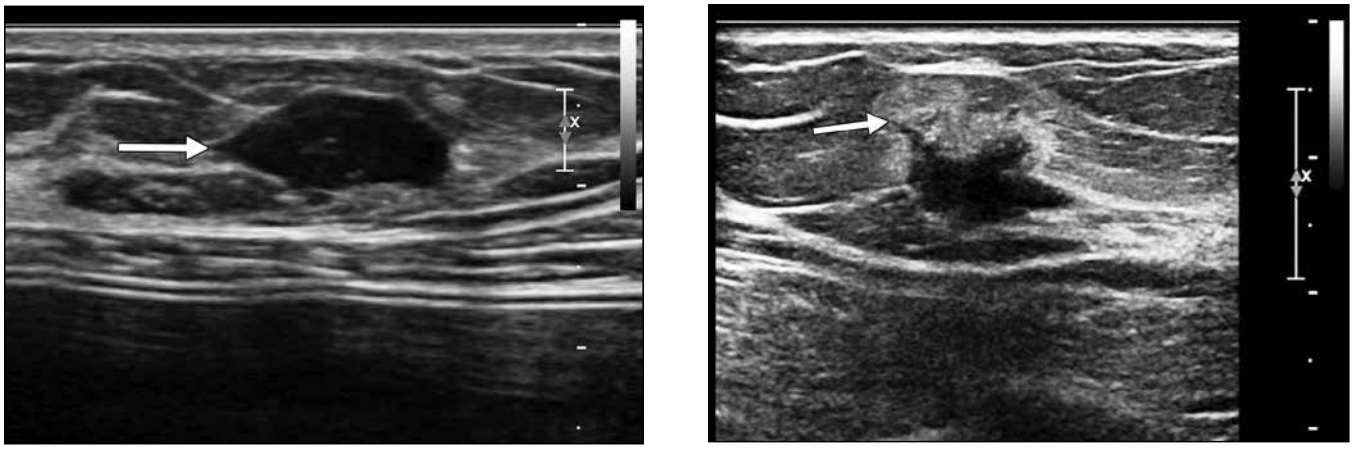
B. MASSES

3. MARGIN

b. Not Circumscribed

ii. Angular

Some or all of the margin has sharp corners, often forming acute angles, but the significant feature is that the margin of the mass is not circumscribed.



A **B**

Figure 57 — MARGIN: NOT CIRCUMSCRIBED, ANGULAR. Orthogonal views of a mass in which the margin appears partially but not completely circumscribed. This palpable mass in an augmented 39-year-old patient might be described as oval and parallel, but it should not be given a probably benign assessment for the following reason: in *(a)*, the margin is ANGULAR *(arrow)*, and in *(b)*, the margin is angular and has an echogenic rim *(arrow)*, descriptors included in the NOT CIRCUMSCRIBED characterization. Histopathology: invasive ductal carcinoma, grade 3.

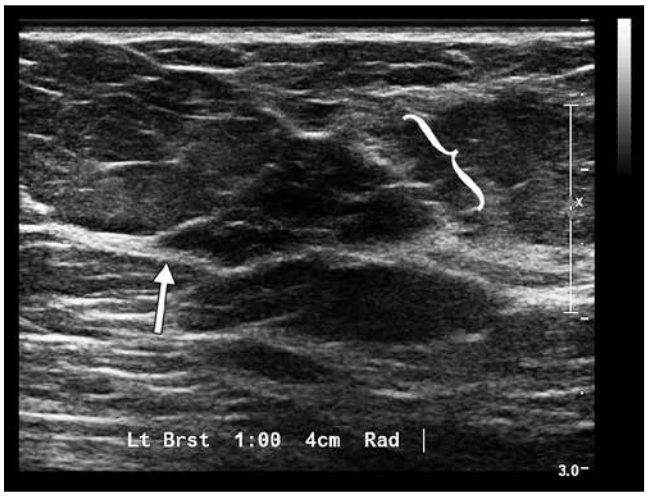


Figure 58 — MARGIN: NOT CIRCUMSCRIBED, ANGULAR. Heterogeneous mass with cystic components in a 64-year-old patient has an ANGULAR *(arrow)* and microlobulated *(brace)* margin. Assessment based on these sonograms would be suspicious — high suspicion (category 4C). Histopathology: invasive lobular carcinoma.

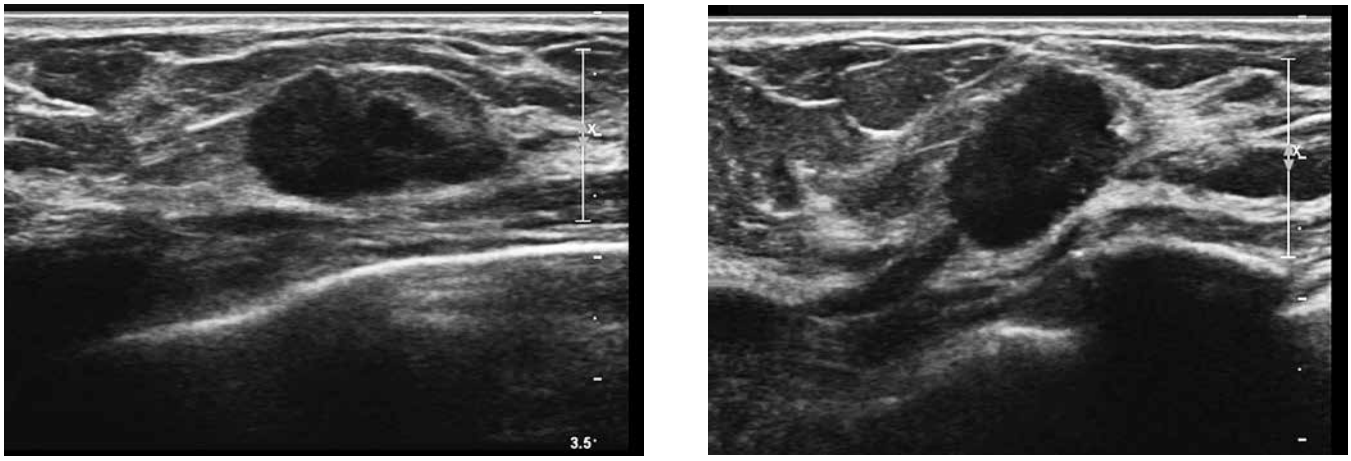
B. MASSES

3. MARGIN

b. Not Circumscribed

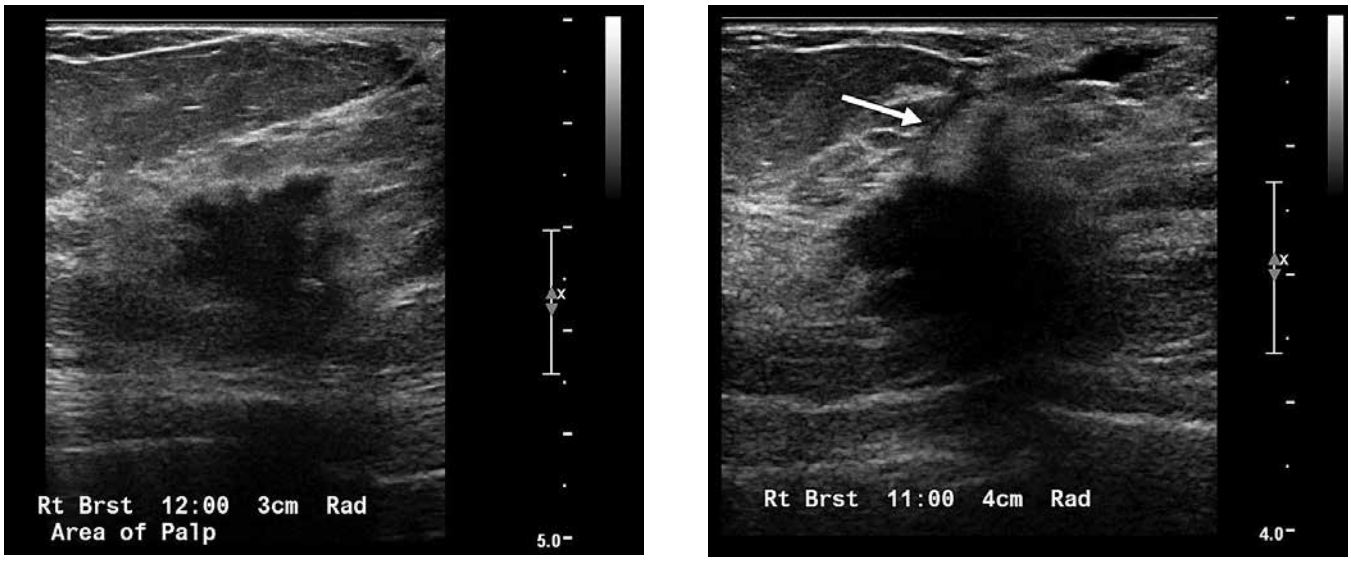
iii. Microlobulated

The margin is characterized by short-cycle undulations, but the significant feature is that the margin of the mass is not circumscribed.



A **B**

Figure 59 — MARGIN: NOT CIRCUMSCRIBED, MICROLOBULATED. A 56-year-old woman with a mass that is NOT CIRCUMSCRIBED, and a margin that is MICROLOBULATED. Invasive ductal carcinoma, grade 3.



A **B**

Figure 60 — MARGIN: NOT CIRCUMSCRIBED, MICROLOBULATED. The margin of the mass is NOT CIRCUMSCRIBED, MICROLOBULATED anteriorly *(a),* ANGULAR *(b),* along with duct extension anteriorly *(arrow)*. The carcinoma is located in this 61-year-old woman's fibroglandular zone. Invasive ductal carcinoma with micropapillary features, grade 3.

B. MASSES

3. MARGIN

b. Not Circumscribed

iv. Spiculated

The margin is characterized by sharp lines radiating from the mass, often a sign of malignancy, but the significant feature is that the margin of the mass is not circumscribed.

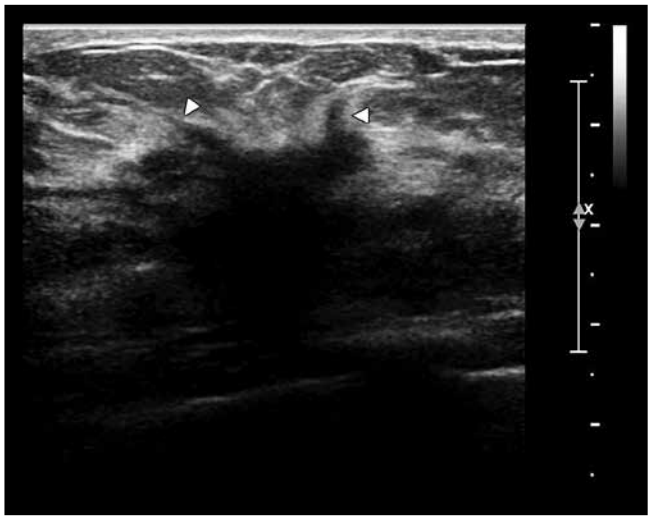
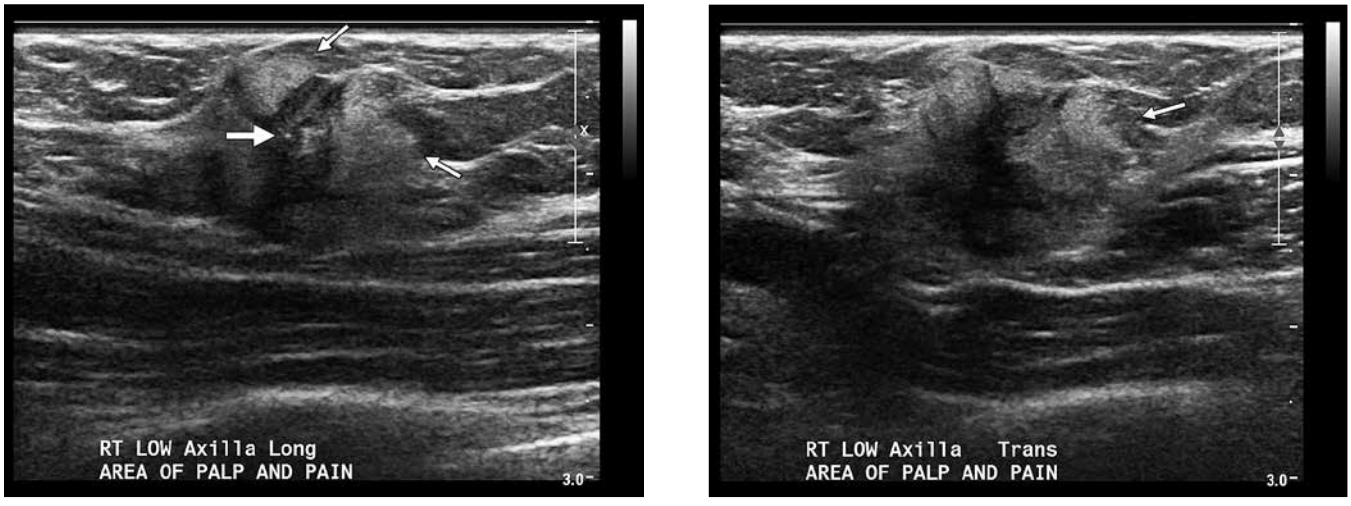


Figure 61 — MARGIN: NOT CIRCUMSCRIBED, SPICULATED. In a 37-year-old woman with a palpable thickening in her left breast, a SPICULATED *(arrowheads)* and indistinct mass is seen, parallel to the skin, with posterior shadowing and surrounding echogenic rim. Histopathology: invasive lobular carcinoma, grade 2.



A **B**

Figure 62 — MARGIN: NOT CIRCUMSCRIBED, SPICULATED. A 31-year-old woman presented with a palpable, tender mass in her right axilla. Mass is irregular in shape with nonparallel orientation. Note the SPICULATED margin anteriorly *(b)*. A single calcification is seen within the mass *(a, thick arrow)*, and surrounding the central hypoechoic components is an echogenic rim *(a* and *b, thin arrows)*. Histopathology: infiltrating ductal carcinoma, grade 3.

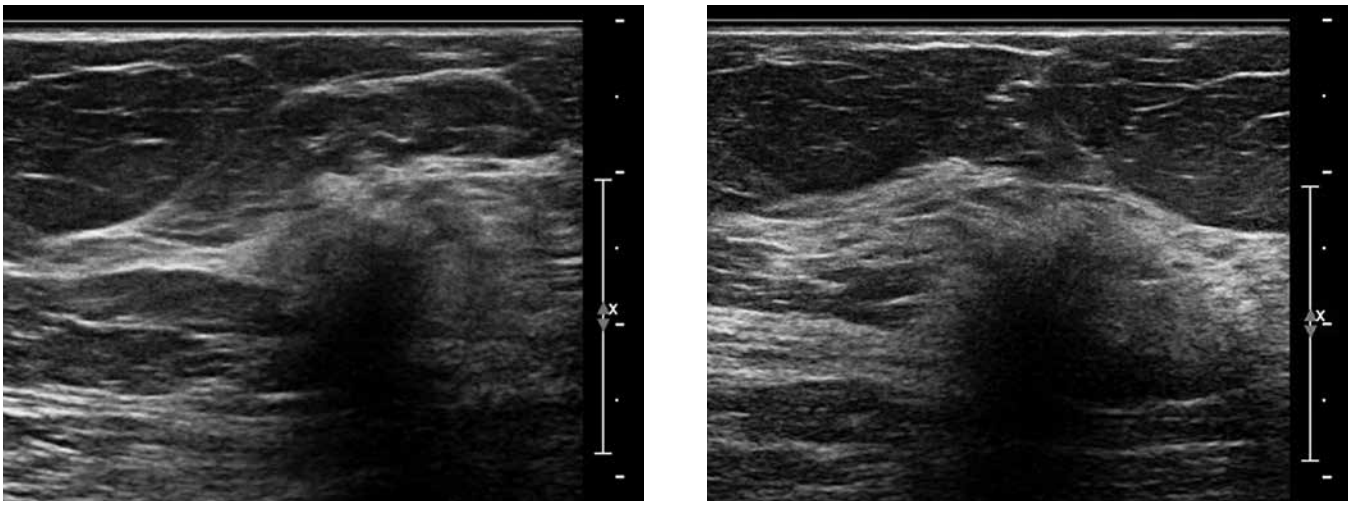


Figure 63 — MARGIN: NOT CIRCUMSCRIBED, SPICULATED. Hypoechoic mass with posterior shadowing has short spicules extending from it anteriorly. Histopathology: invasive lobular carcinoma, grade 2.

B. MASSES

4. ECHO PATTERN

The echogenicity of most benign and malignant masses is hypoechoic compared with mammary fat. While many completely echogenic masses are benign, prospective assessment as benign is more reliable if it is based on margin descriptors. Although the echo pattern contributes with other feature categories to the assessment of a breast lesion, echogenicity alone has little specificity.

a. Anechoic

Without internal echoes.

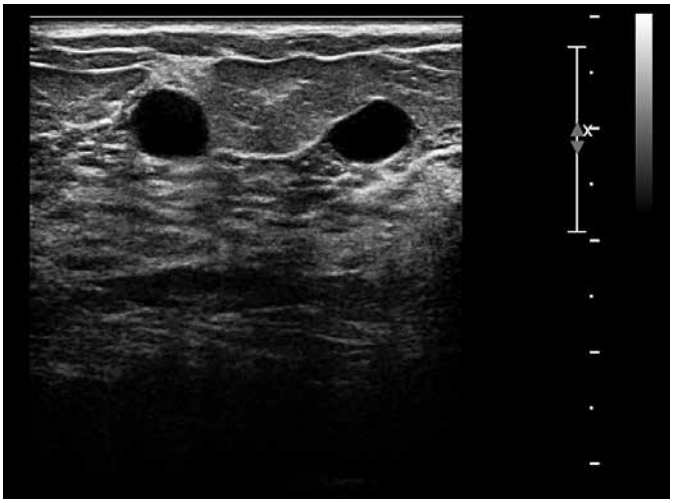


Figure 64 — ECHO PATTERN: ANECHOIC. Two small simple cysts, circumscribed and ANECHOIC, with some posterior enhancement. Assessment is benign (category 2).

B. MASSES

4. ECHO PATTERN

b. Hyperechoic

Hyperechogenicity is defined as having increased echogenicity relative to fat or equal to fibroglandular tissue.

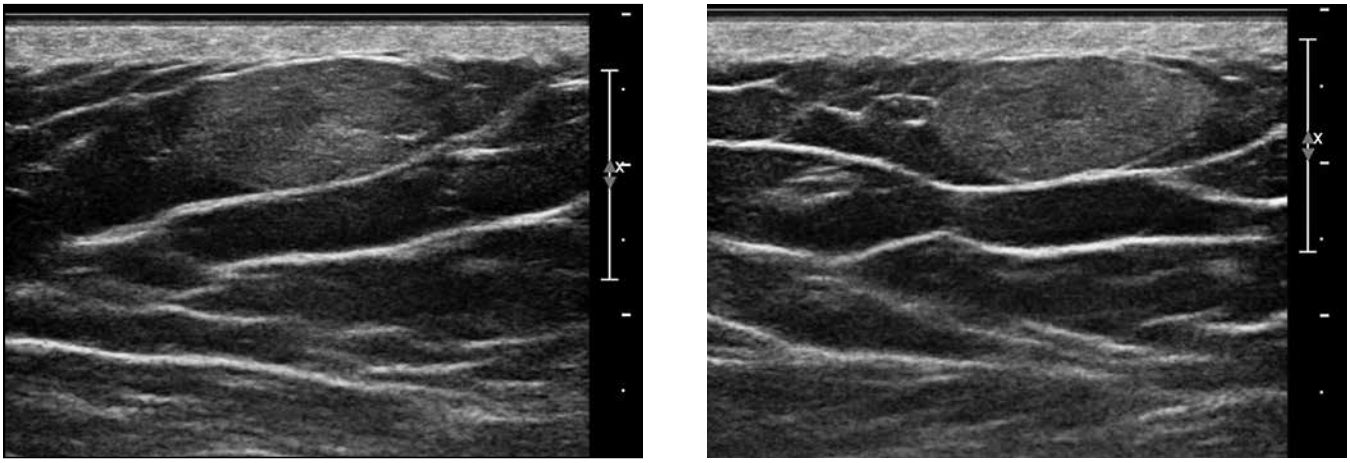
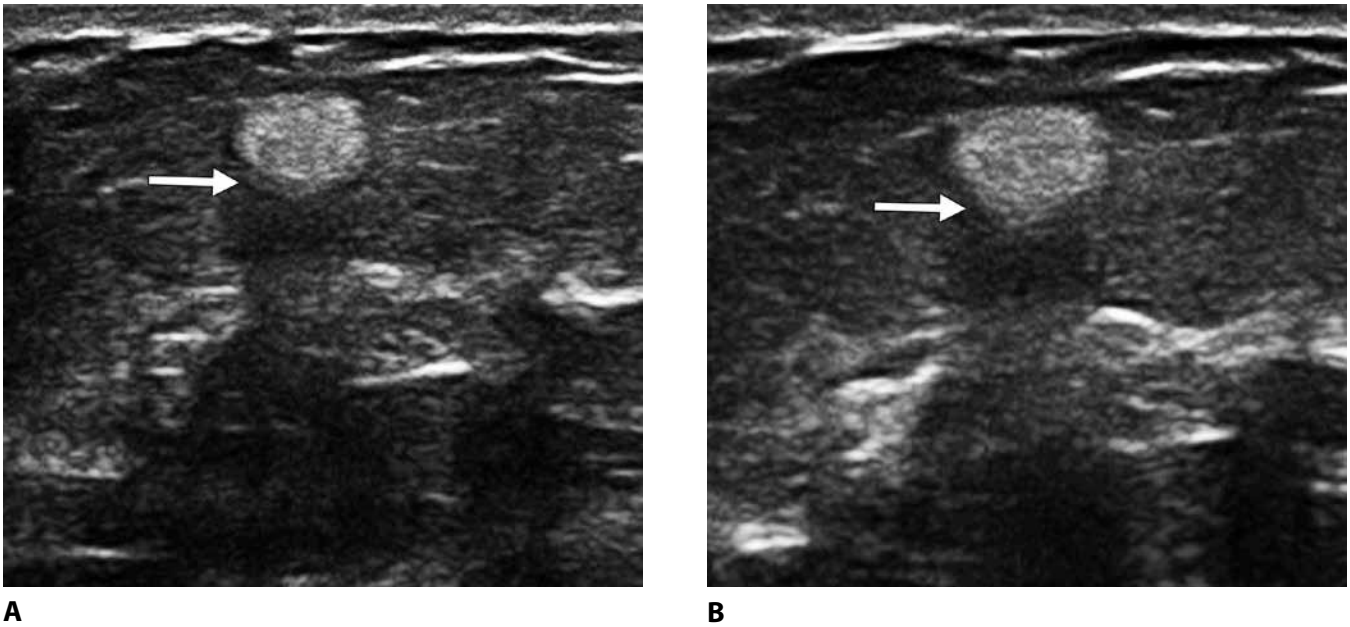


Figure 65 — ECHO PATTERN: HYPERECHOIC. Circumscribed, oval, parallel, HYPERECHOIC mass is a lipoma within a fat lobule. Lipomas are hyperechoic compared with fat lobules. A fibroadenoma superficially located might have a similar appearance, but mammography could help to differentiate between a lipoma, containing fat, and a fibroadenoma of water density.



A **B**

Figure 66 — ECHO PATTERN: HYPERECHOIC. Small, oval, parallel, HYPERECHOIC mass located in subcutaneous fat layer with posterior shadowing. Marginal indistinctness was questioned on both views *(arrows, a* and *b)*. Overall assessment was suspicious — low suspicion (category 4A), likelihood of malignancy, 2%–10%. Histopathology: hemangioma.

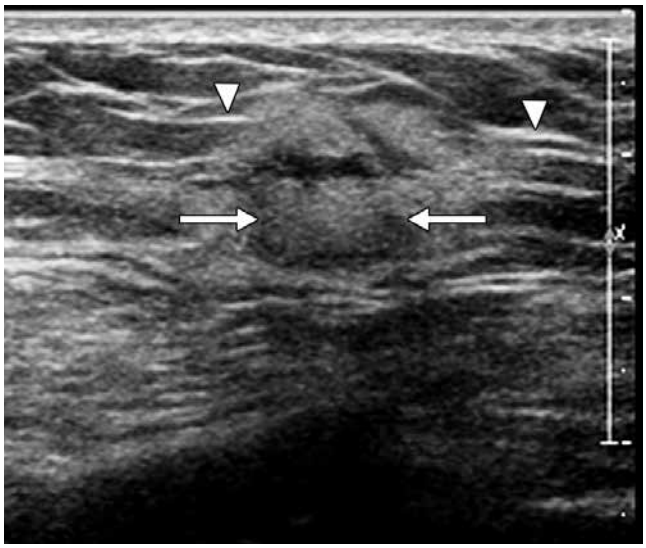
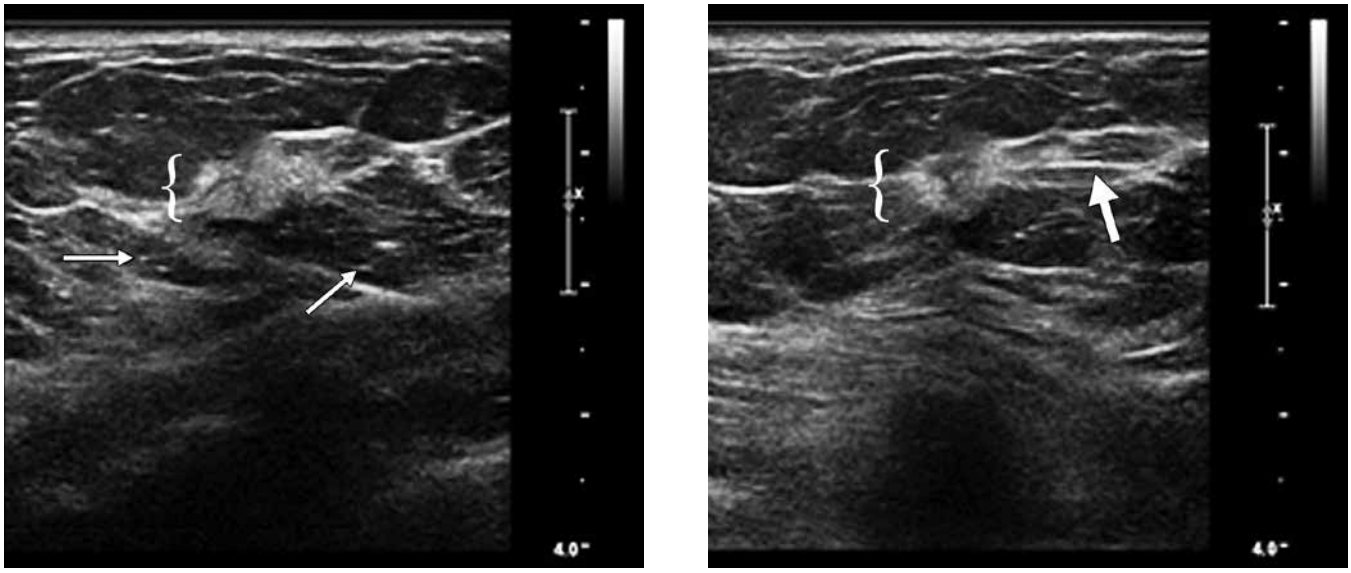


Figure 67 — ECHO PATTERN: HYPERECHOIC. Irregular mass with indistinct margins *(arrows)* and architectural distortion *(arrowheads)*, with both HYPERECHOIC and anechoic features. Histopathology: invasive ductal carcinoma.



A **B**

Figure 68 — ECHO PATTERN: HYPERECHOIC. Carcinoma similar in its characteristics to the preceding case but much smaller — ill-defined echogenic area surrounded by fat, containing small curvilinear hypoechoic areas *(braces)* — was detected on screening mammography in a 75-year-old woman. Calcifications *(thin arrows)* are present in and around the mass *(a)*. The mass, small as it is, causes architectural distortion with straightening of the Cooper ligaments at the right lateral aspect of the mass *(b, thick arrow)*. Histopathology: invasive and intraductal carcinoma, grade 2.

B. MASSES

4. ECHO PATTERN

c. Complex Cystic and Solid

A complex mass contains both anechoic (cystic or fluid) and echogenic (solid) components.

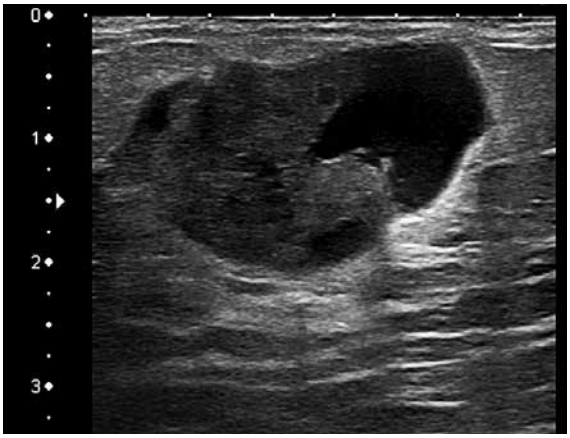


Figure 69 — ECHO PATTERN: COMPLEX CYSTIC AND SOLID. Partially cystic mass with solid component, assessed as suspicious — moderate suspicion (category 4B), likelihood of malignancy 10%–50%, unless known etiology of prior intervention, such as aspiration of a simple cyst with clot formation after the procedure. Histopathology: intracystic papillary carcinoma.

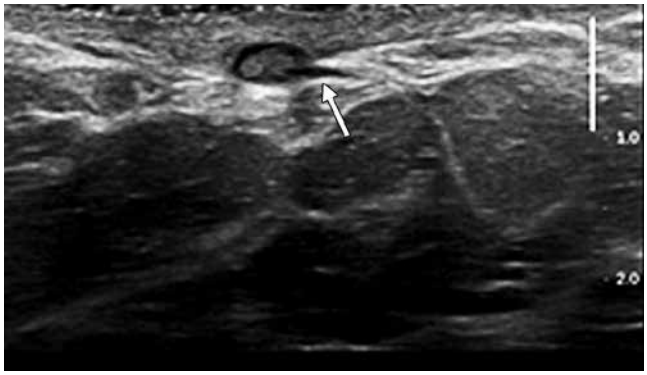


Figure 70 — ECHO PATTERN: COMPLEX CYSTIC AND SOLID. 32-year-old woman with right nipple discharge. This COMPLEX CYSTIC AND SOLID MASS posterior to the nipple, with its small central oval echogenic component and anechoic rim, resembles a lymph node. However, the linear extension at the right lateral border of the mass *(arrow)* is a duct, and the mass is assessed as suspicious (category 4). Histopathology: intraductal papilloma.

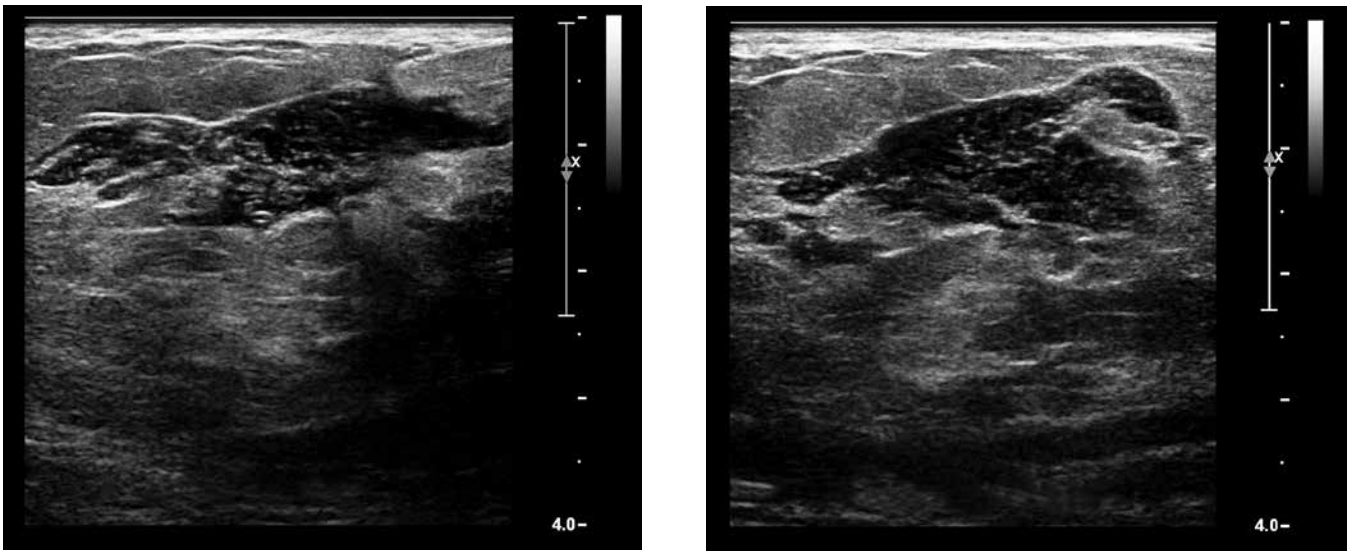


Figure 71 — ECHO PATTERN: COMPLEX CYSTIC AND SOLID. Irregular shape parallel to the skin, with cystic areas and septa, in a 19-year-old woman. Core biopsy histopathology: chronic granulomatous abscess.

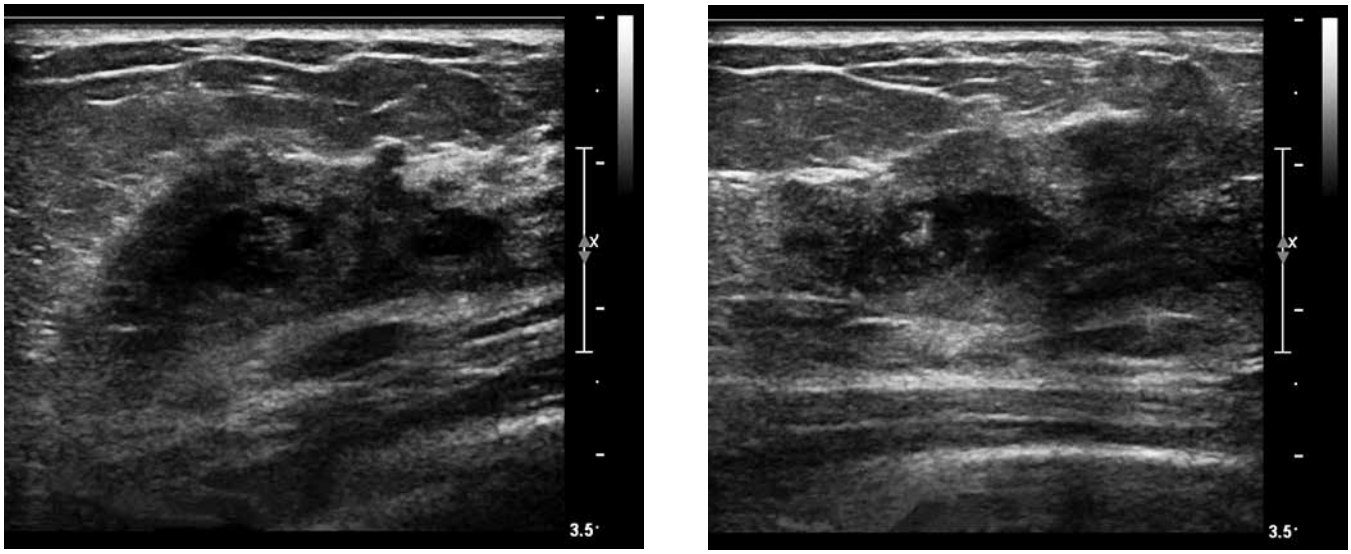


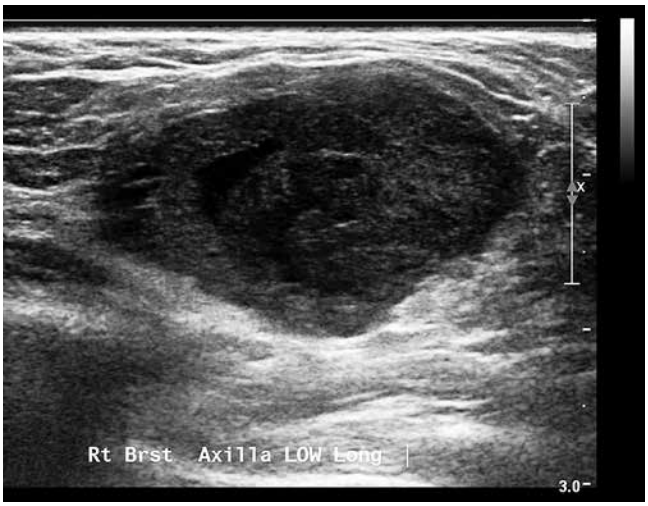
Figure 72 — ECHO PATTERN: COMPLEX CYSTIC AND SOLID. A 55-year-old woman with rheumatoid arthritis and a palpable mass at 1:00 in her left breast. Aspiration yielded a small amount of purulent material; core biopsy showed chronic inflammation.

