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BI-RADS CLASSIFICATION FOR BREAST ULTRASOUND: A REVIEW

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Abstract
Breast cancer is the most common form of cancer in women worldwide. According to statistics from GLOBOCAN 2020, 1.2 million women are diagnosed with breast cancer each year, and 410,000 (35%) will die from this disease. Breast cancer is the most prevalent type of cancer among women in Indonesia, accounting for 30.8% of all female cancer cases in 2020 and causing 20.4% of female cancer-related deaths in the same year. Breast cancer screening plays a vital role in reducing deaths caused by breast cancer. Various breast cancer imaging techniques have been introduced for diagnosing breast cancer, such as Magnetic Resonance (MR) mammography, Ultrasound, Elastography, Mammography, and Automated Breast Ultrasound (ABUS). Ultrasound (US) and mammography are the two most important modalities for breast imaging. In younger women under the age of 35, ultrasound is the primary tool used to investigate breast problems. Even in the older age group, ultrasound plays a crucial role in breast imaging, particularly for the assessment of mass lesions. Breast ultrasound can be used for both screening and diagnostic purposes. Ultrasound evaluates breast tissue without the use of ionizing radiation or the injection of contrast material and is affordable, readily available, and well-tolerated by patients. The American College of Radiology (ACR) proposed the Breast Imaging Reporting and Data System (BI-RADS) to standardize the characterization of sonographic breast lesions according to five criteria categories: mass shape, orientation, margin, echo pattern, and posterior features.

Keywords: *BI-RADS, Breast Cancer, Ultrasound*

1. INTRODUCTION

Ultrasound is an imaging method based on the application of sound waves, i.e., not radiation but mechanical periodic compression/rarefaction waves of a medium, for producing images of the internal body structures. In particular, this method uses sound waves with frequencies above the upper limit of human hearing (typically ranging from 16 Hz to 20 kHz). Images are obtained by sending pulses of ultrasound waves into the tissues using a probe, which is a transducer capable of transmitting and receiving ultrasound.

The role of ultrasound is significant in defining breast masses in areas that are technically difficult to examine with other imaging methods (e.g., on the margin of medial quadrants near the breastbone, in aberrant mammary lobes). Ultrasound is unique for the analysis of the whole-breast vascularity and vascular pattern of its lesions. Additionally, ultrasound precisely characterizes abnormal lymph nodes. Due to the fact that the ultrasound method is harmless, noninvasive, accessible, and quite effective in diagnosing a wide range of breast conditions, it is often performed without special indications, often for preventive purposes. Breast ultrasound does not demand special preparation of the patient (Evans et al., 2018). The optimum period for examination is the first phase of the menstrual cycle in fertile women.

Ultrasonography should be performed as systematically and technologically accurately as possible (Colan-Georges, 2016). It should be comprehensive, understandable, and reproducible for the clinician. Comfort, painlessness, and quick performance are the main criteria for the patient. The benefits of ultrasound as a screening modality are that it does not use ionizing radiation, is well-tolerated, does not require intravenous contrast administration, and is optimally amenable for percutaneous biopsy guidance. One of the most important advantages of using ultrasound is the avoidance of exposing a patient to X-rays, which is particularly important for pregnant or young patients, as their breasts are more sensitive to ionizing radiation. This means that, in comparison with ultrasound, mammography would be associated with a slight increase in the risk of acquiring radiation-induced neoplasms. Furthermore, young women's breasts tend to appear dense on mammograms, reducing the diagnostic sensitivity of mammography.

Ultrasound is capable of identifying small nonpalpable masses, undeterred by the presence of dense breast tissue, which is an inherent limitation of mammography (Madjar & Mendelson, 2008). More than 90% of cancers identified by sonography are in women with over 50% of dense breast tissue. Breast ultrasound is superior to mammography in the evaluation of breast abscesses, breasts with implants, and male breasts. Additionally, ultrasound is a useful supplemental tool in identifying small cancers with subtle findings on a mammogram.

Breast ultrasound is often performed to assess abnormalities detected through mammography or clinical inspection. Standardization of terminology used to describe breast structures and a uniform system of reports facilitate the work of doctors from various specialties. A comprehensive assessment of findings becomes possible when conclusions about the nature of a lesion result not just from separate symptoms but from their complex interplay (Sencha et al., 2014).

The Breast Imaging Reporting and Data System (BIRADS) was initially introduced by the American College of Radiology in 1992 as a tool designed to standardize breast imaging terminology and assist radiologists in reducing false-positive screening mammograms. BI-RADS categorization is an essential stage in the assessment of breast imaging (mammography, ultrasonography, and MRI) and in drawing conclusions in major clinics across the USA and Europe. It has improved the interpretation of breast pathology and standardized diagnostic and treatment algorithms. BI-RADS categories predict potential risks for detected pathology based on the diagnostic possibilities of mammography and ultrasound in each individual case. The BI-RADS US system significantly differs from the traditional assessment of obtained images.

