12 Ultrasound Criteria to Assess Breast Lesions

Knowledge of normal sonographic anatomy of the breast and ultrasound criteria that differentiate or overlap between the benign and malignant breast masses is one of the most important operator- or examiner-dependent factors in breast ultrasound.

Use of consistent terminology and clear communication of the ultrasound findings are critical in patient management. Many of the descriptors have been validated in several studies, and ACR has developed a lexicon for findings seen by ultrasound. This includes terminology to describe the shape, orientation, margins, echogenicity, homogeneity, posterior acoustic features, boundary zone, and effect on surrounding tissues on the breast lesions/masses.

The internal heterogeneity of breast cancers accounts for multiple findings being present partially, completely, or sometimes even absent. Complete scanning of lesion in two orthogonal planes ensures that no finding is missed.

Shape of Lesion

Ovoid masses with less than three gentle lobulations, in general, are benign, whereas a round shape is not reassuring. A well-differentiated malignancy can appear round, and benign lesions like cysts can also be round. Round complex cysts can be quite challenging to differentiate from a solid lesion (Figs. 12.1, 12.2, and 12.3).

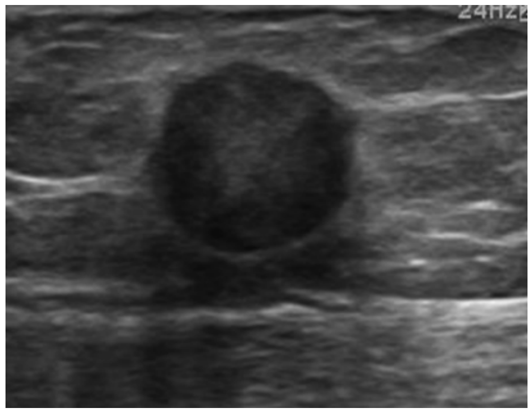

Fig. 12.1 Rounded lesion

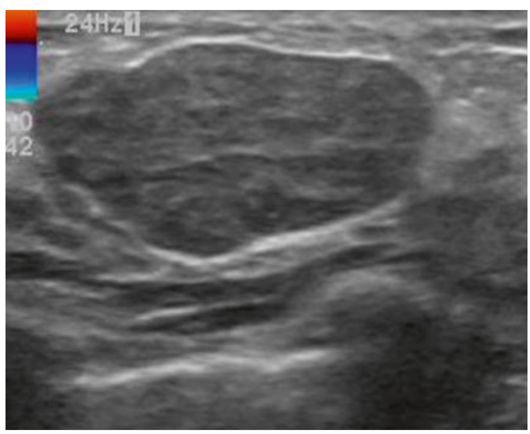

Fig. 12.2 Oval lesion

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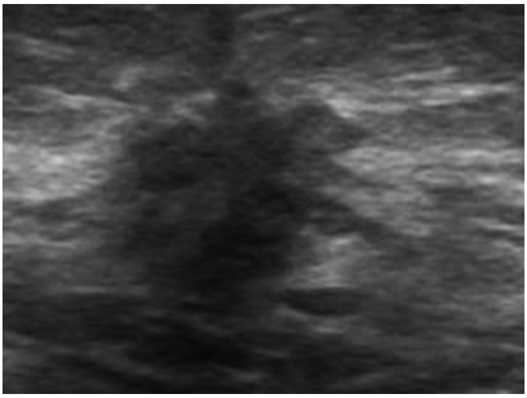


Fig. 12.3 Irregular lesion

Fig. 12.4 Lesion with circumscribed margin

Margins

The lesion should always be scanned in two orthogonal planes for definition of its margin.

Circumscribed Margin

The presence of a well-circumscribed lesion with complete, thin echogenic capsule is indicative of a benign lesion. The echogenic capsule should be demonstrated in its entirety as it is sometimes difficult to see the capsule around the edges of a lesion due to critical angle effect. Heeling and toeing of the probe will demonstrate the completeness of the capsule. Well-differentiated malignancies can also have circumscribed margins, but it may not have

Fig. 12.5 Lesion showing angular margins

complete capsule and they are less likely to be elliptical and or gently lobulated. The combined presence of elliptical or gently lobulated lesion with a complete capsule is indicative of a benign lesion (Fig. 12.4).

Angular Margin

The presence of an angular margin is highly suspicious for a malignancy (Fig. 12.5).

Microlobulated Margin

Microlobulations are small, 1–2-mm lobulations that occur in the periphery of the mass. They may be seen along the entire lesion or in parts. Both invasive and in situ cancers can have microlobulated margins (Fig. 12.6).

Spiculated Margin

Spiculated margin is characteristic of malignant lesions. Spiculations tend to be seen along the lateral edges of the lesion as the spicules are perpendicular to the ultrasound beam. They are less well seen anteriorly and posteriorly because they are parallel to the ultrasound beam. Besides, the posterior acoustic shadowing might also obscure the spiculations (Fig. 12.7).

