Chapter 7
Sonographic Based Imaging: Ultrasound, Color Doppler, Elastography, and Automated Breast Imaging

Juliana Hiraoka Catani

Abbreviations

ABUS	Automated breast ultrasound
HHUS	Handheld ultrasound
MRI	Magnetic resonance imaging
ROI	Region of interest
SE	Strain elastography
SWE	Shear wave elastography
US	Ultrasound

7.1 Introduction

Ultrasound (US) is an interactive, dynamic, and real-time method that has become an indispensable resource for breast assessment, both together and complementary to mammography and magnetic resonance imaging (MRI). In the past, only mammography has been useful for population-based screening. However, high-resolution and quality-controlled ultrasound can further improve early cancer detection.

US has been used to classify benign, solid lesions with a negative predictive value of 99.5% [1].

US advantages include:

(a) No exposure to radiation and its related risks

J. H. Catani (✉)
Instituto de Radiologia INRAD, Hospital das Clinicas HCFMUSP, Faculdade de Medicina, Universidade de Sao Paulo, São Paulo, SP, Brazil
e-mail: juliana.catani@hc.fm.usp.br

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(b) No tissue injury from US waves
(c) No contraindications

Ease of use and real-time imaging capability make breast ultrasound a method of choice for guiding breast biopsies and other interventions.

The limitations include:

(a) Inability to identify and characterize calcifications.
(b) Diagnostic performance is operator dependent.
(c) Large, mobile breasts will be difficult to scan thoroughly.

Currently accepted clinical indications include palpable lump; axillary adenopathy; first diagnostic approach for clinical abnormalities under 40 and in pregnant or lactating women; suspicious abnormalities at mammography or MRI; nipple discharge; recent nipple inversion; skin retraction; breast inflammation; surgical scar abnormalities; abnormalities in the presence of breast implants; screening high-risk women and locoregional staging of a known breast cancer when MRI is not performed; guidance for percutaneous interventions; and monitoring breast cancer neoadjuvant therapy. US can also be used as an adjunctive modality for breast cancer screening in women with dense breast tissue and negative mammography.

The ultrasound device emits and receives high-frequency electromechanical waves (ultrasound) that are generated by the piezoelectric crystals contained in the transducer. According to the impedance of each tissue, images in gray scale (B mode) are generated.

For the examination, proper positioning is essential, aiming at reducing breast thickness and mobility.

7.2 Scanning Technique

For positioning, the patient should lie down in the supine position with the chest undressed and with arms relaxed and flexed behind the head to flatten the breast. It might be necessary to roll the patient slightly to access the breast evenly.

The scan with the transducer should be done in at least two orthogonal planes, including the peripheral regions of the breasts and lymphatic drainage pathways. As the lactiferous ducts are arranged radially in the nipple, and the lesions tend to grow along the ducts, the radial scan is favored by being anatomically guided (Figs. 7.1 and 7.2).

Medial structures should generally be scanned in the supine position, and lateral structures including the armpit should generally be scanned with the patient in the contralateral oblique position. This allows for the elimination of possible artifacts secondary to inadequate compression of the breast tissue.

7.2.1 The Ideal Image

When examining the breast, a 12- to 18-MHz multifrequency linear transducer is commonly used (a minimum frequency of 10 MHz is required) [2, 3] and provides