The accuracy of the terminology of this system is demonstrated by the fact that the same terms are equally applied by both experienced and novice experts and are correctly understood by all specialists. Conclusions drawn from complex examinations involving mammography and ultrasonography are based on the features that most likely indicate a malignant process. The use of standard terms in the examination report allows for a reduction in operator dependency in ultrasound.

The American College of Radiologists (ACR) introduced the BI-RADS Lexicon (5th edition; 2013) to standardize breast imaging terminology, reporting, and assessment. This classification system applies to mammography, ultrasonography, and MRI of the breast. Lesions detected on breast ultrasound are described using descriptors from the ultrasound lexicon. Shape, echotexture, margins, orientation, posterior features, calcifications, and vascularity on color Doppler are effective lexicon descriptors for characterizing breast masses as possibly benign or malignant. They can be used to assign a BI-RADS category. The ultrasound lexicon includes descriptions of the following features: breast tissue composition, breast masses, breast calcifications, associated features, and special cases.

The research objective of this study is to assess the effectiveness of the BI-RADS (Breast Imaging Reporting and Data System) categorization system in enhancing the accuracy and consistency of breast imaging reports, with a particular focus on its impact on the diagnosis and treatment of breast pathology in clinical practice. This evaluation aims to provide insights into how the utilization of standardized terminology and reporting systems, such as BI-RADS, can influence the quality of breast imaging assessments and contribute to improved patient care.

2. RESEARCH METHOD

The research methodology for this study employs a two-pronged approach. First, a retrospective analysis of patient records and imaging reports will be conducted to assess the BI-RADS categorization system's implementation and its influence on diagnostic and treatment outcomes. This analysis will involve data collection from a diverse patient cohort, including details about imaging modalities used, assigned BI-RADS categories, and subsequent treatment decisions.

Additionally, healthcare professionals, such as radiologists, oncologists, and surgeons, will be surveyed and interviewed to gather their perspectives on the BI-RADS system's effectiveness. These qualitative data collection methods will provide valuable insights into how the system is perceived in clinical practice, its strengths, limitations, and suggestions for improvement. This combined quantitative and qualitative approach will offer a comprehensive evaluation of the BI-RADS categorization system's impact on breast imaging accuracy, consistency, and its implications for patient care.

3. RESULT AND DISCUSSION

3.1. Result

Table 1. Breast Ultrasound: Pros and Cons

Advantages	Disadvantages
Identifies small node-negative cancers that are missed by screening mammography	Operator dependent
Better tolerated by the patient, no ionizing radiation, no patient discomfort	Requires longer physician time compared to interpreting mammograms
May be beneficial as a supplemental modality in women with an elevated risk for breast cancer and/or in women with a dense breast	High false-positive rate

Biopsy of a suspicious abnormality is easier to perform than for mammographically identified abnormalities	Mortality rate reduction has not been proven in a randomized clinical trial as has been shown with mammography Lower sensitivity in identifying Ductal Carcinoma In Situ compared with mammography

3.1.1. Sonographic Anatomy of the Breast

The adult female breast is positioned between the second and sixth/seventh ribs. Its lower boundary extends from the sternal border on the inner side to the midaxillary line on the outer side and is enclosed by the layers of superficial and deep chest wall fascia (Ikeda & Miyake, 2016). Approximately two-thirds of the breast is situated in front of the pectoralis major muscle, while the remaining portion is anterior to the serratus anterior muscle. Extending into the axilla, there is a continuation of the upper outer quadrant of the breast, often referred to as the "tail of Spence." (McGuire, 2016)

The composition of the breasts comprises various mixtures of tissue components, and its makeup depends on several factors, including age, hormonal influences, structural changes (congenital, degenerative, or pathologic), and individual characteristics. In young women, breast tissue is primarily composed of parenchyma with minimal fat content. As individuals age, the glandular tissue in the breasts gradually gives way to connective tissue and fat. However, significant individual variability exists, and the breasts of young women who have borne multiple children and breastfed may have a higher fat content, even in young girls, particularly if they have larger breasts.

Conversely, in older women who undergo postmenopausal hormone replacement therapy, there may be an increase in fibro glandular density in their breasts. Consequently, many older women may exhibit mammographically dense breasts, with the density reflecting the predominance of fibrous tissue in their breast composition. This consideration is crucial during breast examinations as it can significantly influence the overall interpretation of clinical, sonographic, and mammographic findings (Madjar & Mendelson, 2008).