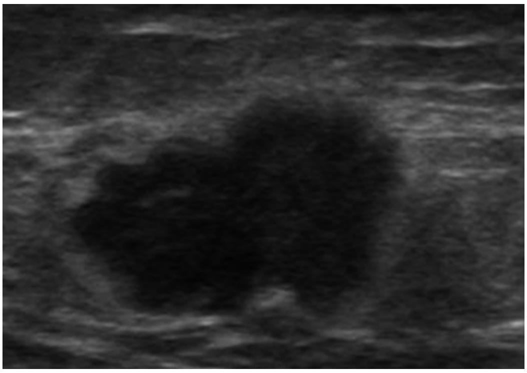


Fig. 12.6 Lesion with micro lobulated margins

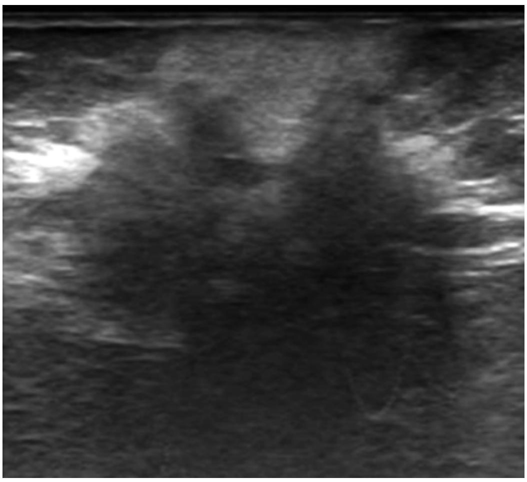


Fig. 12.7 Lesion with spiculated margins

Boundary Zone

An abrupt transition zone between the lesion and the normal tissue is usually benign. An echogenic halo around the lesion is suggestive of malignancy. The thick echogenic halo is usually due to a peritumoral edema or spicules that are too small to be resolved sonographically (Fig. 12.8).

Axial Orientation

The axial orientation of mass in relation to the chest wall should be assessed. Benign lesions grow parallel to the tissue planes and remain within the tissue planes. The long axis of benign lesions are transverse, i.e., "wider than taller" in appearance. Malignant lesions invade and grow against the tissue planes and the long axis is likely to be vertical, i.e., "taller than wider" in appearance (Figs. 12.9 and 12.10).

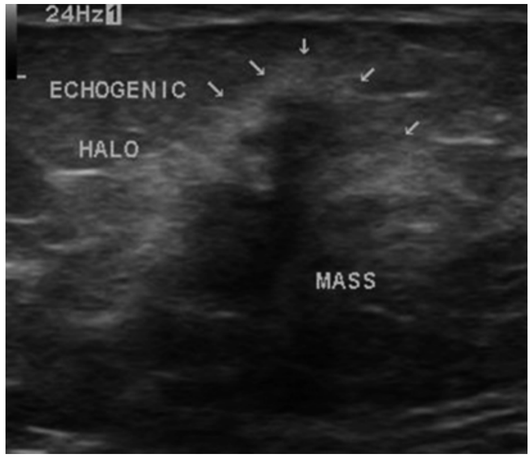


Fig. 12.8 Taller than wide irregular hypoechoic lesion with surrounding echogenic halo in a case of invasive ductal carcinoma. The echogenic halo is more prominent along the lateral aspect of the lesion

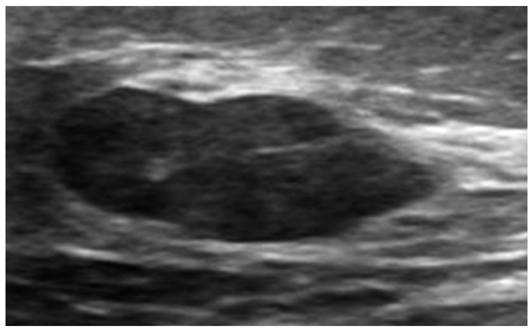


Fig. 12.9 Benign lesion: wider than tall hypoechoic lesion

Echogenicity

The echogenicity of breast lesions should be compared with the echogenicity of fat in the breast. Ultrasound settings should be adjusted such that fat appears medium gray. Gain settings are very important in assessing the echogenicity of the lesion. Incorrect gain settings can make a cyst appear solid and a solid lesion appear like a cyst.

Intensely hyperechoic lesions are benign. They are brighter appearing than the fat (Fig. 12.11).

Isoechoic lesions have an echogenicity similar to that of fat. Lipomas and few fibroadenomas can appear isoechoic (Fig. 12.12). Some malignant lesions can also be isoechoic. Vocal fremitus with power Doppler may help to distinguish an isoechoic abnormal area from normal isoechoic tissue.

Hypoechoic lesions are those that are darker than the fat. Fibroadenomas, complex echogenic cysts, and most carcinomas are hypoechoic (Fig. 12.13). With newer high-end machines, the frequency, bandwidth, and dynamic range have all been increased, which offsets the contrast resolution. This sometimes makes hypoechoic lesions appear isoechoic or mildly hypoechoic.

