# Toward a Standardized Breast Ultrasound Lexicon, BI-RADS: Ultrasound

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SONOGRAPHY IS an important complement to mammography. Analysis of sonographic features may aid in appropriate selection of lesions for follow-up or biopsy. Recognizing that consistent terminology and clear communication of findings and results directly affect patient management, a validated lexicon of descriptors for breast sonography is in development. This includes terms to describe shape, orientation, margin regularity and thickness, matrix echogenicity, matrix homogeneity, acoustic attenuation, and effect on surrounding tissue.

With support from the Office on Women's Health, Department of Health and Human Services, the American College of Radiology (ACR) Commission on Ultrasound has developed the initial draft of a breast ultrasound lexicon to be used for standardized reporting of breast ultrasound findings. Intended to complement the ACR Breast Imaging Reporting and Data System (BI-RADS™) lexicon, the breast ultrasound lexicon (BI-RADS: Ultrasound) will undergo final review in mid 2001 and is expected to be released in December 2001. An overview of the proposed lexicon and examples of features described in the lexicon are presented.

## INTRODUCTION

Although mammography remains the most sensitive method for detecting preclinical breast carcinoma, its limited specificity results in need to biopsy many abnormalities to determine whether they are benign or malignant.[1,2] Indications for breast sonography include the following: the initial evaluation of palpable abnormalities in women under 30, initial identification and characterization of palpable and nonpalpable abnormalities, guidance of interventional procedures, and evaluation of problems associated with breast implants.[3,4] Several recent studies suggest that sonography in combination with mammography can reduce the number of false-positive recommendations for biopsy.[5-8] Mammography remains the standard for breast screening as most ductal carcinoma in situ is missed sonographically.[9-11]

The growing use of ultrasonography has created the need for a standardized method for lesion characterization, description, and reporting.[12] The mammography lexicon developed by the ACR, the Breast Imaging Reporting and Data System (BI-RADS™),[13] provides standardized assessment and associated management recommendations for masses and calcifications. Based on success of BI-RADS with mammography, the development of a lexicon for breast ultrasound (BIRADS:Ultrasound) and breast magnetic resonance imaging[14] has been a high priority for the ACR. The lexicons are designed to use shared terminology whenever possible. When completed, the lexicons will aid referring physicians, radiologists, and patients in describing abnormalities and understanding their management implications. Furthermore, these lexicons will provide a basis for validation of outcomes across multiple centers.

A breast ultrasound lexicon, the Breast Imaging Reporting and Data System: Ultrasound is currently being developed by the ACR. The initial draft was prepared by the Breast Ultrasound Lexicon Subcommittee of an Expert Working Group to Plan and Develop Protocols for Optimization and Clinical Testing of Breast Ultrasound, supported by a contract from the Office of Women's Health, National Institutes of Health, and conducted by the Commission on Ultrasound of the ACR. Techniques adapted from those used in the development of BI-RADS are being used in the formulation of the new ultrasound lexicon. The ACR lexicon is expected to be completed and released in late 2001 following its validation.

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*This work was supported in part by 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.*

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*0037-198X/01/3603-0007$35.00/0*
*doi:10.1053/sroe.2001.25125*

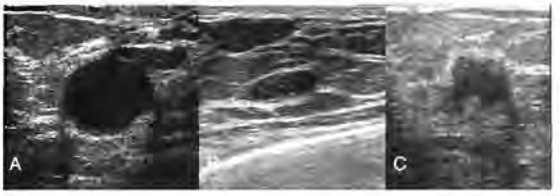


Fig 1. Shape. Masses are described as round (A), oval (B), or irregular (C). A round mass is spherical, ball-shaped, or globular in shape. An oval mass is elliptical or egg-shaped. These descriptors are similar to those used in the ACR BI-RADS lexicon for mammography. (A) A spherical simple cyst is shown. (B) An oval fibroadenoma is shown. The invasive cancer shown in C is irregular.