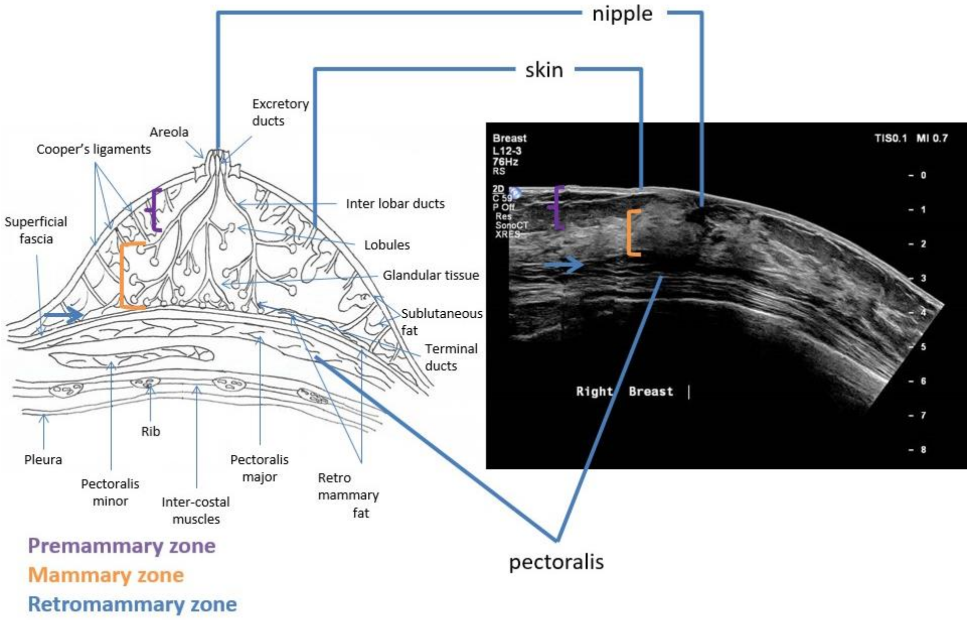


Figure 1. Anatomy of Breast

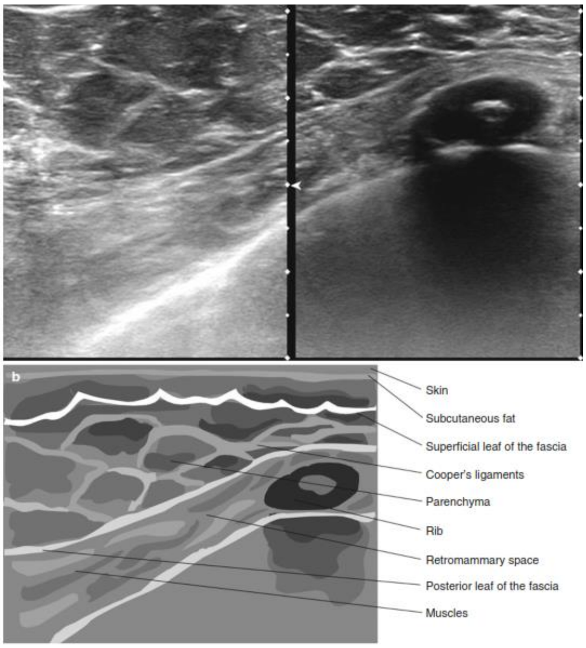


Figure 2. Normal Breast US. (a). Grayscale US. (b). Graphic

Breast structures display various echo characteristics. Echogenicity tissue for breast ultrasound is fat, characterized by low-amplitude echoes. Fat is hypoechoic and on ultrasound images is dark gray. Skin and connective tissue fibers such as Cooper ligaments give rise to high-amplitude echoes. When the scanner is properly adjusted, these echogenic or hyperechoic structures should appear bright on the monitor. Fluid within cysts or ducts is generally anechoic and appears black, although inspissated fluid contains internal echoes. Breast parenchyma is moderately echogenic (compared with fat) and is displayed in varying shades of light gray.

Table 2. Echogenicity of the Various Breast Tissues

Anatomic structure	Echogenicity
Skin	Hyperechoic
Nipple	Hypoechoic
Parenchyma	Hyperechoic
Connective tissue	Hyperechoic
Subcutaneous fat	Hypoechoic
Fatty infiltration	Hypoechoic
Retromammary fat	Hypoechoic
Cooper ligament	Hyperechoic
Lactiferous duct	Anechoic

3.1.2. Breast Tissue Composition

Ultrasound has the capability to depict the numerous variations in breast tissue composition, similar to mammography and MRI. In accordance with the BI-RADS fifth edition for mammography, which loosely correlates with the three densities, there are three ultrasound categories: homogeneous echotexture—fat, homogeneous echotexture—fibro glandular, and heterogeneous background echotexture (Mendelson et al., 2013).