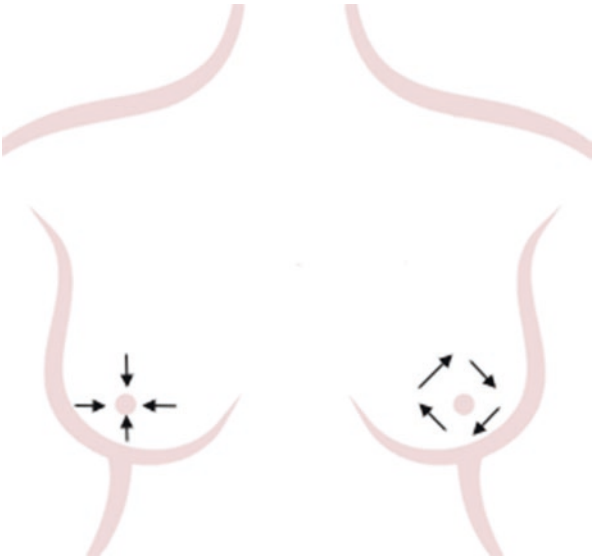

Fig. 7.1 Radial and anti-radial scanning

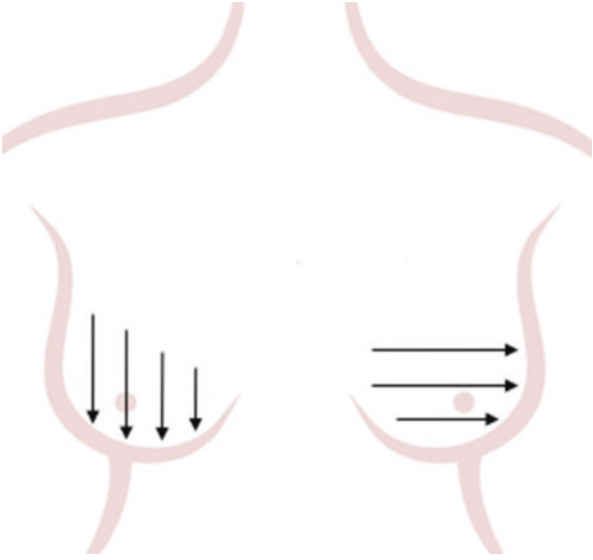

Fig. 7.2 Longitudinal and transverse scan

excellent spatial and soft tissue resolution, allowing for substantially improved differentiation of subtle shades of gray, margin resolution, and conspicuousness of the lesion at the bottom of normal breast tissue [2, 4–8].

The initial gain settings must be adjusted so that the fat at all levels is displayed as medium level gray (calibrated by the superficial fat to the breast area).

The echogenicity of the structures is determined by comparison with the echogenicity of the fat. In comparison with breast fat, most solid masses are hypoechoic and simple cysts anechoic, while skin, Cooper's ligaments, and fibrous tissue are echogenic.

Gentle pressure should be applied to the transducer during the examination. The smaller the thickness of the tissue, the higher the image resolution. The increase in pressure can have a beneficial effect on the acquired image, which can reduce artifactual shadows, as well as making it difficult to evaluate compressible structures (ducts and vessels).

7.2.2 Anatomy

The region of interest in the breast comprises the portion from the skin surface (a) and subcutaneous tissue (b) to the pleural surface/posterior chest wall (Fig. 7.3).

The areolopapillary complex is formed by the areola, papilla, and lactiferous ducts.

The mammary zone (c) is formed by glandular and adipose tissue and Cooper's ligaments, where most of the breast ducts and lobules are located, and therefore the main area of breast diseases.

The retromammary zone (d) is formed by retromammary fat, pectoral muscle, ribs, and pleural surface.

The axillary region is the pyramidal space inferior to the glenohumeral joint, at the junction between the arm and thorax, and contains many neurovascular structures, including the axillary artery, axillary vein, brachial plexus, and lymph nodes.

The anatomical repair used to classify lymph node levels in the axilla is the pectoralis minor muscle (highlighted in red in Fig. 7.4), being:

- Level I: lateral to the pectoralis minor muscle
- Level II: between the medial and lateral borders of the pectoralis minor muscle
- Level III: medial to the pectoralis minor muscle

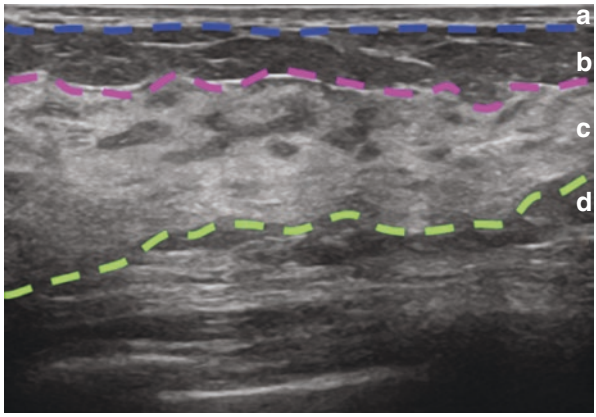

Fig. 7.3 (**a**) – Skin surface. (**b**) – Subcutaneous tissue. (**c**) – Mammary zone. (**d**) – Retromammary zone

7.2.3 *Harmonic*

The harmonic image can also be applied to better characterize a cyst or a subtle solid mass. The generation of harmonic images allows the higher harmonic waves to be selected and used to create the grayscale images with fewer artifacts [9].