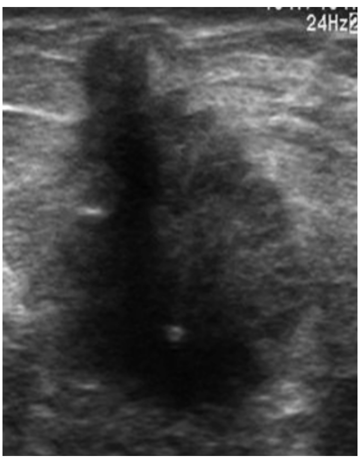


Fig. 12.10 Malignant lesion: taller than wide hypoechoic lesion with irregular margins

Anechoic lesions are usually clear cysts (Fig. 12.14). Sound waves do not penetrate through them and are totally black. They are benign. Sometimes well-differentiated malignancies, medullary carcinomas, and lymphomas have a pseudocystic appearance and appear anechoic. However, Doppler ultrasound on these lesions show increased vascularity which clears the doubts about these lesions being cysts.

Posterior Acoustic Features

The region posterior to the mass may enhance or produce shadows. Sound waves that pass through a fluid-filled cyst lose very little energy to absorption and scattering of acoustic impulse, and the returning signals are brighter than the surrounding tissue resulting in acoustic enhancement posterior to the lesion. Acoustic enhancement occurs in cystic lesions and sometimes in high-grade malignant lesions like mucinous, medullary, and papillary cancers (Figs. 12.15 and 12.16).

Some lesions may not show any posterior feature, i.e., enhancement or shadowing (Fig. 12.17).

Acoustic shadowing is a hard finding and suspicious for malignancy. Intense desmoplastic reaction seen in scirrhous cancers is likely to produce more intense shadowing (Fig. 12.18). Internal heterogeneity of breast cancer sometimes accounts for partial shadowing or no posterior acoustic features.

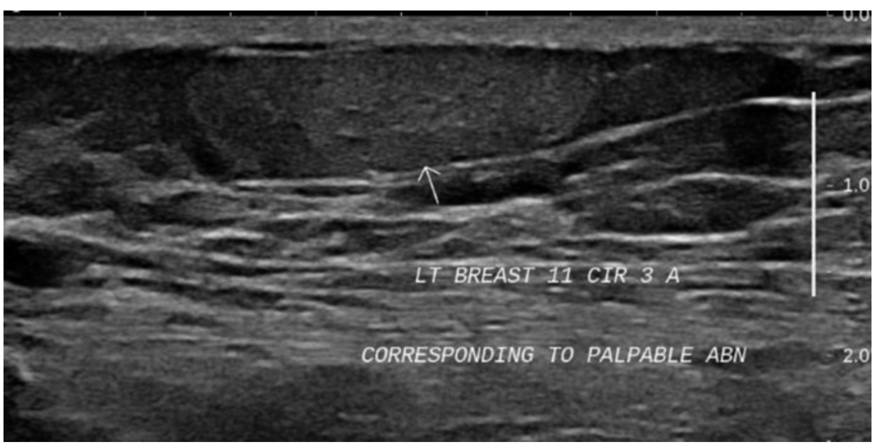


Fig. 12.11 Hyperechoic lesion in the premammary zone suggestive of lipoma

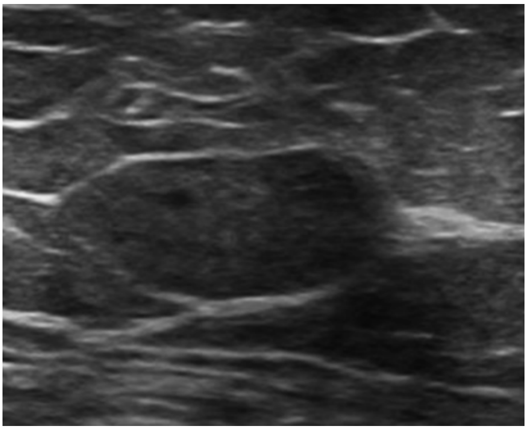


Fig. 12.12 Ovoid isoechoic lesion

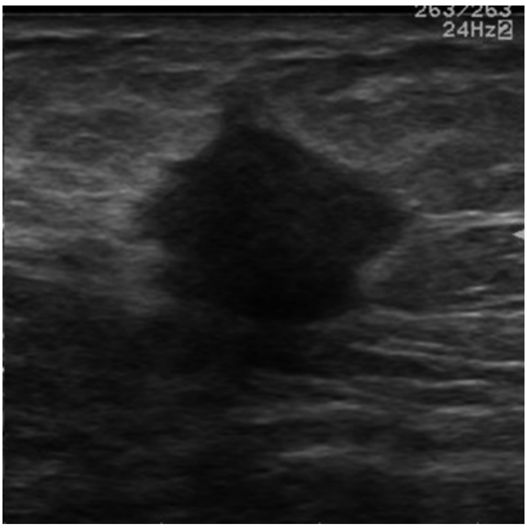


Fig. 12.13 Hypoechoic nonparallel lesion with angular and spiculated margins

Dense shadowing is also found in lesions with coarse calcifications and calcified involuted fibroadenomas (Fig. 12.19).