A. Homogeneous Echotexture – Fat

Figure 3. Ultrasound (panoramic view) of the right breast in a postmenopausal woman showing homogeneous fatty parenchyma (blue arrows) and changes relating to breast involution with atrophy of the glandular mammary zone (yellow arrow)

B. Homogeneous Echotexture-Fibro Glandular

Figure 4. Normal breast ultrasound in a woman aged 34 years with normal fibro glandular tissue. Note homogeneous glandular parenchyma (blue arrow), pre-mammary zone (yellow arrow), mammary zone (green arrow), retromammary zone (pink arrow), and pectoralis muscle (orange arrow)

C. Heterogeneous Echotexture

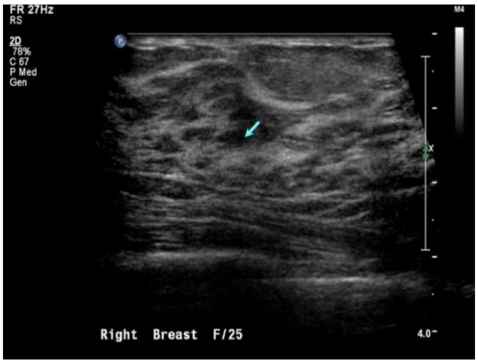


Figure 5. Normal breast ultrasound in a woman aged 25 years with prominent heterogeneous fibro glandular tissue (blue arrow)

3.1.3. Breast Masses

A mass possesses three dimensions and occupies space. It should be discernible in two planes on two-dimensional imaging and in three planes with volumetric acquisitions. Employing multiple sonographic descriptors when characterizing a mass enhances specificity and diagnostic confidence. The three most crucial feature categories, considered together for the assessment of malignancy likelihood, encompass shape, orientation, and margin. Additional feature categories, including echo pattern, posterior features, and architectural distortion (incorporated within associated features), can aid in the evaluation of a mass.

A. Shapes

Mass shapes are categorized as oval, round, or irregular. An oval shape is applied to a mass that is elliptical and exhibits mild lobulation with up to three undulations. A round mass is spherical, ball-shaped, circular, or globular. Round is the least common shape, and for a mass to be termed round on ultrasound, it must appear circular in perpendicular projections. By definition, a mass that is neither round nor oval is deemed irregular.

- Round: A round lesion with well-defined margins is more likely to be benign, whereas a round lesion with unclear margins is more likely to be malignant.
- Oval: An oval lesion is elliptical, wider than tall, and may exhibit 2–3 lobulations. Evaluating the margins and echotexture of an oval lesion is crucial for categorizing the mass as potentially benign or malignant.
- Irregular: An irregular shape suggests a higher probability of the lesion being malignant. Nevertheless, irregular shape can also result from infection, abscess, inflammation, or breast trauma. Surgical scarring and biopsies can similarly yield irregular margins.