B. MASSES

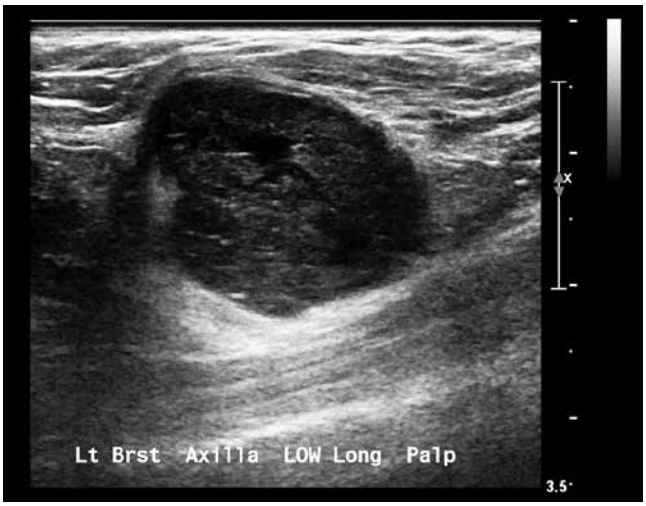
4. ECHO PATTERN

d. Hypoechoic

The term "hypoechoic" is defined relative to subcutaneous fat; hypoechoic masses, less echogenic than fat, are characterized by low-level echoes throughout (e.g., complicated cysts and fibroadenomas).

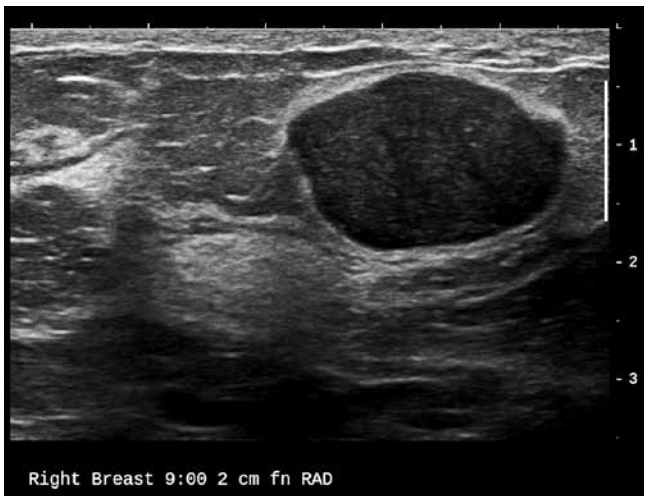


A

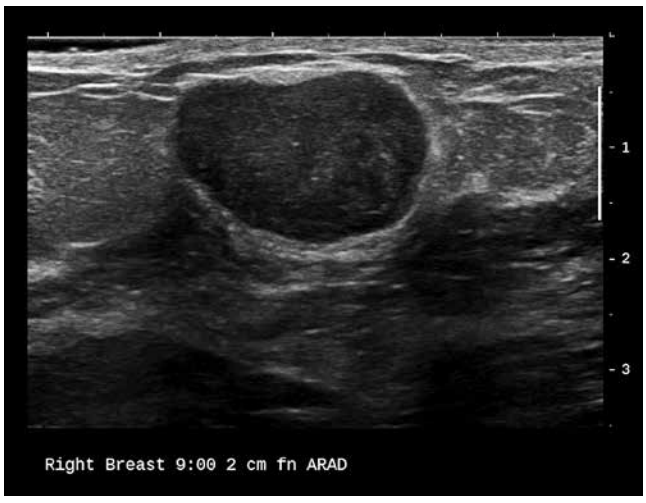


B

Figure 73 — ECHO PATTERN: HYPOECHOIC 32-year-old patient, 37 weeks pregnant, with palpable mass in the axillary tail of the left breast. Orthogonal views demonstrate an oval mass *(a* and *b)*, which is HYPOECHOIC compared with the more anterior subcutaneous fat, as well as being parallel to the skin surface. The mass also is circumscribed, usually a benign feature, but it was assessed as suspicious (category 4) because it was ***newly*** palpable, hence a growing solid mass. Histopathology: invasive ductal carcinoma, grade 3.



A



B

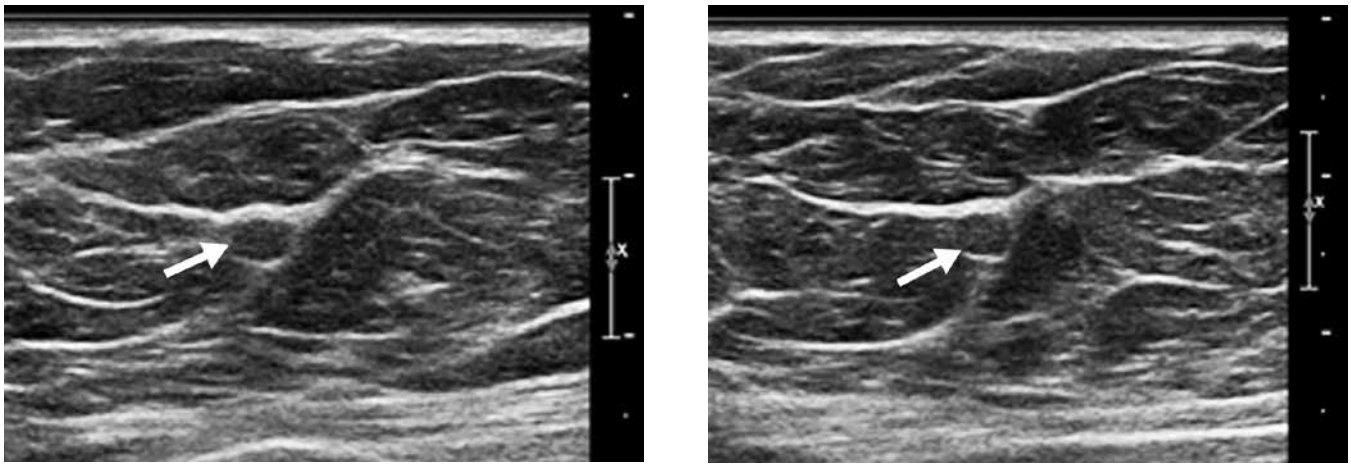
Figure 74 — ECHO PATTERN: HYPOECHOIC. Radial *(a)* and antiradial *(b)* views of an oval, circumscribed, parallel mass. When evaluating echogenicity, comparison is with subcutaneous fat. Histopathology of US-guided biopsy was fibroepithelial lesion, and fibroadenoma at excision.

B. MASSES

4. ECHO PATTERN

e. Isoechoic

Isoechogenicity is defined as having the same echogenicity as subcutaneous fat. Isoechoic masses may be relatively inconspicuous, particularly when they are situated within an area of fat lobules. This may limit the sensitivity of US, especially at screening, in which the presence and location of such a mass are not known at the time of examination.



A **B**

Figure 75 — ECHO PATTERN: ISOECHOIC. Orthogonal views of a small ISOECHOIC mass within fatty breast tissue *(a* and *b, arrows)*. The mass had been identified on baseline screening mammography, and the patient was recalled for additional imaging including US. BI-RADS® assessment category 3, probably benign, was assigned. The patient requested biopsy. Histopathology: invasive ductal carcinoma with mucinous features, grade 1.

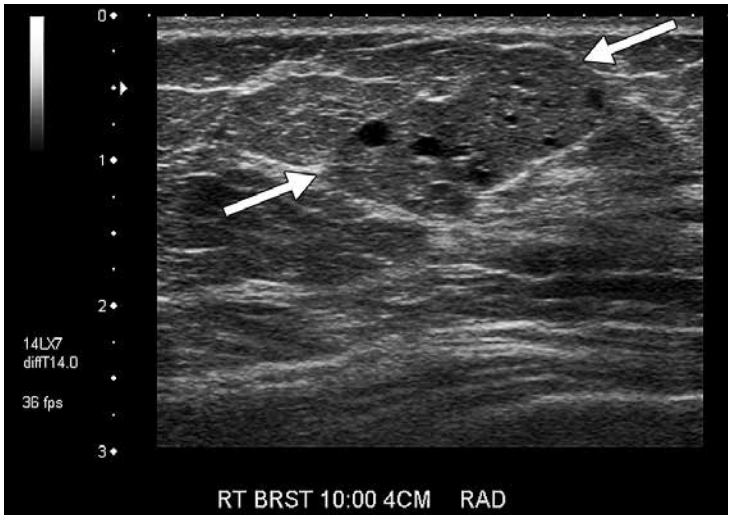


Figure 76 — ECHO PATTERN: ISOECHOIC. In this 44-year-old woman, an ISOECHOIC mass is situated obliquely within fat lobules of similar shape *(arrows)*. The mass contains small cysts. Complex fibroadenomas, those containing a conglomeration of benign histologies, do not require excision. Excision is recommended for fibroepithelial lesions (FELs) and when the possibility of phyllodes tumor is raised in the pathology report. Histopathology: fibroadenoma with fibrocystic changes including sclerosing adenosis, apocrine metaplasia, microcysts, and duct epithelia hyperplasia without atypia (complex fibroadenoma).

B. MASSES

4. ECHO PATTERN

f. Heterogeneous

A mixture of echogenic patterns within a solid mass, heterogeneity has little prognostic value in differentiating benign from malignant masses, and it is not uncommon to observe heterogeneity in fibroadenomas as well as cancers. Clumped areas of different echogenicity may elevate the suspicion for malignancy, particularly in a mass in which the margins are not circumscribed and the shape is irregular.

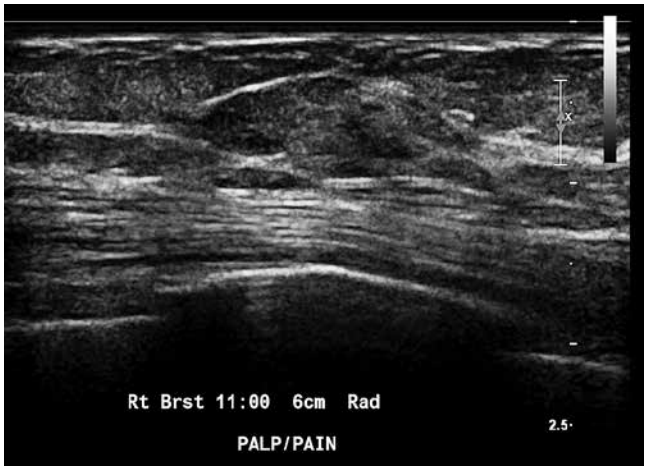
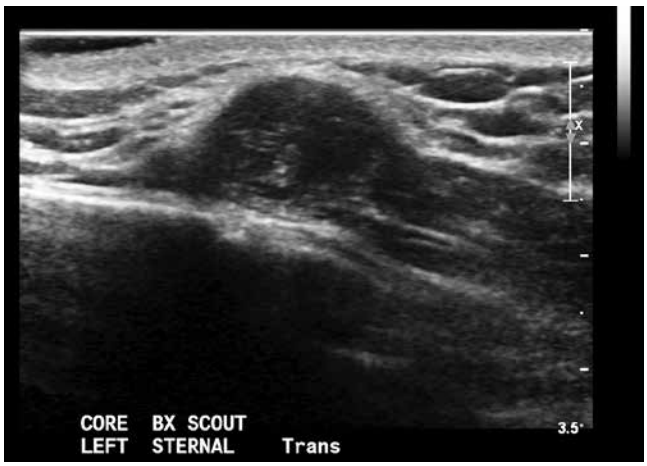


Figure 77 — ECHO PATTERN: HETEROGENEOUS. This palpable, painful new mass in a 75-year-old woman is circumscribed, oval, and parallel to the skin, with HETEROGENEOUS echotexture. Primarily because this solid mass was ***new***, in an elderly woman, it was assessed as suspicious (category 4). Histopathology: low-grade mesenchymal tumor with periductal stromal proliferation and myxoid changes.



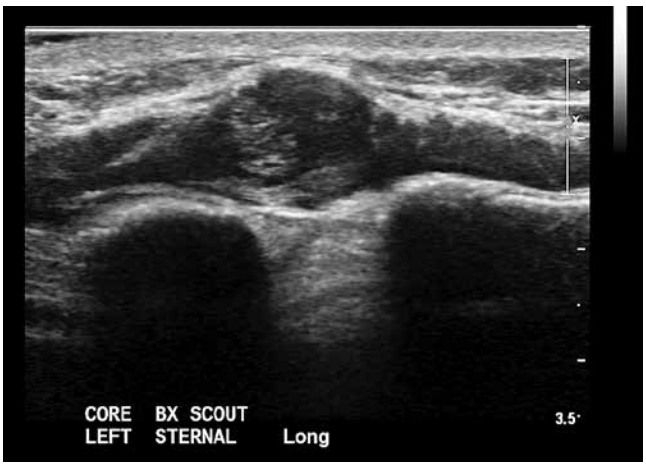


Figure 78 — ECHO PATTERN: HETEROGENEOUS. Palpable presternal mass in a 43-year-old man. It protrudes into the tissue overlying it, but no architectural distortion is present. Histopathology from US-guided core biopsy: granular cell tumor.

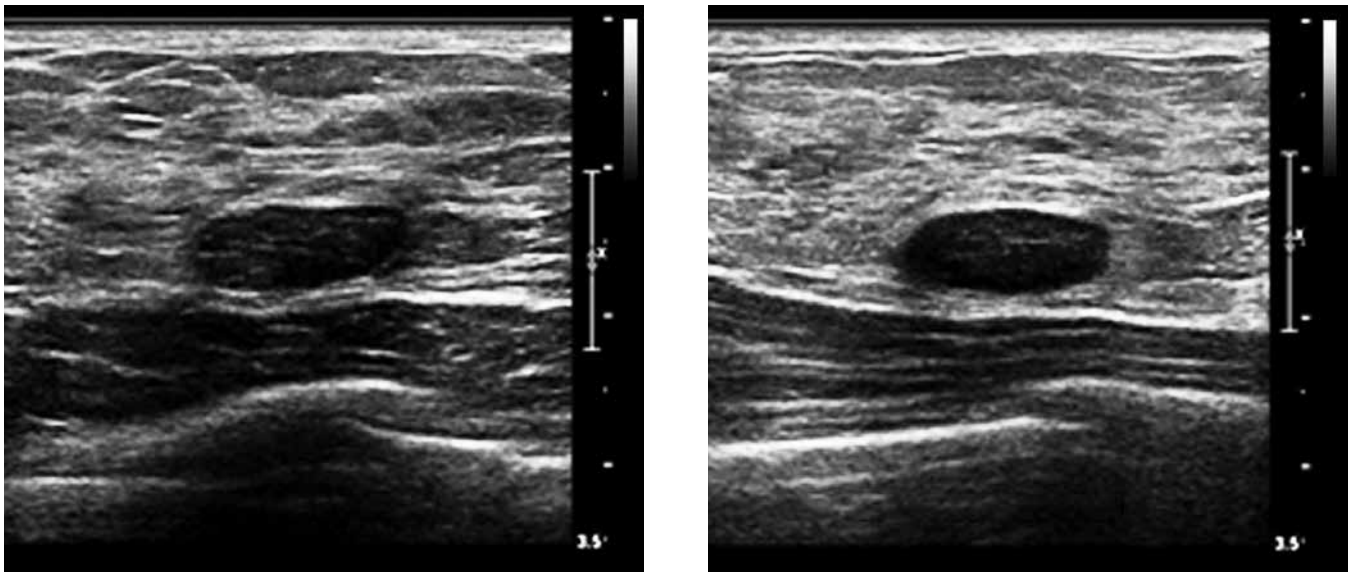
B. MASSES

5. POSTERIOR FEATURES

Posterior features represent the attenuation characteristics of a mass with respect to its acoustic transmission. Attenuation (shadowing) and enhancement are additional attributes of masses, mostly of secondary rather than primary predictive value.

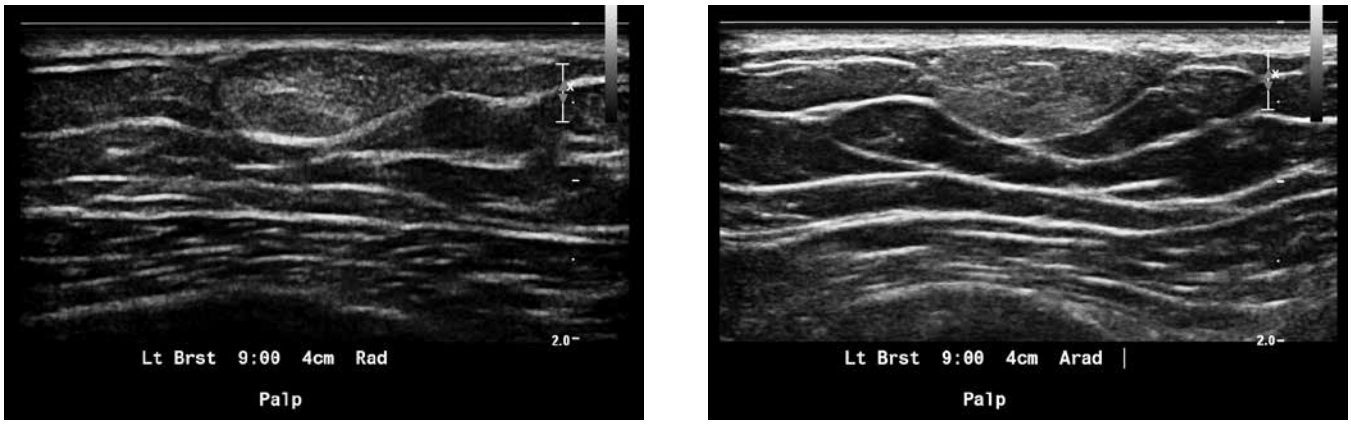
a. No Posterior Features

No shadowing or enhancement is present deep to the mass; the echogenicity of the area immediately behind the mass is not different from that of the adjacent tissue at the same depth.



A **B**

Figure 79 — POSTERIOR FEATURES: NO POSTERIOR FEATURES. Fibroadenoma located within fibroglandular tissue is adjacent to the pectoral muscle in this 35-year-old woman. Although proximity to the pectoral muscle may make enhancement or shadowing difficult to detect, there is no acoustic change on either antiradial *(a)* or radial *(b)* images of this benign mass.



A **B**

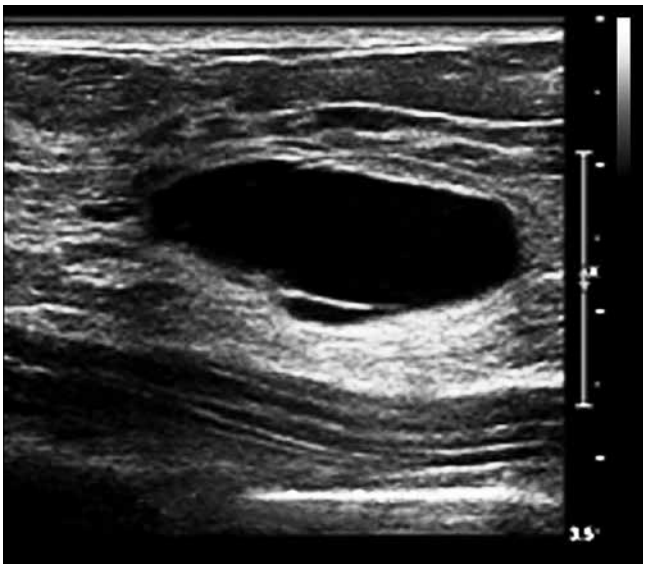
Figure 80 — POSTERIOR FEATURES: NO POSTERIOR FEATURES. Hyperechoic, circumscribed, oval mass *(a, b)* in a 67-year-old man. Increased echogenicity within a circumscribed mass is characteristic of lipomas; in women, mammography can differentiate the fat density of a lipoma from the soft tissue or water density of a fibroadenoma. Fibroadenomas and other lobular lesions are not ordinarily found in men.

B. MASSES

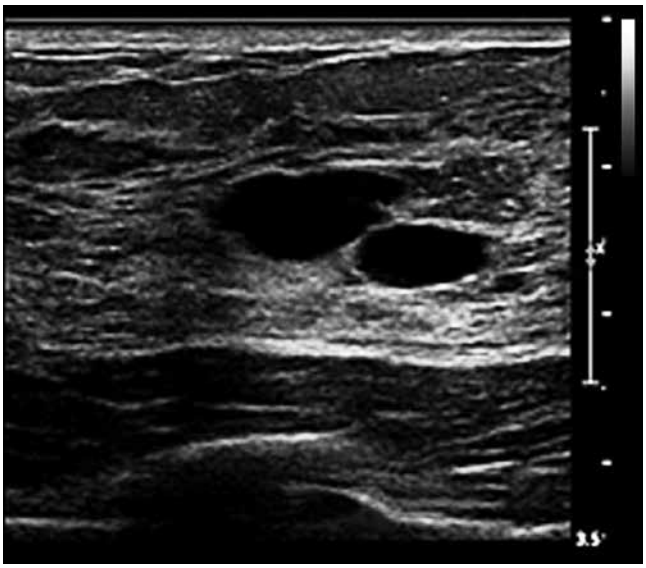
5. POSTERIOR FEATURES

b. Enhancement

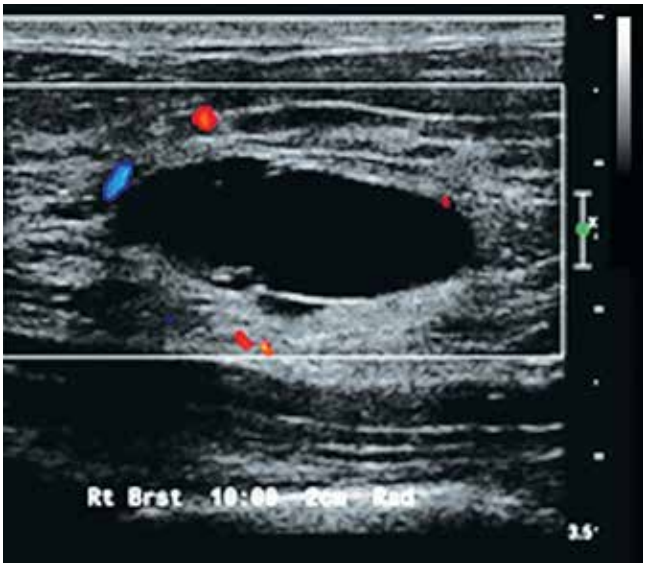
Sound transmission is unimpeded in its passage through the mass. Enhancement appears as a column that is more echogenic (whiter) deep to the mass. One criterion for cyst diagnosis is enhancement. Homogeneous solid lesions, including high-grade carcinomas, may also show enhancement.



A

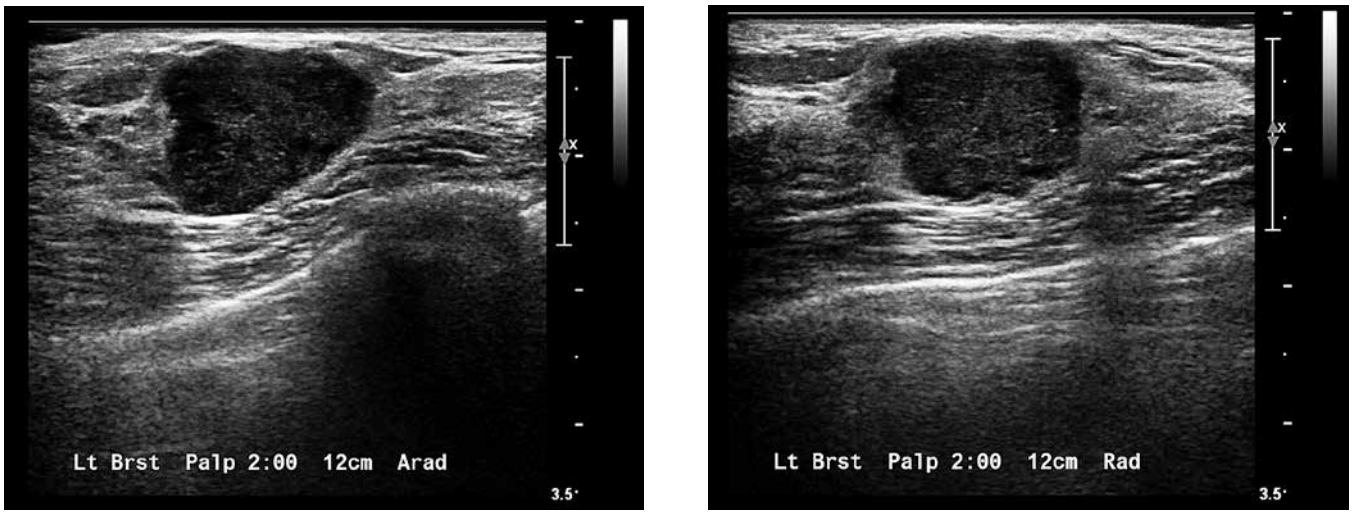


B



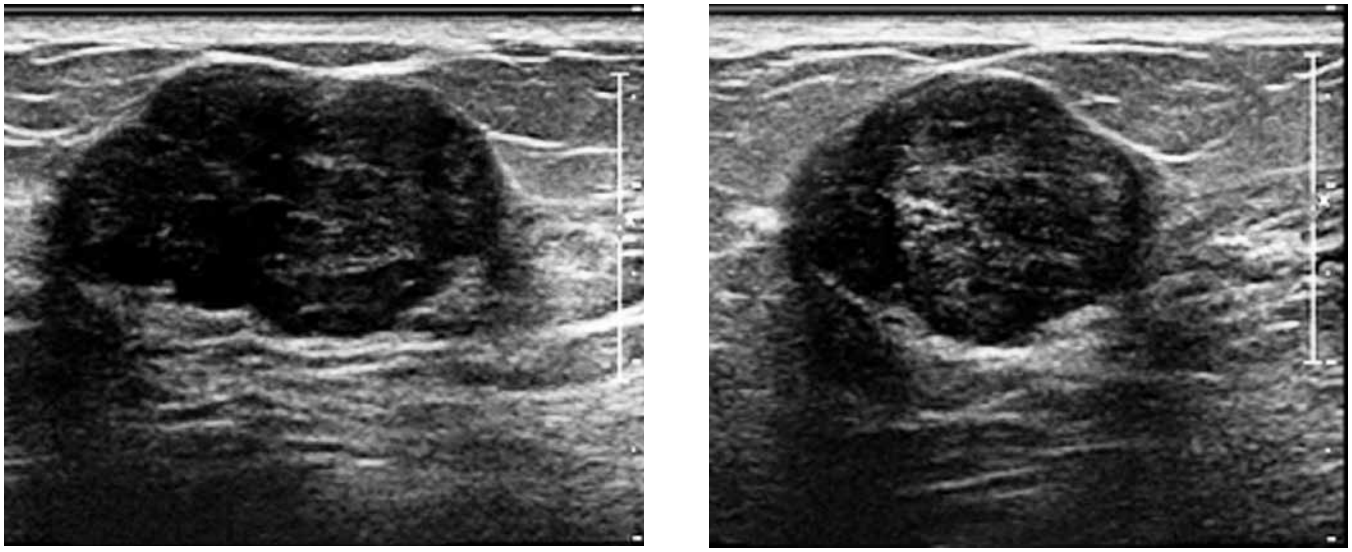
C

Figure 81 — POSTERIOR FEATURES: ENHANCEMENT. The criteria for diagnosing simple cysts are: oval or round shape (round less likely), anechogenicity, circumscribed margin, and POSTERIOR ENHANCEMENT. Simple cyst with a septum *(a)* and a cluster of simple cysts *(b)*. Color Doppler applied to the cyst demonstrates it to be avascular *(c)*. Flow may be seen in the tissue surrounding the cyst. Application of Doppler imaging may be helpful in establishing a mass as being fluid-filled due to lack of internal vascularity. However, for reliability, Doppler parameters must be optimized (Image Quality section, see page 18).



A **B**

Figure 82 — POSTERIOR FEATURES: ENHANCEMENT. Palpable mass, in a 28-year-old woman has an irregular shape *(a)* and a not circumscribed (indistinct) margin. The mass has strong POSTERIOR ENHANCEMENT. Assessment is suspicious — high suspicion (category 4C). Histopathology: invasive ductal carcinoma, grade 3.



A **B**

Figure 83 — POSTERIOR FEATURES: ENHANCEMENT. Radial and antiradial views of an oval, circumscribed, parallel mass, with POSTERIOR ENHANCEMENT. The mass is predominantly hypoechoic with some heterogeneity, but its shape, margin, and orientation are all consistent with the benign etiology of this palpable, biopsy-proven fibroadenoma. Histopathology: fibroadenoma.

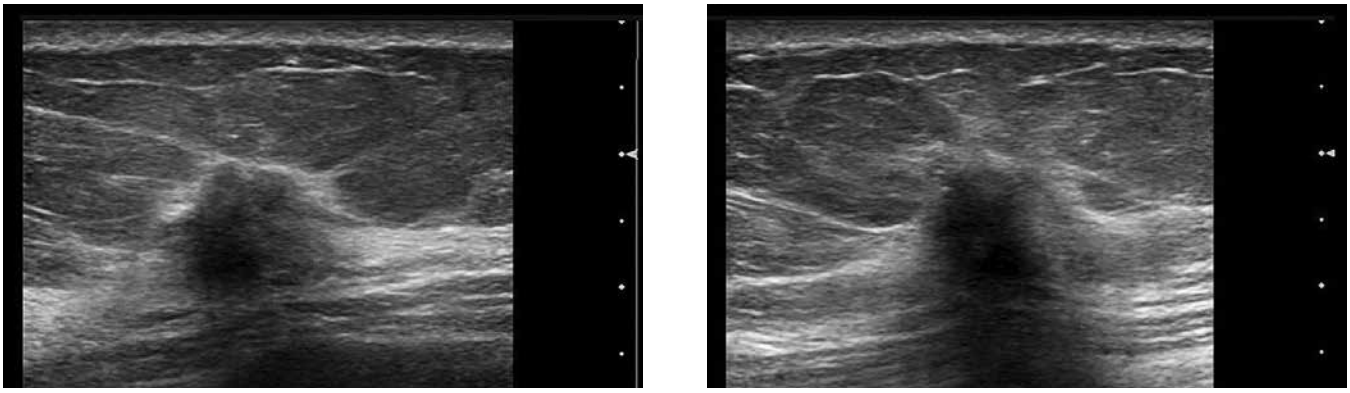
B. MASSES

5. POSTERIOR FEATURES

c. Shadowing

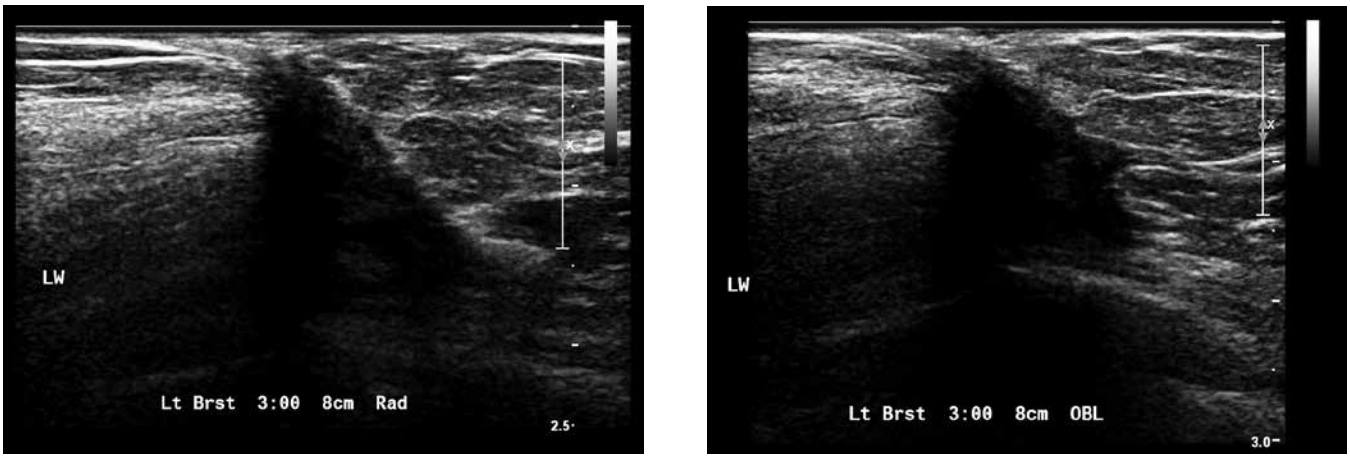
Shadowing is attenuation of the acoustic transmission. Sonographically, the area posterior to the mass appears darker. At the edges of curved masses, acoustic velocity changes and thin shadows are seen. This refractive edge shadowing is of no significance and should be distinguished from central shadowing, which is a property of the mass.

Shadowing is associated with fibrosis, with or without an underlying carcinoma. Postsurgical scars, fibrous mastopathy, and many cancers with or without a desmoplastic response will show posterior shadowing. Macrocalcifications can also attenuate sound. Similar to a vertical (taller-than-wide) orientation, shadowing is a feature more helpful when present than when absent. Many cancers will exhibit enhancement or no change in posterior features, particularly those that are high grade.



A **B**

Figure 84 — POSTERIOR FEATURES: SHADOWING. Irregular, hypoechoic mass with a spiculated, indistinct, and angular margin, with POSTERIOR SHADOWING in a 56-year-old woman. Histopathology: invasive ductal carcinoma.



A **B**

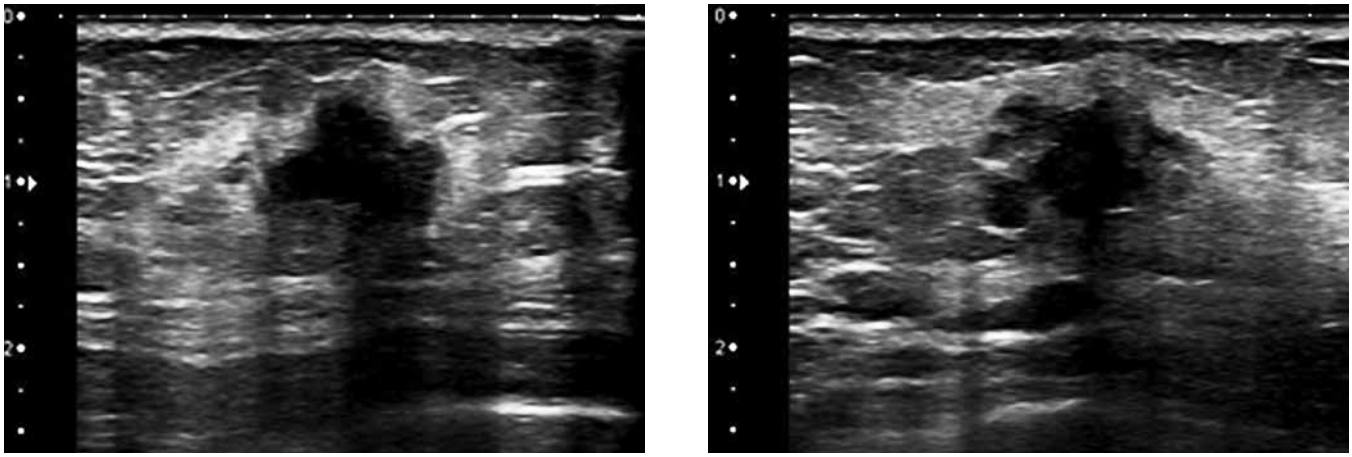
Figure 85 — POSTERIOR FEATURES: SHADOWING. Postsurgical scar in a 64-year-old-patient following lumpectomy and radiation therapy for invasive carcinoma 11 years earlier, depicted as an irregular spiculated mass that produces intense POSTERIOR SHADOWING. Note that the entire posterior aspect of the mass is obscured on both views *(a* and *b)*, with only partial visibility of the chest wall on the oblique view *(b)*. Correct interpretation requires comparison with previous studies and correlation with unchanged mammograms. Assessment category 2: benign.