Edge Shadows

Shadows that arise from the lateral edge of the mass are anechoic bands that extend posteriorly, usually bilateral but sometimes unilateral. They are due to diffraction of sound waves encountering a change in the acoustic impedance. The degree of diffraction is relatively constant at the

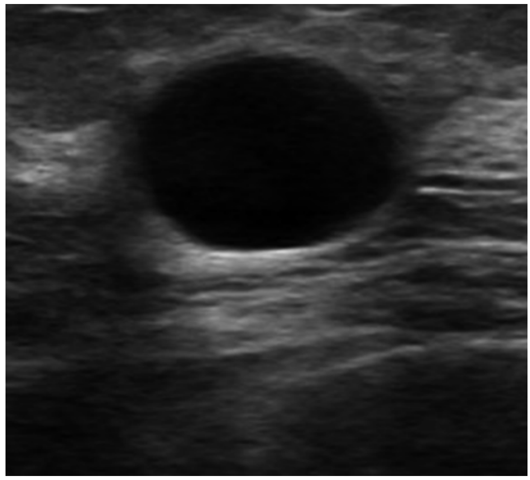


Fig. 12.14 Anechoic lesion suggestive of a simple cyst

Fig. 12.15 Image of a cyst with posterior enhancement

smooth borders of a benign lesion, resulting in the formation of narrow bilateral edge shadows (Fig. 12.20).

Malignant lesion sometimes may show edge shadow, but it is usually thicker and unilateral when compared to edge shadows produced by benign lesions.

Compressibility

The transducer pressure will alter the anteroposterior or mediolateral dimensions of the lesion in a benign lesion which are usually compressible.

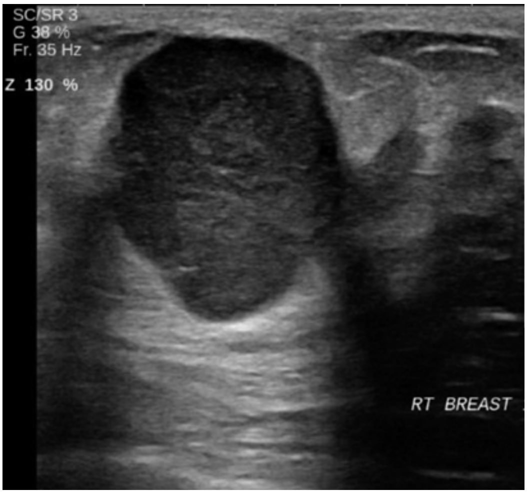


Fig. 12.16 Taller than wider lesion with posterior enhancement and edge shadows

Fig. 12.17 Ovoid hypoechoic lesion without any posterior feature

This can be demonstrated in a split screen image with and without compression in orthogonal planes (Fig. 12.21). Malignant lesions are generally not compressible. Medullary, mucinous, and cellular invasive carcinomas can sometimes be compressible to a smaller degree. It is difficult to assess the compressibility of very small, deep-seated lesions.

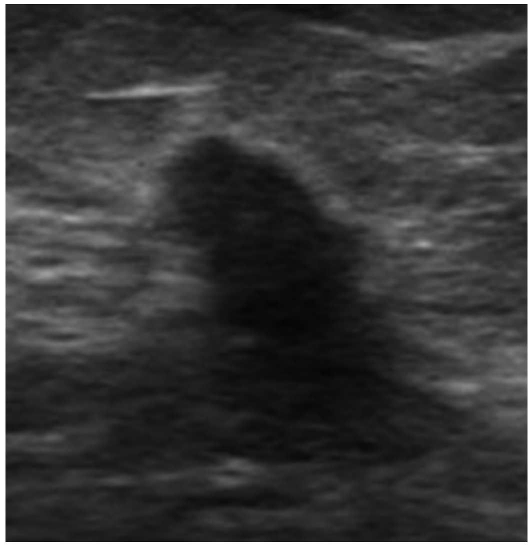


Fig. 12.18 Spiculated nonparallel hypoechoic lesions showing posterior acoustic shadowing

Calcifications

Calcifications are seen as bright specks and are better seen in the background of a tumor mass which is hypoechoic (Fig. 12.22). They are typically associated with DCIS and these are usually and better visible on mammography. They are smaller than the width of the ultrasound beam, and hence, they do not cast an after-shadow. However, coarse, chunky calcifications will be larger than the beam width and therefore may cast dense posterior acoustic shadowing. Benign calcifications are unlikely to be seen on sonography as they are usually present in the background of hyperechoic fibrous or glandular tissue. Large popcorn-type calcifications in an involuted fibroadenoma will be anechoic with very dense acoustic shadowing.