Low-frequency surface reverberation echoes are thus reduced, allowing better characterization of simple cysts (particularly if small) by eliminating artificial internal echoes often seen in fluids (Fig. 7.5).

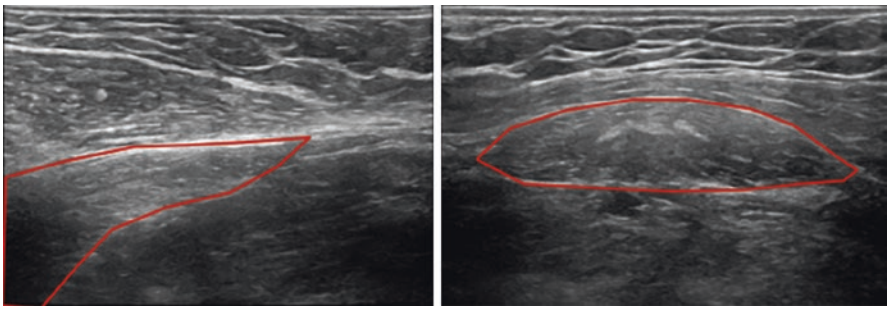

Fig. 7.4 Pectoralis minor muscle (highlighted in red, left axilla)

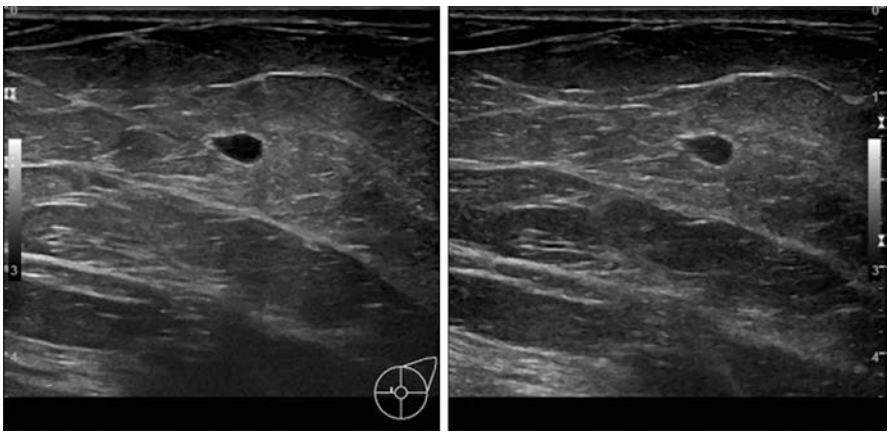

Fig. 7.5 Cyst with harmonic resource (left) and without harmonic resource (right), showing attenuation of internal echoes and confirming that it is a simple cyst

Harmonic imaging also improves lateral resolution and can improve the contrast between adipose tissue and subtle lesions, allowing for better definition of lesion margins and posterior shading.

7.2.4 Compound Imaging

Compound imaging shows improved image quality compared with conventional ultrasound, primarily because of reduction of speckle, clutter, and other acoustic artifacts.

The compound imaging feature acquires images at multiple angles from an insonation plane, reducing artifact echoes and increasing the image contrast, but there is a loss of image quality from the deepest planes (Fig. 7.6).

7.3 Doppler Evaluation

The evaluation through color mapping on the breast is based on the argument that malignant or inflammatory lesions can cause angiogenesis and these vessels are identified on the periphery or inside the lesions.