B. MASSES

5. POSTERIOR FEATURES

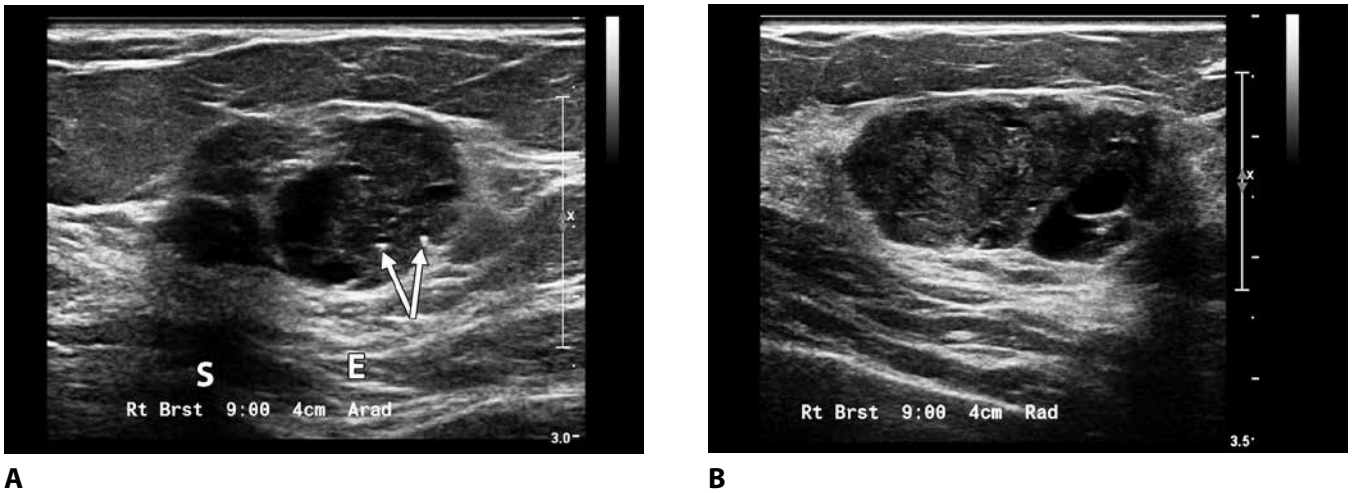
d. Combined Pattern

Some lesions have more than one pattern of posterior attenuation. For example, a fibroadenoma containing a large calcification may demonstrate shadowing posterior to the calcified area but enhancement of the tissues deep to the uncalcified portion. A combined pattern of posterior features also may be seen in lesions that are evolving. One such example is a post-lumpectomy seroma, which enhances posteriorly. As the fluid is resorbed and scarring develops, the features of fibrosis become evident as spiculation of the margins and posterior acoustic shadowing.



A **B**

Figure 86 — POSTERIOR FEATURES: COMBINED PATTERN. Partial shadowing combined with no posterior features. The mass is hypoechoic and irregular in shape (*a*), with an indistinct margin. Histopathology: invasive ductal carcinoma.



A **B**

Figure 87 — POSTERIOR FEATURES: COMBINED PATTERN. Shadowing *(S)* and enhancement *(E)* are shown in *(a)*, the antiradial view of this palpable, oval, circumscribed, complex cystic and solid mass, containing calcifications *(arrows)*, in a 49-year-old woman. The long axis view *(b)*, in which the mass is imaged radially, shadowing is less conspicuous than enhancement. Angle of insonation and compression force of the probe against the tissue can also affect depiction of posterior features. Histopathology of core biopsy specimens: fibroepithelial lesion.

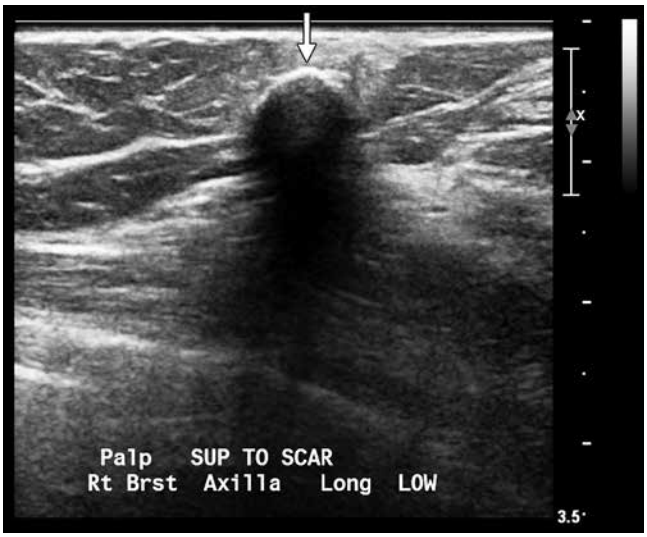
C. CALCIFICATIONS

Calcifications have been poorly characterized with US compared with mammography, but they can be recognized as echogenic foci, particularly when in a mass. High-frequency, high-resolution transducers in current use can depict intraductal calcifications well, particularly if they are superficial, and groups of microcalcifications concentrated in fibroglandular tissue can be recognized and biopsied with US guidance.

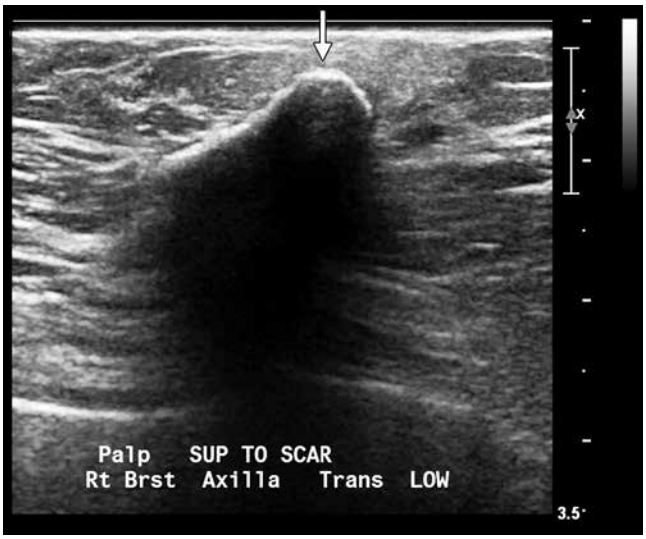
Note that calcifications that are obviously benign need not be reported, especially if the interpreting physician is concerned that the referring clinician or patient might infer anything other than absolute confidence in benignity were such calcifications to be described in the report.

The microcalcifications seen at mammography do not occupy enough of the acoustic beam to attenuate it, and they may be seen as echogenic flecks that do not cause shadowing and are sometimes indistinguishable from noise. Aggregates of microcalcifications and large calcifications may attenuate the acoustic beam and cause shadowing.

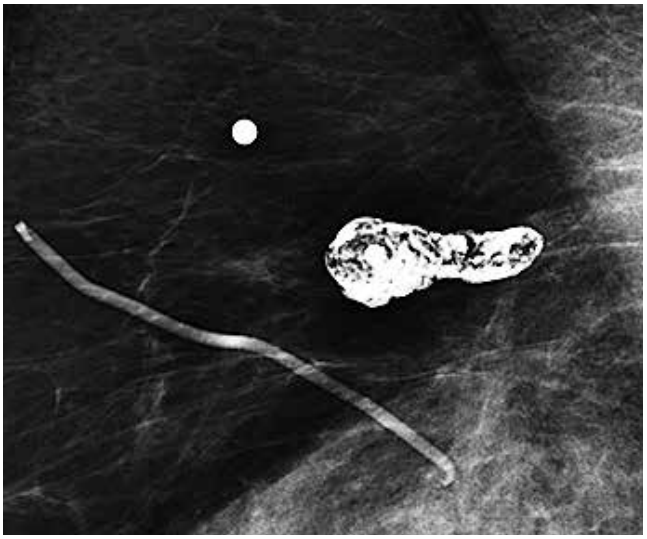
C. CALCIFICATIONS



A



B



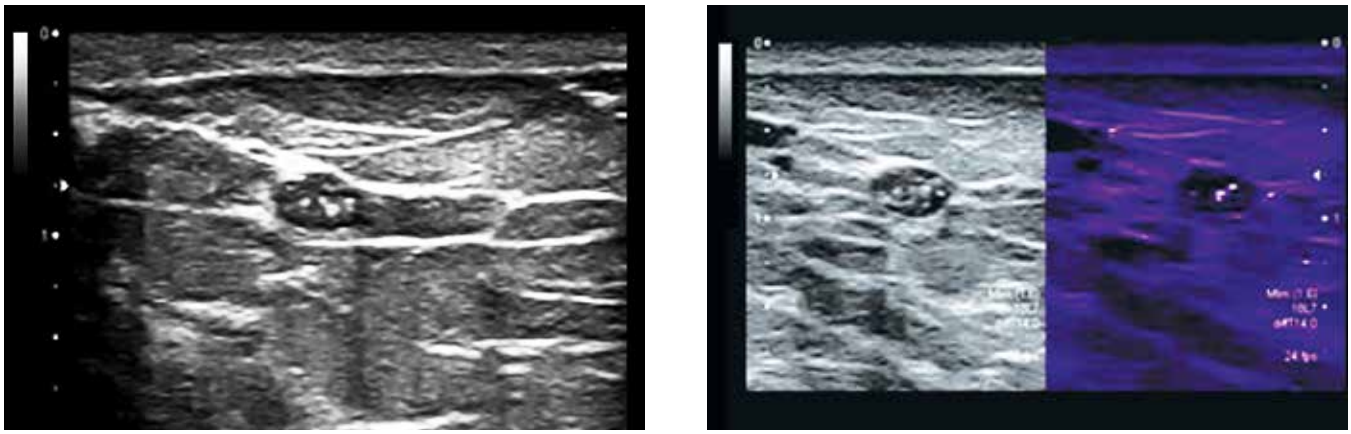
C

Figure 88 —CALCIFICATIONS. Dystrophic CALCIFICATION forming at the biopsy site in a 61-year-old woman who, 5 years earlier, underwent lumpectomy and radiation therapy for invasive and intraductal carcinoma, grade 1. The anterior crescent of the calcification *(a* and *b, arrow)* correlates with the shape of the rim of the characteristically benign dystrophic calcification seen at mammography in the axillary tail of the breast *(c)*.

C. CALCIFICATIONS

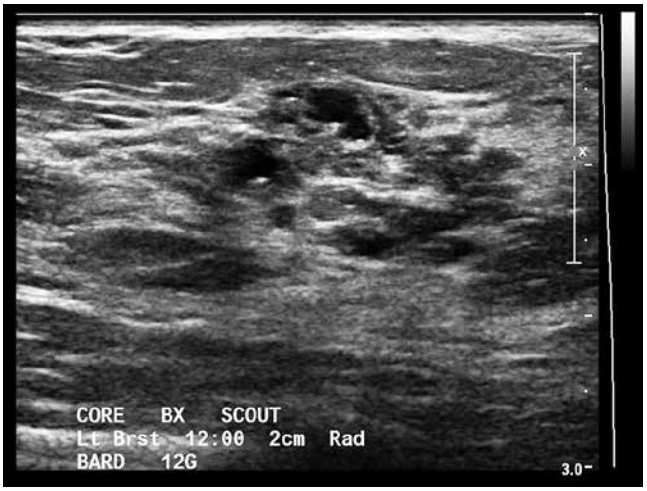
1. CALCIFICATIONS IN A MASS

Calcifications embedded in a mass may be well depicted at US, but their morphology will not be as readily discernible as at mammography. These small hyperechoic foci will be more conspicuous in a hypoechoic mass than within a volume of fibroglandular tissue. Unless mammographic microcalcifications are grouped very closely together or are individually coarse, they will not attenuate the US beam.

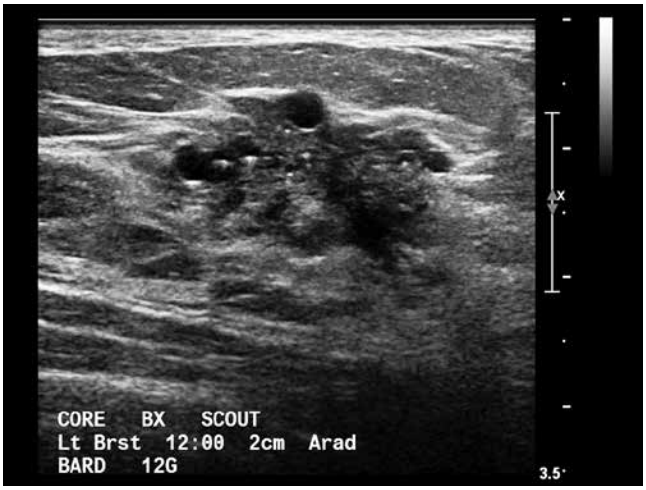


A **B**

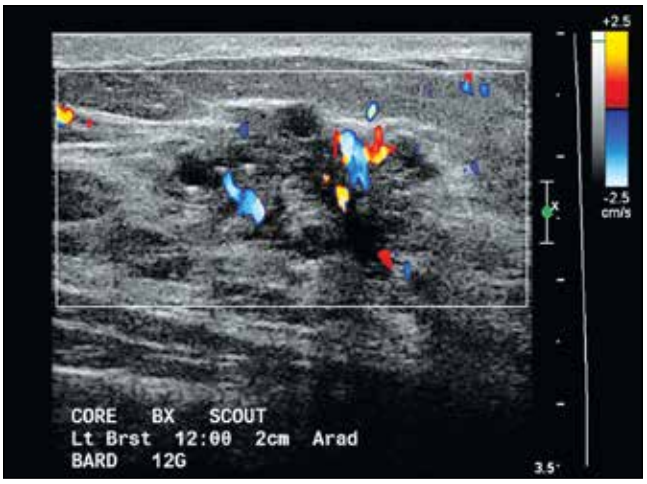
Figure 89 — CALCIFICATIONS IN A MASS. Located in a fatty breast, this calcified fibroadenoma is seen to contain CALCIFICATIONS of varying size within it. These calcifications are too small to attenuate the beam, so they do not cause shadowing *(a* and *b)*. On the right side of the split-screen image *(b)*, the calcifications are depicted with a calcification-enhancing algorithm, but the gray-scale images show the calcific particles more clearly.



A



B



C

Figure 90 — CALCIFICATIONS IN A MASS. Two orthogonal views *(a* and *b)* of an irregular, complex, cystic and solid mass with an indistinct margin, which contains CALCIFICATIONS. The color Doppler image *(c)* shows the distribution of vessels within the mass. Core biopsy histopathology: sclerosing adenosis and radial scar, not upgraded at excision.

C. CALCIFICATIONS

2. CALCIFICATIONS OUTSIDE OF A MASS

At US, calcifications situated in fat or fibroglandular tissue are less conspicuous than when present within a mass. Small echogenic flecks grouped in tissue may sometimes be identified because they have patterns different from those of acoustic speckle and transversely sectioned Cooper ligaments or pectoral muscle fascicles. Because they occupy too small a portion of the acoustic beam, individual calcifications that are not coarse will not shadow. If calcifications are sufficiently numerous for a pattern to be discerned, they may be perceived as grouped in the area of tissue being examined with US.

When small calcifications within or outside a mass are seen well enough to target, US may be used to provide imaging guidance for percutaneous biopsy, preferably using a vacuum-assisted biopsy device. Specimen radiography should always be obtained to verify sampling of the targeted calcifications. A marker clip should be placed at the biopsy site, and its location demonstrated on postbiopsy craniocaudal and 90º lateral mammographic images.

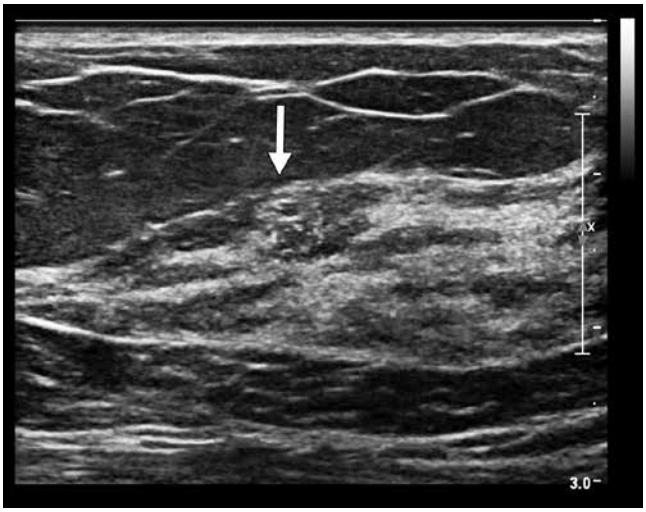
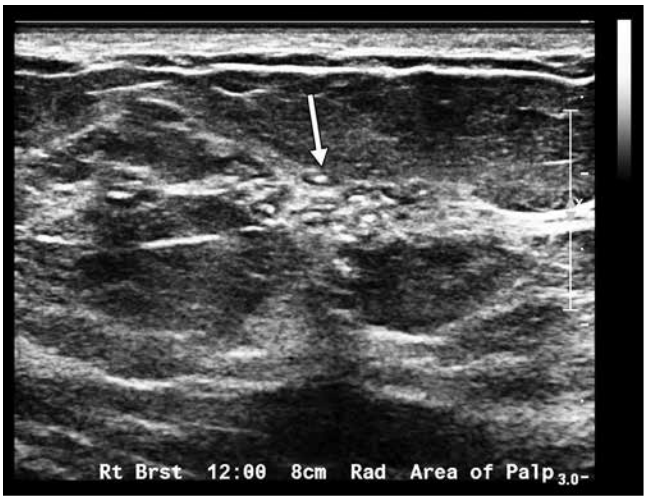


Figure 91 — CALCIFICATIONS OUTSIDE OF A MASS. US imaging was performed to look for a mass in which mammographically detected CALCIFICATIONS might be embedded. In this 53-year-old patient, no mass is seen within the dense fibroglandular tissue surrounding the calcifications *(arrow)*. Assessment at mammography was suspicious (category 4B), but depiction of some of the calcifications at US enabled sonographically guided percutaneous biopsy. Concordant histopathology: extensive adenosis.



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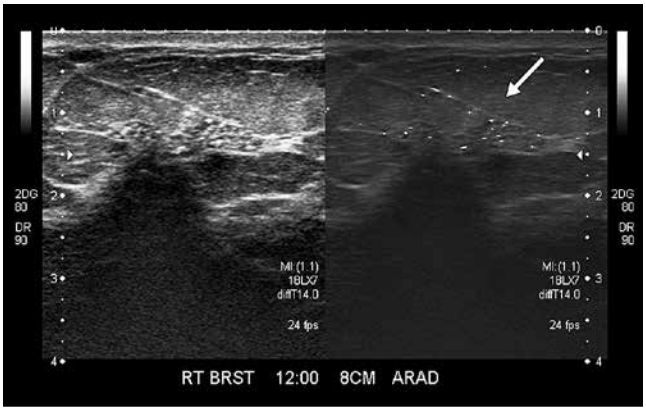
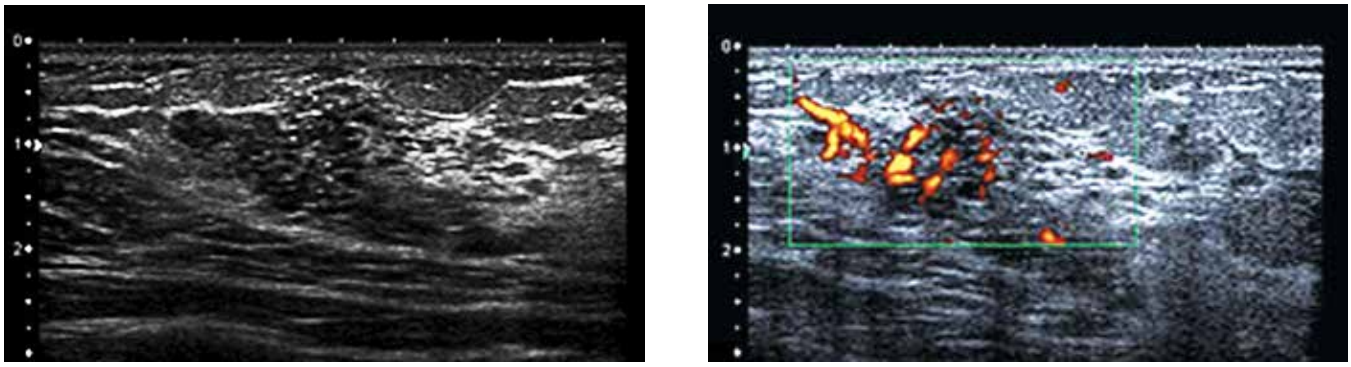


B

Figure 92 — CALCIFICATIONS OUTSIDE OF A MASS. A 33-year-old woman with palpable thickening of the right breast. Mammography (not shown) demonstrated fine pleomorphic calcifications in linear distribution. Calcifications are seen within the fibroglandular zone of the radial US image *(a, arrow)*. In the split image sonogram of the same area, antiradial view *(b)*, the linear distribution of these calcifications are shown using a special calcification depiction algorithm *(arrow)*. Although US was not able to depict calcification morphology or extent nearly as well as mammography, the visibility of some of the mammographically demonstrated calcifications did enable sonographically guided percutaneous biopsy. Histopathology: DCIS with microinvasion, grade 3.

C. CALCIFICATIONS

3. INTRADUCTAL CALCIFICATIONS



A **B**

Figure 93 — INTRADUCTAL CALCIFICATIONS. Echogenic flecks within tiny round dark areas are calcifications within ducts *(a).* Doppler US *(b)* shows vascularity within the region containing the dilated ducts and calcifications. Calcifications within ducts should be considered suspicious.

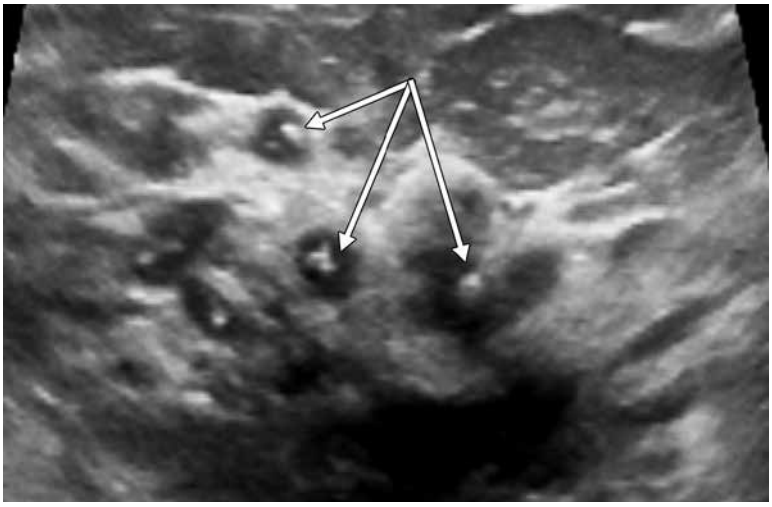


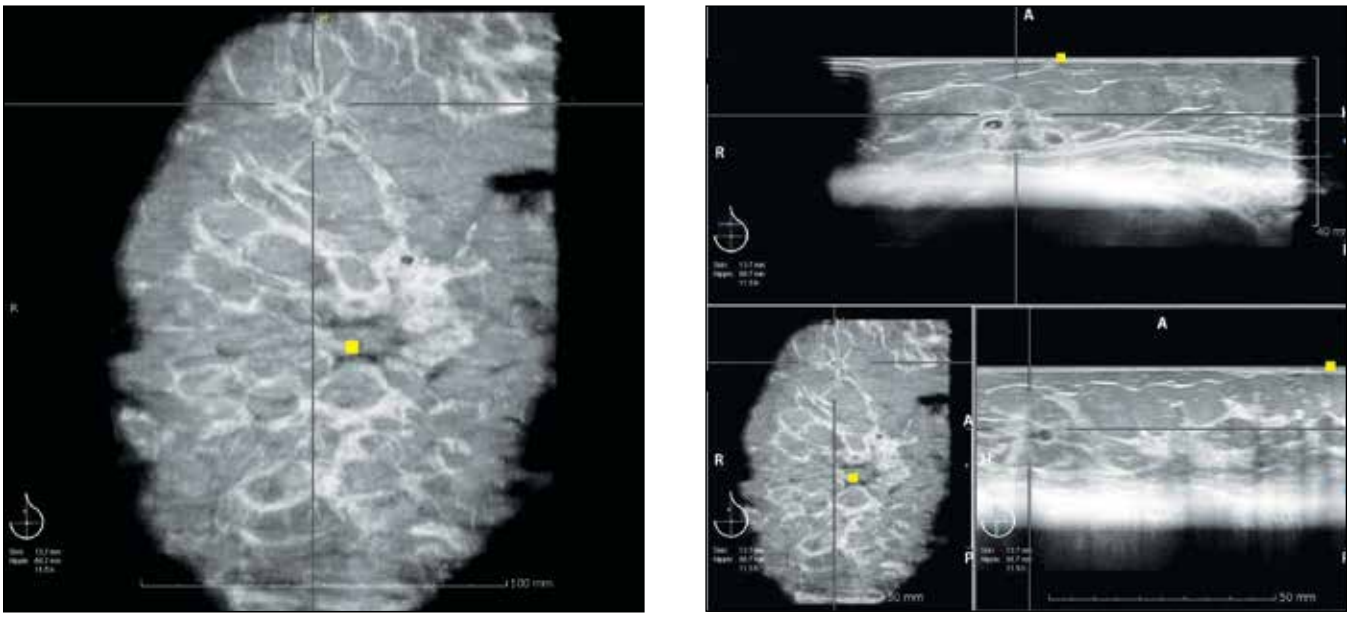
Figure 94 — INTRADUCTAL CALCIFICATIONS. The extensive intraductal component of this invasive ductal carcinoma is manifested by the several calcifications *(arrows)* within ducts depicted superior to the hypoechoic irregular mass. This coronal plane depiction enabled by volumetric acquisition (3-D) enhances the conspicuity of the INTRADUCTAL CALCIFICATIONS, as well as architectural distortion.

D. ASSOCIATED FEATURES

Effects of a mass on its surroundings are: architectural distortion that may be manifested by compression of the tissue around the mass, obliteration of the tissue planes by an infiltrating lesion, straightening or thickening of Cooper ligaments, aberrations of ductal patterns, and an echogenic rim. These findings in the mammography lexicon are included in "architectural distortion." For MRI, they may categorized as non-mass features. Findings of breast edema and skin thickening may be present, caused by inflammatory carcinoma, radiation therapy, mastitis, or a systemic process such as congestive heart failure. Color and power Doppler vascular findings of an abnormality and tissue stiffness characteristics are also associated features.

D. ASSOCIATED FEATURES

1. ARCHITECTURAL DISTORTION



A B

Figure 95 — ARCHITECTURAL DISTORTION. Automated US, whole breast coronal reconstruction *(a)*, shows crosshairs defining small hypoechoic mass at 11:00 in the left breast with spicules radiating around it. Top image *(b)* is from the volumetric acquisition *(transverse)*, crosshairs correlating the small mass with its appearance on the other views, coronal on lower left and sagittal on lower right image, to provide 3-D depiction. Tissue composition is fatty, and black hole at the upper right edge of the coronal view is due to lack of contact of the transducer with the skin. Histopathology: invasive ductal carcinoma, grade 2.

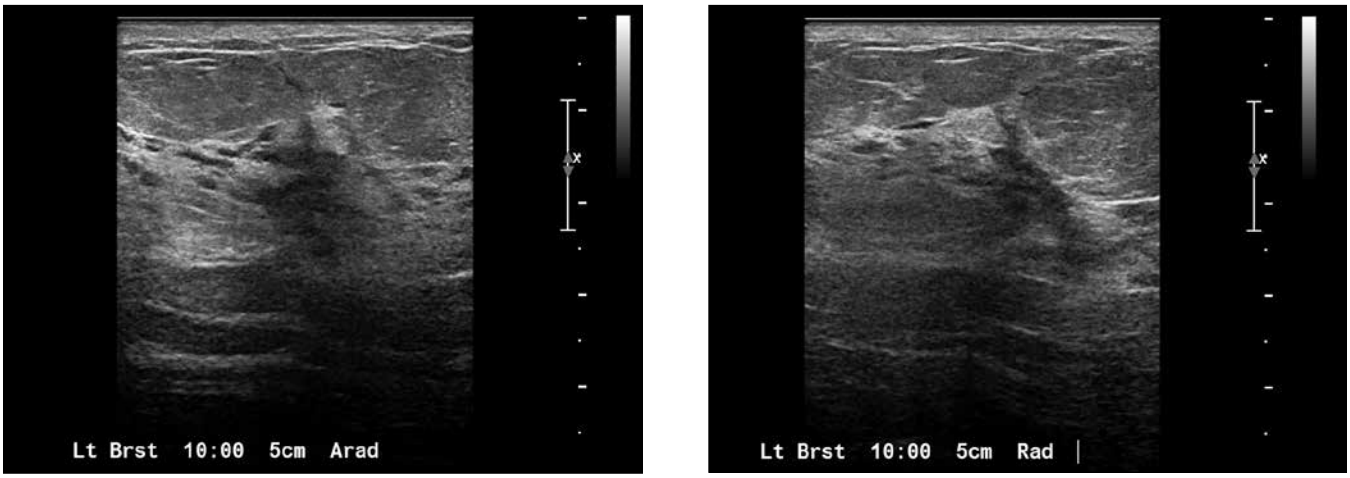
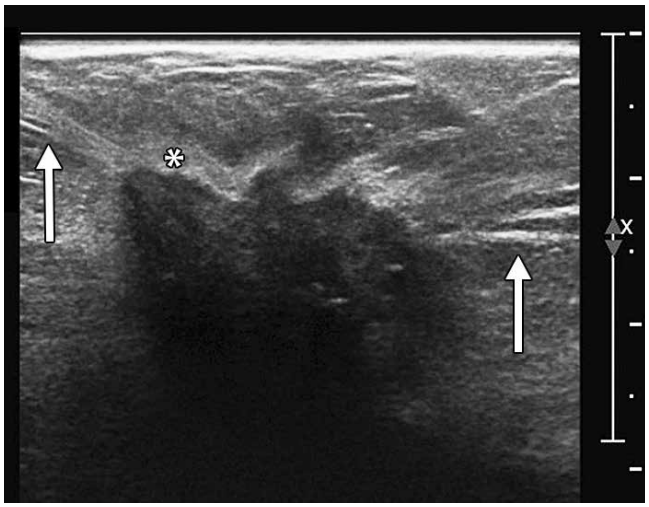


Figure 96 — ARCHITECTURAL DISTORTION. In a 56-year-old woman with pain, swelling, and redness of the left upper inner quadrant, a hypoechoic mass is seen within the fibroglandular tissue extending into the fat anterior to it, distorting the ducts within the adjacent fibroglandular tissue. Clinical considerations were mastitis and inflammatory carcinoma. Core biopsy histopathology: acute mastitis. Etiology of the acute mastitis is uncertain, but there was no history of skin abrasion, spider bite, trauma, nipple ring, or interventional procedure.



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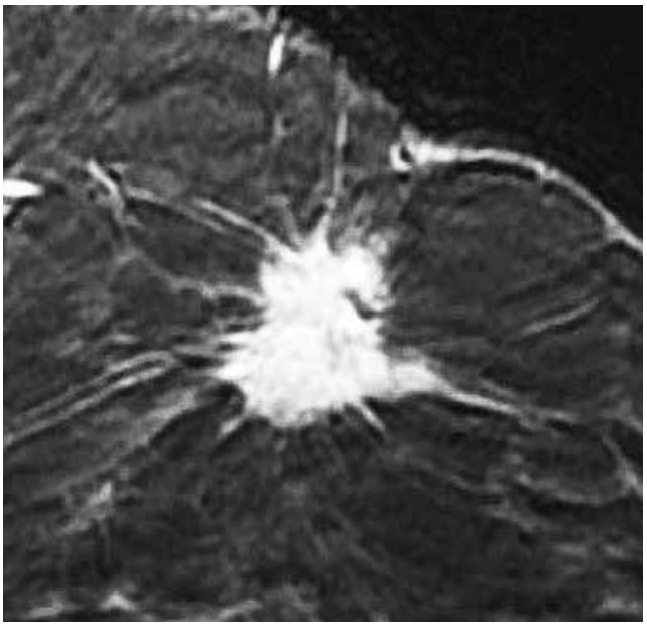

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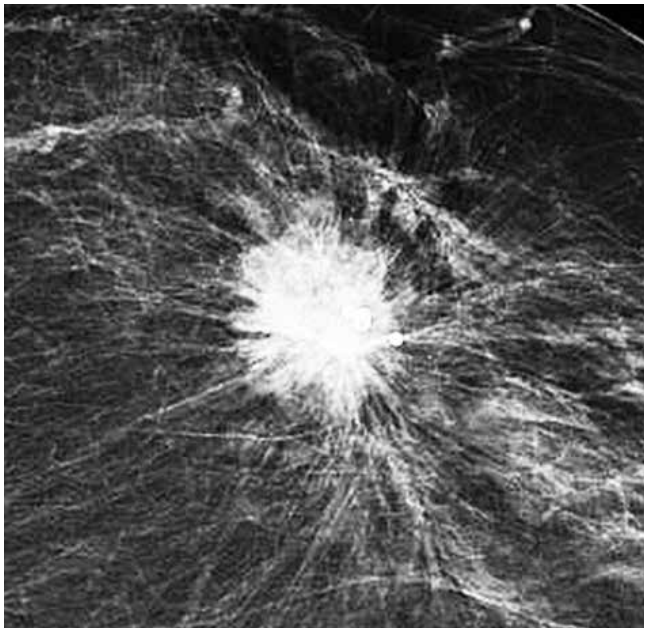

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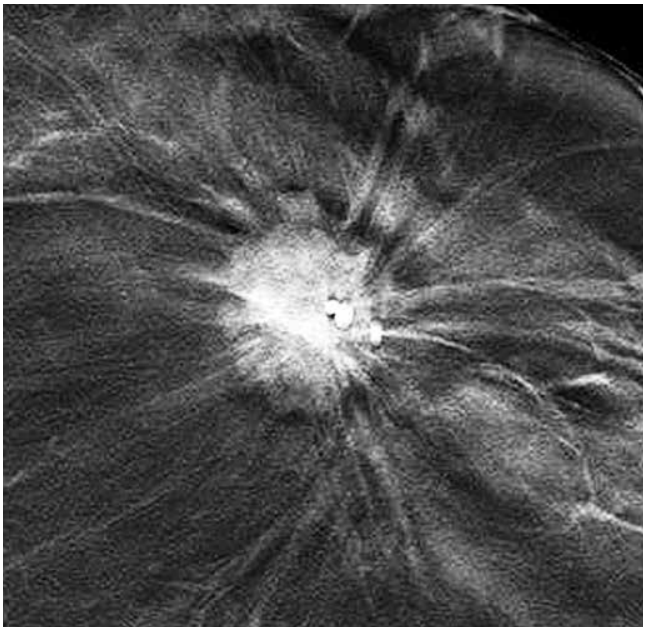


D

Figure 97 — ARCHITECTURAL DISTORTION. US image *(a)* of a mass in a 60-year-old woman demonstrates an irregular shape, spiculated margin, echogenic rim *(asterisk)*, orientation parallel to the skin, with posterior shadowing. Manifestation of ARCHITECTURAL DISTORTION is that Cooper ligaments are straight *(a, arrows)* versus their normal arc shape. The postcontrast sagittal MRI *(b)*, and craniocaudal 2-D digital *(c)* and tomosynthesis *(d)* views all show the features of a spiculated mass with associated architectural distortion. Histopathology: invasive ductal and lobular carcinoma, grade 2.