Duct Extension and Branch Pattern

Ductal extension of lesions is best demonstrated when scanned in radial planes in relation to the ducts. Duct extensions are usually associated with DCIS or invasive tumor with a DCIS component (Fig. 12.23). The bulging duct is directed

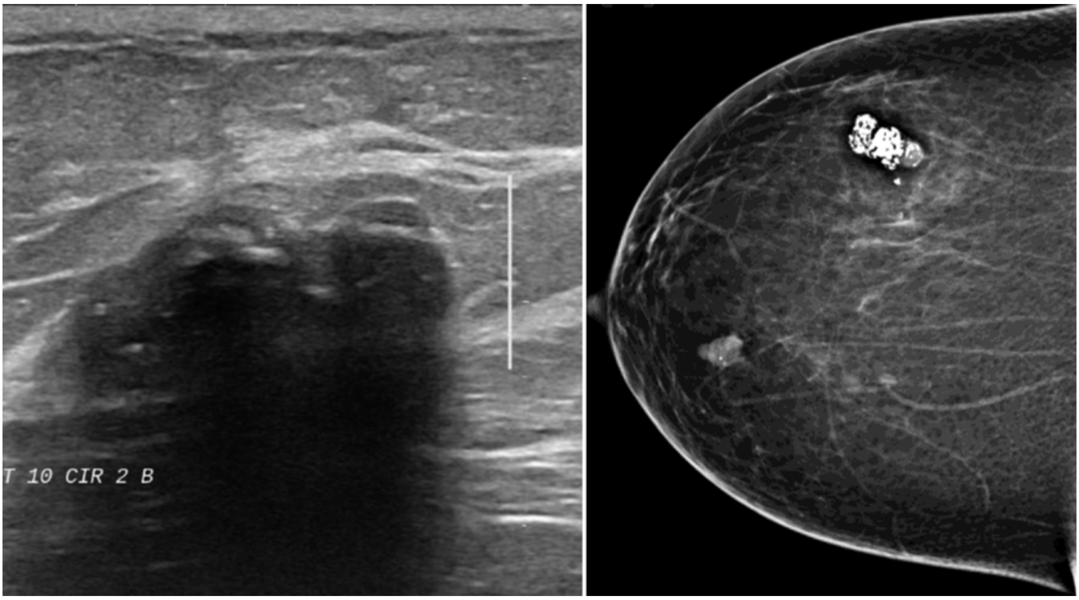
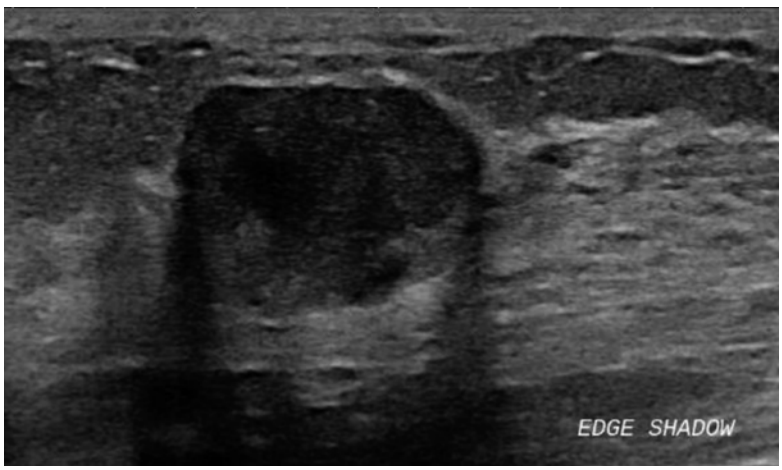


Fig. 12.19 Image of involuting fibroadenoma on ultrasound showing severe shadowing. Correlating with the mammogram is essential for the diagnosis. Corresponding to the area of severe shadowing, there is coarse popcorn-type calcification on mammogram

Fig. 12.20 Benign lesion producing edge shadows



towards the nipple and is usually filled with tumoral component. This is a very important finding to document, as the operating surgeon will have to take this into account to plan the extent of resection to obtain tumor-free margin clearance at surgery.

Branch pattern ducts involve smaller peripheral ducts that lie away from the nipple. Both duct extensions and branch ducts can be seen in benign intraductal papillomas (Fig. 12.24).

Effect on the Surrounding Tissue

Architectural Disruption

Benign lesions are expansile and grow without disrupting the tissue planes. They may displace the tissue places but do not cause disruption. Malignant lesions invade the surrounding structures, altering the echogenicity of the surrounding structures. It may also produce inflammatory