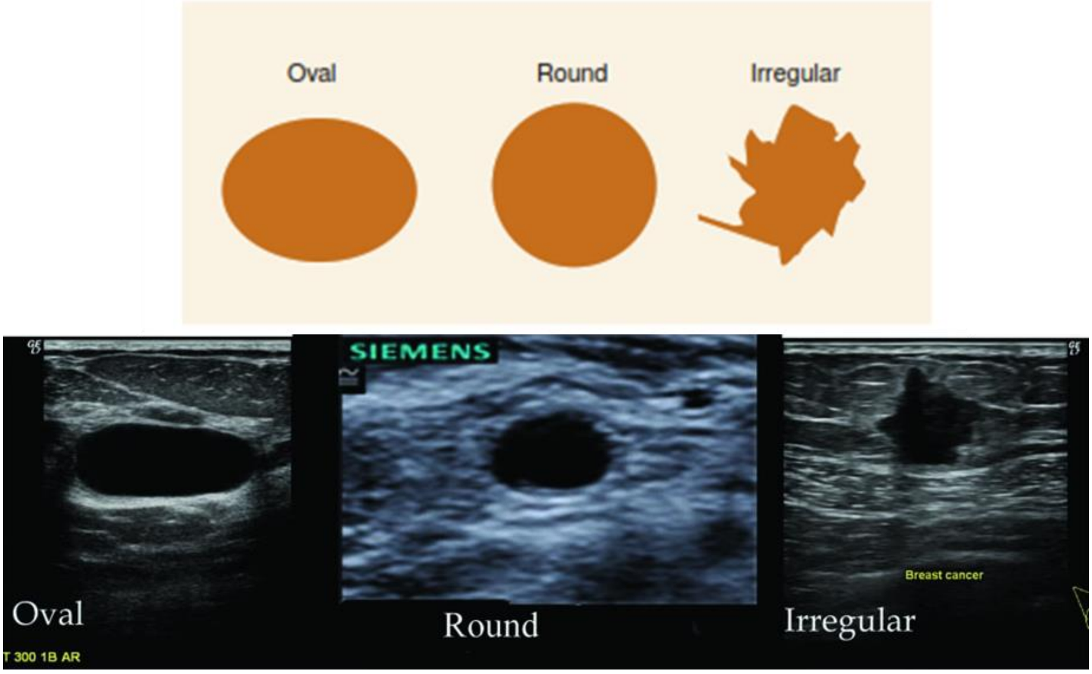


Figure 6. Three Mass Shapes in Ultrasound

B. Orientation

The orientation of a mass is categorized as parallel or not parallel. Benign breast masses are commonly oriented with their long axis parallel to the breast skin. A non-parallel orientation suggests a high likelihood of malignancy.

- Parallel or “wider-than-tall” or “horizontal” orientation is a property of most benign masses, notably fibroadenomas.
- Not Parallel: 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. (Mendelson et al., 2013)

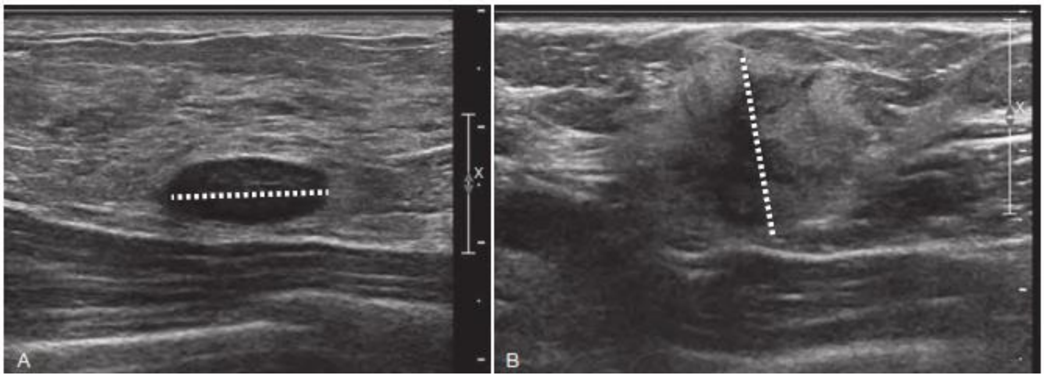


Figure 7. Mass Orientation: Parallel and Not Parallel

C. Margin

Margin is the edge or border of the lesion and is an important predictor of the likelihood of malignancy of a mass. Margins are circumscribed or not circumscribed.

- Circumscribed margin is one that is well defined or sharp, with an abrupt transition between the lesion and the surrounding tissue.
- Not circumscribed includes *indistinct*, *angular*, *microlobulated*, and *spiculated*. Indistinct margin means there is no clear demarcation between any portion of the mass and surrounding tissue. The boundary is poorly defined and includes masses such as some cancers and abscesses with an echogenic rim, which is historically called an "echogenic halo".

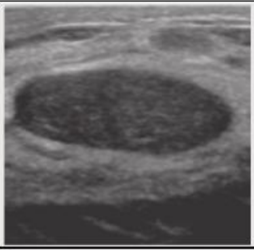
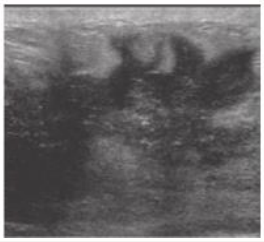
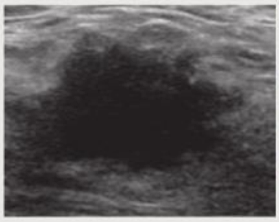
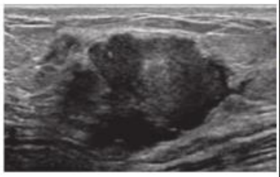
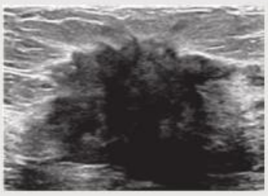
Circumscribed		The margins of this mass are clearly demarcated and can be traced by a thin pen. Additional features: Oval, hypoechoic, parallel, no posterior features.
Angular		The margins form sharp angles. Presence of angular margins is a sensitive and reliable feature of malignancy. Additional features: Irregular, hypoechoic, antiparallel containing calcifications within the mass.
Indistinct		The margins are not clearly demarcated; rather there is an ill-defined appearance of the margins. In cancers, the indistinct margins are due to infiltration of the surrounding tissue by tumor. Additional features: Irregular shape, hypoechoic, antiparallel orientation and posterior shadowing.
Microlobulated		This feature is similar to mammography. Increasing number of lobulations (more than 2-3) increases the risk of malignancy.
Spiculated		Straight lines that extend perpendicular from the surface of the mass. It has the highest positive predictive value for malignancy. It is a representation of the desmoplastic reaction and infiltrating tumor cells.