## FEATURE ANALYSIS

Lesion features include primary features such as shape (Fig 1), orientation (Fig 2), margins (Figs 3 through 5), matrix echogenicity and homogeneity (Figs 6 and 7), and attenuation (Fig 8), which should be described and applied in a consistent fashion. In addition, secondary associated findings such as architectural distortion (Fig 9), retraction or angulation of Cooper's ligaments (Fig 9B), dilated ducts, calcifications (Fig 10) and changes in the skin, subcutaneous fat, and pectoral muscle can be recorded as well. These features of masses have been enumerated previously.[5,7,15,16] The utility of each category of features requires validation along with that of individual descriptors. For example, matrix homogeneity probably has less specificity and significance than description of mass margins. The most appropriate descriptor for each category of characteristics should be applied when describing a lesion (Table 1). Wherever possible, feature descriptors similar to those used by BI-RADS for mammography have been imported. As with mammography, use of the lexicon is predicated on

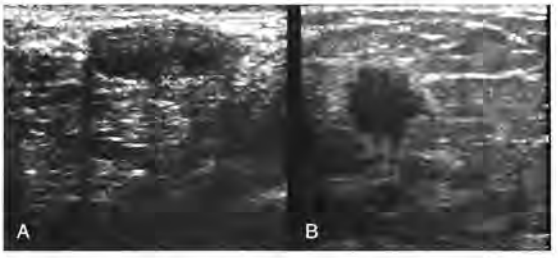


Fig 2. Orientation. Mass orientation refers to the relationship of the long axis of the mass to the skin. This may be parallel as is common with fibroadenomas (A) or not parallel, a common orientation for many cancers (B). Because round lesions do not have one axis that is longer than another, they should be classified as *not* parallel.

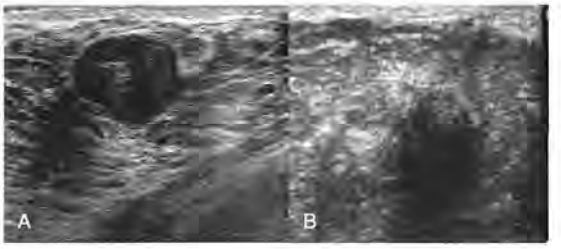


Fig 3. Margins. The margin is the boundary between the lesion and its surroundings. Several characteristics of the lesion margin are important. The margin should be described as circumscribed (distinct and smooth) (A) or irregular (indistinct, microlobulated, angular, or spiculated) (B). In A, the circumscribed margin of a fibroadenoma is shown. In B, an invasive cancer demonstrates an ill-defined or indistinct interface with the surrounding tissues. As in mammography, ill-defined margins are associated with higher risk of malignancy than circumscribed margins.

excellent sonographic technique using a linear transducer whose center frequency is at least 7 MHz. Documentation should be performed in accord with the American College of Radiology Standards.[3] Orthogonal views of the lesion should be obtained, and the orientation of the transducer and location of the abnormality should be described using quadrant, clock-face location, and/or labeled diagram of the breast, ideally including distance from the nipple.

Several previous studies[5,7,15] reach the conclusion that multiple features must be analyzed to achieve as great a specificity as possible in sonographic characterization. As an example, the diagnosis of a mass as a simple cyst requires that the *shape* be round oval, or gently lobulated, *margin* circumscribed, *echogenicity* (echo pattern) anechoic, and that there be *acoustic enhancement*. Based on these combined features, the impression is that of a simple cyst (Figs 1, 5, and 6). The final assessment for the *combination* of mammographic

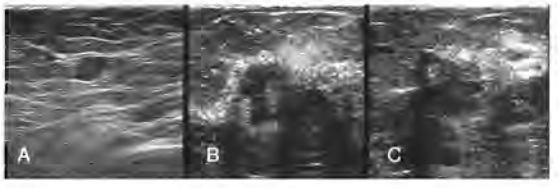


Fig 4. Margin thickness. Circumscribed margins may be thin, thick, or of mixed thickness. The fibroadenoma (A) has a thin and distinct boundary delineating it from surrounding breast tissue. The invasive cancer in 4B has generally thick margins, whereas the cancer in C shows a margin composed of thick, thin, and indistinct segments. Barely perceptible margins favor benign etiology.