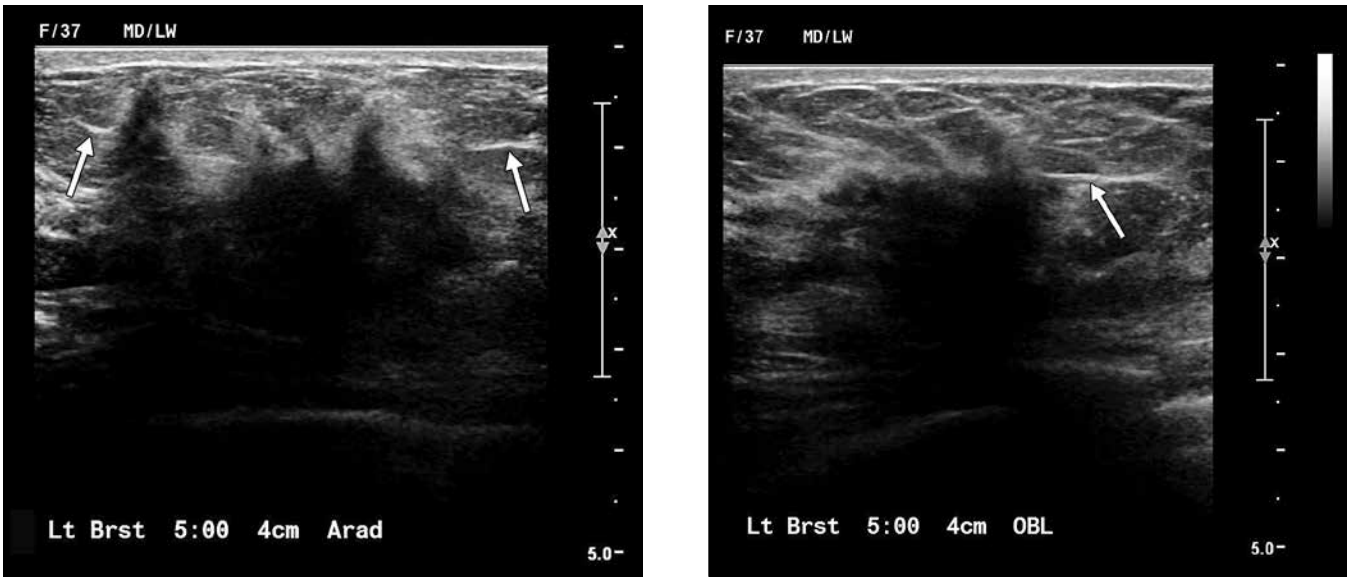
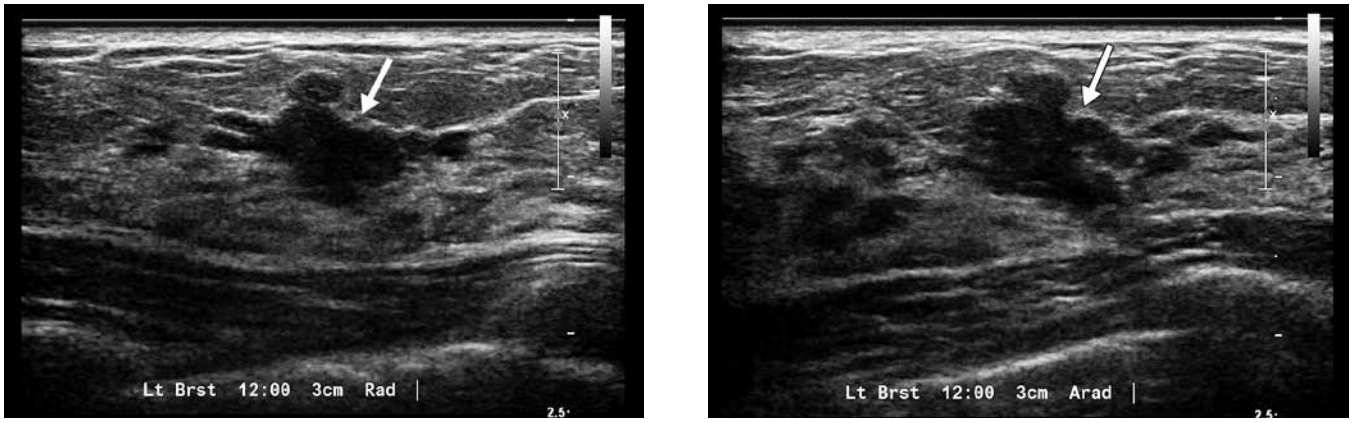


Figure 98 — ARCHITECTURAL DISTORTION. All of the findings of ARCHITECTURAL DISTORTION as an associated feature are present in this invasive lobular carcinoma, grade 2. Orthogonal US views show the tumor crossing the tissue planes, infiltrating the fat anterior to it, and straightening and shortening the nearby Cooper ligaments *(arrows)*. Orientation of the mass, similar to that of many invasive lobular carcinomas, is parallel to the skin, with angular protrusion and echogenic rim extending into the overlying fibroglandular tissue and fat planes. The appearance of this case is similar to that of Figure 97 (see page 83), a combined invasive ductal and lobular carcinoma.

D. ASSOCIATED FEATURES

2. DUCT CHANGES

Ducts normally arborize in a smooth, regular, stepwise fashion, becoming progressively narrower in caliber from the base of the nipple distally into the parenchyma. Abnormal duct changes are manifested by the cystic dilatation of a duct or ducts involving irregularities in caliber and/or arborization, extension of duct(s) to or from a malignant mass, or the presence of an intraductal mass, thrombus, or detritus.



A **B**

Figure 99 — DUCT CHANGES. A 34-year-old woman with nipple discharge. Radial *(a)* and antiradial *(b)* views of the left breast at 12 o'clock, 3 cm posterior to the nipple show DUCT CHANGES characterized by irregular cystic dilatation of duct segments *(arrows)*. Histopathology: intraductal papillomas, no atypia.

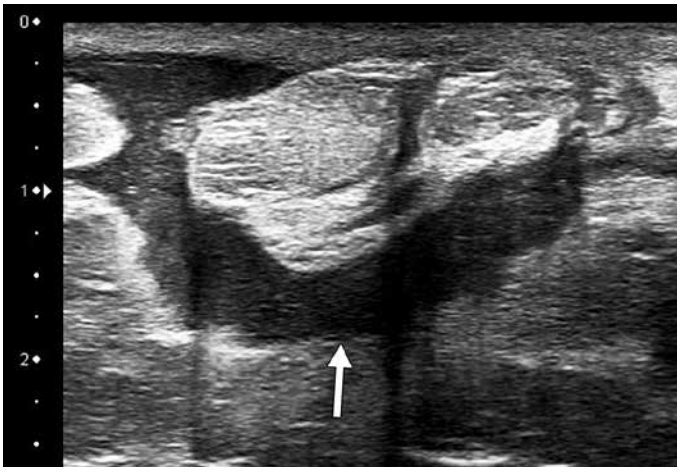


Figure 100 — DUCT CHANGES. A 19-year-old patient, whose nipple ring had been removed a month earlier, had purulent discharge from her left nipple with DUCT CHANGES characterized by irregular dilatation of a single duct *(arrow)*. Pus was aspirated from this duct, and then successful treatment with antibiotics was provided.

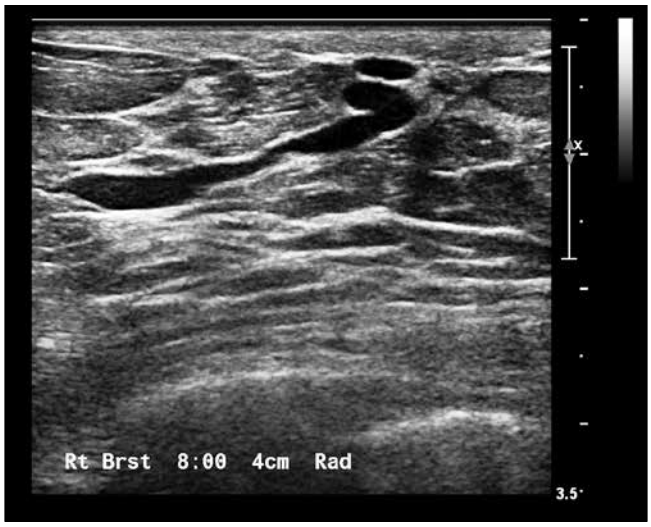
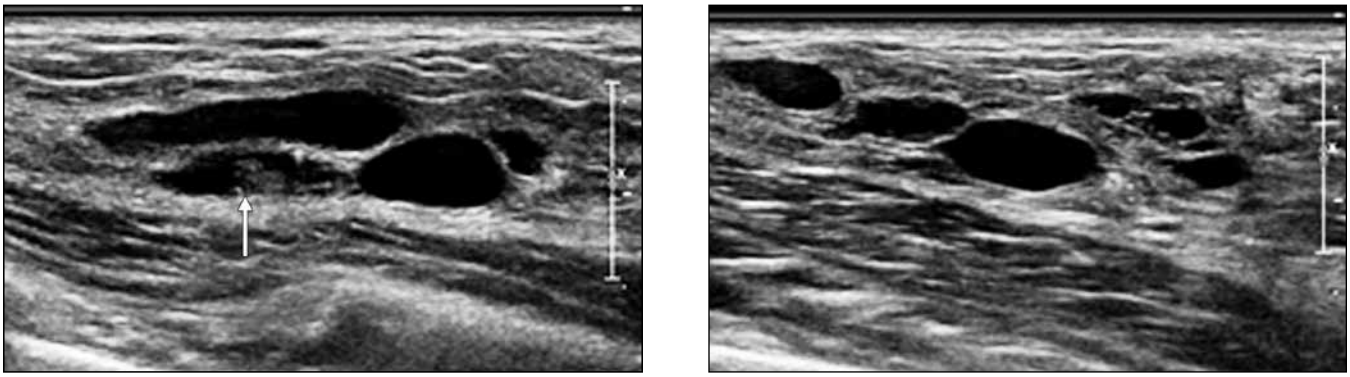


Figure 101 — DUCT CHANGES. A 64-year-old patient was noted to have a solitary dilated duct at screening mammography. US was performed, showing anechoic fluid within a smoothly dilated duct. Previous outside-facility mammograms dating back a decade were obtained, showing the dilated duct to be stable. Assessment was benign (category 2).



A **B**

Figure 102 — DUCT CHANGES. Baseline screening mammography in a 35-year-old woman with strong family history of breast cancer showed several dilated ducts in one breast (not shown). The patient requested supplementary US screening when she learned she had dense breasts. Dilated ducts *(a* and *b)* again were seen, with some echogenic intraductal material *(arrow)*. Assessment was suspicious and US-guided biopsy was performed, with histopathologic diagnosis of mucocele-like lesion (MLL). At excision, ductal carcinoma in situ and atypical ductal hyperplasia were found.

D. ASSOCIATED FEATURES

3. SKIN CHANGES

a. Skin Thickening

Skin thickening may be focal or diffuse, and is defined as being > 2 mm. However, in the peri-areolar area and inframammary folds, normal skin thickness may be up to 4 mm.

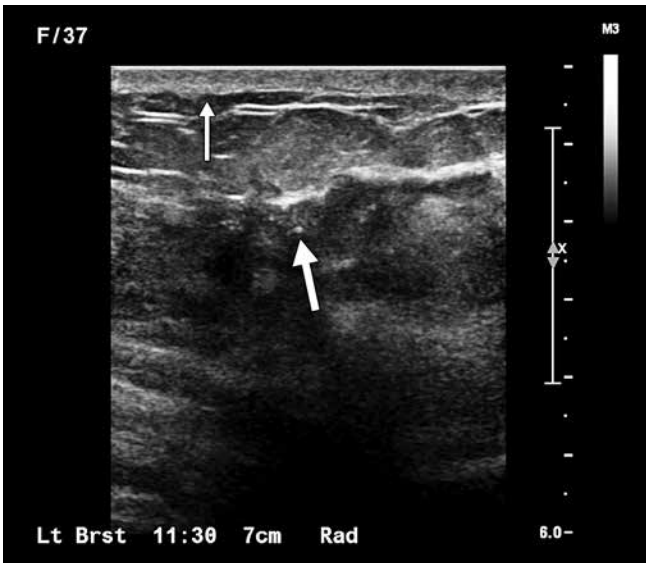


Figure 103 — SKIN CHANGES: SKIN THICKENING. Sonogram of the upper central breast shows the skin to be 5 mm thick *(thin arrow)*. Large underlying mass has irregular shape, margin that is not circumscribed, and parallel orientation with posterior shadowing. Echogenic flecks *(thick arrow)* grouped in the anterior aspect of the mass are calcifications. Assessment is highly suggestive of malignancy (category 5). Histopathology: invasive and intraductal carcinoma with lymphovascular invasion.

D. ASSOCIATED FEATURES

3. SKIN CHANGES

b. Skin Retraction

The skin surface is concave or ill-defined and appears pulled in.

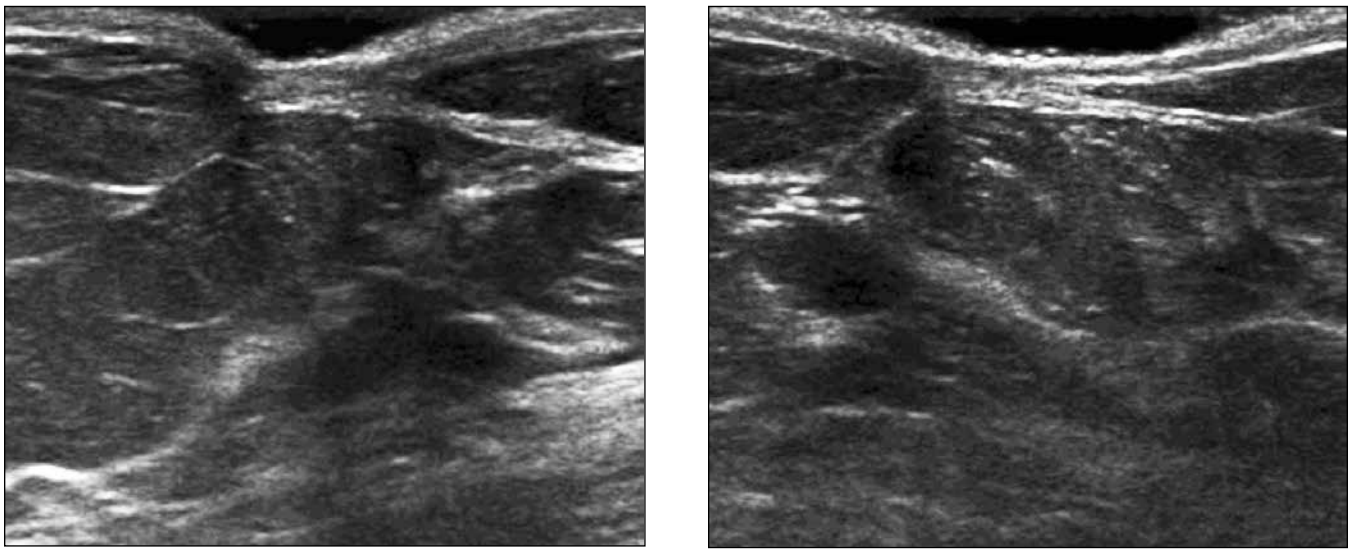


Figure 104 — SKIN CHANGES: SKIN RETRACTION and SKIN THICKENING. Focal SKIN RETRACTION and SKIN THICKENING at the incision site for a benign surgical biopsy performed many years earlier.

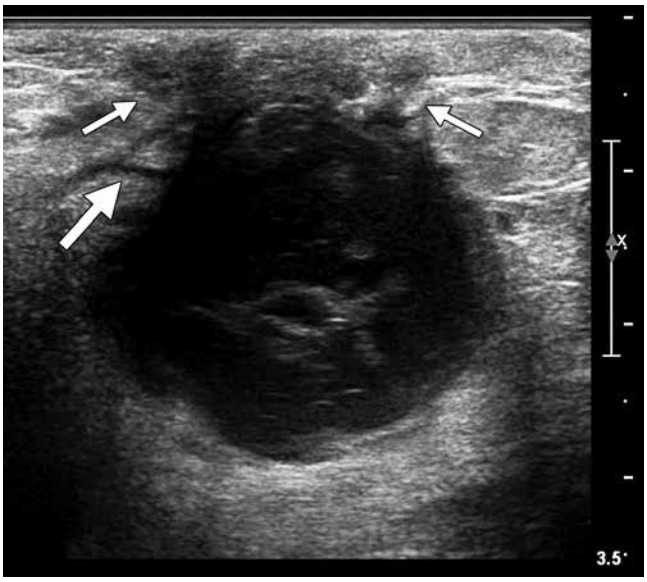
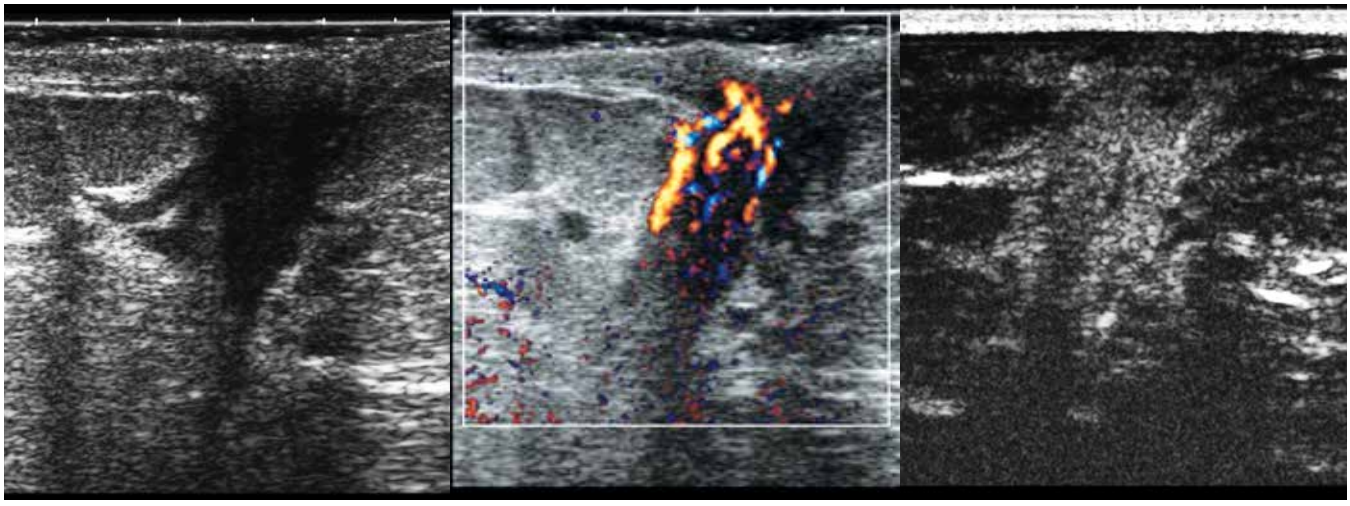


Figure 105 — SKIN CHANGES: SKIN RETRACTION and SKIN THICKENING. Hypoechoic skin immediately above an abscess shows V-shaped RETRACTION and THICKENING *(thin arrows)*. The underlying round inflammatory mass is partially circumscribed, partially spiculated *(thick arrow)*.



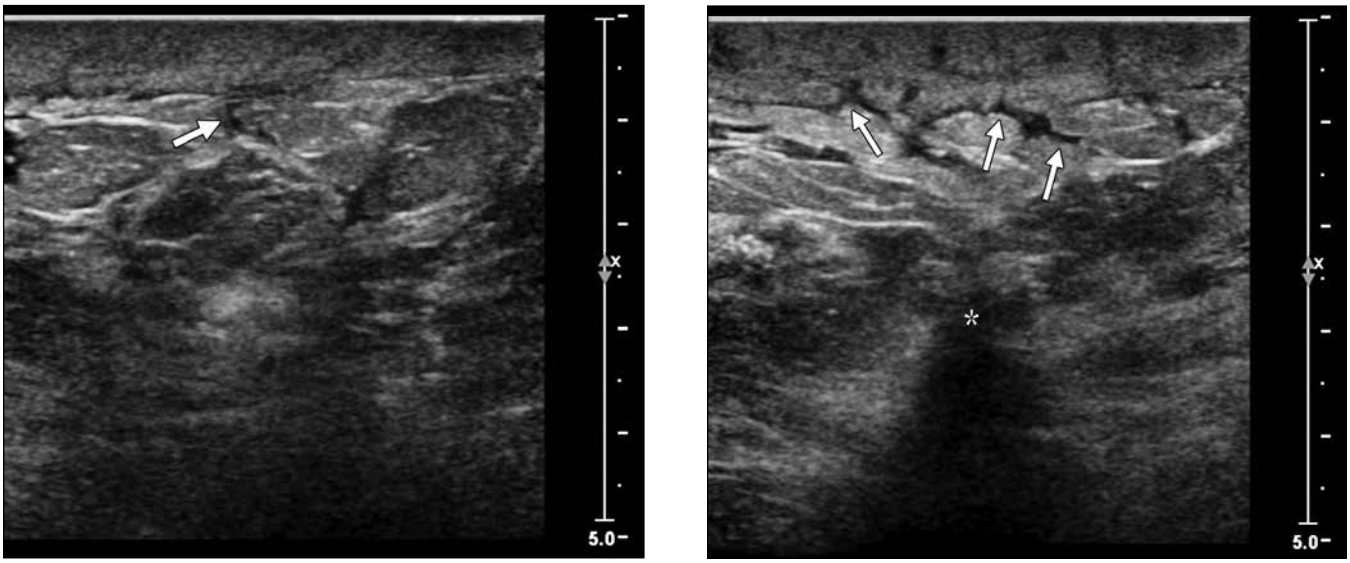
A **B** **C**

Figure 106 — SKIN CHANGES: SKIN RETRACTION and SKIN THICKENING. There is SKIN RETRACTION and SKIN THICKENING above a small hypoechoic invasive ductal carcinoma as seen on a gray scale image *(a)*, as well as with color Doppler *(b)* that shows hypervascularity of the tumor, and perfusion imaging *(c)* after US contrast medium injection, at which the tumor appears hyperechoic.

D. ASSOCIATED FEATURES

4. EDEMA

Edema is indicated by increased echogenicity of the surrounding tissue and reticulation (angular network of hypoechoic lines representing either dilated lymphatics or interstitial fluid). Pronounced skin thickening and edema are often companion findings in inflammatory breast cancer, mastitis, and systemic disorders such as congestive heart failure.



A **B**

Figure 107 — EDEMA. Visible in inflammatory breast carcinoma. Increased echogenicity of surrounding tissue and a reticulated network of irregular hypoechoic lines *(a* and *b, arrows)* signifies EDEMA, in this case associated with inflammatory breast cancer. Skin thickening also is present. A hypoechoic, irregular mass with posterior shadowing is also seen *(b, asterisk)*.

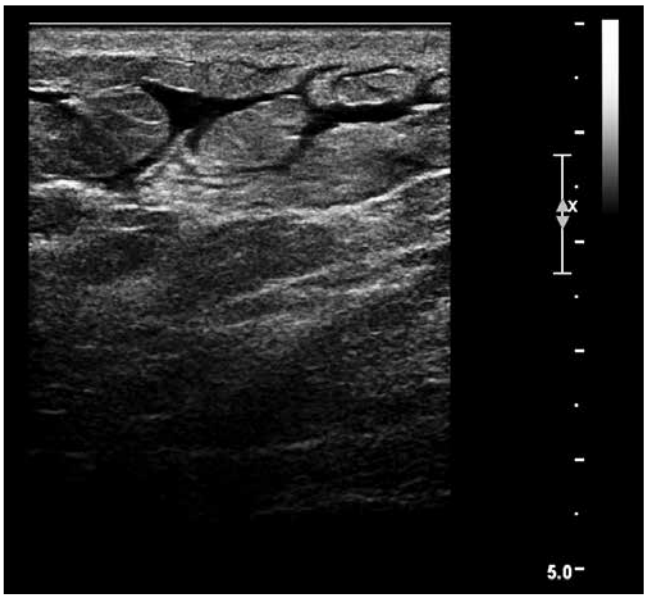


Figure 108 — EDEMA. Inflammatory carcinoma with dilated lymphatics or interstitial fluid collections in a reticulated pattern in the subcutaneous fat indicate the presence of EDEMA.

D. ASSOCIATED FEATURES

5. VASCULARITY

To describe a mass or other lesion as hypovascular or hypervascular, one must reference a contralateral normal area or unaffected site in the same breast as the basis for comparison. No vascular pattern is specific for any particular diagnosis. Both power and color Doppler are highly dependent on technical factors, and it is important not to use vascularity as the only diagnostic feature in interpretation. Malignant lesions may not be hypervascular, while some benign lesions, such as papillomas and inflammatory processes, may be highly vascular.

a. Absent

Cysts are the most common avascular lesions. Some solid masses also have little or no vascularity. However, technical factors such as sensitivity settings for color Doppler (pulse repetition frequency should be set for low flow) may suppress the display of vascularity, falsely making a lesion appear avascular. Additionally, vigorous compression may occlude small vessels; so when scanning with color or power Doppler, little or no pressure should be applied.

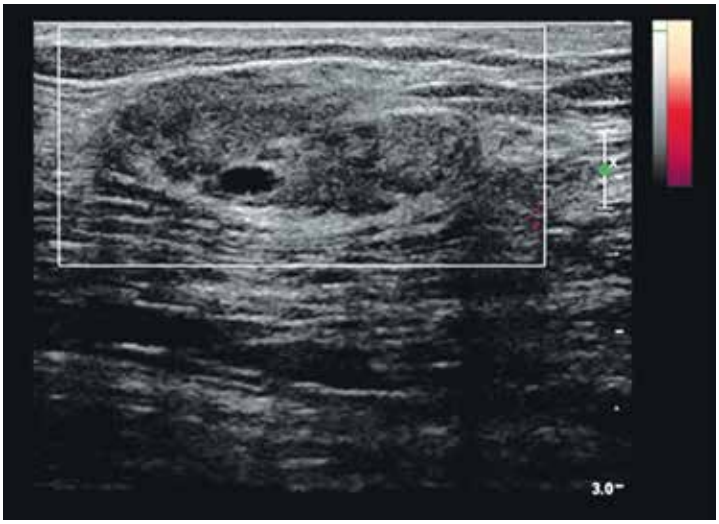


Figure 109 — VASCULARITY: ABSENT. This benign-appearing solid, circumscribed, oval mass of heterogeneous echogenicity, containing small cysts, is avascular. It had increased in size over time and biopsy was advised. The absence of vascularity does not change the morphologic analysis of the mass or its assessment. Histopathology: pseudoangiomatous stromal hyperplasia (PASH).

D. ASSOCIATED FEATURES

5. VASCULARITY

b. Internal Vascularity

Blood vessels are present within the mass. Vessels may penetrate the margin of the mass, or display an orderly or disorderly pattern within the mass. Abnormal flow patterns also may be found in breast tissue without the presence of a mass.

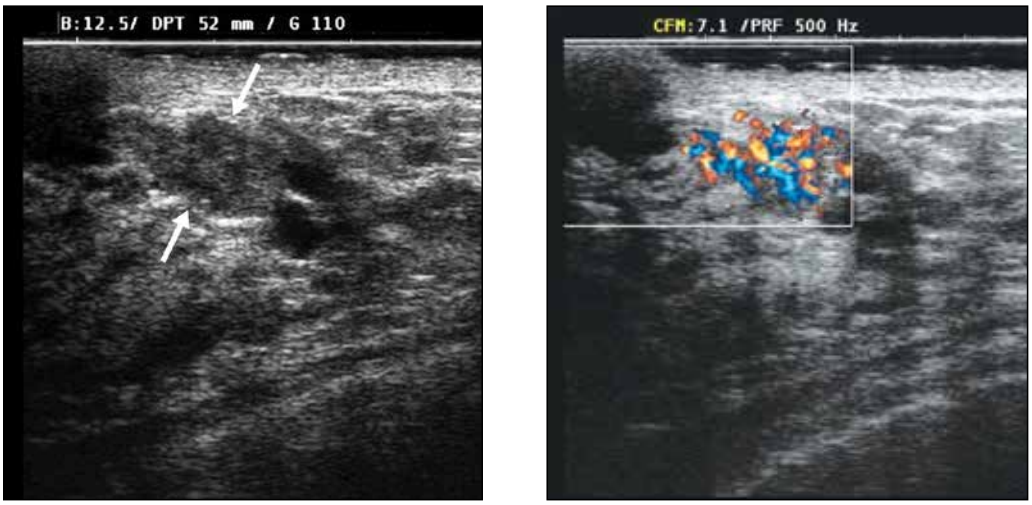


Figure 110 — VASCULARITY: INTERNAL VASCULARITY. Conventional US *(a)* shows a markedly dilated duct *(arrows)* distended with echogenic material extending towards the nipple at the upper left corner of the image frame. Color flow image *(b)*, without compression and with correct pulse repetition frequency (PRF) parameters, confirms a solid intraductal mass that shows an increased and markedly abnormal vascular pattern. Histopathology: invasive and intraductal carcinoma.

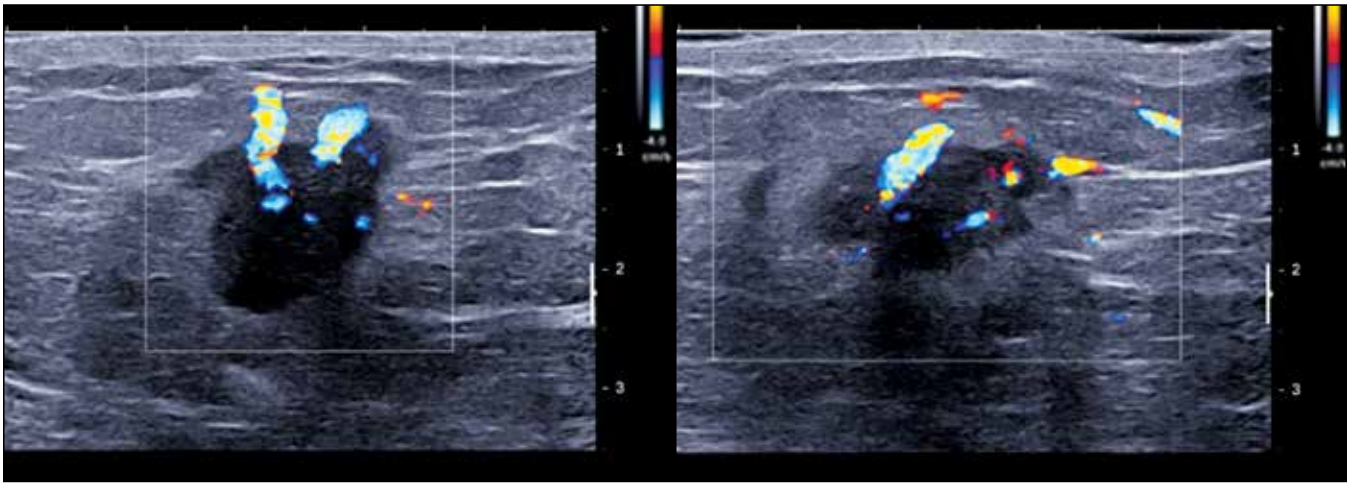


Figure 111 — VASCULARITY: INTERNAL VASCULARITY. Vessels from outside the mass penetrate its margin to supply the tumor *(a* and *b)*. Histopathology: invasive ductal carcinoma, grade 3.

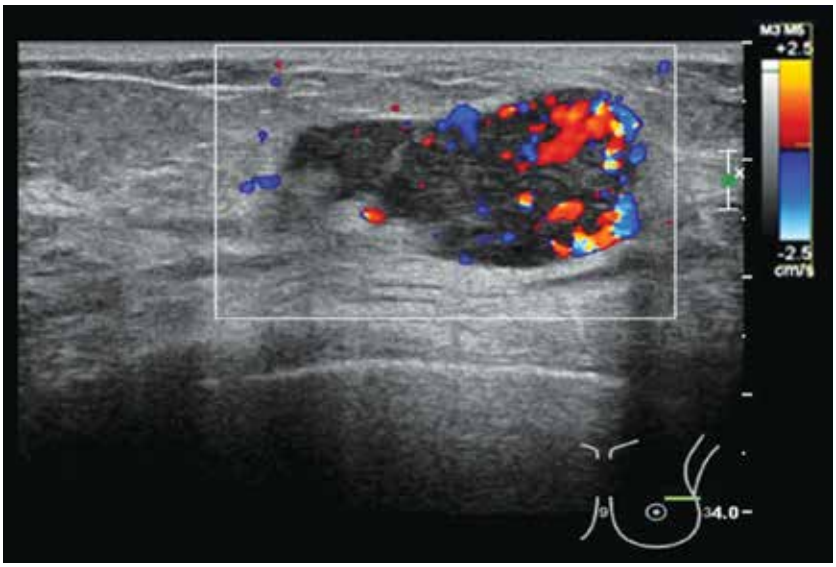


Figure 112 — VASCULARITY: INTERNAL VASCULARITY. The vessels of this invasive ductal carcinoma, grade 3, have a chaotic and disorderly branching pattern.

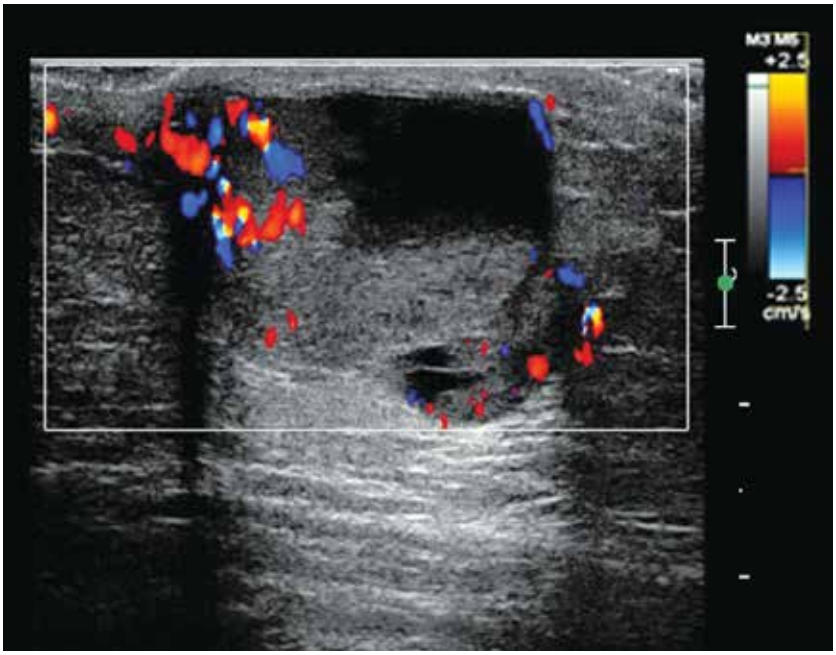
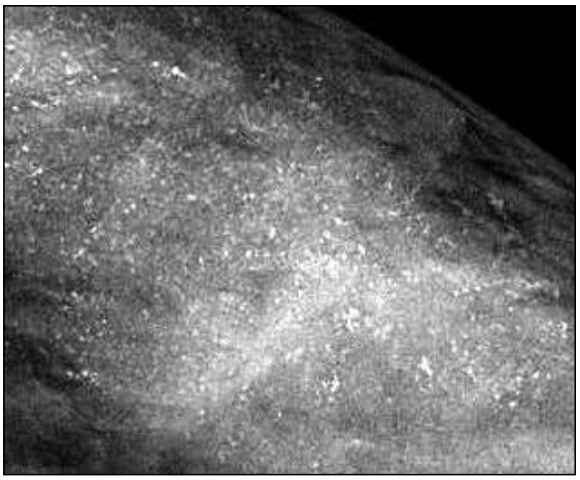
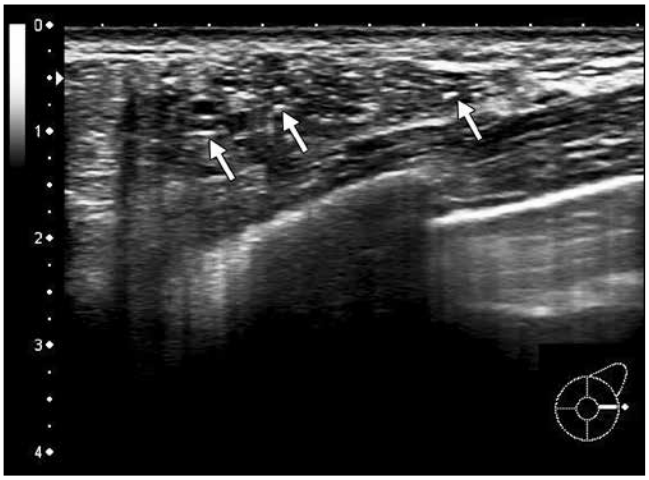


Figure 113 — VASCULARITY: INTERNAL VASCULARITY. Vessels in a disorderly pattern penetrate the margin of the lesion and are grouped within the solid portion of this complex cystic and solid mass in a 57-year-old man. Presence of vessels within the hypoechoic component helps differentiate this solid portion of the mass from detritus or clot in the dependent portion of what might have been considered a complicated cyst. Histopathology: intracystic papillary carcinoma.