Figure 8. Ultrasound Mass Margin

D. Echo Pattern

The internal echo pattern is described as anechoic, hyperechoic, complex cystic and solid, hypoechoic, isoechoic (equal), or heterogeneous. The echogenicity of a mass is defined relative to subcutaneous fat. An anechoic mass exhibits no internal echoes and appears black inside. Hyperechoic, isoechoic, and hypoechoic masses are characterized by increased, equal, and decreased echogenicity, respectively, in comparison to subcutaneous fat. A complex cystic and solid mass comprises both an anechoic cystic area and echogenic solid components, such as an intracystic papilloma. Heterogeneous echotexture describes a mixture of echogenic patterns within a solid mass. In most cases, both benign and malignant masses exhibit hypoechoic echogenicity relative to subcutaneous fat.

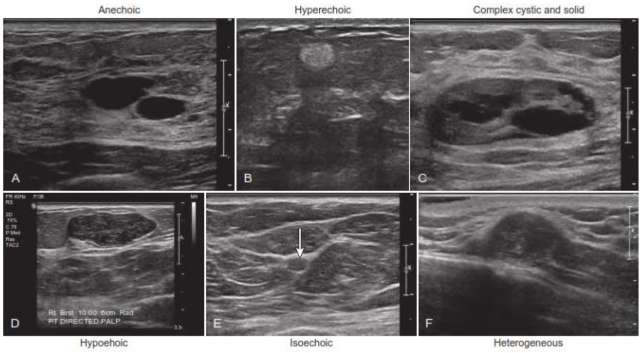


Figure 9. Echo Pattern

Generally, echogenic masses tend to be benign, although the final assessment should also consider margin descriptors.

- Anechoic: Denotes the absence of internal echoes. The structure is fluid-filled and transmits sound well.
- Hyperechoic: Indicates increased echogenicity, with the mass reflecting sound more intensely than fat or equivalent to fibro glandular tissue.
- Complex Mass: Comprises both sonolucent or anechoic and echogenic or hyperechoic components.
- Hypoechoic: Characterized by low-level echoes, with sound reflection of lower intensity, appearing darker than fat or surrounding tissues.
- Isoechoic: Exhibits the same echogenicity as, or is very close to, the normal echogenicity of surrounding breast fat.

E. Posterior Echo

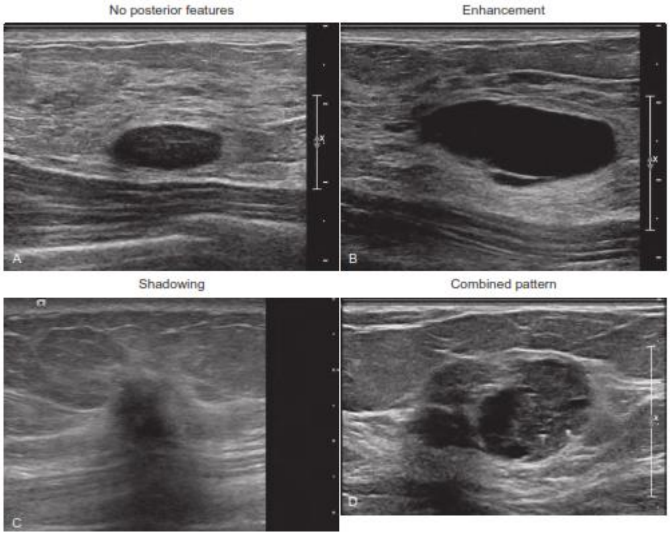


Figure 10. Posterior Echo

Posterior features represent the attenuation characteristics of a mass in terms of its acoustic transmission. Posterior acoustic features are described as having no posterior acoustic features, enhancement, shadowing, or a combined pattern.

- No Posterior Acoustic Features: This indicates that there is no enhancement or shadowing deep to the mass. It implies that the echogenicity of the area just behind the mass is not different from that of adjacent tissues at the same depth.
- Enhancement: Enhancement manifests as a column deep to the mass that appears more echogenic (whiter) than the adjacent tissue. Posterior enhancement occurs when the sound beam is not attenuated by the mass. Posterior acoustic enhancement is one criterion for diagnosing a simple cyst, but it should be noted that enhancement is not always a benign characteristic. Although many benign masses, such as fibroadenomas, may enhance or show no change in posterior features, some high-grade carcinomas may also exhibit enhancement.
- Shadowing: Shadowing occurs when there is an attenuation of sound beams, and it appears as an area posterior to the mass that is hypoechoic (darker) compared to the adjacent tissue. Acoustic shadowing can be caused by fibrosis, which may occur with cancer, as desmoplasia, but it is also observed with certain benign conditions, such as postsurgical scars or diabetic mastopathy.
- Combined Pattern: The combined pattern is observed when there is more than one pattern of posterior attenuation. Although not commonly seen, it may be present with lesions that are evolving, like a *post-lumpectomy* seroma, where posterior shadowing is seen with developing fibrosis.