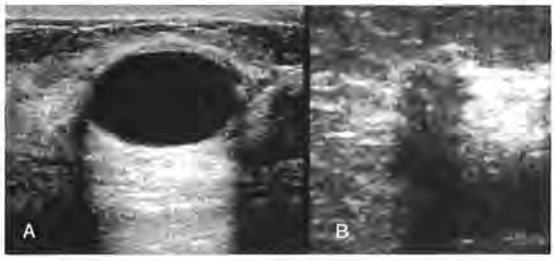


Fig 5. Margins. The smooth, barely perceptible margin of a simple cyst (A) is contrasted with the irregular margins of a small invasive cancer (B). Margin irregularities may include angular edges, microlobulation, and spiculation.

and sonographic findings using BI-RADS is category 2, benign, with routine screening recommended. The accuracy of sonographic identification of cysts approaches 100%, provided strict adherence to the classical sonographic characteristics are observed.[17]

Practical use of any lexicon requires an understanding of the definitions of each term. An example is *complicated* versus *complex*. The presence of homogeneous low-level internal echoes throughout a cystic lesion that has all the other features of a simple cyst as above results in its designation as "complicated."[18] Many of these masses appear solid, albeit benign, and may be reported as "complicated cyst or probably benign solid lesion." Often, such lesions are incidentally found during ultrasound examination performed for other reasons. Recent studies cumulatively evaluating 567 incidental complicated cysts identified only one 3-mm in situ malignancy (positive predictive value [PPV] 0.2%).[19-21] Based on these data, short-term follow-up appears appropriate (BI-RADS category 3, probably benign), although further validation is


Fig 6. Echogenicity/echotexture/echo pattern. The matrix of a mass may be homogeneous or heterogeneous. Homogeneous masses may be anechoic, hypoechoic, or hyperechoic. Cysts are typically anechoic (A). The echogenicity of hypoechoic and hyperechoic masses should be compared with the echogenicity of fibroglandular tissue. In this example, a hamartoma produces a homogeneous mass (arrows) that is hyperechoic compared with fat (B). Invasive cancer (C) is often hypoechoic both to fat and to glandular tissue (same lesion as in Fig. 2B).


Fig 7. Echogenicity/echotexture/echo pattern. Heterogeneous masses may be solid or complex, containing a mixture of solid and cystic components. The invasive cancer in A is predominantly hypoechoic, but contains some areas of increased echogenicity resulting in a heterogeneous echotexture. Complex masses may be predominantly solid (B) or cystic (C, both intracystic papillary carcinomas) and should be regarded as suspicious for cancer in the absence of clinical findings suggesting an abscess.

encouraged. Interval enlargement (mammographically or sonographically), or the presence of any suspicious features, should prompt aspiration and possible core biopsy if it proves solid.[22]

Suspicious features include an intracystic mass/mural nodule, thick septations, or a thick or irregular wall. When such features are present, the mass should be described as a "complex" cystic mass (Figs 7B and C). These lesions generally require aspiration or biopsy (BI-RADS category 4, suspicious).