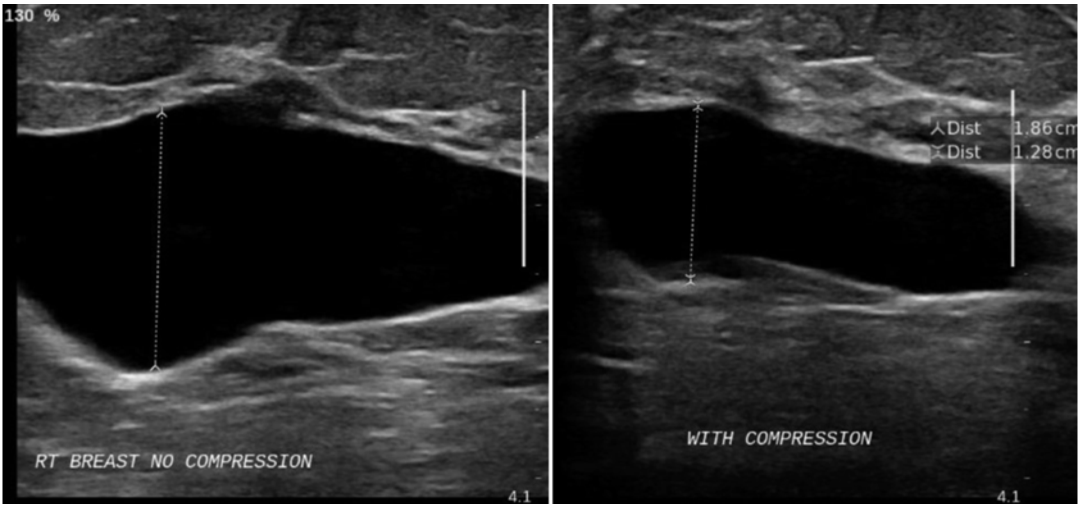


Fig. 12.21 Benign lesions are compressible. The anteroposterior diameter is reduced in benign lesion with compression

Fig. 12.22 Spiculated hypoechoic lesion with echogenic foci (calcifications) within

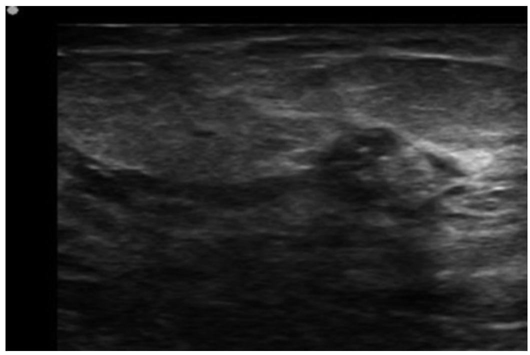


Fig. 12.23 Lesion with heterogeneous echotexture and calcifications within showing a duct extension. The duct is usually filled with DCIS. Mapping the exact extent of this lesion is important to get a clear margin at surgery

reaction or edema around the tumor. Involvement of the Cooper's ligament can result in tethering or retraction of the overlying skin (Fig. 12.25).

Role of Doppler

Tumors form new blood vessels (neoangiogenesis) to grow. The increase in blood flow can be studied with Doppler. Color Doppler, power Doppler, and pulsed Doppler spectral flow analyses are all useful tools in the assessment of breast lesions. Scanning technique is important, as vigorous compression can decrease or cut off the blood flow. The probe should just make contact with the skin without much compression.

There is a considerable overlap of blood flow characteristics in normal, benign, and malignant tissues. The presence of flow, the number of blood vessels per unit area, and the pattern of flow (peripheral or central) could help in differentiating benign from malignant tumors (Fig. 12.26a, b).

Pulsed Doppler criteria include measurements of peak systolic velocity, pulsatility, and

Fig. 12.24 Branch duct pattern is suggestive of smaller peripheral ducts that may be extensions of ductal carcinoma in situ