A



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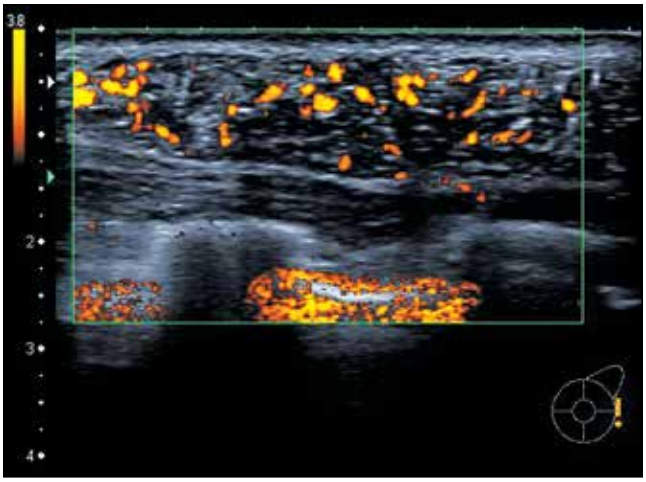


C

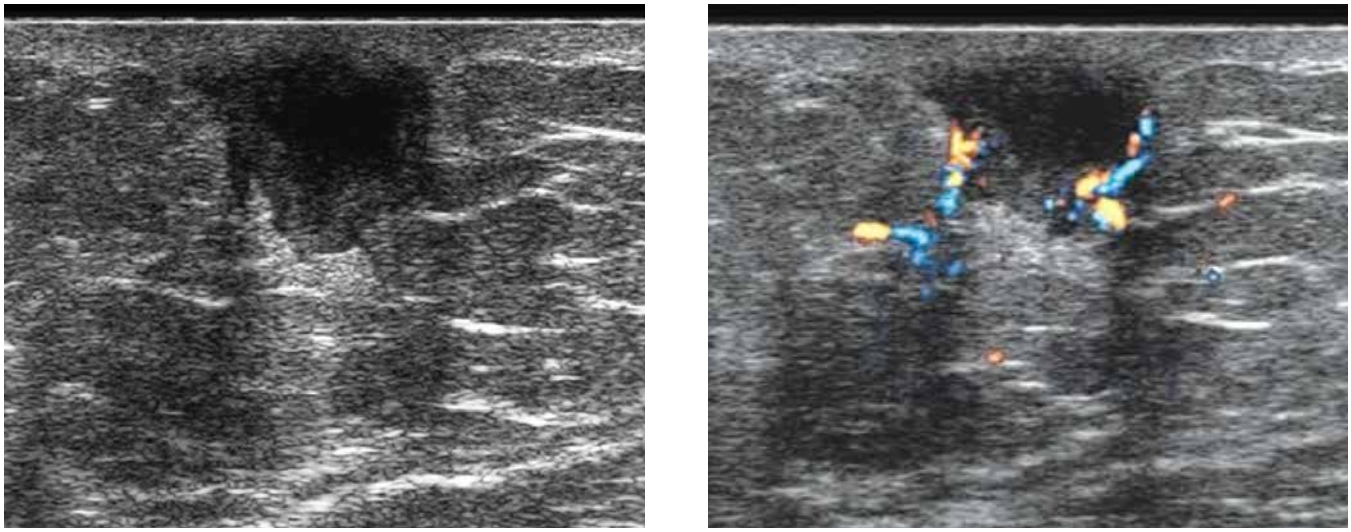
Figure 114 — VASCULARITY: INTERNAL VASCULARITY. Calcifications in extensive ductal carcinoma in situ at mammography *(a),* at B-mode image *(b, arrows)*. Increased flow is present in the area of involvement on power Doppler *(c)*.

D. ASSOCIATED FEATURES

5. VASCULARITY

c. Vessels in Rim

The blood vessels may be marginal, forming part or all of a rim around a mass.



A **B**

Figure 115 — VASCULARITY: VESSELS IN RIM. Retroareaolar abscess in a man. B-mode image of irregularly shaped, complex cystic and solid mass *(a)*. Color flow image *(b)* shows VESSELS IN RIM and in adjacent tissue.

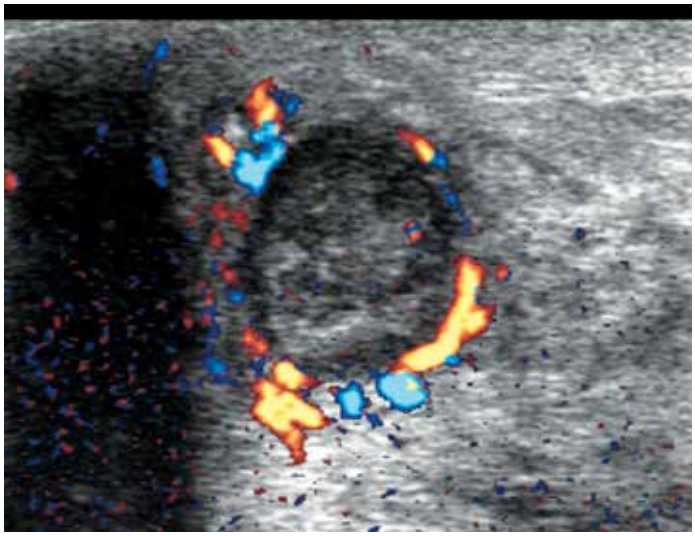


Figure 116 — VASCULARITY: VESSELS IN RIM. Circumscribed 6 mm mass with rim and peripheral vascularity. Diagnosis: abscess.

D. ASSOCIATED FEATURES

6. ELASTICITY ASSESSMENT

Stiffness as a feature of masses and surrounding tissue may be considered along with their much more important morphologic characteristics. This feature may be elicited either by manual compression of the mass ("strain") or by introduced ultrasonic energy into a mass ("shear wave"). Cancers and surrounding tissue are expected to be hard, and benign lesions are expected to be softer; although, as with all other sonographic criteria, there is overlap. Determination of the predictive value of various measurements of tissue stiffness is an area of current research for both strain and shear-wave elastographic methods. The FDA recently approved m/s and kPa as a unit of measure of lesion stiffness for shear-wave elastography. As research continues, some of the BI-RADS® descriptors listed in this section may be validated, others rejected, and new descriptors identified. Standardization of the color scale needs to occur to help prevent misinterpretation. Descriptors that are applicable to all methods and all systems are SOFT, INTERMEDIATE, and HARD.

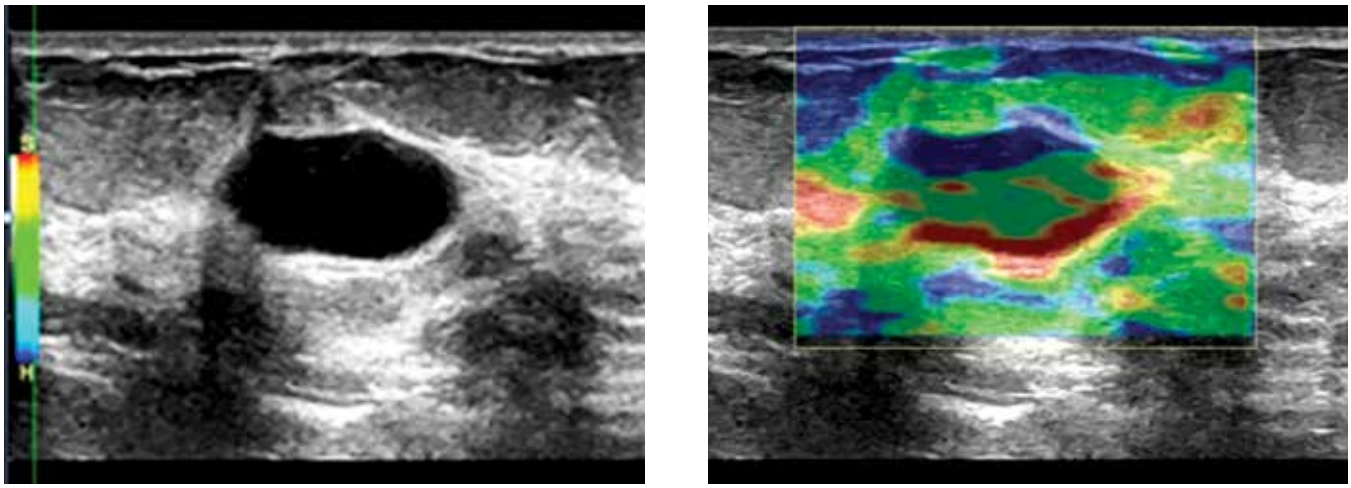
It must be emphasized that the ultrasonic criteria of shape, margin, and echogenicity are far more predictive for malignancy than hardness or softness, and elastography evaluation should not override the more predictive morphologic features of malignancy for patient management. Elastography has been included in the lexicon because it is available as a feature on many modern US units, and it is important to establish the names and definitions of descriptors for elasticity assessment. Inclusion should not be misinterpreted as an endorsement of the clinical validity of elasticity assessment.

D. ASSOCIATED FEATURES

6. ELASTICITY ASSESSMENT

   a. Soft

      Until color coding is standardized, always check the color or black-and-white scale for the labeling of soft and hard. While blue is frequently used to symbolize soft, some equipment manufacturers use red or another color as their default setting for soft. When a gray scale is used, white most often indicates soft.



A **B**

Figure 117 — ELASTICITY ASSESSMENT: SOFT. Simple cyst: B-mode image *(a)* shows four criteria for a simple cyst: anechogenicity, oval shape, circumscribed margin, and posterior enhancement. The strain elastogram *(b)* shows the trilaminar appearance of a simple cyst, displayed by some US systems. In this color scale, red represents soft and blue represents hard.

D. ASSOCIATED FEATURES

6. ELASTICITY ASSESSMENT

b. Intermediate

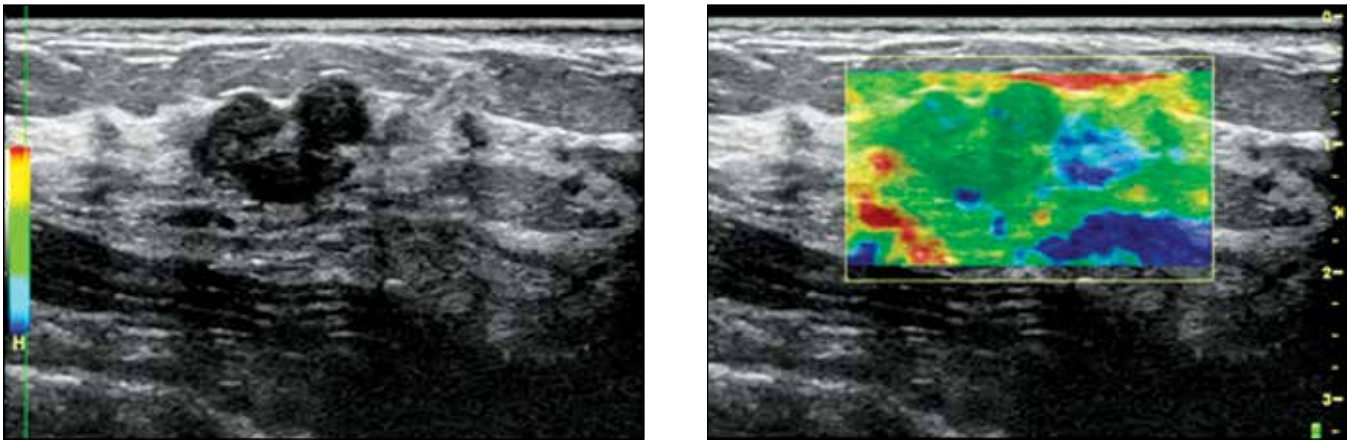
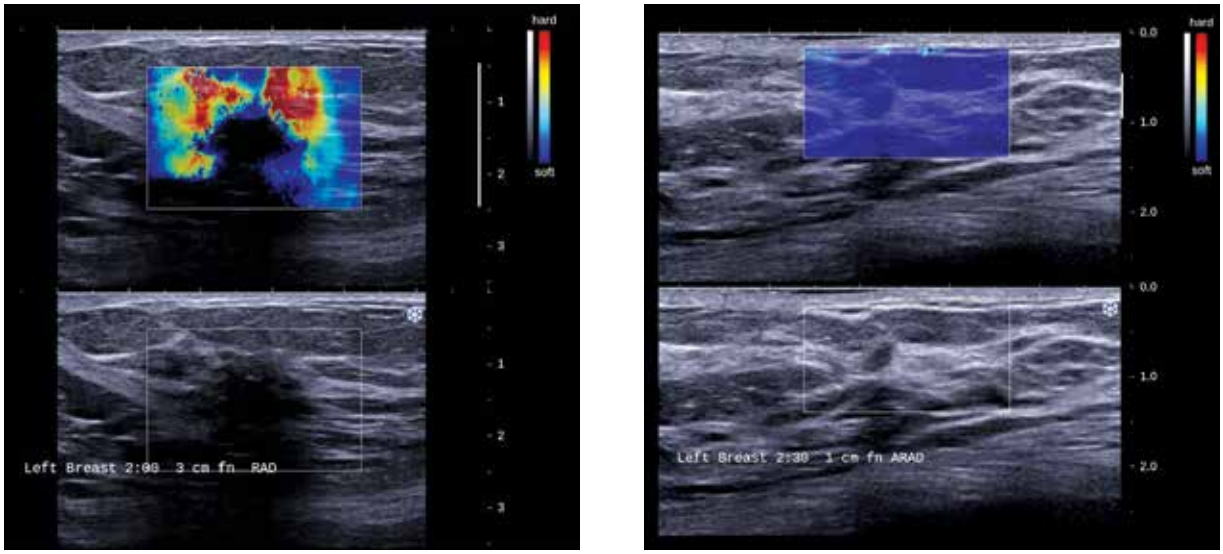


Figure 118 — ELASTICITY ASSESSMENT: INTERMEDIATE. Lobulated fibroadenoma with heterogeneous echogenicity; intermediate pattern on strain elastography. In this color scale, red represents soft and blue represents hard. Because of variability in labeling hard and soft, it is always important to refer to the color scale (left image) of each system.

D. ASSOCIATED FEATURES

6. ELASTICITY ASSESSMENT

   c. Hard



A **B**

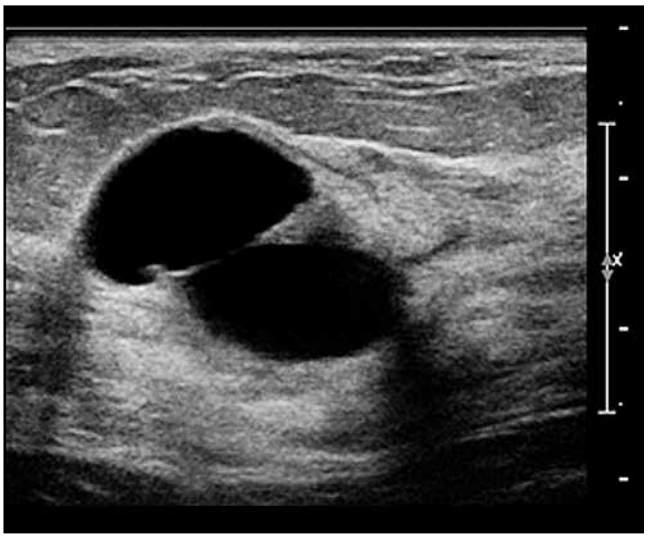
Figure 119 — ELASTICITY ASSESSMENT: HARD (red depicted as hard and blue as soft). Invasive lobular carcinoma in two sites in left breast, the larger is HARD *(a)* and the smaller is soft *(b)*. Both cancers have suspicious morphologic features on the gray scale sonograms displayed below the elastograms. The two cancers also were assessed as suspicious at both mammography and MRI (not shown). Take-home message: do not let a soft elastogram supersede morphologic analysis, especially when the imaging features on two or three different modalities suggest a suspicious assessment.

E. SPECIAL CASES

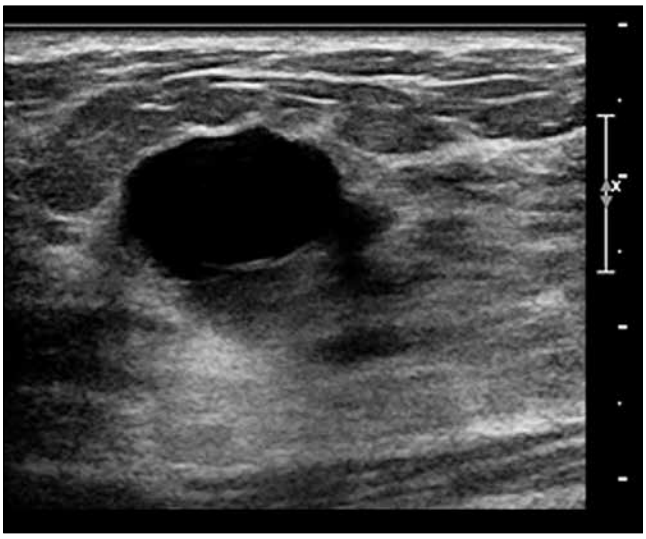
Special cases are those with a unique diagnosis or findings.

1. SIMPLE CYST

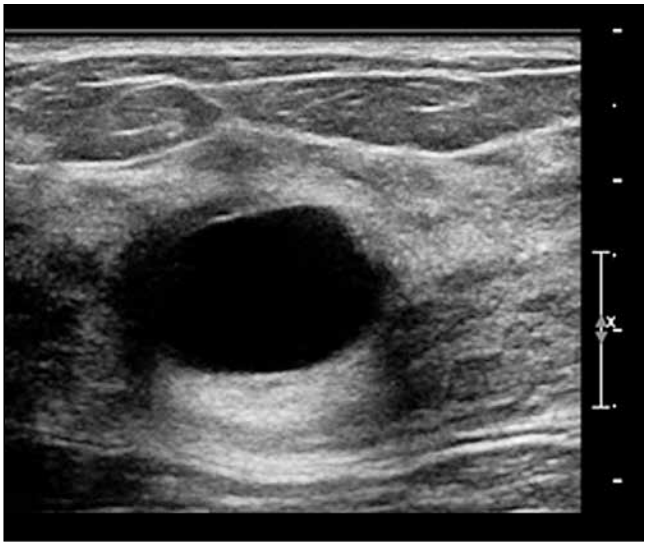
   The diagnosis and management of cystic breast lesions are addressed in detail in the Guidance chapter. A simple cyst has four features: it is circumscribed, round or oval, anechoic, and shows posterior enhancement. When all four features are depicted, this establishes the diagnosis of simple cyst, a characteristically benign finding.



A



B



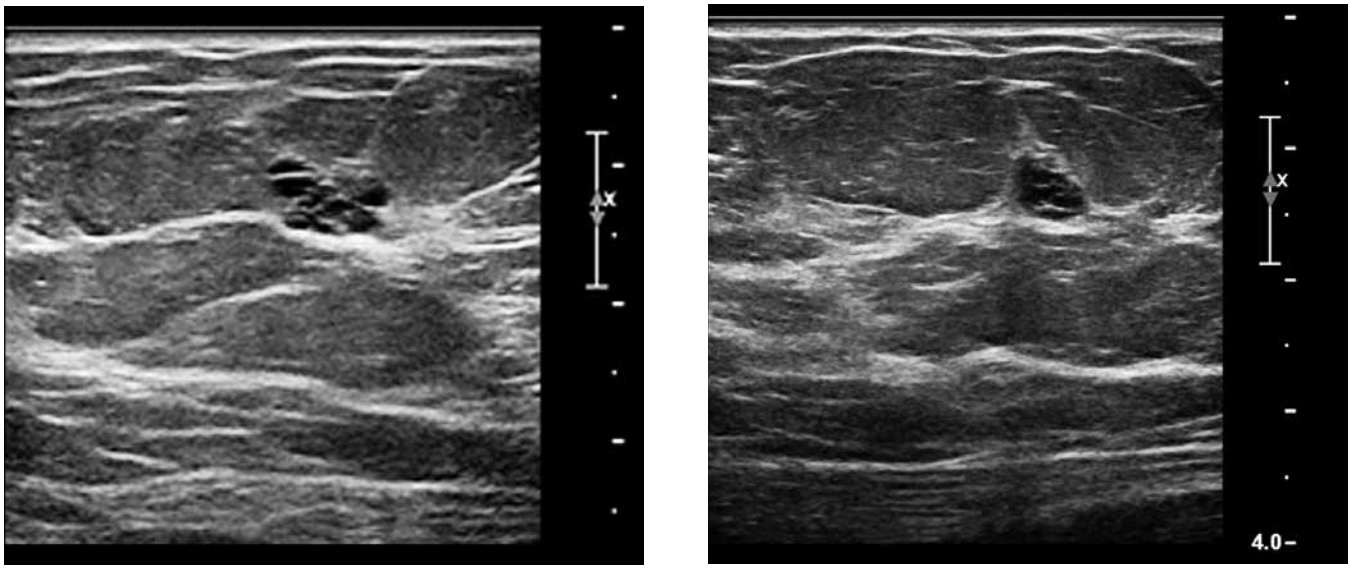
C

Figure 120 — SPECIAL CASES: SIMPLE CYST. Radial image *(a)* shows anechoic, circumscribed masses, one superficially located with respect to the other, with the antiradial image of the more superficial one *(b)* and that of the deeper one *(c)*. When masses are grouped as these cysts are, all will not be in the same plane and margins may not be sharp. For similar masses in proximity, measurement of the depth from the skin to the anterior aspect of the mass can help differentiate.

E. SPECIAL CASES

2. CLUSTERED MICROCYSTS

The lesion consists of a cluster of anechoic masses, individually < 2–3 mm, with thin (< 0.5 mm) intervening septations and ***no discrete solid*** component. While margins may reflect microlobulation due to individual small cysts, the margin should not be indistinct. Tissue diagnoses associated with clustered microcysts include fibrocystic change and apocrine metaplasia.



A **B**

Figure 121 — CLUSTERED MICROCYSTS. Note the grouping of tiny cysts (CLUSTERED MICROCYSTS) shown on radial *(a)* and antiradial views *(b)*. No solid component is present in any of the tiny cysts. If not palpable, an assessment of probably benign (category 3) or, especially if stable, benign (category 2) may be appropriate.

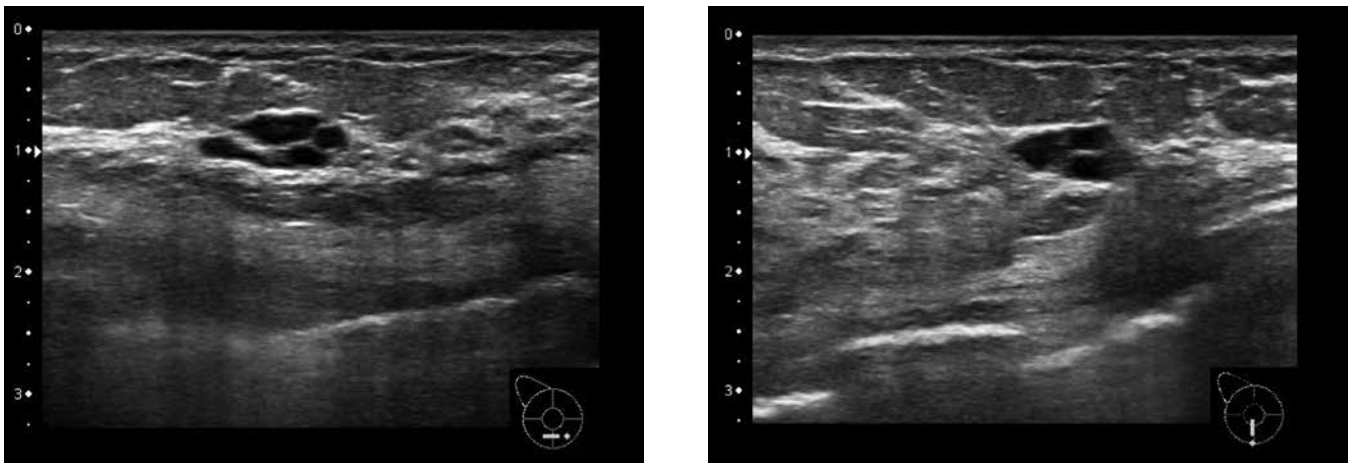
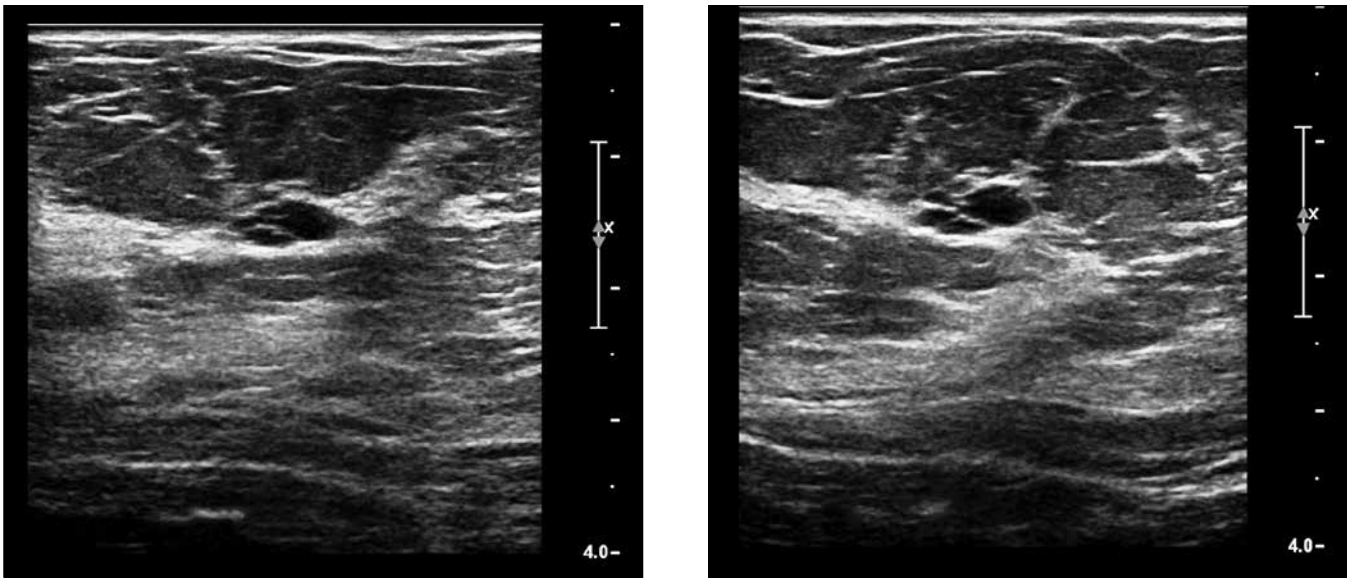


Figure 122 — CLUSTERED MICROCYSTS. Elongation and distention of the lobule by a grouping of distended acini. CLUSTERED MICROCYSTS are often assessed as probably benign (category 3) or benign (category 2). The presence of an indistinct margin or a discrete solid component should prompt a BI-RADS® 4 assessment and recommendation for biopsy, particularly if the mass is new or in a post-menopausal patient.



A B

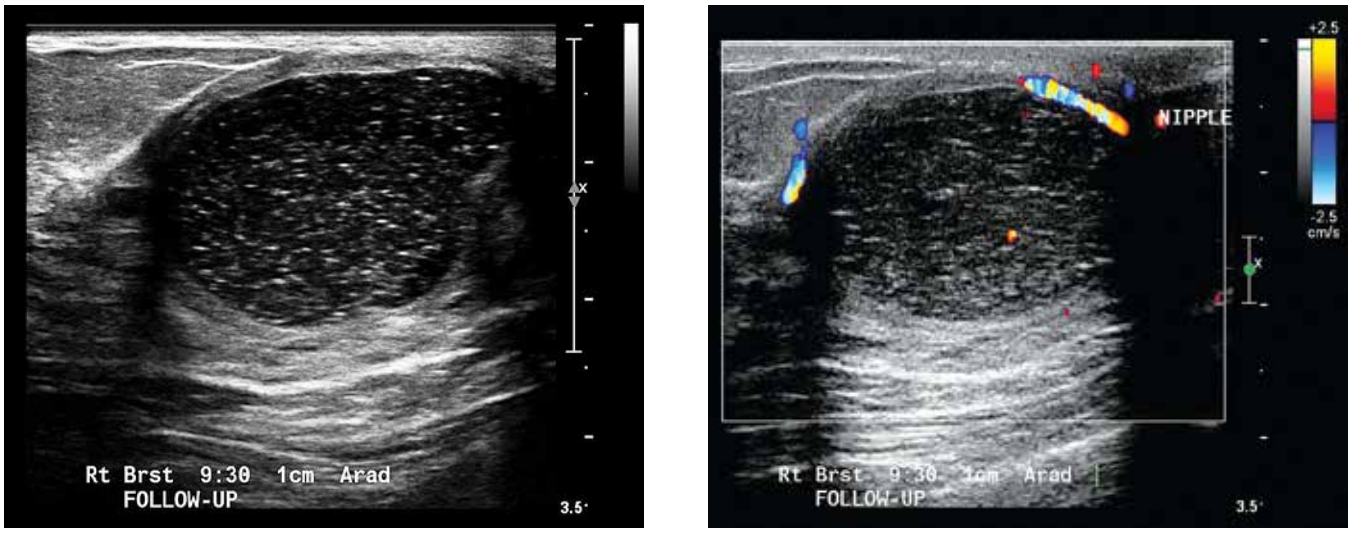
Figure 123 — CLUSTERED MICROCYSTS. This 44-year-old woman who had multiple bilateral simple and complicated cysts (not shown), also has a grouping of CLUSTERED MICROCYSTS found incidentally *(orthogonal views, a* and *b)* during supplementary US screening. Assessment was benign (category 2), given the multiplicity and bilaterality of these findings.

E. SPECIAL CASES

3. COMPLICATED CYST

These are cysts that contain debris, often manifest as homogeneous, low-level echoes, without a discrete solid component, and with an imperceptible wall. At real-time scanning, these echoes may have a layered appearance that may shift slowly with changes in the patient's position. A complicated cyst also may contain echogenic foci that appear to scintillate as they shift in position.

> **Note:** The presence of a discrete solid component (including solid mural nodules) should cause what otherwise might be considered a complicated cyst to be described as a "complex cystic and solid" mass. In the past, "complicated" and "complex cystic and solid" masses were confused, because this important distinction was not respected in the reporting.



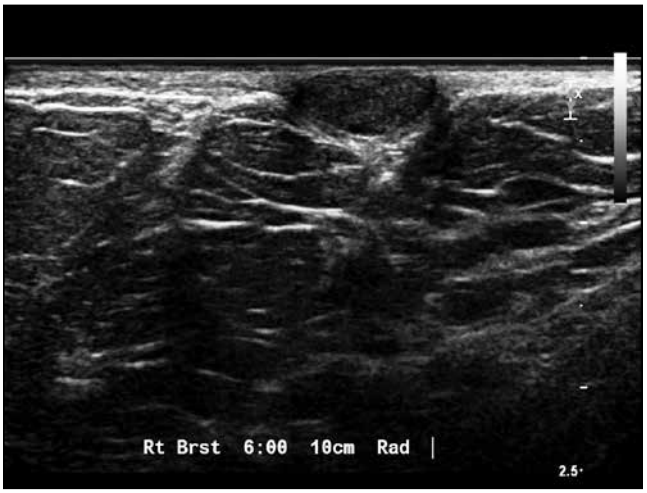
A **B**

Figure 124 — COMPLICATED CYST. A 56-year-old woman with palpable mass just lateral to the nipple. This COMPLICATED CYST fulfills all of the sonographic criteria that define a simple cyst except that it contains low-level echoes throughout *(a)*. Note the visible rim vascularity *(b)*.

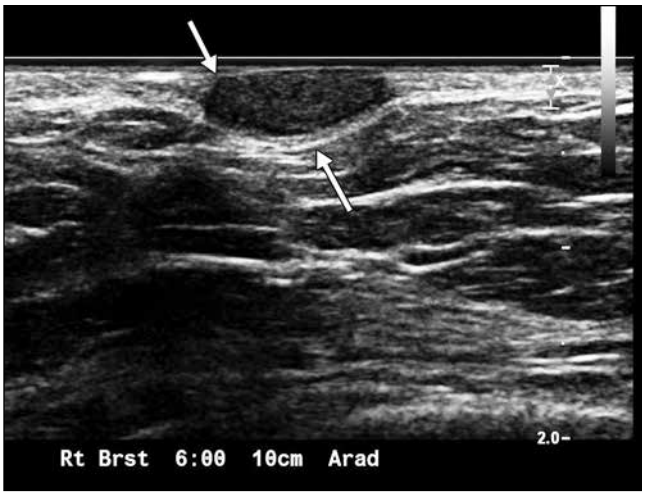
E. SPECIAL CASES

4. MASS IN OR ON SKIN

These benign masses are usually clinically apparent and include sebaceous or epidermal inclusion cysts, keloids, moles, pimples, neurofibromas, and accessory nipples. Rarely, a mass in the skin is found to be a metastasis, particularly in the setting of a mastectomy scar; but then, clinical information about the primary tumor should be available to guide image interpretation. It is important to recognize the interface between skin and parenchyma and to establish that the mass is at least partially within the two thin echogenic bands of skin.



A



B

Figure 125 — MASS IN OR ON SKIN. Sebaceous cyst has formed between the two layers of skin *(a* and *b, orthogonal views)*. The skin layers enclosing the mass are best seen on *(b, arrows)*. With use of a gel offset or offset pad, a stalk can sometimes be seen through which the fatty contents of a sebaceous cyst are occasionally extruded.

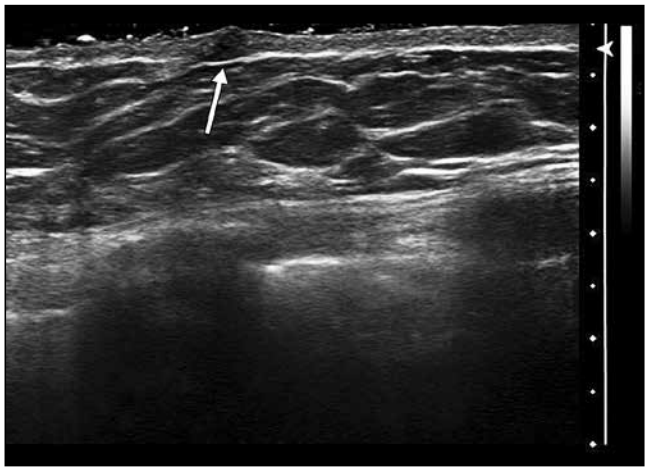


Figure 126 — MASS IN OR ON SKIN. An accessory nipple *(arrow)* may form along each of the embryonic milk lines that extend from axilla to groin.