When a solid lesion is present, careful analysis of contour, margins, matrix, and attenuation may allow classification of some nodules as BI-RADS category 3, probably benign, and provide the option of short interval follow-up at 6 months, 12 months, and 24 months, rather than biopsy.[5-7] As in mammography, for a lesion to be assessed as "probably benign," it should have <2% risk of malignancy.[23,24] As mentioned, preliminary data suggest cysts with internal echoes can be so classified as can clusters of tiny cystic foci with thin intervening septations compatible with apocrine metaplasia.[25]

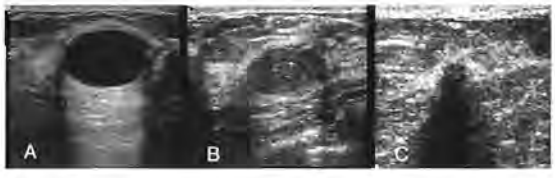


Fig 8. Shadowing/enhancement. Enhancement may be seen with cysts (A), fibroadenomas (B), and high-grade invasive cancers (C). Central shadowing is associated with the small invasive cancer is shown in C. Refractive edge shadowing (present in A and B) is excluded from consideration. A single echogenic calcification is present in the fibroadenoma (B).

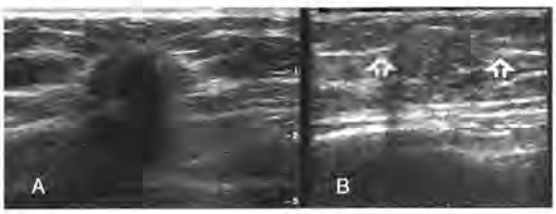


**Fig 9. Effect on surrounding tissue. Masses may affect surrounding breast tissues resulting in architectural distortion. (A) Extensive distortion of breast architecture by a small scirrhous cancer is shown. (B) A more subtle change is seen where a Cooper ligament is interrupted by a cancer (open arrows).**

Stavros et al[5] proposed three categories of solid lesions that could be classified as BI-RADS category 3, probably benign, in the absence of any suspicious features: (1) masses with intense and uniform hyperechogenicity relative to fat; (2) masses with an ellipsoid shape and thin echogenic capsule; and (3) masses with two or three gentle lobulations and a thin echogenic capsule. Individually each of these characteristics had a negative predictive value for malignancy of 98.8% to 100%.[5] Although accepted by some, it is important to note that these results have not been validated across multiple centers. Indeed, one recent study[26] suggests that not all readers achieve sufficiently high specificity to follow solid lesions. In the draft BI-RADS:Ultrasound lexicon, the concept of a thin echogenic capsule or "pseudocapsule" has been replaced by that of a thin, smooth margin, analogous to a "circumscribed" mass mammographically. Although palpable, solid lesions are generally recommended for biopsy,[23,24] it is not yet clear whether any size criterion or palpability of the lesion influences the absolute risk of malignancy.

For solid masses, irregularity of shape and margins dominate other features suggesting malignancy, with a PPV of malignancy of 86% to 93%[5,7]: such lesions are appropriately classified as BI-RADS category 4 or 5 with biopsy recommended. Other features have lower specificity. *Orientation* of the long axis of the mass nonparallel to the skin, synonymously termed "taller than wide,"[5] has been associated with a 62% to 81% likelihood of malignancy[5,7] and is more commonly seen in cancers <1 cm in size.[5] Most fibroadenomas as well as many cancers are oriented with their long axes parallel to the skin ("wider than tall").[31] *Echotexture/echo pattern* appears to be less helpful in differentiating benign from malignant solid masses[31] as most masses will be hypoechoic to parenchyma. *Acoustic attenuation* (shadowing) is suspicious for malignancy, but as many as 21% of benign lesions will show shadowing.[7] Similarly, acoustic enhancement, while common in benign lesions, may be present in up to 42% of cancers.[5] Several typically benign lesions are included as special cases (Fig 11). This includes lymph nodes with a thin circumscribed capsule and central echogenic hilum. Foreign bodies are special cases and include siliconomas and free extracapsular silicone (Fig 11).[27] Description of vascularity of the lesion is not a required standard (Fig 12) as no reliable distinction has yet been made between benign and malignant lesions on this basis.[28-30] Vascularity is described as the same, increased, or decreased, relative to surrounding parenchyma.