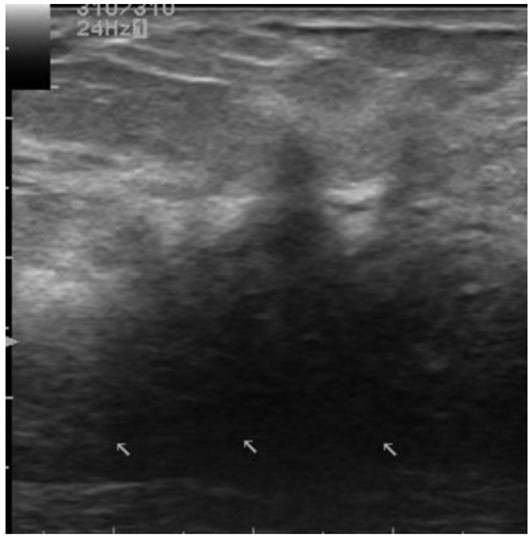


Fig. 12.25 Malignant lesion producing disruption of normal anatomical planes

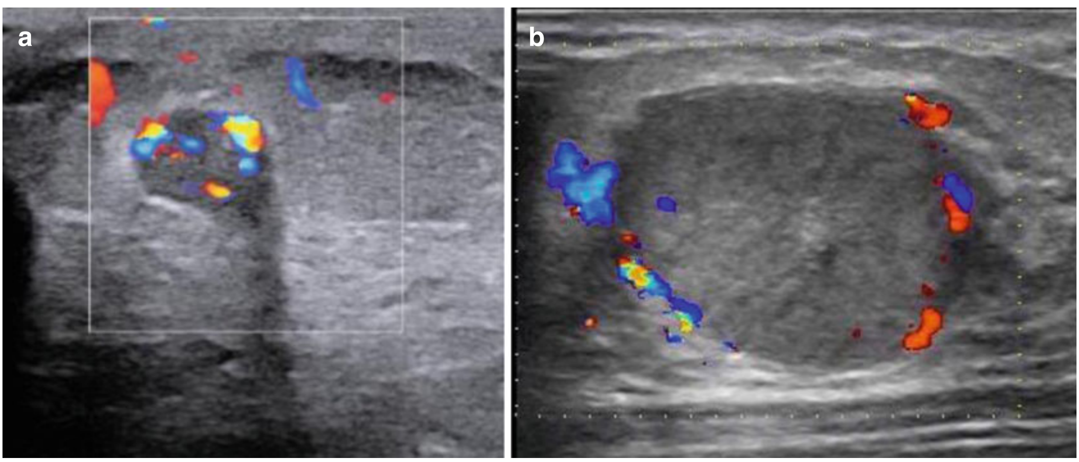


Fig. 12.26 (**a**) Hypoechoic lesion with central vascularity. (**b**) Hypoechoic lesion showing peripheral marginal vascularity

resistivity indices. The peak systolic velocity and resistivity indices are more in the center of the tumor than the periphery in malignant tumors, whereas they are the same in the center and periphery of benign lesions in fibroadenomas.

Doppler examination could also be very useful in determining the aggressiveness of malignant lesions. Low-grade lesions with predominant desmoplasia are paucicellular and are less likely to be very vascular. High-grade lesions are well circumscribed and cellular and they elicit very little desmoplasia, but they are very vascular.

It is a challenge to differentiate scar tissue and fat necrosis from a local recurrence with B-mode findings. The presence of flow indicates the possibility of a local recurrence. Similarly, it is sometimes difficult to differentiate intraductal

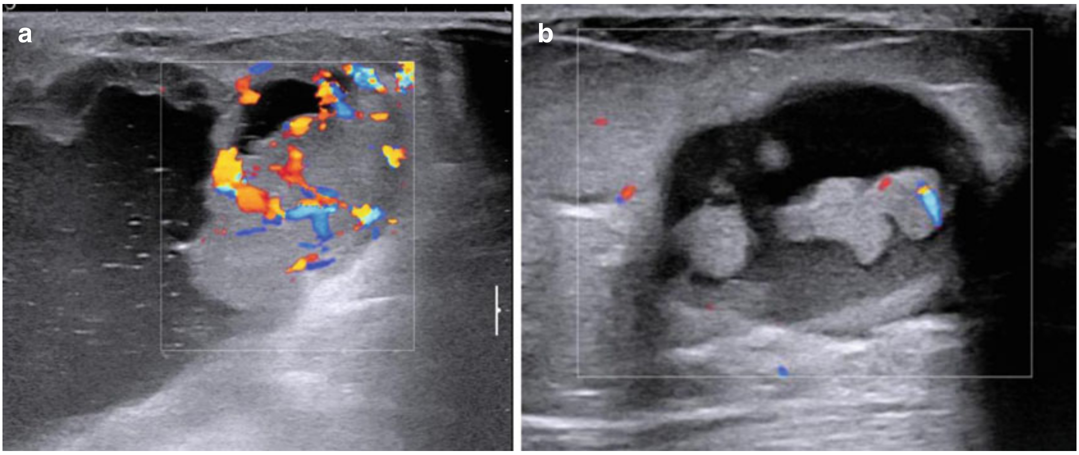


Fig. 12.27 (**a**, **b**) Cyst with solid component. The blood flow within the solid lesion helps to differentiate it from debris within the cyst

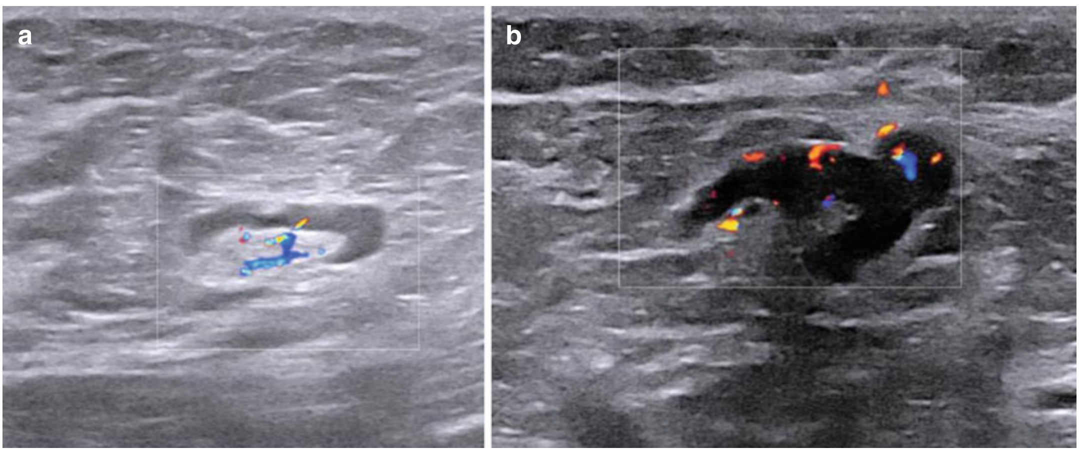


Fig. 12.28 (**a**) Image showing a central hilar flow in a normal lymph node. (**b**) Image showing an irregularly thickened cortex with marginal blood flow. HPE: metastatic lymph node

papilloma from inspissated duct contents. Intracystic and intraductal solid components and debris could pose a similar challenge. The presence of blood flow within the lesion indicates that a papilloma or carcinoma is more likely than debris (Fig. 12.27a, b).