E. SPECIAL CASES

5. FOREIGN BODY INCLUDING IMPLANTS

Foreign bodies include marker clips, coils, wires, catheter sleeves, injected or leaked silicone, metal or glass related to trauma, and implants. History is usually helpful in establishing the presence and nature of foreign matter within the patient. Silicone within the parenchyma has a characteristic "snowstorm" appearance at US, depicted as echogenic noise, which propagates posterior to the mass and obscures deep structures. Extravasated silicone or silicone gel bleed can travel through lymphatics and lodge in lymph nodes, which then exhibit similar characteristics.

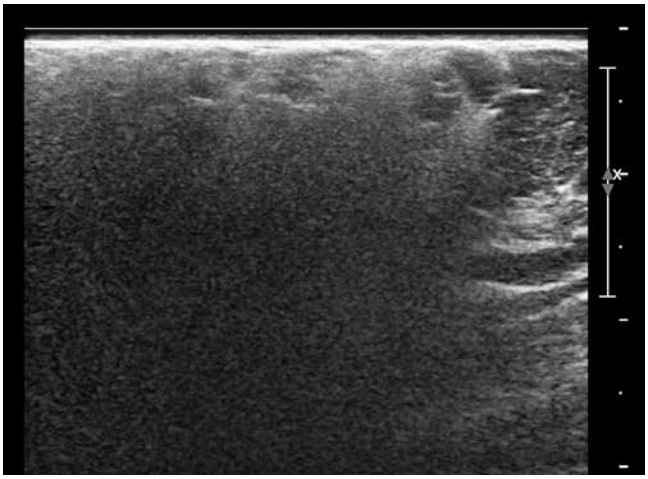


Figure 127 — FOREIGN BODY INCLUDING IMPLANTS. A 39-year-old patient who had injections of free silicone into her breasts at the age of 20. She began feeling masses in her breasts 1 year later but does not think they have changed. US shows marked attenuation of sound, as well as a "snowstorm" pattern or echogenic noise.

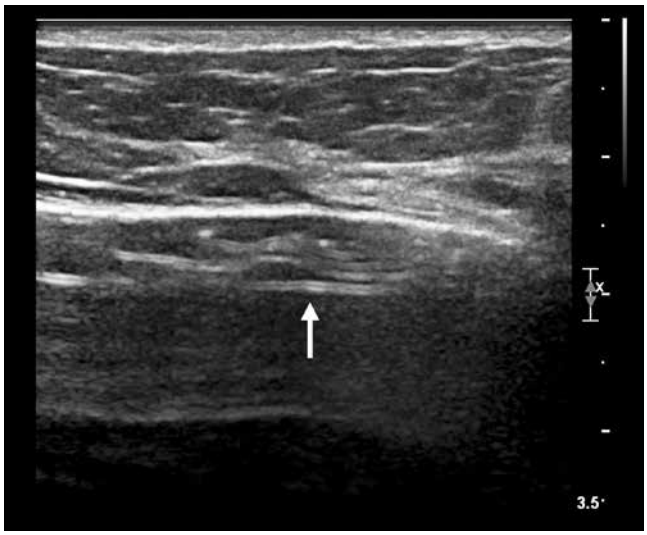


Figure 128 — FOREIGN BODY INCLUDING IMPLANTS. This 55-year-old woman had retroglandular silicone implants placed 30 years earlier. On radial US, performed to assess a parenchymal abnormality (not included), collapsed layers of the silicone implant shell were noted (the "stepladder sign"), indicative of intracapsular rupture *(arrow)*. This is a benign finding, BI-RADS® category 2, but should be included in the report.

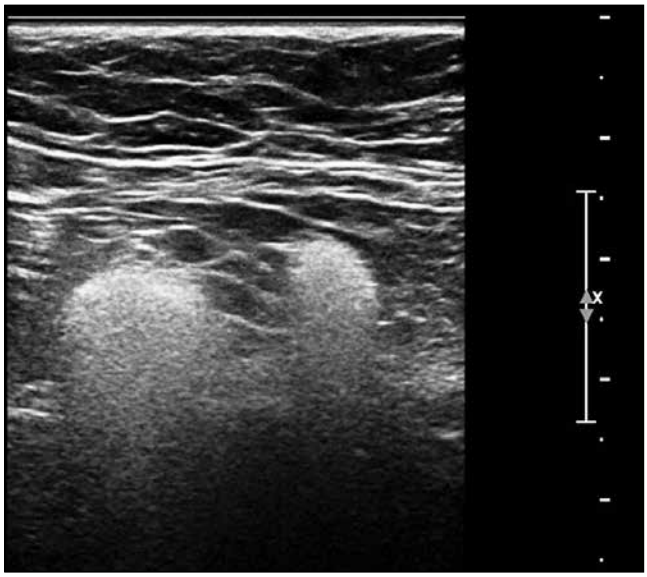


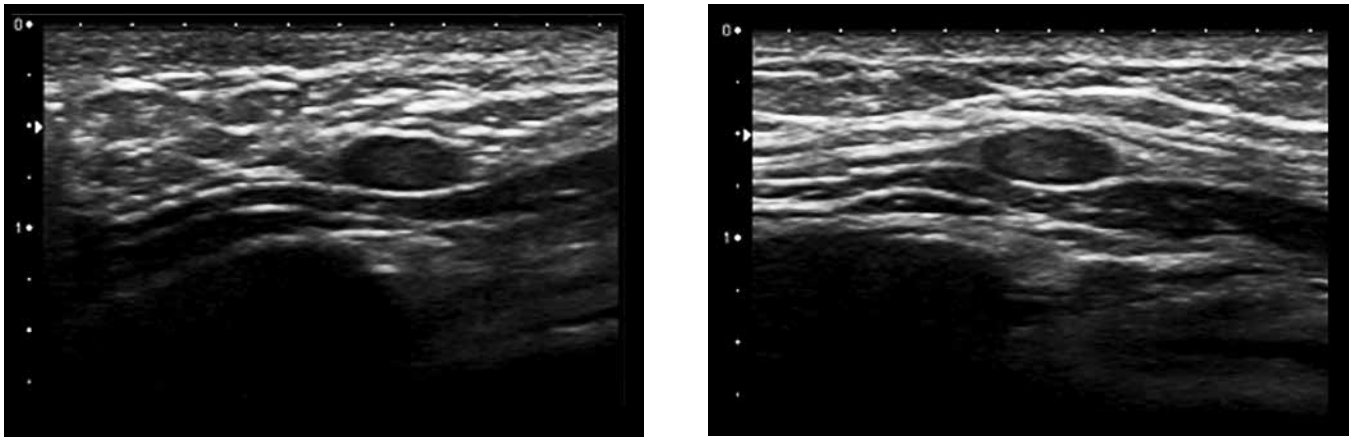
Figure 129 — FOREIGN BODY INCLUDING IMPLANTS. Silicone uptake in lymph nodes within the pectoral muscle. Given the pertinent clinical history of previous placement of a silicone implant, no interventional procedure is necessary to establish the diagnosis of extracapsular silicone.

E. SPECIAL CASES

6. LYMPH NODES — INTRAMAMMARY

These are circumscribed oval masses that often are reniform and contain hilar fat. Lymph nodes exist throughout the breast, but they are most commonly seen in the upper outer quadrant (especially the axillary tail) because they normally are larger the closer they are located to the axilla. The usual size of normal intramammary lymph nodes ranges from 3 to 4 mm up to approximately 1 cm. Whether present within the breast or axilla, lymph nodes have a distinctive appearance, with a hypoechoic cortex and echogenic fatty hilus.

When the typical features of an intramammary lymph node are depicted, the finding may be considered to be characteristically benign.



A **B**

Figure 130 — LYMPH NODES — INTRAMAMMARY. Small, enhancing, oval mass on MR thought to be an INTRAMAMMARY LYMPH NODE is confirmed on MRI-directed US examination. The hypoechoic cortex and echogenic hilus are identifiable on orthogonal views *(a* and *b)*.

E. SPECIAL CASES

7. LYMPH NODES — AXILLARY

Enlarged axillary lymph nodes may warrant comment, clinical correlation, and additional evaluation, especially if they are new or considerably larger or rounder when compared to previous examination. Although there is no specific agreed-upon measurement, a normal axillary lymph node may be up to 2 cm in its longest dimension and contain hyperechoic fatty hilar areas. Lymph nodes much larger than 2 cm may be normal when a very thin cortical rim is seen around a massive collection of hilar fat. A lymph node with no fatty hilum or with a compressed fatty hilum may be abnormal, whereas depiction of a cortical bulge or cortical area of altered echogenicity suggests the presence of metastasis. However, there is no specific sonographic feature that reliably distinguishes a nodal metastasis from a benign reactive node. Because of individual variability in the size and number of axillary lymph nodes, assessment of side-to-side symmetry may be helpful.

Following is an outline of the parameters that may be used to characterize a lymph node at US:

a. Size

b. Shape

   i. Oval

   ii Round

   iii. Irregular

c. Cortical thickening

   i. Uniform, concentric: be wary of oblique angle of insonation as the explanation for cortical thickening, both concentric and focal. Real-time scanning should help distinguish true cortical thickening.

   ii. Focal

d. Margin

   i. Circumscribed

   ii Not circumscribed

e. Hilar compression or displacement

   Note that the presence of fat in a nodal hilus does not exclude metastatic involvement; the hilar fat may be compressed and displaced by the metastasis. Replacement of a node by tumor may be gradual and best detected by interval change. However, images of normal-appearing lymph nodes in an axilla rarely are recorded at US (because they are characteristically benign), so it may not be possible to assess for interval sonographic change. On the other hand, increasing nodal size at mammography may be a cause for concern and underlie a recommendation for biopsy. In this case, it is important to measure the node in the same, or similar, projection on the current and previous mammograms.

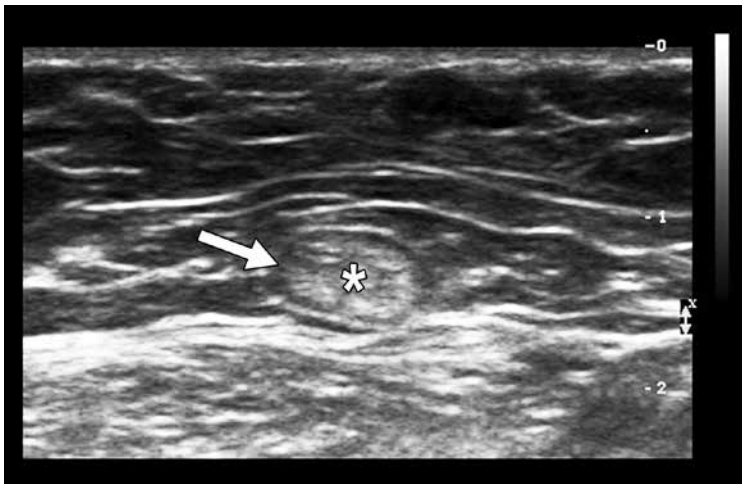


Figure 131 — LYMPH NODES — AXILLARY. Small, benign AXILLARY LYMPH NODE with very thin cortex *(arrow)* and large area of hilar fat *(asterisk)*.

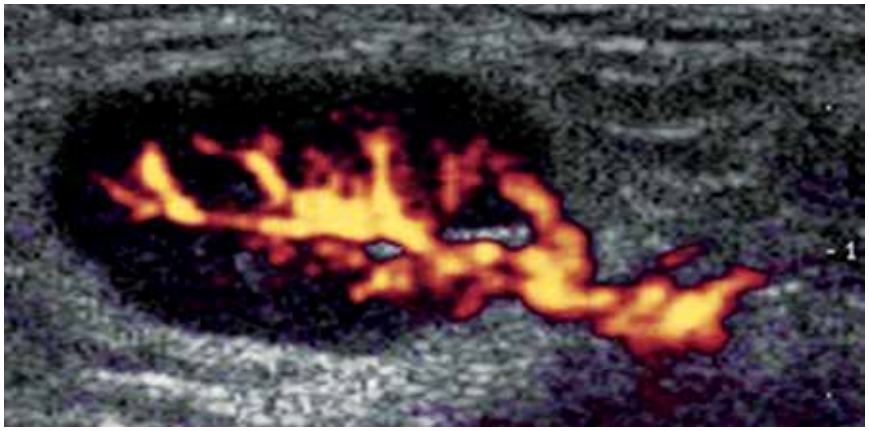
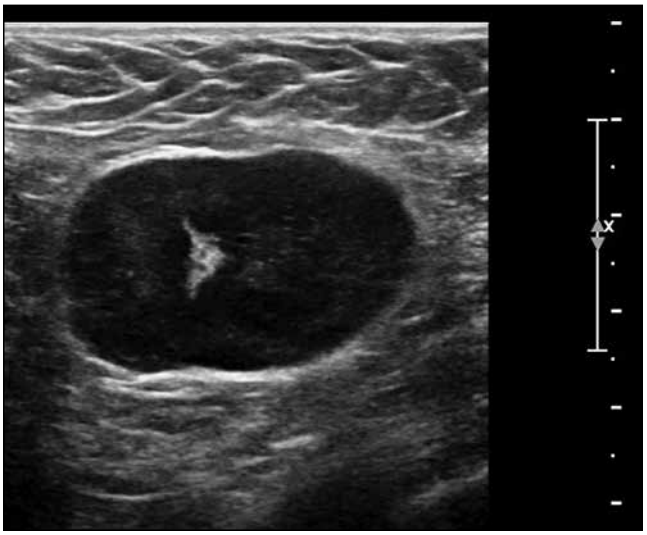
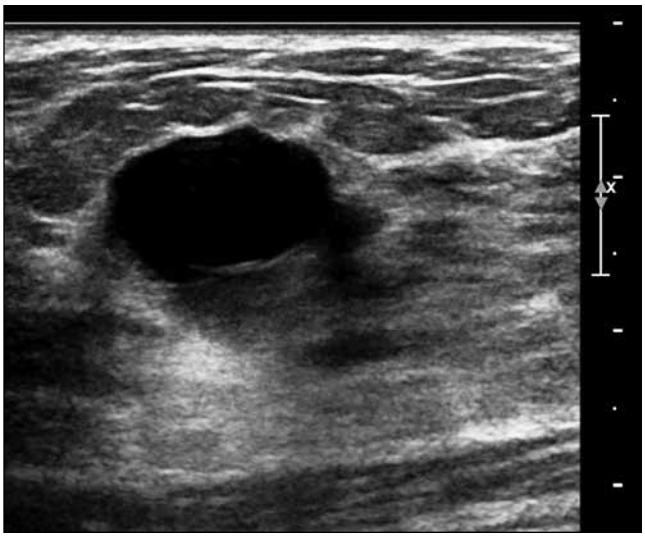


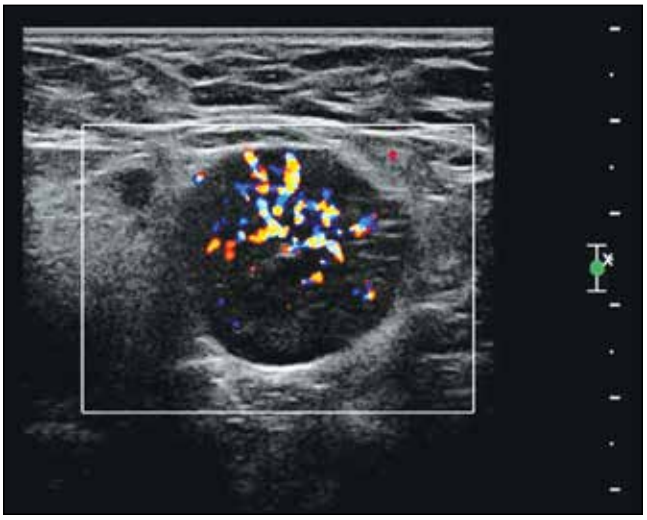
Figure 132 — LYMPH NODES — AXILLARY. Exuberant blood supply to a benign, reactive AXILLARY LYMPH NODE is shown on this power Doppler image. Blood vessels are depicted entering the nodal hilus and arborizing into the cortex.



A



B



C

Figure 133 — LYMPH NODES — AXILLARY. Orthogonal US views of an AXILLARY LYMPH NODE *(a* and *b)* with very thick cortex and compression of hilar fat, due to metastasis from ipsilateral invasive ductal carcinoma, grade 3, in a 42-year-old woman. Cortical vascularity is shown on color Doppler image *(c)*.

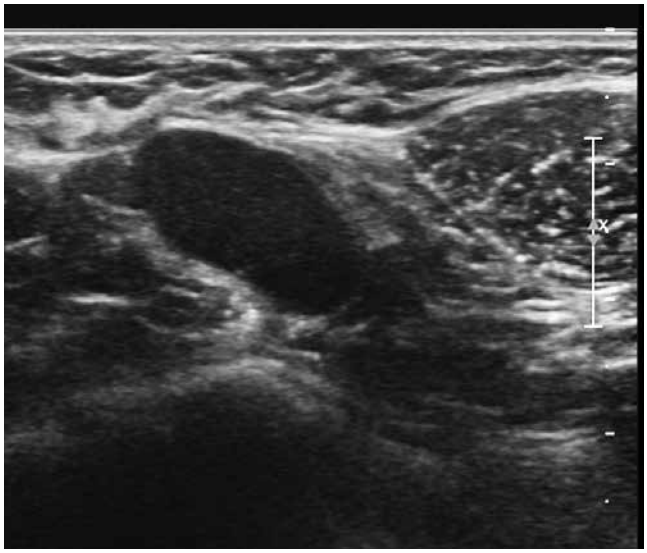
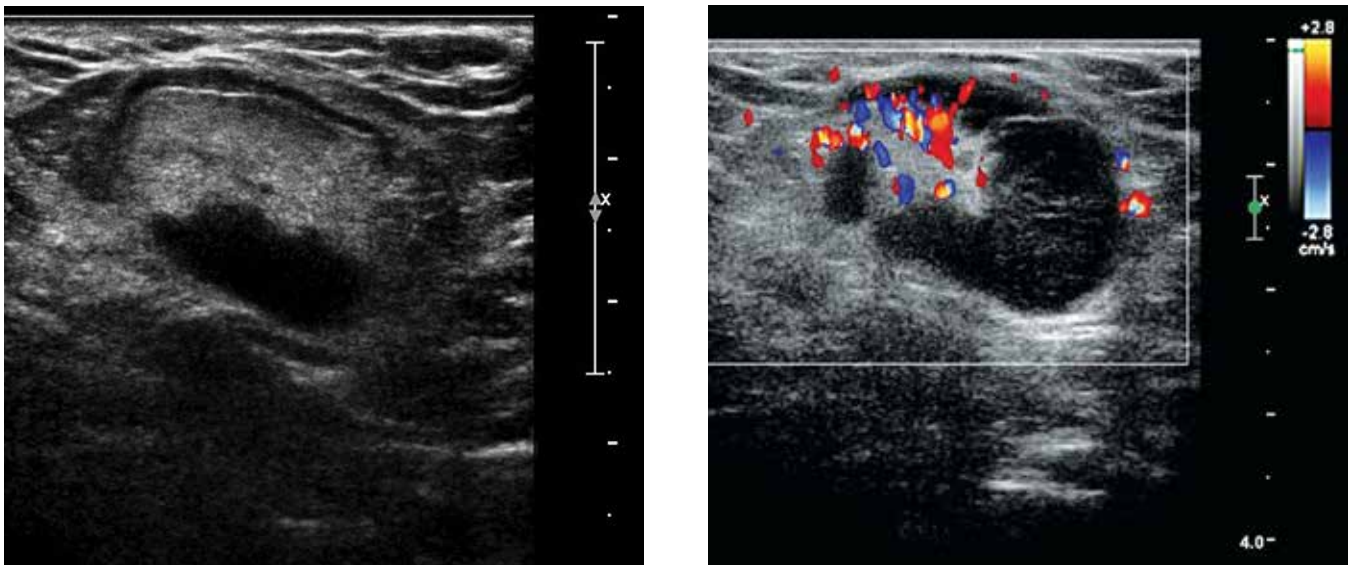
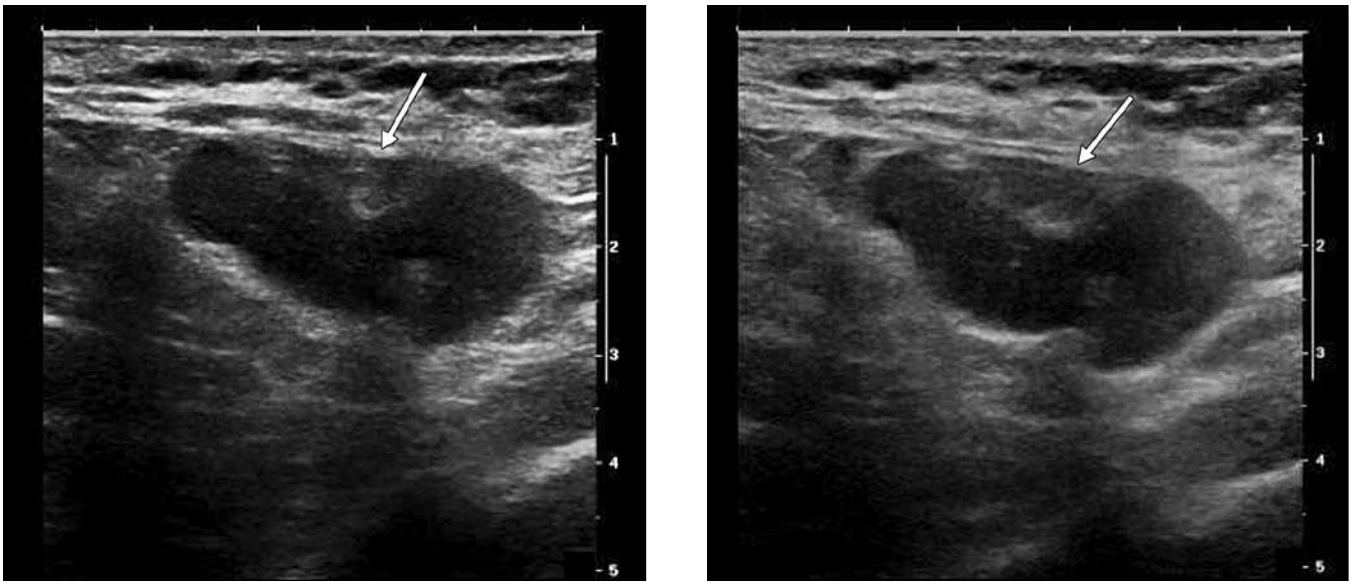


Figure 134 — LYMPH NODES — AXILLARY. AXILLARY LYMPH NODE completely replaced by metastasis from invasive ductal carcinoma. No hilar fat remains. The reniform shape and normal size of the node are retained.



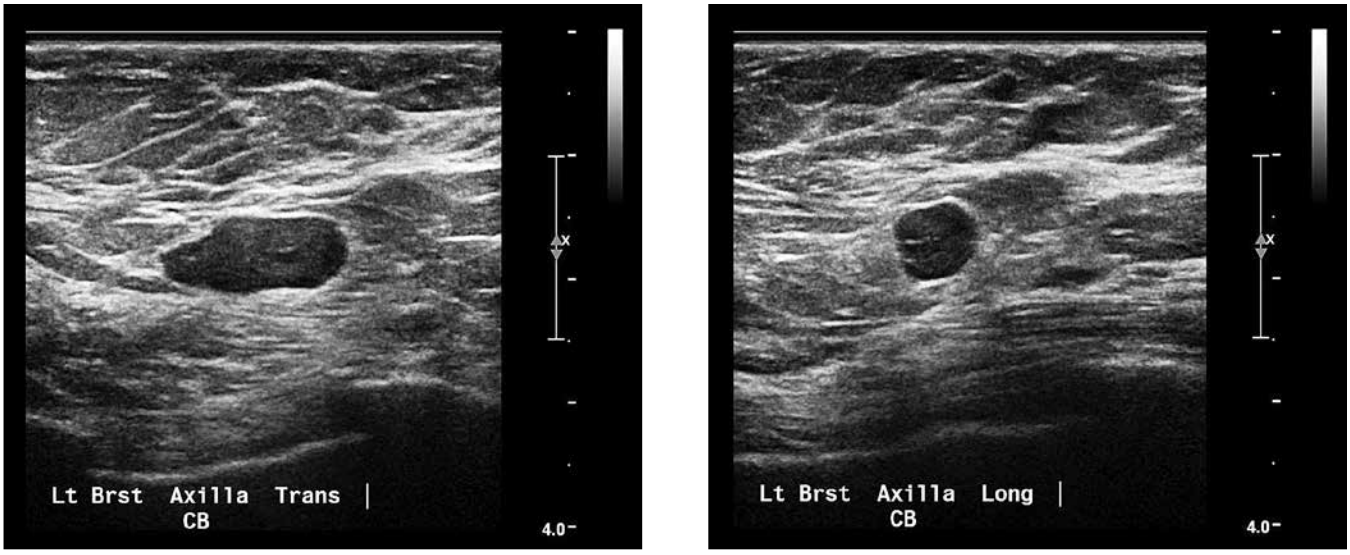
A **B**

Figure 135 — LYMPH NODES — AXILLARY. Metastatic involvement of this LYMPH NODE *(a)* B-mode; *(b)* color Doppler, showing eccentric focal cortical thickening with a large area of hilar fat compressed by the cortical metastasis. The focal metastasis shows decreased echogenicity, and vascularity is absent *(b)*.



A B

Figure 136 — LYMPH NODES — AXILLARY. Two US views *(a* and *b)* of this AXILLARY LYMPH NODE metastasis in a woman with invasive ductal carcinoma show thickened cortex at the periphery of the node, except anteriorly where a remnant of hilar fat is visible *(arrows)*.



A B

Figure 137 — LYMPH NODES — AXILLARY. A 43-year-old woman with newly diagnosed invasive ductal carcinoma, grade 2, and ductal carcinoma in situ, grade 3. Core biopsy of this AXILLARY LYMPH NODE confirmed metastatic involvement. Note the absence of hilar fat and nonreniform shape. This lymph node could be mistaken for a benign-appearing mass, such as a fibroadenoma, in the axillary tail.

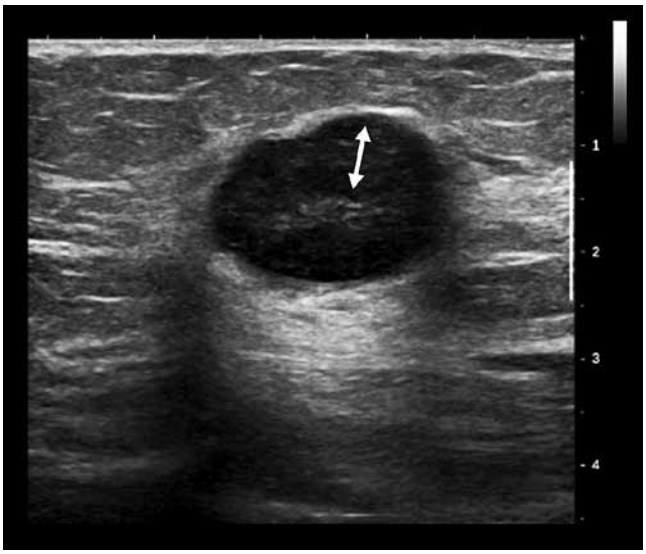


Figure 138 — LYMPH NODES — AXILLARY. Hilar fat is compressed by metastatic involvement of the markedly thickened cortex *(double arrow)*. Core biopsy histopathology of AXILLARY LYMPH NODE: totally replaced by invasive ductal carcinoma, grade 3.

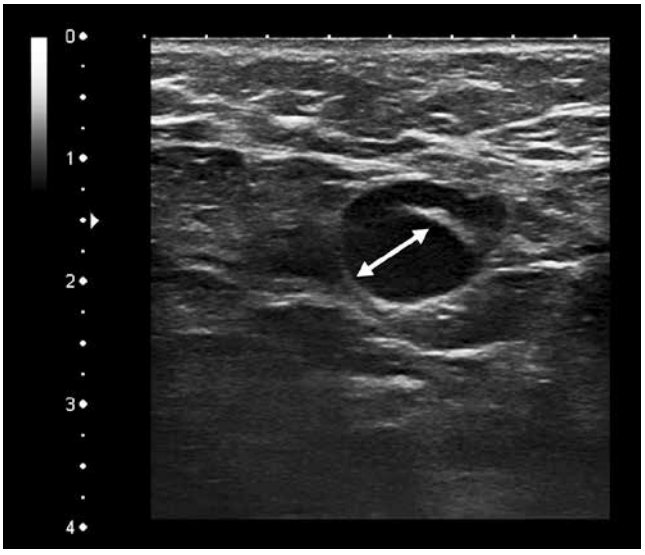
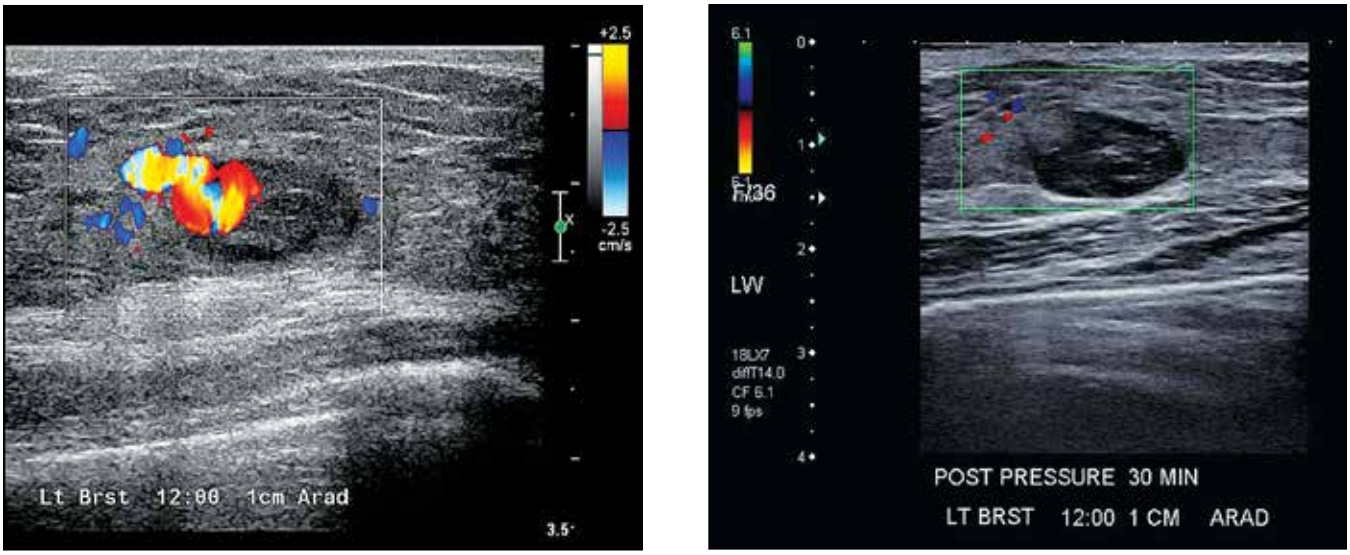


Figure 139 — LYMPH NODES — AXILLARY. There is marked cortical thickening of the posterior aspect of this AXILLARY LYMPH NODE *(double arrow)*, with compression of the more anterior hilar fat into a thin crescent. Histopathology: metastasis from invasive ductal carcinoma, grade 3.

E. SPECIAL CASES

8. VASCULAR ABNORMALITIES

a. AVMs (Arteriovenous Malformations/Pseudoaneurysms)



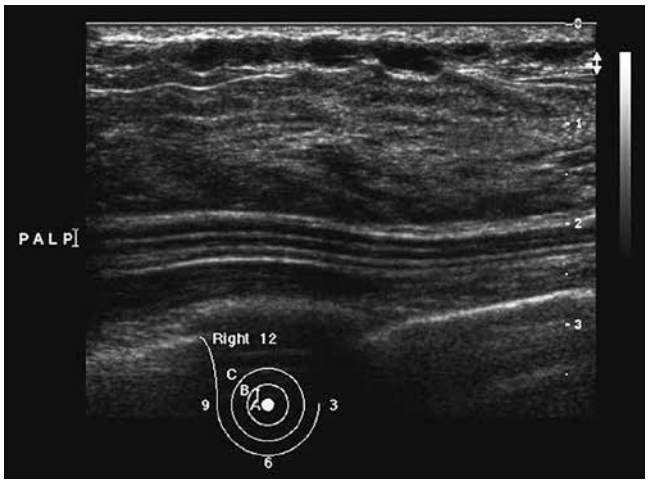
A **B**

Figure 140 — VASCULAR ABNORMALITIES: AVMs (ARTERIORVENOUS MALFORMATIONS/ PSEUDOANEURYSMS). A rare complication, this pseudoaneurysm developed after a stereotactically-guided vacuum-assisted biopsy of microcalcifications *(a)*. After 30 minutes of direct compression over the site, thrombosis was successful *(b)*. The patient had no further problems.

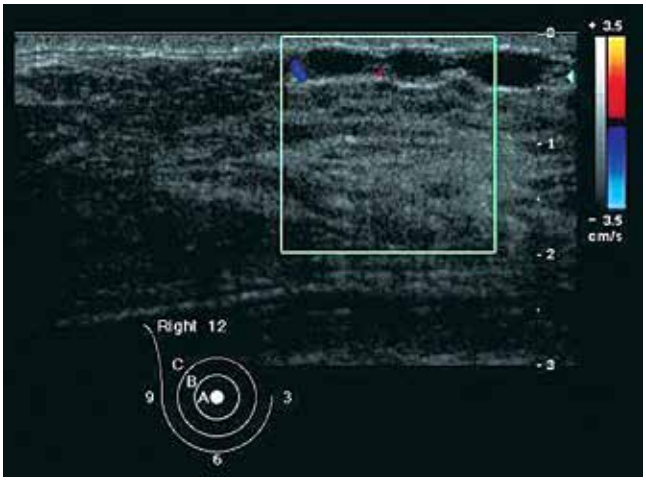
E. SPECIAL CASES

8. VASCULAR ABNORMALITIES

b. Mondor Disease



A



B

Figure 141 — VASCULAR ABNORMALITIES: MONDOR DISEASE. This 23-year-old woman developed a painful cord in the right axillary tail. The cause was a thrombosed superficial lateral thoracic vein, seen in long axis just beneath the skin *(a)*. Color Doppler image *(b)* showing essentially no vascular flow within the vein confirms the diagnosis. MONDOR DISEASE is self-limited and does not require anticoagulation.

E. SPECIAL CASES

9. POSTSURGICAL FLUID COLLECTION

(For implants, see Special Cases, item 5: Foreign Body, see page 105). The only postsurgical sonographic findings that are characteristically benign involve fluid collections, especially postoperative seroma (entirely cystic, however, at times, also containing retained blood products that are mobile on real-time evaluation). Most other postsurgical findings, especially those involving scar tissue, usually display suspicious sonographic findings, such as posterior shadowing, hypoechogenicity, an irregular and occasionally spiculated lateral margin, and architectural distortion. To avoid unnecessary biopsy, interpretation of breast imaging studies of the treated breast should be made with reference to clinical history of previous surgery, with a skin scar apparent by visual inspection at the location of the sonographic findings or a linear scar marker placed on the skin at the site of incision with a mammographic view tangential to the scar marker that correlated with US findings. The histopathology of the tumor, marginal status at the time of excision, and history of radiation therapy and chemotherapy should also be taken into account when imaging findings are interpreted. Comparison with previous studies is crucial for accuracy in follow-up.

Postsurgical scars commonly evolve over time, usually contracting as they develop marginal irregularity and spiculation; these interval changes are observed much more commonly at mammography than at US because postsurgical mammography is performed much more frequently than US. The common postsurgical changes of edema and skin thickening, which tend to decrease in extent and severity over time, are depicted equally well at mammography and US, and in this context are considered to be benign. The remaining postsurgical changes that are visible at US are more accurately assessed at mammography. This includes almost all cases of fat necrosis, because the oil cyst is characteristically benign at mammography (but not at US), whether solitary or multiple, whether calcified or noncalcified. Hence, when fat necrosis is suspected at US, and when other more suspicious sonographic features are displayed that potentially represent fat necrosis, the next step before rendering a final assessment should be correlation with a concurrent mammography examination that likely will justify a benign (category 2) assessment that cannot be made at US.