Table 1 is a working draft of a breast ultrasound lexicon including feature categories and descriptors. Although different in format, this draft was based largely on the version developed by the Lexicon Committee of the Expert Working Group. It is important to note that these recommendations await validation and are subject to modification before release of the final draft of the ACR BIRADS:Ultrasound. Descriptors are illustrated in Figures 1 through 12. The illustrations show only a

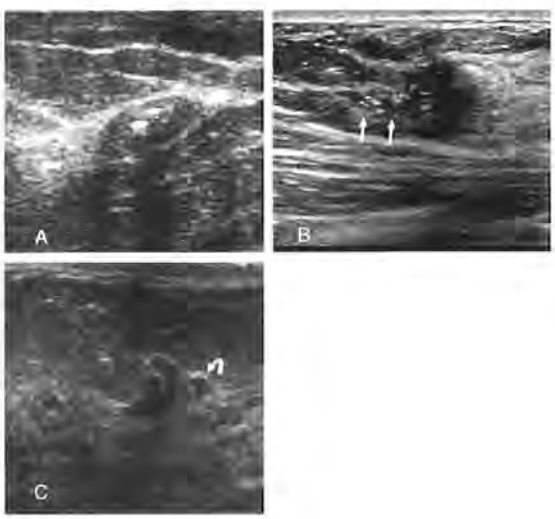


**Fig 10. Associated findings. Dilated ducts, skin changes, and calcifications associated with breast masses may be seen with ultrasonography and should be described when present. (A) Macrocalcifications (≥0.5 mm) associated with a fibroadenoma are shown (arrowheads). (B) Microcalcifications (<0.5 mm) in an invasive ductal carcinoma are shown (arrows). (C) Microcalcifications not in a mass, and particularly within a tubular dilated duct (curved arrow), are suspicious and may be seen in ductal carcinoma in situ as in this example.**

**Table 1.**
**Draft ACR BI-RADS Ultrasound Lexicon Classification Form 4-4-01**

Case _____ Reviewer _____

| CLASSIFICATION CATEGORIES & TERMS | | | DESCRIPTION |
|---|---|---|---|
| **Masses:** A mass occupies space and should be seen in two different projections | Shape (select one) | ☐ Oval<br>☐ Round<br>☐ Irregular | elliptical or egg-shaped (may include two or three undulations, ie, "lobular")<br>spherical, ball-shaped, circular, or globular<br>neither round nor oval |
| | Orientation (select one) | ☐ Parallel<br>☐ Not Parallel | long axis of lesion oriented along skin line ("wider than tall")<br>no long axis, or axis not oriented along skin line ("taller than wide") |
| | Margin: | Circumscribed (select all that apply)<br>☐ YES (if yes, check one option below)<br>☐ No perceptible rim or thin rim<br>☐ Thick rim<br>☐ NO (if no, go to irregular)<br>☐ IRREGULAR (select all that apply)<br>☐ Indistinct<br>☐ Angular<br>☐ Microlobulated<br>☐ Spiculated | Smooth, distinct margin with thin, thick, or no perceptible linear rim<br>circumscribed margin w/thin, linear rim<br>circumscribed margin w/measurable thick rim >1mm between lesion and surrounding tissue<br>margins demonstrating a combination of features including at least 1 of those listed below<br>poorly defined margin<br>part or all of the margin formed by sharp linear intersections that form acute angles<br>margin characterized by by >3 small, short cycle undulations<br>margin characterized by sharp projecting lines |
| | Echo Pattern: | ☐ Anechoic<br>☐ Hyperechoic<br>☐ Complex<br>☐ Hypoechoic | without internal echoes<br>defined relative to fat; equal to fibroglandular tissue<br>combined cystic (anechoic) and echogenic components<br>defined relative to fibroglandular tissue; isoechoic or hypoechoic to fat; contains low-level echoes throughout (eg, complicated cyst or fibroadenoma) |
| | Posterior Acoustic Features | (select one)<br>☐ No posterior acoustic features<br>☐ Enhancement<br>☐ Shadowing<br>☐ Combined pattern | no posterior shadowing or enhancement<br>increased posterior echoes<br>decreased posterior echoes; excluding edge shadows<br>both shadowing and enhancement |
| | Surrounding Tissue | ☐ No effect<br>Identifiable effect (select all that apply)<br>☐ Ducts<br>☐ Cooper's ligament changes<br>☐ Edema<br>☐ Architectural distortion<br>☐ Skin Thickening<br>☐ Skin retraction/irregularity<br>☐ Pectoral muscle seen, but plane with anterior tissue is unclear | surrounding tissue unaffected by lesion<br>abnormal caliber and/or arborization<br>straightening or thickening of Cooper's ligaments (curvilinear connective tissue bands providing support for the breasts)<br>increased echogenicity of surrounding tissue, reticulation: includes angular hypoechoic lines<br>disruption of normal anatomic planes<br>focal/diffuse skin thickening-normal skin is >2mm in thickness except in the periareolar area and lower breasts.<br>skin surface is concave or ill-defined, appears pulled in<br>disordered echo pattern involving pectoral muscle suggestive of invasion (exclude technical causes such as improperly placed focal zone) |