Doppler findings are useful in differentiating a normal lymph node from a metastatic lymph node. The blood flow in and out of normal and reactive lymph nodes is usually through central hilar vessels, but in metastatic nodes there are new marginal vessels in the periphery of the lymph node (Fig. 12.28).

Role of Elastography

Breast elastography is an emerging ancillary tool to characterize focal breast lesions in addition to conventional ultrasonography and mammography. Initial evidence from clinical trials suggest that elastography can improve the ultrasound capability particularly in category 3 and 4a lesions, thus reducing the number of breast biopsies in benign lesions. The standard descriptors of elastography are as follows:

1. Soft
2. Intermediate
3. Hard

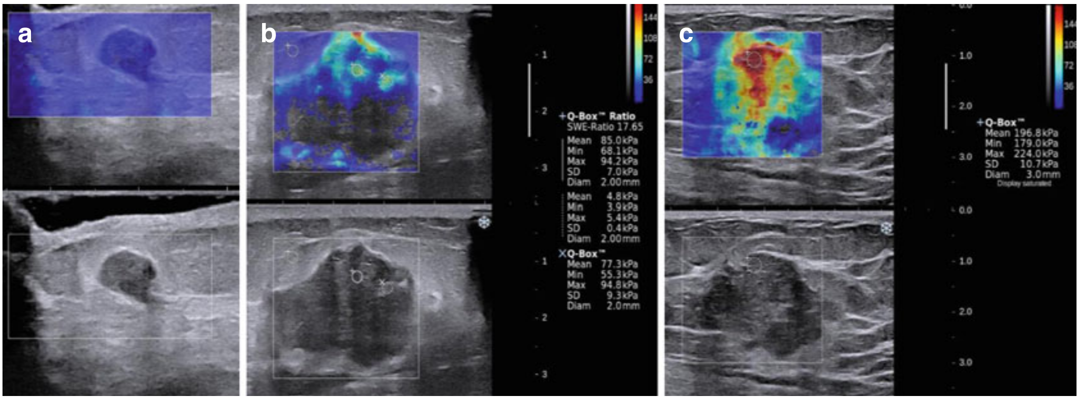


Fig. 12.29 (**a**) Shear-wave elastography showing a soft lesion. HPE: fibroadenoma. (**b**) Shear-wave elastography showing an intermediate lesion. HPE: fibroadenoma. (**c**) Shear-wave elastography showing a hard lesion. HPE: invasive carcinoma

Generally, benign lesions are harder than normal breast tissue but softer than malignant tumors, but there is a considerable overlap as with all other sonographic criteria. Exceptions can occur and some benign lesions, such as hyalinized fibroadenoma and fat necrosis, can cause false positives at elastography examination (Fig. 12.29a).

Cancers with their surrounding tissues are expected to be harder than benign masses (Fig. 12.29b). Softer malignant lesions, including medullary, mucinous, papillary, cystic, and some necrotic infiltrating ductal carcinomas are uncommon (Fig. 12.29c).

The combination of US elastography and color Doppler US can help in differentiating benign from malignant breast lesions with increased accuracy and specificity, thereby helping in deciding biopsy recommendation of lesions identified on B-mode US.

Summary of Sonographic Criteria for Malignant Breast Lesion

Hard Findings

1. Spiculations
2. Thick echogenic halo
3. Angular margins
4. Vertical orientation (taller than wider)
5. Acoustic shadowing

Soft Findings

1. Microlobulations
2. Microcalcifications
3. Ductal extensions
4. Branch pattern ducts

Summary of Sonographic Features of a Benign Breast Lesion

1. Pure hyperechoic lesion
2. Ovoid, wider than taller lesion
3. Complete thin echogenic capsule
4. Less than three gentle lobulations
5. No malignant findings

Algorithm for Sonographic Evaluation of Solid Lesions

Lessons Learned from Dr. Stavros

1. Look for malignant findings. Classify as BI-RADS 4a, 4b, 4c, or 5 and then biopsy.
2. If no malignant findings are seen, look for benign findings.
3. If benign findings are present, follow up in 6 months/biopsy.
4. If no benign findings are seen, classify the lesion as BI-RADS 4a and biopsy.

Suggested Reading

1. Madjar H, Mendelson EB, Jellins J. The practice of breast ultrasound: techniques, findings, differential diagnosis. Chicago: Georg Thieme Verlag: 2008.
2. Sohn C, Blomer J-U, Hamper UM. Breast ultrasound – a systematic approach to technique and image interpretation. New York: Thieme Publishers; 1999.
3. Thomas Stavros A, Rapp CL, Parker SH. Breast ultrasound. Philadelphia: Lippincott, Williams and Wilkins; 2004.