E. SPECIAL CASES

9. POSTSURGICAL FLUID COLLECTION

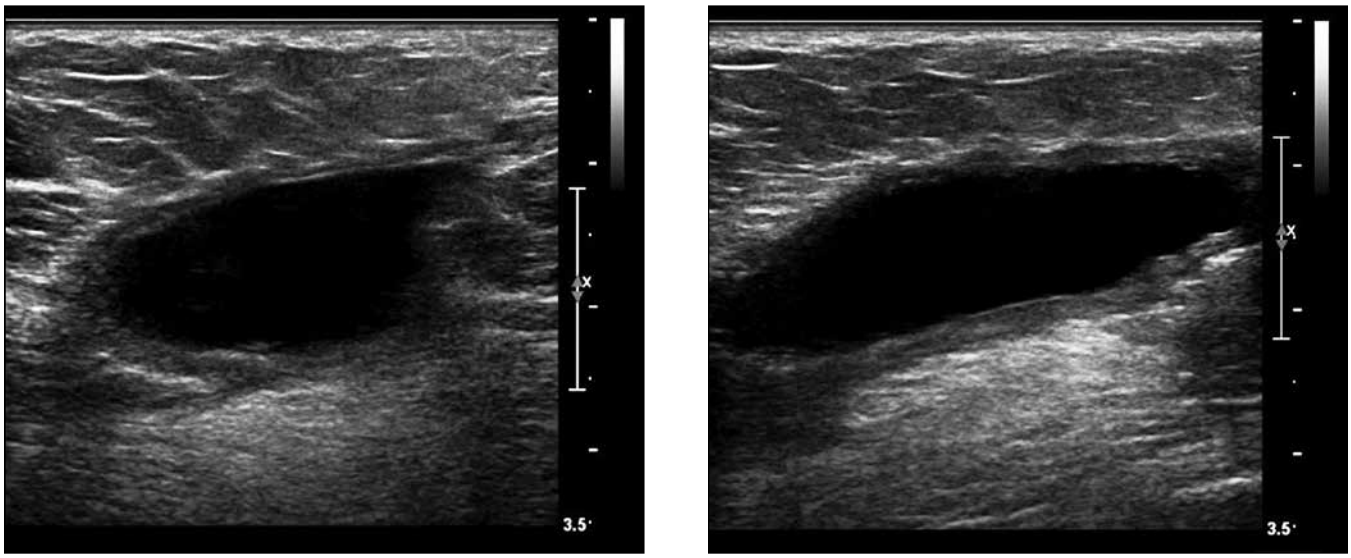
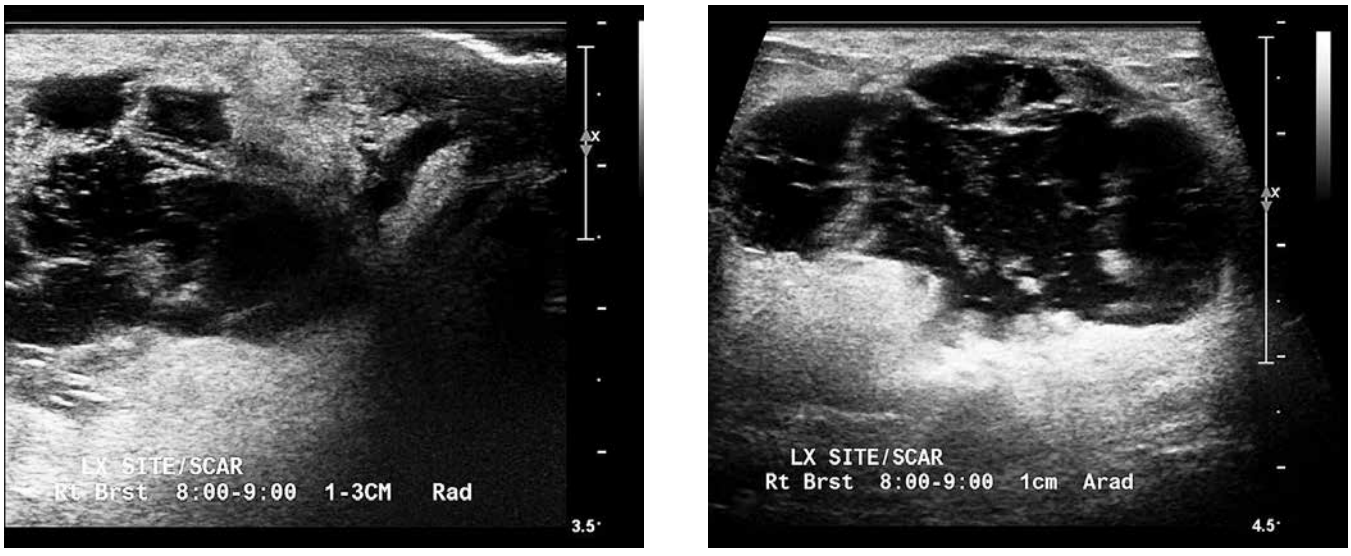


Figure 142 — POSTSURGICAL FLUID COLLECTION. Six months after lumpectomy and radiation therapy for invasive and intraductal carcinoma, grade 2, baseline post-treatment imaging of a 79-year-old woman shows elliptical FLUID COLLECTION on orthogonal US views. The thickened wall of the seroma on the US images is of no significance.

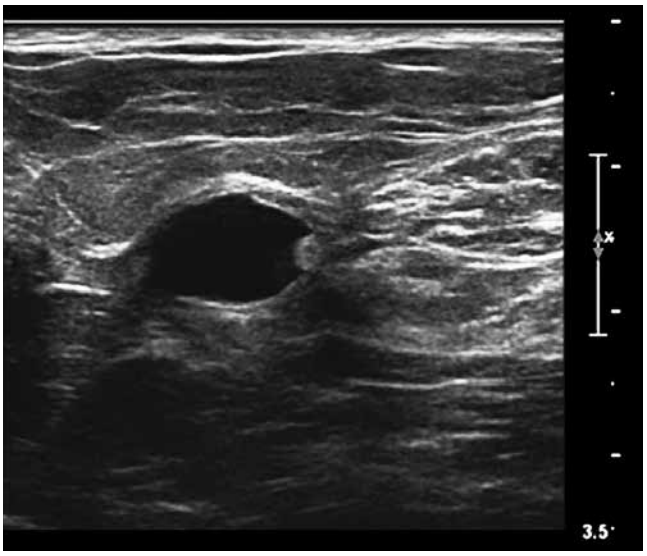


A **B**

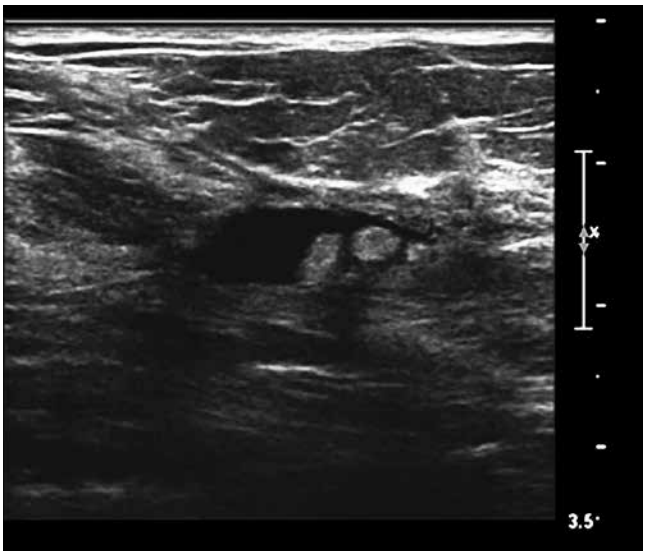
Figure 143 — POSTSURGICAL FLUID COLLECTION. Postoperative FLUID COLLECTION in a 66-year-old woman who had surgical excision of an invasive ductal carcinoma, grade 3, with 10 mm margins. Ductal carcinoma in situ, however, was present within 1 mm of the anterior, posterior, and lateral margins. Four weeks after surgery, rectangular and trapezoidal images (*a* and *b* respectively) show a large postoperative fluid collection, the septa and areas of hyperechogenicity reflecting maturing blood products in a serosanguinous collection, for which no intervention was necessary. Assessment is benign (category 2), based on clinical information that this collection developed following surgical excision.

E. SPECIAL CASES

10. FAT NECROSIS

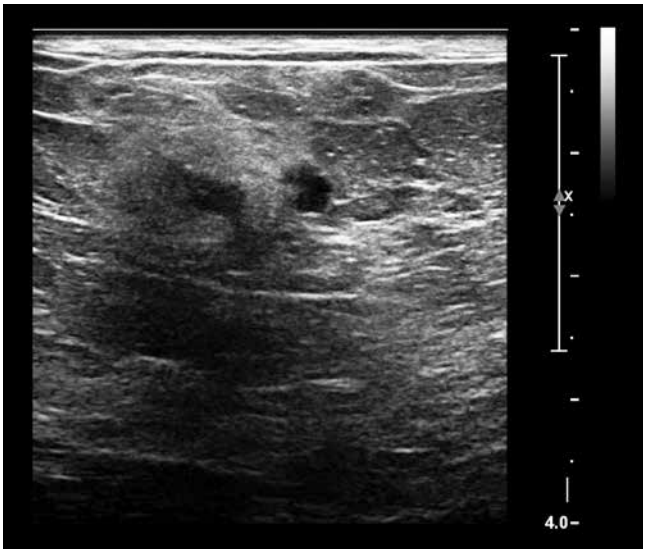


A



B

Figure 144 — FAT NECROSIS. Early FAT NECROSIS in postoperative fluid collection is manifested by an oil cyst and architectural distortion *(a* and *b)* with three echogenic lipid nodules seen within the cyst *(b)*.



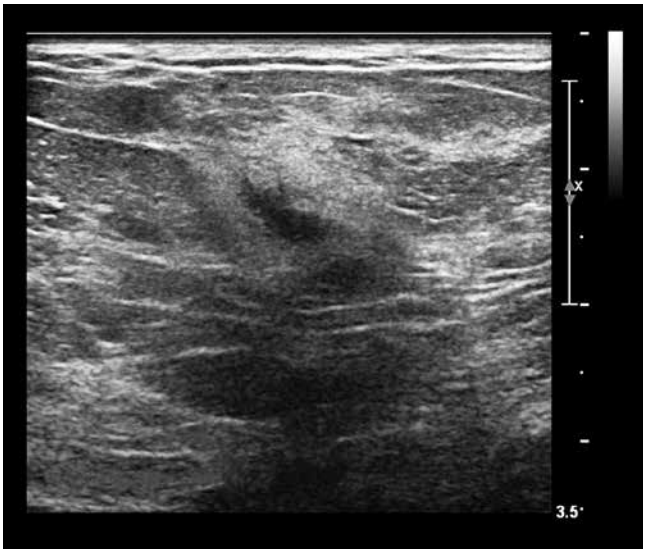
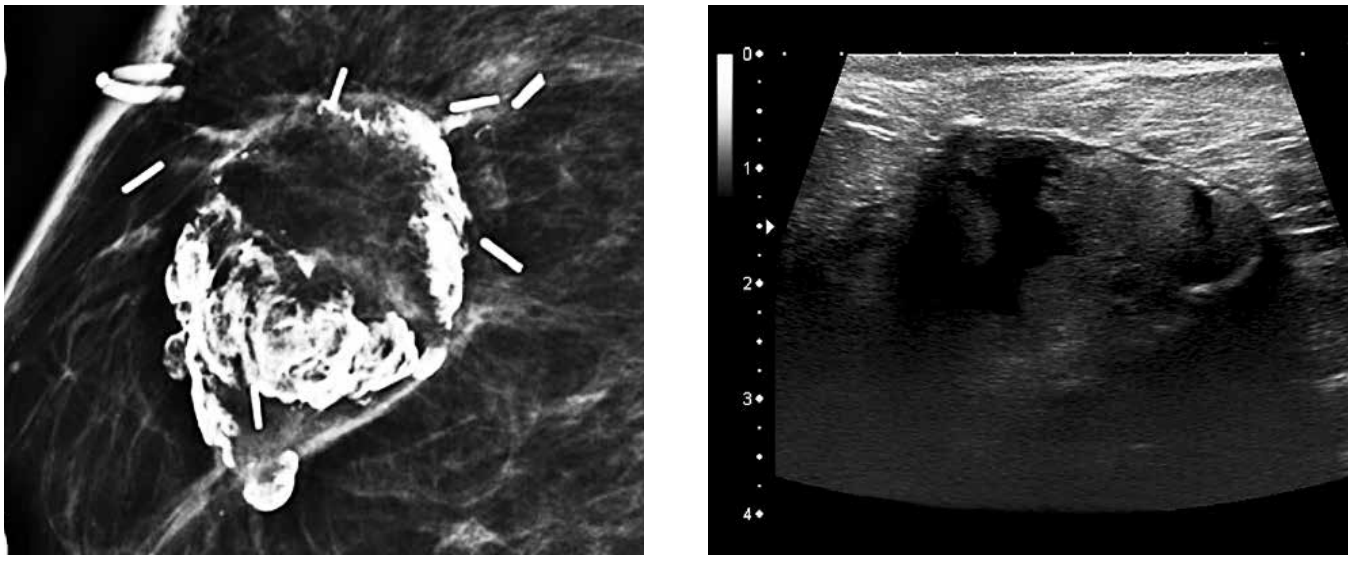


Figure 145 — FAT NECROSIS. FAT NECROSIS developing in an area of a breast hematoma is observed in this 62-year-old woman whose breast remained ecchymotic 1 month after an automobile accident with airbag injury to her right breast. BI-RADS® assessment was 3, probably benign, and when she returned 6 months later, physical, mammographic, and US findings had resolved (not shown).



A **B**

Figure 146 — FAT NECROSIS. Five years earlier, this 77-year-old patient had undergone lumpectomy for invasive carcinoma, grade 1, with placement of a balloon catheter for partial breast irradiation. Follow-up imaging showed no sign of recurrence on tangential mammographic spot-compression view. The rim calcification surrounding the oil cyst of FAT NECROSIS at mammography (characteristically benign) *(a)* caused posterior shadowing at US *(b)*, as well as the V-shaped incision at the skin.

III. REPORTING SYSTEM

A. REPORT ORGANIZATION

The report should be concise and organized using a structure such as that provided in Table 2 (below). Assessments and management recommendations are discussed in item B of this chapter on the reporting system, as well as in the Guidance chapter and in answer to some specific questions among the Frequently Asked Questions.

The indication for examination, relevant clinical history, and pertinent risk factor information should be clearly stated. If the study is performed for follow-up of a specific mass or area of concern, this should be described. The dates of any comparison examinations should be specified. As detailed in the General Considerations section on Labeling and Measurement (see page 30), when a specific sonographic finding is documented by recording a complete set of images, the longest horizontal dimension should be reported first, followed by the vertical measurement, and the orthogonal horizontal dimension last. Multiple simple cysts or a combination of multiple simple and complicated cysts need not be reported individually. If any lesions have been biopsied previously, this should be noted together with the prior biopsy results, if known. Correlation of any clinical, mammographic, and MRI findings with the sonographic findings should be specifically stated in the report. For diagnostic evaluations involving US characterization of mammographic abnormalities or confirmation of a mass suspected but not delineated mammographically, a single report integrating the two modalities will clearly communicate a final assessment based on the highest likelihood of malignancy and appropriate management recommendations.

Table 2. Report Organization

Report Structure
1. Indication for examination
2. Statement of scope and technique of breast US examination
3. Succinct description of the overall breast composition (screening only)
4. Clear description of any important findings
5. Comparison to previous examination(s), including correlation with physical, mammography, or MRI findings
6. Composite reports
7. Assessment
8. Management

Consistent use of BI-RADS® descriptors for US, as for mammography and MRI, helps in lesion assessment and clarifies communication with physicians and patients. Also, structured, software-based reporting should be based on BI-RADS® terminology.

For coding and reimbursement, consider the advisability of splitting the report combining the findings of two or more concurrently performed imaging modalities or procedures into specific sections or paragraphs, one for each type of examination. However, a single assessment and recommendation for patient management should reflect integration of the findings from all of the imaging studies. Note that an assessment based on specific findings needing most urgent attention will have the greatest clinical utility.

1. INDICATION FOR EXAMINATION

   The reason for performing the examination should be stated briefly at the beginning of the report. The most common indications for breast US are confirmation and charac-

terization of a palpable mass or mammographic or MRI abnormality, guidance of interventional procedures, and as the initial imaging technique for young, pregnant, or lactating patients. Additional applications are listed in the ACR Practice Guideline for the Performance of the Breast Ultrasound Examination and include the extent of disease evaluation supplementing mammography in high-risk women who are not candidates for breast MRI or who have no easy access to MRI, and in breast imaging practices that provide the service, supplementary whole-breast screening in order to increase cancer detection in asymptomatic women with mammographically dense breasts.

2. STATEMENT OF SCOPE AND TECHNIQUE OF BREAST US EXAMINATION

   The scope of examination and technique used should be stated, for example, whether the examination was directed or targeted to a specific location, or whether it was performed for supplementary screening. It is important, since US is a real-time examination, to indicate who performed the examination (sonographer, sonographer and physician, physician alone) or whether an automated whole-breast scanning system was used. If a lesion was evaluated with color or power Doppler or with strain or shear-wave elastography, observations relevant to the interpretation should be reported.

   In certain situations, it may be beneficial to describe the position of the patient during the examination (e.g., "The breasts were imaged in both supine and lateral decubitus position." or "The patient was imaged in seated position, the position in which she feels the left breast thickening best.").

   Automated whole breast scanners that acquire in 3-D are available for clinical use and can be formatted in three planes. These scanners depict the entire breast in coronal, transverse, and sagittal planes, with the coronal view similar to the coronal MRI view. Reporting of these studies continue to evolve, but where possible the interpretation structure outlined in Table 2 (see page 123) and the reporting procedures described earlier in this section should be followed.

3. SUCCINCT DESCRIPTION OF THE OVERALL BREAST COMPOSITION (screening only)

   Tissue composition patterns can be estimated more easily in the large FOVs of automated US scans but can also be discerned in the small FOV of a handheld US scan. The three US descriptors for tissue composition described earlier in the US lexicon, "homogeneous background echotexture-fat," "homogeneous background echotexture-fibroglandular," and "heterogeneous background echotexture" (Table 3) (below) correspond loosely to the four density descriptors of mammography and the four fibroglandular tissue descriptors of MRI. At US, breast tissue composition is determined by echogenicity. Subcutaneous fat, the tissue relative to which echogenicity is compared, is medium gray and darker than fibroglandular tissue, which is light gray. Heterogeneous breasts show an admixture of hypoechoic and more echogenic areas. Careful real-time scanning will help differentiate a small hypoechoic area of normal tissue from a mass.

Table 3. Breast Tissue

Tissue Composition
a. Homogeneous background echotexture-fat
b. Homogeneous background echotexture-fibroglandular
c. Heterogeneous background echotexture

4. CLEAR DESCRIPTION OF ANY IMPORTANT FINDINGS

   The description of important findings should be made, in order of clinical relevance, using lexicon terminology, and should include:

   a. Characterization of a mass using the morphological descriptors of shape, margin, and orientation. Note should be made of the lesion's effect on the surrounding tissue, such as architectural distortion. Feature categories, such as posterior features and echogenicity, and techniques, such as color or power Doppler and elastography, may contribute information to the analysis, but only pertinent positives need to be described. Recognition of special case findings, such as simple and complicated cysts, clustered microcysts, intramammary lymph nodes, and foreign bodies, should simplify interpretation. In reporting screening examinations in asymptomatic women, as in mammography, characteristically benign findings may be reported (assessment category 2), but it is not obligatory, and the appropriate assessment would then be negative (assessment category 1).

   b. For important findings, lesion size should be given in at least two dimensions; three dimensions are preferable, especially if the volume of a mass is compared with one or more previous examinations. It is not necessary to report the measurements of every small simple cyst, and if numerous cysts are present, especially in both breasts; location and measurements of the largest cyst in each breast will suffice.

      If a mass is measured, images should be recorded with and without calipers. Marginal characteristics are one of the most important criteria to be applied in assessing the likelihood of malignancy of a mass, and, particularly with small masses, caliper markings may obscure the margin, hindering analysis.

   c. Location of the lesion(s) should be indicated using a consistent and reproducible system, such as clock-face location and distance from the nipple. When more than one mass or abnormality is located in the same scan frame or in the same locale, measurement of the distance from the skin to the center of the mass or its anterior aspect may help to differentiate one lesion from another. This measurement may be particularly useful when one mass is singled out for biopsy and others are depicted in the field.

      There may be variability within breast imaging practices, and members of a group practice should agree upon a consistent policy for documenting lesion location on subsequent examinations. In some practices, for all examinations that follow the initial US study, the lesion location annotation will be repeated without change. Other breast imagers may report a different location to signify the same lesion but indicate in their reports that the lesion is now seen at another clock-face position and distance from the nipple (these differences are often related to positioning and technique). A more complete discussion of this common scenario is provided in the Frequently Asked Questions, see page 142).

   d. As at mammography, multiple bilateral circumscribed masses usually are assessed as benign (category 2) unless one mass has different imaging features than all the others. In the unusual circumstance in which the interpreting physician chooses to describe multiple benign-appearing masses individually within the US report, the masses should

be listed by breast, by location within in the breast, and by size. The reader of the report will be less confused, and, if surveillance is suggested as management, the performer of the subsequent examination will appreciate a list rather than verbose text. For bilateral findings, describe all the findings in each breast in a separate paragraph.

5. COMPARISON TO PREVIOUS EXAMINATION(S), INCLUDING CORRELATION WITH PHYSICAL, MAMMOGRAPHY, OR MRI FINDINGS

   Breast US should be correlated with physical findings, mammography, MRI, or other imaging studies, if performed. If no statement of comparison is included in the US report, it will be assumed that no comparison was made. Note that some report templates include a "comparison" heading, in which the word "none" (if appropriate) may be entered.

   When correlating US findings with those seen at mammography and/or MRI, the operator performing handheld scanning should correlate the size and location of lesions and match the type and arrangement of tissues surrounding the lesion in order to reduce the likelihood of misregistration (identifying a different lesion or lesions at different imaging modalities). In doing this, allowance for positional changes should be made going from upright with mammography and prone with MRI to supine or supine-oblique with US. If it is determined that a sonographic finding corresponds to a palpable abnormality, or to a mammographic or MRI finding, this should be stated explicitly in the US report. If the US finding is new or has no correlate, this should also be stated in the report.

   If the US examination was performed as part of a surveillance protocol to assess a previously identified finding, or if the finding was reported on a previous examination, the current report should describe any changes. An increase of 20% or more in the longest dimension of a probably benign solid mass within 6 months may prompt biopsy.[1] An increase of only 1–2 mm in lesion size may be related to differences in scanning technique or patient positioning.

6. COMPOSITE REPORTS

   When more than one type of examination is performed concurrently (on the same day), it is preferable that the examinations be reported together. The findings for each examination should be described in separate paragraphs with an overall assessment and management recommendations for the combined examinations. In general, when the assessments for two examinations differ, the overall assessment (and concordant management recommendations) should reflect the more abnormal of the individual assessments (whatever management is expected to come first, supplemented by likelihood of maligancy), according to the following hierarchy of increasing abnormality: category 1, 2, 3, 6, 0, 4, 5 (Table 4, see page 127).

   Exceptions to this rule occur when the characteristically benign features of a given imaging finding on one examination supersede the less specifically benign features of the same finding on the other examination. An example is that of a partially circumscribed, noncalcified mass at mammography, superseded by simple cyst at US.

Table 4. Abnormality Hierarchy

BI-RADS Assessment Category	Degree of Abnormality
1	Lowest
2	
3	
6	
0	
4	
5	Highest

7. ASSESSMENT

   The report should conclude with a concise summary of pertinent US findings with a final assessment using BI-RADS® US categories 1–6 and the phrases associated with them. If report of a US examination is integrated with that of a concurrently performed mammography examination, the combined final assessment should reflect the highest likelihood of malignancy assessed at the two examinations. Clear and consistent communication is a goal that can be achieved for breast US by using the same assessment categories and similar wording described in the BI-RADS® Mammography section.

   In some cases, the interpreting physician may render an incomplete assessment (category 0) in order to request additional examination(s), such as mammography, comparison with previous but currently unavailable examinations, or additional physican-performed real-time scanning after either a sonographer-produced, real-time or automated whole-breast screening US examination.

8. MANAGEMENT

   Management recommendations should be included in every report. Clear recommendations should be made as to the next course of action. Recommendations may include routine age-appropriate screening, surveillance imaging for a probably benign mass, annual follow-up after percutaneous or surgical biopsy, and clinical management. If an imaging-guided interventional procedure is recommended, the type of imaging for the procedure might also be suggested, for example, stereotactic, US, or MRI guidance.

B. ASSESSMENT CATEGORIES

Table 5. Concordance Between BI-RADS® Assessment Categories and Management Recommendations.

Assessment	Management	Likelihood of Cancer
Category 0: Incomplete — Need Additional Imaging Evaluation	Recall for additional imaging	N/A
Category 1: Negative	Routine screening	Essentially 0% likelihood of malignancy
Category 2: Benign	Routine screening	Essentially 0% likelihood of malignancy
Category 3: Probably Benign	Short-interval (6-month) follow-up or continued surveillance	> 0% but ≤ 2% likelihood of malignancy
Category 4: Suspicious	Tissue diagnosis	> 2% but < 95% likelihood of malignancy
Category 4A: *Low suspicion* for malignancy		> 2% to ≤ 10% likelihood of malignancy
Category 4B: *Moderate suspicion* for malignancy		> 10% to ≤ 50% likelihood of malignancy
Category 4C: *High suspicion* for malignancy		> 50% to < 95% likelihood of malignancy
Category 5: Highly Suggestive of Malignancy	Tissue diagnosis	≥ 95% likelihood of malignancy
Category 6: Known Biopsy-Proven Malignancy	Surgical excision when clinically appropriate	N/A

a. Assessment Is Incomplete

Category 0: Incomplete — Need Additional Imaging Evaluation and/or Prior Images for Comparison

There is a finding for which additional imaging evaluation is needed. This is almost always used in a screening situation. In this context, additional imaging evaluation includes the recording of (nonstandard) US images to supplement the standard images recorded for a screening examination. Note that this does not include repeat real-time scanning by the interpreting physician and/or colleague as long as additional images are not recorded. This respects the unique real-time nature of US and does not penalize its use. (For further information please refer to the Follow-Up and Outcome Monitoring section, see FOM on page 128.)

Under certain circumstances, assessment category 0 may be used in a diagnostic US report, such as when equipment or personnel are not immediately available to perform a needed concurrent diagnostic mammography examination, or when the patient is unable or unwilling to wait for completion of a full diagnostic examination. Category 0 should ***not*** be used for diagnostic breast imaging findings that warrant further evaluation with MRI. Rather, the interpreting physician should issue a final assessment in a report that is made before the MRI examination is performed.

In most circumstances and when feasible, if a screening US examination is not assessed as negative or benign, the current examination should be compared to prior examination(s), if any exist. The interpreting physician should use judgment on how vigorously to attempt obtaining prior examinations, given the likelihood of success of such an endeavor and the likelihood that comparison

will affect the final assessment. In this context, it is important to note that comparison to previous examination(s) may be irrelevant when a finding is inherently suspicious for malignancy.

Category 0 should be used for prior image comparison only when such comparison is ***required*** to make a final assessment. When category 0 is used in the context of awaiting prior examinations for comparison, there should be in place a tracking system guaranteeing with 100% reliability that a final assessment will be made within 30 days (preferably sooner), even if prior examinations do not become available. Some breast imaging practices may reasonably choose never to use category 0 in the context of awaiting prior examinations simply because they do not have a 100% reliable tracking system. If an US examination is assessed as category 0 in the context of awaiting prior examinations and then the prior examinations do become available, an addendum to the initial US report should be issued, including a revised assessment. For auditing purposes, the revised assessment should replace the initial assessment.

A need for previous studies to determine appropriate management might also temporarily defer a final assessment.

b. Assessment Is Complete — Final Categories

Category 1: Negative

There is nothing to comment on. This is a normal examination.

Category 2: Benign

As with category 1, this is a "normal" assessment, but here the interpreter chooses to describe a benign finding in the US report. For example, the interpreter may choose to describe one or more simple cysts, intramammary lymph nodes, postsurgical fluid collections, breast implants, or complicated cysts/probable fibroadenomas that are unchanged for at least 2 or 3 years, while still concluding that there is no sonographic evidence of malignancy. On the other hand, the interpreter may choose not to describe such findings, in which case the examination should be assessed as negative (category 1).

Note that both category 1 and category 2 assessments indicate that there is no sonographic evidence of malignancy. Both should be followed by the management recommendation for routine age-appropriate screening. The difference is that category 2 should be used when describing one or more specific benign sonographic findings in the report, whereas category 1 should be used when no such findings are described (even if such findings are present).

Category 3: Probably Benign (Guidance chapter, see page 139.)

Assessment category 3, probably benign, is ***not*** an indeterminate category for use simply when the radiologist is unsure whether to render a benign (BI-RADS® category 2) or suspicious (BI-RADS® category 4) assessment, but one that is reserved for specific imaging findings known to have > 0% but ≤ 2% likelihood of malignancy. ***For US, there is robust evidence that a solid mass with a circumscribed margin, oval shape, and parallel orientation (most commonly fibroadenoma), and an isolated complicated cyst have a likelihood of malignancy in the defined (≤ 2%) probably benign range, for which short-interval (6-month) follow-up sonography and then periodic sonographic surveillance may represent appropriate management.[2–4] Similar data have been reported for clustered microcysts, but these data are less strong because they involve many fewer cases***.[2] The use of assessment category 3 for sonographic findings other than these three should be considered only if the radiologist has personal experience to justify a watchful-waiting approach, preferably involving observation of a sufficient number of cases of an additional sonographic finding to suggest a likelihood of malignancy within the defined (≤ 2%) probably benign range.

This edition of the BI-RADS® Atlas also emphasizes the recommendation that a category 3 assessment should not be made at screening; rather, this should be done only after completion of a full diagnostic breast imaging examination. This recommendation is appropriate for screening mammography, for which batch interpretation usually is utilized, because in this setting there is no opportunity to complete the diagnostic workup before interpreting the screening examination. However, screening US almost always is interpreted online, so a full diagnostic examination also is completed while the patient remains in the breast imaging facility, and a single breast imaging report may be issued that combines the findings of both screening and diagnostic components of the examination. Hence, there is no purpose in recommending against category 3 assessment at screening US because the diagnostic workup would be completed simultaneously. This issue is discussed in more detail in Frequently Asked Question #2 for US in the Follow-up and Outcome Monitoring section, see FOM on page 62). Note that for auditing purposes, the screening component of a category 3-assessed screening US examination will be audit-positive, not only because additional nonstandard (diagnostic) images will be recorded but also because a category 3 assessment at screening is defined as being audit-positive.

For category 3 assessments, the initial short-term follow-up interval is usually 6 months, involving the breast(s) containing the probably benign finding(s). Assuming stability at this 6-month examination, a category 3 assessment again is rendered with a management recommendation for a second short-interval follow-up examination in 6 months. Again assuming stability at this second short-interval follow-up, the examination is once more assessed as category 3, but now the recommended follow-up interval usually is lengthened to 1 year due the already-observed 12-month stability. Note that although the 1-year follow-up coincides with the routine screening interval in the United States, a category 3 assessment is rendered, to indicate that the period of imaging surveillance is still underway. As with surveillance using mammography, after 2–3 years of stability, the final assessment category should be changed to benign (BI-RADS® category 2). A benign evaluation may also be rendered before completion of category 3 analysis if, in the opinion of the interpreter , the finding has no chance of malignancy and is thus a category 2.

Category 4: Suspicious

This category is reserved for findings that do not have the classic appearance of malignancy but are sufficiently suspicious to justify a recommendation for biopsy. The ceiling for category 3 assessment is a 2% likelihood of malignancy, and the floor for category 5 assessment is 95%, so category 4 assessments cover the wide range of likelihood of malignancy in between. Thus, almost all recommendations for breast interventional procedures will come from assessments made using this category. By subdividing category 4 into 4A, 4B, and 4C, as recommended in and using the cut points indicated in the Guidance chapter, it is hoped that patients and referring clinicians will more readily make informed decisions on the ultimate course of action. An example of separating the BI-RADS® assessment category from the management recommendation (new to fifth edition — see Follow-up and Outcome Monitoring section) occurs when a simple cyst, correctly assessed as BI-RADS® 2, undergoes cyst aspiration for pain control.

Category 5: Highly Suggestive of Malignancy

These assessments carry a very high probability (≥ 95%) of malignancy. This category initially was established to involve lesions for which 1-stage surgical treatment could be considered without preliminary biopsy in an era when preoperative wire localization was the primary breast interventional procedure. Nowadays, given the widespread acceptance of imaging-guided percutaneous biopsy, 1-stage surgery rarely if ever is performed. Rather, current oncologic management almost

always involves tissue diagnosis of malignancy via percutaneous tissue sampling to facilitate treatment options, such as when sentinel node imaging is included in surgical management or when neoadjuvant chemotherapy is administered prior to surgery. Therefore, the current rationale for using a category 5 assessment is to identify lesions for which any nonmalignant percutaneous tissue diagnosis is considered discordant, resulting in the recommendation for repeat (usually vacuum-assisted or surgical) biopsy. Also note that whereas the fourth edition simply indicated that "appropriate action should be taken" as management for category 5 assessments, the fifth edition provides the more directed management recommendation that "biopsy should be performed in the absence of clinical contraindication." This new text unequivocally specifies tissue diagnosis as the interpreting physician's management recommendation for category 5 assessments, appropriately and effectively transferring the burden of establishing a contraindication to this recommendation to the referring clinician.

Category 6: Known Biopsy-Proven Malignancy

This category is reserved for examinations performed after biopsy proof of malignancy (imaging performed after percutaneous biopsy but prior to surgical excision), in which there are no abnormalities other than the known cancer that might need additional evaluation.

C. WORDING THE REPORT

When performed concurrently, breast US examinations are sometimes reported separately from mammography examinations and sometimes reported as part of a combined examination. In both situations, the current examination should be compared to prior examination(s) when appropriate. The indication for examination, such as screening or diagnostic (targeted), should be stated. The report should be organized with a brief description of the composition of the breast (screening only) and any pertinent findings, followed by the assessment and management recommendations. ***Any verbal discussions between the interpreting physician and the referring clinician or patient should be documented in the original report or in an addendum to the report.***

The report should be succinct, using terminology from the latest approved lexicon without embellishment. Definitions of lexicon terms for mammographic findings should not appear in the report narrative. Following the impression section and the (concordant) management recommendation section of the report, both the assessment category number and text for the assessment category should be stated. Other aspects of the report should comply with the ACR Practice Guideline for Communication of Diagnostic Imaging Findings.[5]

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IV. GUIDANCE

Many substantive changes were incorporated into the US section of this edition of the BI-RADS® Atlas to improve its clinical utility and supply a unified base for research involving breast imaging. This chapter expands on these changes as they appear in each part of the US section and provides more complete explanations for the changes. ***What follows is intended for guidance and is not meant to imply required standards of practice.***

It is important to review the beginning text of the Follow-up and Outcome Monitoring section (see FUOM page 5) **and its Frequently Asked Questions** (see FUOM page 57) **to fully understand how auditing definitions will affect the outcomes (performance metrics) for screening examinations as well as the benchmarks that are derived from these outcomes.**

A. BREAST ULTRASOUND LEXICON

Since the 2003 edition of BI-RADS® was published, the practice of breast imaging has evolved further into a more clinically oriented subspecialty of diagnostic radiology. Multimodality imaging and interventions offer options to the breast imager in designing a workup for many different diagnostic scenarios. In addition, limited for decades to mammography and physical examination, screening approaches have broadened, with supplements to mammography utilizing MRI and/or US. Interventional procedures guided by all imaging techniques are in common use, and diagnoses are rarely made through more costly and invasive open surgical procedures. Percutaneous imaging-guided core and vacuum-assisted biopsies provide most of the diagnoses, with relatively few facilities performing fine-needle aspiration cytology and even fewer open surgical procedures. In recognition of these changes, several new sections have been added to this edition of BI-RADS® for US.