| CLASSIFICATION CATEGORIES & TERMS | | DESCRIPTION |
|---|---|---|
| **Calcifications:**<br>Calcifications are poorly characterized with ultrasound but can be recognized particularly in a mass | ☐ None seen | no calcifications seen |
| | If present, (select all that apply) | |
| | ☐ Macrocalcifications | ≥0.5 mm |
| | ☐ Microcalcifications out of mass | |
| | ☐ Microcalcifications in mass | |
| **Special Cases:**<br>Special cases are those with a unique diagnosis or finding | ☐ None | |
| | (select all that apply) | |
| | ☐ Mass in or on skin | including sebaceous or epidermal inclusion cyst; keloid, etc. |
| | ☐ Foreign body | including clip, coil, wire, catheter sleeve, silicone, etc. |
| | ☐ Lymph nodes-intramammary | in breast, including axillary tail |
| | ☐ Lymph nodes-axilla | |
| **Vascularity** | (select one) | |
| | ☐ Cannot assess vascularity | color flow not done or inadequate for interpretation |
| | ☐ None | no color flow |
| | ☐ Same as in normal tissue | |
| | ☐ Decreased | less than in normal tissue |
| | ☐ Increased | more than in normal tissue |
| ***There are limited data to support management recommendations for solid masses based on ultrasound findings at this time. However, what would be your best assessment and management recommendation in each case?*** | | |
| **Incomplete Assessment** | ☐ Incomplete | additional evaluation needed before final assessment |
| **Final Assessment Category** | ☐ Negative | no lesion found (routine follow-up) |
| | ☐ Benign finding | no malignant features; ex-cyst (routine follow-up) |
| | ☐ Probably benign | low probability of cancer, ex-fibroadenoma (short interval follow-up) |
| | ☐ Suspicious abnormality | intermediate probability of cancer (tissue sampling) |
| | ☐ Highly suggestive of malignancy | high probability of cancer (tissue sampling) |

For each of the above categories, select the term that best describes the dominant lesion feature.

Wherever possible, definitions and descriptions used in BI-RADS (Reston, VA) for mammography will be applied to ultrasound.
Please mark the box beside your selection.