3.1.4. Breast Calcifications

Calcifications are generally poorly characterized by sonography but can occasionally be identified, especially within a mass. They may vary in size, appearing either large or small, round or amorphous, irregular or indistinct in shape, punctuate or smooth, or clustered or linear. Calcifications can also be situated within vessels, such as small arteries that have calcified. The location of calcifications can be segmental, regional, or diffuse.

A. Macrocalcifications: These are calcifications that measure greater than or equal to 0.5 mm in size.
B. Microcalcifications: Often, microcalcifications are too small, typically less than 0.5 mm in size, to produce shadowing.

Figure 11. Macrocalcification and Microcalcification in Ultrasound

3.1.5. Associated Features

Associated features on breast ultrasound are additional findings used to differentiate between a probably benign lesion and a suspected malignant mass. The associated features that need to be considered are architectural distortion, edema, duct changes, skin changes, and vascularity.9.

A. **Architectural Distortion**: Architectural distortion is the most crucial among the associated features. When interpreting breast ultrasound images, it is essential to first examine the area surrounding a mass to determine if the lesion has affected the tissue around it. Architectural distortion presents as the disruption or blurring of normal anatomic planes. A mass causing this distortion may or may not be present. When architectural distortion is not a result of postsurgical changes, it raises suspicion for malignancy or radial scar and should be subjected to biopsy.
B. **Abnormal Duct Changes**: Abnormal duct changes encompass duct ectasia, cystic ductal dilatation, abnormal arborization patterns such as beading, extension of ducts to or from a suspicious mass, or the presence of intraductal masses like papilloma, thrombus, or detritus.
C. **Skin Changes**: Skin changes include skin thickening and skin retraction. Skin thickening may refer to focally or diffusely thickened skin (>2 mm), as observed in inflammatory processes, abscesses, and inflammatory carcinoma. Skin retraction is characterized by a concave or ill-defined skin surface. The causes of skin retraction include breast cancer, granular cell tumors, and scars.
D. **Breast Edema**: Breast edema often accompanies skin thickening in conditions like inflammatory breast cancer, mastitis, and systemic disorders such as congestive heart failure. It is indicated by increased echogenicity of the surrounding tissue and reticulation, which is an angular network of hypoechoic lines representing dilated lymphatics or interstitial fluid.
E. **Vascularity**: Vascularity is classified as absent, internal vascularity, and vessels in the rim.
F. **Elasticity Assessment**: Elasticity assessment is categorized as soft, intermediate, and hard. Some additional elastographic features recently described include a larger area of involvement of the elastography pattern compared to the grayscale lesion size.

3.1.6. Special Cases

Special cases include simple cyst, clustered microcysts, complicated cyst, mass in or on skin, foreign body, including implants; lymph nodes, intramammary and axillary, vascular abnormalities (arteriovenous malformation and Mondor disease), postsurgical fluid collection and fat necrosis.

Table 3. ACR BI-RADS: Ultrasound Lexicon Classification Form

Table 7.1. 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**		

3.2. Discussion

A comprehensive ultrasound report should succinctly summarize the relevant ultrasound findings and provide a final assessment using BI-RADS US categories 1–6, along with the corresponding phrases. When an ultrasound examination is combined with a concurrently performed mammography examination, the final assessment should reflect the highest likelihood of malignancy as assessed by both examinations. To ensure clear and consistent communication in breast ultrasound reporting, it is essential to employ the same assessment categories and similar wording as described in the BI-RADS Mammography section.

In certain scenarios, the interpreting physician may issue an incomplete assessment (category 0) to request additional examinations, such as mammography, a comparison with previously unavailable studies, or additional physician-performed real-time scanning following a sonographer-produced, real-time, or automated whole-breast screening ultrasound examination. This approach enhances the accuracy and completeness of breast ultrasound reporting and aids in guiding further clinical management decisions.

3.2.1. Examination Technique

A. Patient Positioning

The patient is generally studied in a supine or slightly oblique position, with the ipsilateral arm comfortably elevated. The supine position causes the breast to flatten on the chest wall, and elevating the arms places tension on the pectoralis muscles, further helping to flatten and immobilize the breast. This facilitates a complete, systematic examination and enhances the reproducibility of findings. The flattening of the breast reduces the thickness of the tissue to be traversed by the acoustic beam, allowing for higher frequencies to be used and resulting in better spatial resolution in the area to be scanned. Also, the reduced tissue thickness and flattening of breast structures improve sound penetration, reducing the likelihood of troublesome acoustic shadows due to refraction effects (Allan et al., 2011).