Detailed knowledge of normal anatomy is important in interpreting images of all organ systems, and in all imaging modalities, more of the normal breast anatomy is routinely being documented. In the mammography and MRI sections of this edition of the BI-RADS® Atlas, description of the variable balance of fat and fibroglandular tissue in normal breasts has been updated and discussed in detail. The material under the heading Background Echotexture in the 2003 edition of BI-RADS® for US has been expanded and the heading renamed Tissue Composition. Here we include examples of the observed spectrum of breast patterns, with wide differences in the fat-to-fibroglandular balance seen in the normal breast. Unlike mammography, one need not state the breast composition in diagnostic breast US reports. However, especially for US examinations in which the admixture of fat and fibroglandular tissue produces numerous acoustic interfaces and areas of artifactual shadowing, US may be more difficult to interpret. In these cases, at the discretion of the interpreting physician, it may be appropriate to include a statement that the breast composition is heterogeneous, which may lower the sensitivity of sonography. Although there are no data that document changes in the sensitivity of US for breasts of different tissue composition, clinical experience suggests that this may be true. Further study of this issue is encouraged in order to yield reproducible, clinically relevant data. It is strongly recommended that future research utilize the descriptors of breast tissue composition newly established in this edition of the BI-RADS® Atlas.

There are physiological changes that occur throughout life, reflective of hormonal shifts. Young nursing mothers concerned about abscesses may come for evaluation of a red, tender area, and with US being the preferred initial imaging examination, it is important for the breast imager to recognize the parenchymal findings of mastitis as distinct from the appearance of normal fibroglandular tissue stimulated by the hormones supporting lactation. Examples of involutional changes after lactation and menopause and the appearances of gynecomastia also have been added.

Sonographic correlates to mammographic breast density appear under the Tissue Composition heading, obtained with both conventional high-resolution linear transducers as well as wider FOV probes used in automated US systems. The multiplanar reconstructions provided by these automated systems also make comparisons with MRI examinations more intuitive. The larger FOV also facilitates cross-modality recognition of the various types of breast tissue composition, but correlation with mammography and MRI is also possible with commonly used small FOV US (5 cm in its greatest dimension).

In the past, many breast imagers avoided sonographic imaging of the male breast over concerns that one of several normal appearances of gynecomastia has feature characteristics of carcinoma and might result in unnecessary biopsy. However, many men present with tender, palpable areas behind

the nipple. Mammography in most instances is definitive, but the expectation that palpable areas will be evaluated with US both in women and men has led to greater use of US for men. We have included gynecomastia (which resembles the developing breasts of adolescent girls) in Tissue Composition, and the benign and malignant abnormalities found in male breasts are included within the appropriate descriptors of the lexicon.

With careful attention to proper scanning technique and use of widely accepted interpretive criteria, handheld US may be as reproducible and consistent as any other breast imaging technology[1]. New material on image quality includes descriptions of transducer selection and proper positioning. Fields of view, focal zone settings, gray scale gain, and contrast should be appropriately adjusted for each patient. Ergonomics of scanning should be respected, and the appropriate table height, insonation angles, and comfortable grasp of the probe housing should be chosen. Annotation recommendations are provided, and examples are shown of how and how not to measure masses. We include examples of scans whose image quality is poor for various reasons and recommendations for how they could be improved.

Nearly all of the cases selected to exemplify feature categories and their descriptors are shown in orthogonal views to emphasize that real-time scanning completely through a lesion in perpendicular planes ensures that the mass has been seen in its entirety. Focal zone settings should be appropriately placed and clearly indicated on the images, so they are included in the illustrations that we provide. Because it also is important to evaluate the skin (normally 2 mm thick, except in the periareolar area and inframammary fold where it may be thicker), our illustrations include the skin. Gel offsets are used for the most superficial findings to keep skin lesions within the appropriate focal zone.

Techniques are available on most US systems to reduce artifacts. For example, spatial compounding reduces speckle (or noise) and smoothes the image. Spatial compounding has been available on most systems for many years, and most handheld scanning is currently done in a spatial compounding mode.

Tissue harmonic imaging, which enhances contrast, is also available. It sharpens the margin of a mass and is said to "clean out" low-level echoes from cysts. However, care must be taken not to heighten contrast so much that a poorly differentiated invasive cancer is called a cyst. Breast US should display the numerous available shades of gray in order to depict the several individual anatomic components of breast tissue (i.e., skin, fat, connective tissue, fibroglandular tissue, and ducts).

Several refinements have been made to the terminology used for assessment and management. In previous editions of the BI-RADS® Atlas, management recommendations were included in the text used to describe several of the assessment categories. In this edition, we have removed the management recommendations from this text in order to provide more flexibility for several specific clinical scenarios for which a seemingly discordant management recommendation might be appropriate for a given assessment. However, except for these few scenarios, the management recommendation should be fully concordant with the assessment. Assessment-management concordance is a hallmark of appropriate interpretation. Deviating from this concordance invites confusion with the potential for producing incorrect treatment. Although relatively uncommon, many clinical scenarios in which the appropriate management recommendation may appear to be discordant with the proper BI-RADS® assessment category are described in detail in the Mammography section, and the reader is referred there for a complete discussion. The few such scenarios that are specifically pertinent to breast US are discussed among the frequently asked questions (FAQs) provided in this chapter.

Although there is no statutory requirement to use BI-RADS® final assessment phrases in the reports of breast US examinations, as there is for mammography under FDA's Mammography Quality Standards,

Final Rule,[2] using the same terminology as mammography is strongly encouraged. As discussed under the heading Report Organization, if both mammography and breast US are performed concurrently, results of the two modalities should be provided in an integrated report containing a single combined assessment and management recommendation(s), with the most abnormal finding, or the finding that requires the most immediate attention, taking precedence.

For the vast majority of examinations, the BI-RADS® assessment reported for US should prompt the same standard recommendations that apply to mammography (Table 5). (See page 128.) As in mammography, the subdivision of assessment category 4 (suspicious) is optional, although recommended. This is designed to communicate to pathologists and referring physicians the relative level of suspicion of the imaging findings, to facilitate improved patient care.

The Subcommittee on BI-RADS® Ultrasound has also made several changes in the feature analysis parts of the lexicon:

- Although there are several descriptors used when the margin of a mass is not circumscribed, the key distinction is whether the margin is circumscribed or not. In future research studies involving BI-RADS® — US terminology, investigators are encouraged to report results at the circumscribed/not circumscribed level. Additional analyses utilizing the subcategories of not circumscribed margin (indistinct, angular, microlobulated, and spiculated) may also be reported.
- Lesion boundary is no longer a major feature category (shape and margin remain major feature categories). Since the presence of an echogenic transition zone (echogenic rim historically, "echogenic halo") may be seen with malignancies and abscesses, its presence should be noted. Additionally, because the absence of an echogenic transition zone is quite common and now considered to be of no diagnostic significance, the term "abrupt interface" has been dropped.
- Simple and complicated cysts are included among the Special Cases. Because confusion may persist on the distinction between "complicated cysts" and masses with complex echotexture, we have refined the terminology to clarify these entities. Specifically, a complicated cyst represents a cyst with debris, indicating that this is a finding highly likely to be benign. The debris is usually unspecified, possibly proteinaceous or cellular, sometimes containing blood or pus. The echoes visible within a complicated cyst should be homogeneously low-level echoes throughout, with no mural nodules, thick septa, thick walls, or any other suggestion of a solid component. Complex cystic and solid masses include those with a thick wall, thick septations, intracystic or mural mass, and predominantly solid masses with cystic spaces. On real-time evaluation, these echoes may be seen to be mobile if the complicated cysts are large enough. Also, if the contents of complicated cysts are very thick, mobility may not be elicited. Therefore, the only difference between a complicated cyst and a simple cyst should be the presence of internal, mobile echoes. The margin of a cyst, simple or complicated, should be circumscribed, with no echogenic rim present. Complicated cysts may also display fluid-fluid levels (with a straight or sigmoidal separation). What previously was called a "complex mass" should now be described as a "complex cystic and solid mass" (see page 62) to indicate the mass contains a solid component. Such lesions usually are assessed as suspicious (category 4), accompanied by a recommendation for biopsy.[3]
- Two other descriptors, architectural distortion and duct changes, are now listed as Associated Features. This was done because such findings may be associated with a breast mass, or may stand alone as Findings when no other abnormality is present. Cooper ligament changes are a manifestation of architectural distortion; this is now listed as a subset of architectural distortion. We emphasize that architectural distortion is an important feature that influences BI-RADS®

assessments. Many breast masses are found within the zone of fibroglandular tissue or at a fat-fibroglandular junction. If the mass blurs a tissue plane between fat and fibroglandular tissue or if the mass produces distortion of the ducts, these findings may be termed architectural distortion.

- Vascularity within an anechoic mass suggests that the mass is solid, possibly a primary breast cancer or metastatic lymph node. Although reporting the presence of vascularity can be helpful, its absence cannot be used to establish an anechoic or hypoechoic mass as a cyst. However, absence of flow may support the diagnosis of cyst if the mass has the features of a circumscribed margin, has an oval shape, and is anechoic. This is why vascularity, as a supportive rather than primary feature, is now listed among Associated Features.

  Since most new US equipment has tissue stiffness assessment capability, elastography, whether strain or shear wave, may be used (optionally) in characterizing masses and surrounding tissue. Research is underway to determine the role of elastographic findings, if any, in lesion assessment and recommendations for management. In this edition of BI-RADS® we provide terminology for elastographic findings not to signify endorsement of this developing technology, but rather, to provide the framework for future research involving outcomes analysis. Although there are many methods to assess tissue stiffness, nearly all use a color scale or spectrum and some form of quantitation. (Quantitation is used widely outside the United States). The FDA recently approved m/s and kPa as a unit of measure of lesion stiffness for shear-wave elastography. Because there is variability among systems manufacturers in color or black and white labeling conventions, to avoid confusion, we recommend that color displays of stiffness be standardized. Most systems display blue as soft and red as hard. Black and white labeling would be more appropriate to aid color-blind breast imagers.

- Special Cases are those with pathognomonic appearances. A simple cyst is one such lesion, and the criteria for this designation are an anechoic, circumscribed, oval or round mass with an imperceptible wall, and posterior enhancement. Occasionally, simple cysts < 8 mm may be difficult to characterize, particularly when located deep in the breast.[4,5] Use of tissue harmonic imaging may reduce artifactual internal echoes within cysts, although great care and caution are required not to tune out true echoes from potential solid masses. Posterior features such as enhancement may be subtle but are usually discernible with small cysts even when multiple off-angle beams are used to generate the image (i.e., spatial compounding) and when small cysts are located adjacent to pectoral muscle.

- We have added the description of implants to Special Cases. Recognition of normal and abnormal implant appearances with US is encouraged, and, when imaged, should be reported.[6] Features of the postsurgical breast are also described in Special Cases with examples.

B. PROBABLY BENIGN (CATEGORY 3) ASSESSMENTS

It is well known that for mammography several specific findings have been validated by robust literature as being probably benign, with a likelihood of malignancy > 0% but ≤ 2 %, hence appropriate for category 3 assessment and a recommendation for surveillance imaging.[7–10] Several specific findings that may be appropriate for probably benign assessment at US are proposed in this edition of the BI-RADS® Atlas. The literature supporting our proposals is not as robust as exists for mammography, and in some cases it is so sparse as to involve only expert opinion rather than data from prospective clinical studies. For all findings assessed as probably benign at US, the surveillance protocol should be identical to that used for mammographically characterized lesions, involving follow-up examinations at 6, 12, and 24 months, with the option to extend the surveillance period to 36 months.

1) Circumscribed, oval, solid masses, parallel to the skin in orientation, hypoechoic to fat with no posterior features or minimal posterior enhancement. There is robust evidence that these lesions, most of which represent fibroadenomas, have a ≤ 2% likelihood of malignancy.[11] However, the literature for circumscribed, oval, solid masses that are palpable is strong only for women younger than age 40, who comprise the majority of studied cases and among whom the prior probability of malignancy is low.[12,13] If there is interval decrease in the size of a mass under surveillance as a probably benign finding, the mass should be assessed as benign (category 2), and if such a mass completely resolves, a negative (category 1) assessment is appropriate. An increase in diameter of more than 20% in 6 months[14] or other suspicious change should prompt assessment as suspicious (category 4), with recommendation for biopsy. As with multiple bilateral mostly circumscribed masses at mammography,[15] with at least three overall and one in each breast, such findings seen only at US may be assessed as benign, with a recommendation for routine screening. Note that because US is tomographic, with each captured image representing a thin slice, the margin should be documented as completely circumscribed. Real-time evaluation will allow a more accurate and efficient evaluation.

2) Isolated, complicated cyst with uniform low-level echoes. The likelihood of malignancy has been shown to be 4/1,244 (0.3%).[16–20] Across three series, 12% of masses thought to be complicated cysts proved to be solid, with 2/64 (3.1%) of these solid masses proving malignant.[17,19,20] This represents robust evidence that the likelihood of malignancy for an isolated complicated cyst is > 0% but ≤ 2%, hence appropriate for category 3 assessment at US. As is the case for multiple bilateral mostly circumscribed masses at mammography, multiple bilateral complicated cysts (at least three overall and one in each breast) seen only at US may be assessed as benign, with a recommendation for routine follow-up.

3) Microlobulated or oval masses composed entirely of clustered microcysts. These findings may be assessed as benign (category 2) when clearly composed of simple cysts. However, imaging surveillance may be appropriate for smaller or deeper clustered microcysts, for which there is reduced diagnostic certainty, with one malignancy (0.5%) reported among 216 such masses across multiple centers.[3,17,19–22] The relatively small number of cases studied limits precision in estimating the likelihood of malignancy to be ≤ 2%; the data would be more convincing if at least 500 cases were studied.

4) A hyperechoic mass with central hypoechoic to anechoic components and surrounding edema is consistent with but not diagnostic of fat necrosis. There are very sparse published data indicating the likelihood of malignancy for this combination of sonographic findings, so the decision to assess such findings as probably benign (category 3) would be based only on expert opinion.

However, whether or not a history of trauma or prior surgery is elicited, the preferred approach is to correlate these sonographic finding(s) with those visible at mammography, because 1) if a mass representing fat necrosis is depicted at US, it also should be visible at mammography as an oil cyst, and 2) fat necrosis presenting as oil cyst(s) has a characteristically benign mammographic appearance, whether or not rim calcification is depicted. Therefore, virtually all such cases will confidently be assessed as benign (category 2).

5) While refraction shadowing at the edges of fat lobules is often easily recognized as non-pathologic, posterior shadowing seen in two projections may pose problems. Careful real-time scanning may exclude the presence of an associated mass; one should be able to dismiss the shadowing as artifactual if it changes in appearance on the different views, with an increase or decrease in transducer pressure on the skin, and with alterations of the angle of insonation. What should be done if a confident benign assessment cannot be rendered? There are no published data indicating the likelihood of malignancy for this sonographic scenario, so the decision to assess as probably benign (category 3) would be based only on expert opinion. However, it is important to realize that category 3 assessments should not be rendered because the interpreting physician is unsure whether to assess as benign (category 2) or suspicious (category 4); in this situation, it would be prudent to render a suspicious (category 4) assessment.

6) Architectural distortion thought to be due to postsurgical scar. The patient's clinical history may be helpful in this situation, and a track may be evident sonographically that can be followed to focally thickened skin at the site of incision. However, there are very sparse published data indicating the likelihood of malignancy for sonographic findings thought to be due to postsurgical scarring, so the decision to assess as probably benign (category 3) would be based only on expert opinion. Furthermore, such an assessment would be inadvisable without first correlating the sonographic findings with those visible at mammography. A previous breast biopsy for benign disease rarely complicates or alters the interpretation at mammography.[23]

In summary, among the six specific sonographic findings proposed as being appropriate for assessment as probably benign (category 3) at US, there is strong evidence supporting the first two (circumscribed, oval, solid, parallel-oriented mass and complicated cyst), less strong evidence supporting the third (clustered microcysts), and only expert opinion supporting the rest. Individual interpreting physicians should be cautious about adopting an interpretive approach to recommend surveillance imaging based only on expert opinion, unless the physician has personal experience to justify a watchful-waiting approach, preferably involving observation of a sufficient number of cases to suggest a likelihood of malignancy within the defined (≤ 2%) probably-benign range. Alternatively, one should consider waiting for publication of more robust data. Further clinical studies for the latter four proposed sets of sonographic findings, involving at least 500 cases for each proposed set, should be undertaken to demonstrate whether the likelihood of malignancy for any of the findings is in the defined (≤ 2%) probably-benign range and, when appropriate, the frequency with which concurrent mammography will permit a benign (category 2) assessment instead.

C. FREQUENTLY ASKED QUESTIONS

1. ***Which type of breast imaging examination should I recommend for my patients?***

   When in doubt, refer to the ACR Appropriateness Criteria® (http://www.acr.org/Quality-Safety/Appropriateness-Criteria/Diagnostic/Breast-Imaging). The ACR Appropriateness Criteria® provides recommendations for both screening and diagnostic breast imaging procedures.

2. ***A woman in her 20s consulted a gynecologist, who discovered a palpable breast mass; the woman thinks that the mass has been palpable for a long time, but the gynecologist insists on imaging, which shows probable fibroadenoma. What should the assessment be? Is biopsy always necessary?***

   This scenario often presents a dilemma for the breast imager. Using feature analysis, a mass that is oval, circumscribed, solid, and oriented parallel to the skin is very likely to be benign and most commonly a fibroadenoma. Especially for a woman in her 20s, palpability of the mass will not appreciably affect the very low likelihood of malignancy. The correct assessment in this scenario would be probably benign (category 3), recommend surveillance imaging, unless the woman prefers biopsy or even excision if the mass is cyclically painful. However, even if the woman declines surveillance imaging and a biopsy is done for this category 3 lesion, the probably benign assessment should ***not*** change.

3. ***A woman undergoes breast US examination to evaluate spontaneous bloody nipple discharge, and I see a mass within a duct. How do I describe this using the BI-RADS® lexicon?***

   In such a case, the location of the mass is intraductal, in addition to a specified clock-face position and distance from the nipple. Most intraductal masses are papillomas, and a vascular stalk may be evident on color or power Doppler while scanning along the length of the duct from the nipple to the periphery. Stating the length of the duct segment that contains the mass or debris, size and intraductal location of such masses, presence of vascularity, clock-face position, and distance from the nipple is the most important information to convey, together with whether or not these masses are felt to explain the patient's symptoms (if any). Most of these masses require biopsy. The risk of malignancy in one series of intraductal masses (involving 79 associated with nipple discharge) was 8%, but the subset of cases with bloody nipple discharge was not stated.[24] Other considerations include clot or detritus, ductal carcinoma in situ (DCIS) with or without an invasive component, and intracystic papillary carcinoma (encapsulated papillary carcinoma). Some irregular masses will show intraductal extension, with the latter often representing a DCIS component to an otherwise mostly invasive malignancy; in such cases, this is an associated feature of the main mass which itself should be more fully described by its shape, margins, orientation, posterior features, and echo pattern.

   If no abnormality is identified in scanning over the length of the duct segment as it approaches the nipple, consider attempting a ductogram (galactogram), which may show peripheral abnormalities more effectively than US.

4. ***A 52-year-old woman with a family history of unilateral breast cancer (mother diagnosed at the age of 67) presents with a large, painful breast mass. Her mammograms show no abnormalities other than a 4 cm circumscribed mass, characterized at US as a simple cyst. For relief of her symptoms, she requests aspiration. What assessment and management recommendations should be provided in the breast imaging report?***

   The breast imaging report for her concurrent mammography and US examinations should provide a benign (category 2) assessment, audit negative. This is because the combination of mammographic and sonographic findings is characteristically benign (simple cyst). A management rec-

ommendation of routine screening mammography in 1 year (concordant with the benign imaging findings) should be provided. Note that the requested cyst aspiration is for therapeutic rather than diagnostic purposes. This case illustrates one of several assessment-management discordance scenarios, in which assessment should match the imaging findings, not the planned management.

5. ***When a woman is recalled from screening for an asymmetry, and spot-compression or spot-compression magnification views show no persistent abnormality, is it necessary to perform US?***

   It is neither necessary nor appropriate to perform US in this scenario, because diagnostic mammographic evaluation has proved that the asymmetry identified at screening was a summation artifact (superimposition of normal breast structures) — this, of course, assumes that the spot-compression/spot-compression magnification views were of diagnostic image quality, with the area of concern centered in the spot-compression paddle. Because there are no imaging findings at diagnostic mammography, this examination should be assessed as negative (category 1) with a recommendation for routine screening mammography in 1 year. The above described scenario is quite common. An asymmetry is a noncalcified finding seen on only one standard mammographic view, and approximately 80% of asymmetries are found to represent summation artifacts.[25]

   Had this scenario been slightly different, with spot-compression or spot-compression magnification views depicting a focal asymmetry (non-mass lesion visible on two different mammographic projections) as the only imaging finding, then it would indeed be appropriate to perform US targeted at the mammographic lesion. In most such cases, US examination will not affect subsequent management, identifying either normal-appearing fibroglandular tissue as correlate to the focal asymmetry or no sonographic finding at all. Such cases would be assessed as probably benign (category 3) unless prior mammograms demonstrated at least 2–3 years of stability resulting in a benign (category 2) assessment. However, the value of US in this scenario is that in a few cases it will depict a suspicious finding instead, leading to biopsy and often a cancer diagnosis that would otherwise have been deferred.

6. ***In reporting the findings of a US examination, how many sonographic descriptors of a mass should be used to support its assessment? Is it acceptable to simply report that the mass has benign characteristics?***

   There is no specific number of descriptors that must be used, but the three feature categories whose descriptors are applicable to characterizing a mass as benign are margin, shape, and orientation, all of which should be used to completely characterize the mass. Within these feature categories, the descriptors that justify a benign assessment are a circumscribed margin, oval shape (this now includes the term macrolobulated), and parallel orientation. If any other sonographic descriptor within these three feature categories is applicable to the mass, such as indistinct margin, irregular shape, or not parallel orientation, the mass should be assessed as suspicious rather than as benign.

   Reports should be clear and concise, and too many adjectives may detract from the message, but the referring clinician or the next radiologist who views the sonograms may appreciate knowing the criteria used to justify a benign assessment. ***Note that these descriptors need not be repeated in the assessment that is provided at the end of the sonographic report.***

7. ***How should lesion location be reported on follow-up sonograms of a mass?***

   A 42-year-old woman was found to have a circumscribed mass at baseline mammography. At diagnostic mammography and US, the mass was assessed as probably benign and its location at US was recorded as right breast, 10 o'clock, 5 cm posterior to the nipple. She returned for a 6-month follow-up US, and the sonographer told the interpreting physician that the mass was

located at 11:00 in the right breast 6 cm posterior to the nipple but that she had labeled her images of the mass exactly as they had been annotated on the previous US examination. The technologist asked the physician if what she had done was correct.

One could argue that there should be precise agreement concerning the location of a sonographic finding on successive surveillance examinations, for the sake of consistency. However, due to minor differences in both patient positioning and angles of insonation that are inherent in real-time scanning with a handheld transducer, it may be difficult to precisely duplicate the scanning conditions of a previous examination. As a result, the apparent clock-face location and distance from the nipple of a mass may vary slightly between examinations. The key here is to determine that the mass depicted on both examinations is one and the same. This is accomplished by real-time scanning not only at but also adjacent to the expected location of the targeted mass, to ensure that the currently visible mass is the only such finding in the area. Once this has been confirmed, a full set of diagnostic images should be recorded, with the images labeled either precisely as on the previous examination or as actually located on the current examination. If the current actual location is used in labeling, and if there is a slight difference between this location and the location labeled previously, the report could state, "The right breast mass seen previously at 10:00 position, 5 cm posterior to the nipple is the same mass seen on today's exam in the right breast at 11:00 position, 6 cm posterior to the nipple, the minor difference being due to variability in patient positioning." Thus, there will be no confusion concerning the slight differences in lesion location described in the successive US reports.

8. ***US revealed a large axillary mass in a patient with known metastatic melanoma. Previously, this mass had been biopsied and shown to represent an axillary lymph node with metastatic melanoma. Except for the axillary mass, US examination revealed no abnormalities in the breast. What is the appropriate assessment for this examination?***

   The appropriate assessment is benign (category 2). An assessment of known biopsy-proven malignancy (category 6) would not be appropriate, as this assessment is used for known breast cancers (defined in the BI-RADS® Atlas as being either invasive breast carcinoma or ductal carcinoma in situ). Note that other malignancies (lymphoma, leukemia, sarcoma, metastasis, etc.), even when present in the breast or axilla, are not considered to be breast cancer. To avoid confusion concerning a benign assessment despite the presence of a non-breast malignancy, the report should contain an added sentence explaining the situation. In this case, the report could indicate that the axillary mass represents biopsy-proven metastatic melanoma, but that there is no sonographic evidence of breast cancer.

   Had this scenario been slightly different, with a sonographic depiction of not only the axillary mass but also a mostly circumscribed but slightly indistinct solid mass within the breast, then the appropriate assessment would be suspicious (category 4). The reason is that although this in-breast lesion could represent another melanoma metastasis, it also could be a primary breast carcinoma, such that biopsy is needed to make the distinction.

9. ***Should assessment category 0 be applied to breast US examinations?***

   In general, assessment category 0 should not be assigned to ***diagnostic*** breast US examinations. This is because a full diagnostic breast imaging examination (involving both US and mammography, if both are needed) should be completed before the patient leaves the breast imaging facility. Rarely, if for either equipment or personnel issues, completion of the diagnostic US examination can not be completed or the patient decides to leave before completion of her workup, a category 0 may be given. In this scenario, if the diagnostic US examination is the one performed first, it should be assessed as incomplete (category 0), and the patient will be asked to return to complete her

examination. When the patient returns and her examination is completed, the initial category 0 assessment is replaced by a final assessment.

However, assessment category 0 indeed is appropriate for ***screening*** breast US examinations. Like screening mammography, for which a small set of standard images is routinely obtained, a similar small set of standard images is routinely obtained at screening US. When additional images are recorded to further evaluate a screening-detected mammographic or sonographic finding, the screening examination is assessed as incomplete (category 0), and the additional images then constitute the subsequent diagnostic examination, regardless of whether the patient needs to be recalled on a different day or the additional images are obtained only a few minutes afterwards.

Note that in scenarios in which both screening and diagnostic components of an examination are performed one after the other, it may be awkward to report the two examinations separately. A single report may be issued instead, containing a combined assessment that reflects the (more completely evaluated) findings at diagnostic examination. However, the screening and diagnostic components of such a combined examination must be audited separately, audit-positive for the screening examination (effectively reflecting a category 0 assessment), and either audit-positive or audit-negative for the diagnostic examination depending on the final assessment that is rendered.

10. For bilateral screening US performed either by the technologist or the physician with no abnormality identified, what images should I record?

Although no standard has been set for documenting a negative screening US examination, what was done in ACRIN 6666[26] has served well in many breast imaging practices that now offer screening US: in addition to demographics (patient's name, unique identifier, date of birth or age, facility name, and location), record one image in one plane (ordinarily radial) for each quadrant, at the same distance posterior to the nipple (4 cm for an average breast), and record one image of the retroareolar region just behind the nipple. The axilla could be scanned as well, but this was not required in the ACRIN 6666 protocol, nor was there a requirement to record a representative negative image. The standard set of five images per breast was recorded at the completion of real-time scanning, given that no abnormalities were suspected or observed.

11. Should I avoid using breast US for male patients with clinical findings because gynecomastia may be misinterpreted as malignancy?

No, US is indicated for evaluation of most palpable abnormalities, regardless of the patient's gender. Men with palpable masses located far from the nipple would be referred for US on completion of mammography. Gynecomastia itself is frequently palpable and tender, with mammography most commonly being definitive in confirming the diagnosis. If US is performed, however, gynecomastia may also be recognized (please see the discussion of anatomy in the lexicon).

As we do in mammography and in imaging other paired organs, it is important to keep the principle of symmetry in mind. If there is doubt about whether US shows a physiologic change (such as gynecomastia) or an abnormality that requires biopsy, scan the contralateral retroareolar area for a similar but usually smaller area (in this case, of gynecomastia). Palpable masses at sites away from the nipple, usually in fatty areas of the male breast, can be completely characterized using mammographic feature analysis, with the role of US limited to providing imaging guidance for biopsy, if palpation-guided biopsy is not performed.

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APPENDIX

ACR BI-RADS® — Ultrasound Lexicon Classification Form

For each of the following categories, select the term that best describes the dominant lesion feature. Whenever possible, definitions and descriptions used in BI-RADS® for mammography should be applied to ultrasound.

BREAST TISSUE		
A. Tissue composition (screening only): Heterogeneous background echotexture of the breast may affect the sensitivity of breast sonograms for lesion detection. *(select one)*		
☐ 1. a. Homogeneous background echotexture — fat		
☐ 2. b. Homogeneous background echotexture — fibroglandular		
☐ 3. c. Heterogeneous background echotexture		
FINDINGS		
B. Masses: A mass is three dimensional and occupies space. In 2-D US, it should be seen in two different planes; with volumetric acquisitions, in three planes.		
1. **Shape** *(select one)*	☐ a. Oval	Elliptical or egg-shaped (may include two or three undulations, i.e. gently lobulated or macrolobulated)
	☐ b. Round	Spherical, ball-shaped, circular, or globular
	☐ c. Irregular	Neither round nor oval
2. **Orientation** *(select one)*	☐ a. Parallel	Long axis of lesion parallels the skin line (wider than tall or horizontal)
	☐ b. Not parallel	Long axis not oriented along the skin line (taller than wide or vertical) — includes round
3. **Margin** *(select all that apply)*	☐ a. Circumscribed	Entire margin is well defined or sharp, with an abrupt transition between the lesion and surrounding tissue
	b. Not circumscribed	The mass has one or more of the following features: indistinct, angular, microlobulated, or spiculated in any portion of the margin
	☐ i. Indistinct	No clear demarcation between a mass and the surrounding tissue anywhere on the margin
	☐ ii. Angular	Some or all of the margin has sharp corners, often forming acute angles
	☐ iii. Microlobulated	Margin is characterized by short-cycle undulations
	☐ iv. Spiculated	Margin is characterized by sharp lines radiating from the mass
4. **Echo pattern** *(select one)*	☐ a. Anechoic	Without internal echoes
	☐ b. Hyperechoic	Having increased echogenicity relative to fat or equal to fibroglandular tissue
	☐ c. Complex cystic and solid	Contains both anechoic (cystic or fluid) and echogenic (solid) components
	☐ d. Hypoechoic	Defined relative to subcutaneous fat; less echogenic than fat; characterized by low-level echoes throughout (e.g., complicated cysts or fibroadenomas)
	☐ e. Isoechoic	Having the same echogenicity as subcutaneous fat
	☐ f. Heterogeneous	A mixture of echogenic patterns within a solid mass

5. **Posterior features** *(select one)*	☐ a. No posterior features	No shadowing or enhancement deep to the mass
	☐ b. Enhancement	Appears as a column that is more echogenic (whiter) deep to the mass
	☐ c. Shadowing	The area posterior to the mass appears darker; (refractive edge shadowing is of no significance)
	☐ d. Combined pattern	More than one pattern of posterior attenuation, both shadowing and enhancement
C. Calcifications: Calcifications are poorly characterized with US but can be recognized as echogenic foci, particularly when in a mass. *(if present, select all that apply)*		
☐ 1. **Calcifications in a mass**		Small hyperechoic foci will be more conspicuous in a hypoechoic mass than within a volume of fibroglandular tissue (unless grouped very closely or individually coarse, they will not attenuate the US beam)
☐ 2. **Calcifications outside of a mass**		Calcifications situated in fat or fibroglandular tissue are less conspicuous than when present within a mass
☐ 3. **Intraductal calcifications**		
D. Associated features *(select all that apply)*		
☐ 1. **Architectural distortion**		
☐ 2. **Duct changes**		Manifested by cystic dilation of a duct or ducts involving irregularities in caliber and/or arborization, extension of duct(s) to or from a malignant mass, or the presence of an intraductal mass, thrombus, or detritus
3. **Skin changes** *(select all that apply)*	☐ a. Skin thickening	May be focal or diffuse, > 2 mm in thickness (in the periareolar area and inframammary folds up to 4 mm)
	☐ b. Skin retraction	Skin surface is concave or ill-defined, and appears pulled in
☐ 4. **Edema**		Increased echogenicity of surrounding tissue and reticulated (angular network of hypoechoic lines)
5. **Vascularity** *(select one)*		Must reference a contralateral normal area or unaffected site in the same breast as the basis for comparison
	☐ a. Absent	
	☐ b. Internal vascularity	Blood vessels present within the mass
	☐ c. Vessels in rim	Blood vessels may be marginal, occupying part or all of the rim of the mass
6. **Elasticity assessment** *(select one)*		Stiffness as a feature of malignant masses may be considered along with their much more important morphologic characteristics
	☐ a. Soft	
	☐ b. Intermediate	
	☐ c. Hard	

E. Special cases: These are cases with a unique diagnosis or finding. *(select all that apply)*		
☐ 1. **Simple cyst**		Circumscribed, round or oval, anechoic, shows posterior enhancement
☐ 2. **Clustered microcysts**		A cluster of anechoic masses, each < 2–3 mm in diameter with thin (< 0.5 mm) intervening septations and no discrete solid component
☐ 3. **Complicated cyst**		Cysts that contain debris; characterized by homogeneous, low-level internal echoes without a discrete solid component, and with an imperceptible wall: may have layered appearance which may shift slowly with changes in the patient's position; may also contain echogenic foci that appear to scintillate as they shift
☐ 4. **Mass in or on skin**		These masses are clinically apparent and may include sebaceous or epidermal inclusion cysts, keloids, moles, pimples, neurofibromas, and accessory nipples
☐ 5. **Foreign body including implants**		May include marker clips, coils, wires, catheter sleeves, injected or leaked silicone, metal or glass related to trauma, and implants
☐ 6. **Lymph nodes — intramammary**		Circumscribed, oval masses with hypoechoic cortices and echogenic fatty hila, often reniform and containing hilar fat; most commonly seen in the upper outer quadrant (especially the axillary tail); usually 3 mm to 1 cm
☐ 7. **Lymph nodes — axillary**		
8. **Vascular abnormalities** *(select one)*	☐ a. AVMs (arteriovenous malformations/ pseudoaneurysms)	
	☐ b. Mondor disease	
☐ 9. **Postsurgical fluid collection**		
☐ 10. **Fat necrosis**		

ASSESSMENT CATEGORIES *(select one)*		
Incomplete Assessment	**Management**	**Likelihood of Cancer**
☐ Category 0: Incomplete — Need Additional Imaging Evaluation	Recall for additional imaging	N/A
Final Assessment	**Management**	**Likelihood of Cancer**
☐ Category 1: Negative	Routine screening	Essentially 0% likelihood of malignancy
☐ Category 2: Benign	Routine screening	Essentially 0% likelihood of malignancy
☐ Category 3: Probably Benign	Short-interval (6-month) follow-up or continued surveillance	> 0% but ≤ 2% likelihood of malignancy
☐ Category 4: Suspicious	Tissue diagnosis	> 2% but < 95% likelihood of malignancy
☐ Category 4A: *Low suspicion for malignancy*		> 2% to ≤ 10% likelihood of malignancy
☐ Category 4B: *Moderate suspicion for malignancy*		> 10% to ≤ 50% likelihood of malignancy
☐ Category 4C: *High suspicion for malignancy*		> 50% to < 95% likelihood of malignancy
☐ Category 5: Highly Suggestive of Malignancy	Tissue diagnosis	≥ 95% likelihood of malignancy
☐ Category 6: Known Biopsy-Proven Malignancy	Surgical excision when clinically appropriate	N/A

This US lexicon classification form is for data collection and does not constitute a written US report.