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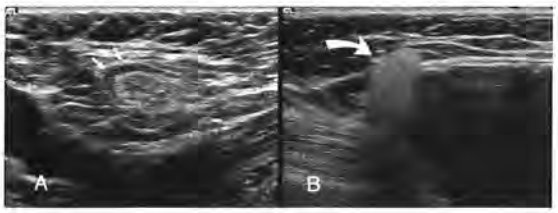


Fig 11. Special cases. Skin lesions, lymph nodes, and foreign bodies are also demonstrable with breast ultrasonography. (A) A typical intramammary lymph node with an echogenic hilum is shown (arrows). (B) Extracapsular spread of silicone gel from a ruptured silicone implant usually manifests itself as echogenic noise or a "snowstorm" pattern[27] (curved arrow).

single view of each lesion. In practice, descriptors should be based on multiple views of masses obtained in orthogonal imaging planes, in accord with the ACR Standard for the Ultrasound Examination of the Breast.[3] Primary descriptors of masses (shape, orientation, margin, and echo pattern) are generally listed in order of increasing risk of malignancy, top to bottom, although further validation of the risk of malignancy is needed. Secondary features, associated findings, or effects on surrounding tissue are not listed in any particular order, as further assessment of the risk of malignancy for each feature is needed. In referring to Table 1, it is important to re-emphasize that greatest specificity is achieved by the evaluation of multiple features of the mass rather than any single attribute.

Certain problems of description, nomenclature, and categorization have not been resolved.

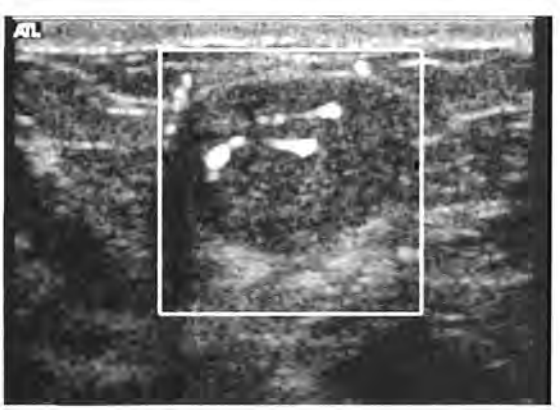

Fig 12. Vascularity. The role of vascularity in the characterization of breast masses is not fully defined. Therefore, description of vascular features is optional. Vascularity assessed with color or power Doppler is described as the same, increased, or decreased compared with adjacent normal breast tissue. Power Doppler of a high-grade carcinoma with increased vascularity (arrowheads) is shown.

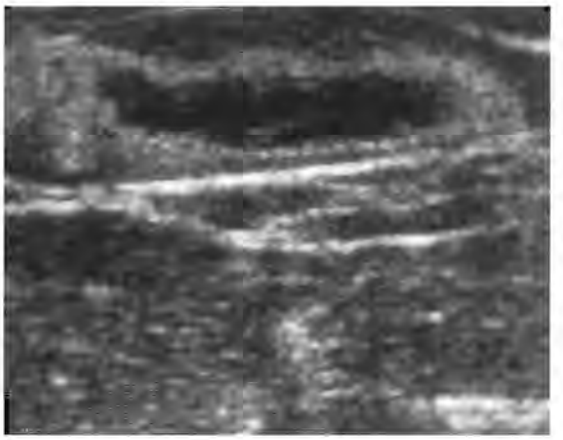

Fig 13. Tubular mass. A complex, centrally cystic mass, tubular in shape, with hyperechoic, indistinct rim and heterogeneous internal echoes is noted. This patient is on coumadin and developed a hematoma in the breast. Although the features suggest potential need for biopsy, the combination of clinical history and imaging findings allows classification of this finding as probably benign, with short-interval follow-up recommended.

For example, overlap of shape and margin categories (eg, irregular) has been discussed in the development of both mammography and ultrasound lexicons. Use of the term "tubular" may be appropriate as a shape (Fig 13) or special case (eg, dilated duct). The benign lesion, *apocrine metaplasia*,[25] with its characteristic microlobulated margin but otherwise identifiably benign microcystic components (Fig 14), might be a special case, better included and described for its uniqueness than analyzed by individual descriptors such as irregular, microlobulated, and complex that would otherwise prompt tissue diagnosis.