For lesions in the lateral breast, or for large-breasted women, positioning the patient in a supine-oblique position with a pillow or firm wedge beneath her back and shoulder on the side to be scanned is also effective in minimizing the tissue thickness. The breast is additionally stabilized as the patient’s arm is raised, bent at the elbow, and hand placed behind her neck. The aim is to flatten the breast tissue against the chest wall, reducing the thickness of breast tissue to be imaged. It is best to scan in two planes at 90° to each other. Many operators scan the breast in a longitudinal and transverse direction. Scanning the breast in a radial direction is advocated by some operators, potentially allowing better demonstration of the duct system and ductal pathology. This involves moving the transducer in a direction similar to the pattern of the spokes of a bicycle wheel. The breast is then again imaged at 90° in an anti-radial direction (Ng et al., 2013).

If a palpable mass cannot be located in the supine or supine-oblique position, ask the patient in what position she can most easily feel the mass. Ultrasound can be done with the subject in any position, standing, seated, or reclining and moving the patient to a sitting position may enable the examiner to locate the lesion, stabilize it between two fingers, and place the probe directly over it. When a patient not in the supine or supine-oblique position is scanned, the patient’s position should be labeled on the electronic image or film for reproducibility or follow-up. Although ultrasound characterization of a palpable mass, particularly in the upper breast, may be facilitated in an upright patient, it is difficult to conduct a systematic breast survey in the sitting position, because the breast is freely mobile and has a larger volume, and the lower breast is inaccessible.

B. Scanning Technique

Technical Aspects of Breast Ultrasound Breast sonography is performed with a high-frequency linear array transducer operating at a center frequency of at least 10 MHz, with electronic adjustment of the focal zone. The highest frequency that is capable of satisfactory penetration to the depth of interest is desirable to obtain the best resolution; for very superficial lesions or lesions suspected to be in the dermis, standoff gel pad or a blob of gel and/or use of small hockey stick transducers is helpful. In special circumstances such as in deep lesions in large breasts or when a large abnormality is being assessed, lower-frequency transducers that allow better penetration can be used (Shetty, 2021).

The transducer should be held firmly with gentle pressure applied on the breast. An adequate amount of coupling gel should be used to avoid interference of the interposed air. The transducer should be held at the base, and the examiner’s forearm should rest lightly on the patient’s torso. The transducer should be moved with the wrist, not with the entire arm.

Table 4. Examination Technique for Breast Ultrasound

Standard scan planes for breast ultrasound
Sagittal scan
Transverse scan
Radial and anti-radial scan
Parasternal sagittal scan (internal thoracic artery)
Parasternal transverse scan (intercostal)
Transverse axillary scan (axillary vein)
Sagittal axillary scan (thoracodorsal artery and vein)

C. Indication

- Evaluation and characterization of palpable breast masses and other breast related signs and symptoms.
- Additional evaluation of abnormal findings seen on a mammogram or a breast MRI.
- Imaging modality of choice in women under the age of 30 years or those who are pregnant or lactating. Given the low incidence of breast cancer and to minimize exposure of the breast glandular tissue to diagnostic radiation.
- Evaluation of breast implants.
- For guidance of breast interventional procedures.
- Treatment planning for radiotherapy.
- Supplemental screening for occult breast cancer in defined population of women in whom MRI is not an option due to a contraindication or lack of access. These include women who are newly diagnosed with breast cancer or those who have a dense breast and are in addition at an elevated risk for breast cancer.
- To detect a mass associated with architectural distortion or suspicious microcalcifications when surrounded by dense glandular tissue.
- Assessment and biopsy guidance of abnormal axillary nodes such as in patients diagnosed with breast cancer.

4. CONCLUSION

Breast cancer is the leading cause of cancer-related deaths among females worldwide. Access to adequate breast cancer detection through imaging is the crucial first step in the diagnostic pathway to reduce mortality from this disease. Breast ultrasound is not only one of the major tools for imaging breast tissue but also an important method for breast tumor screening. It is non-radiative, non-invasive, harmless, simple, and cost-effective for screening.

The imaging approach for evaluating breast lesions was standardized with the introduction of the Breast Imaging Reporting and Data System (BI-RADS), developed by the American College of Radiology (ACR) in 1992. This systematization serves as a data control system that provides a lexicon for describing lesions. BI-RADS has three primary objectives: 1. Standardizing breast imaging interpretation terminology (the BI-RADS lexicon), final assessments (the BI-RADS categories), and management recommendations. 2. Reducing confusion and enhancing communication among radiologists, referring physicians, and patients. 3. Facilitating outcomes tracking and ensuring quality assurance.

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