Another dilemma is classification of lesions by

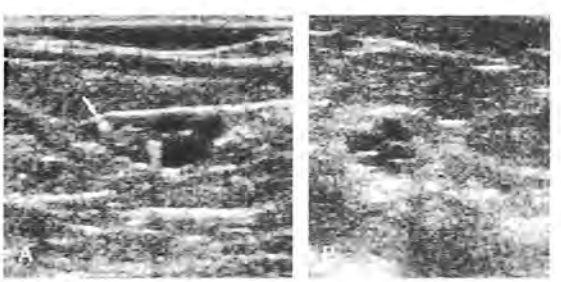

Fig 14. Apocrine metaplasia. (A) Microlobulated masses with microcysts are typical of apocrine metaplasia and may rarely contain calcifications (arrow). (B) Enhancement is sometimes evident. Such lesions can be considered benign or probably benign and followed.[25]

**Table 2. BI-RADS: Ultrasound Final Assessment Categories**

| Assessment Categories and Codes | Recommendations |
|---|---|
| 0—Incomplete | Needs additional imaging evaluation |
| 1—Negative | Routine follow-up for age |
| 2—Benign finding | Routine follow-up for age |
| 3—Probably benign finding | Short-term follow-up (usually in 6 months) |
| 4—Suspicious abnormality | Requires tissue sampling |
| 5—Highly suggestive of malignancy | Requires tissue sampling |

their echogenicity, that is, defined relative to fat or fibroglandular tissue. Some masses, notably fibroadenomas, are similar to fat lobules in shape and echogenicity. Should they be described as "hypoechoic," using fibroglandular tissue as the basis for comparison, just as fat lobules are hypoechoic to fibroglandular tissue, or should they be termed "isoechoic" to fat? Further in need of validation are the categories of thickness of circumscribed margins and the characterization of solid masses by their matrix homogeneity. Many fibroadenomas are heterogeneous and some carcinomas are homogeneous. What is the predictive value of these features, alone or in combination with other features?

## FINAL ASSESSMENT

As with mammography, a BI-RADS final assessment and recommendation should be specified (Table 2). When breast sonography is performed as an adjunct to mammography, one final assessment and management recommendation should be specified, which reflects combined mammographic and sonographic findings. Final assessment and management should be predicated on the basis of the most suspicious feature(s) present.

## SUMMARY

The approach outlined above for describing and reporting sonographic features of breast masses represents only the initial step in the development of a comprehensive system to enhance the accurate identification, reporting, and analysis of sonographic abnormalities of the breast. Future revisions, with validation of interobserver consistency in application of these descriptors across multiple centers, with feedback from potential users in the breast imaging community, will undoubtedly expand the utility of this effort.

## ACKNOWLEDGMENTS

Participating in the development of the standardized breast lexicon were the members of the Expert Working Group to Plan and Develop Protocols for Optimization and Clinical Testing of Breast Ultrasound: Steering Committee—Christopher R. B. Merritt, MD, Chairman, Barry B. Goldberg, MD, Ellen B. Mendelson, MD; Lexicon Subcommittee—Ellen B. Mendelson, MD, chair, Janet K. Baum, MD, Christopher R. B. Merritt, MD, Eva Rubin, MD; Expert Working Group—Janet K. Baum, MD, Lawrence W. Bassett, MD, Paul L. Carson, PhD, David Cosgrove, MD, A. Pat Romilly, MD, Barbara S. Hertzberg, MD, Valerie P. Jackson, MD, Robert R. Kuske, Jr, MD, Helmut Madjar, MD, PhD, Jonathan Ophir, PhD, Steve H. Parker, MD, Catherine W. Piccoli, MD, Eva Rubin, MD, Gordon F. Schwartz, MD, Edward A. Sickles, MD, and Jonathan Sunshine, PhD.

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