Currently, both power and color Doppler are complementary tools to the gray-scale image, although power Doppler mode is favored for being more sensitive when viewing small vessels, and factors such as flow direction and spectral evaluation are not relevant.

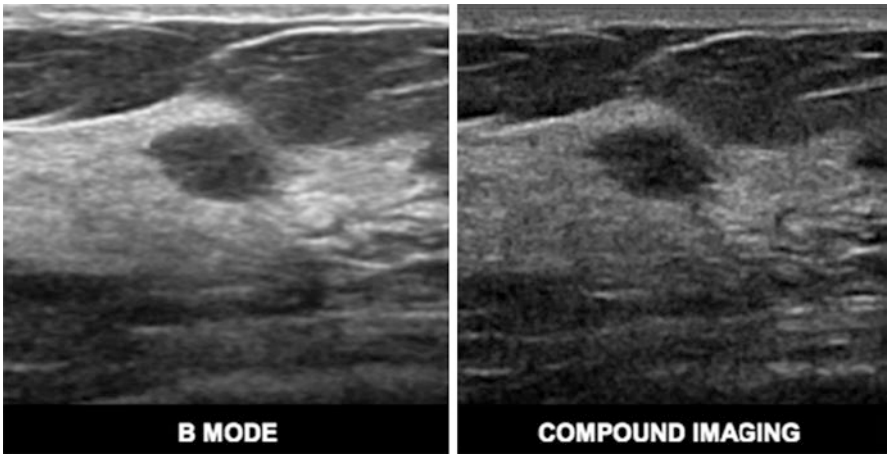

Fig. 7.6 Left – B mode. Right – compound imaging

Malignant breast lesions typically produce pro-angiogenic factors that stimulate neoangiogenesis and the growth of new irregular and branching vessels. Aggressive malignant lesions can exhibit little or no blood flow due to small lesions (bigger lesions tend to show more vascularization), the presence of posterior acoustic shadowing, and necrotic anechoic areas. Benign lesions usually do not show irregular branching, chaotic vessels, or formation of sinusoids and arteriovenous shunts [2, 3].

The evaluation of masses must be correlated with ultrasound findings, emphasizing that no vascular pattern is specific to a particular diagnosis.

The technique consists of visualizing the area of interest with the Doppler mode, performing small compression on the breast, as small vessels may not be identified with too much pressure from the transducer.

The demonstration of central or penetrating vascularization of irregular branching within a solid mass raises suspicion of malignant neovascularization [2, 3].

Color Doppler and power US are also useful for evaluating cysts and complex cystic masses that contain a solid component. The demonstration of flow within an apparently simple cyst, a complicated cyst, or a complex mass confirms the presence of a suspect solid component, which requires biopsy. The twinkle artifact seen with color Doppler is useful for identifying a biopsy marker or subtle echogenic calcifications.

By ACR BI-RADS, the findings on color Doppler mapping are classified as (Figs. 7.7, 7.8, and 7.9):

(a) Absent
(b) Internal vascularization
(c) Peripheral vascularization

It is important to note that these findings can overlap and sometimes benign lesions have internal and exuberant vascularization and malignant lesions can present absent or peripheral vascularization (Fig. 7.10).

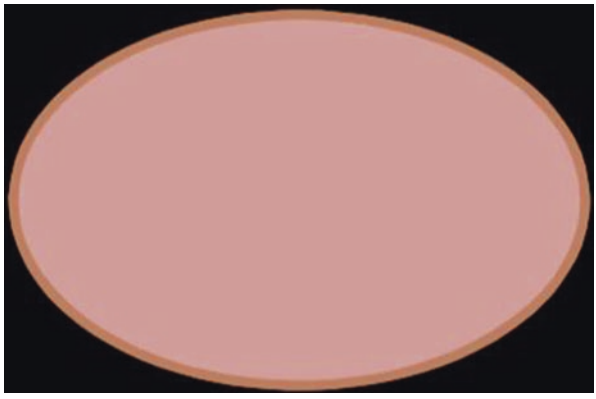

Fig. 7.7 Absent, when no vessel is identified in the region of interest, common in simple cysts and some benign masses

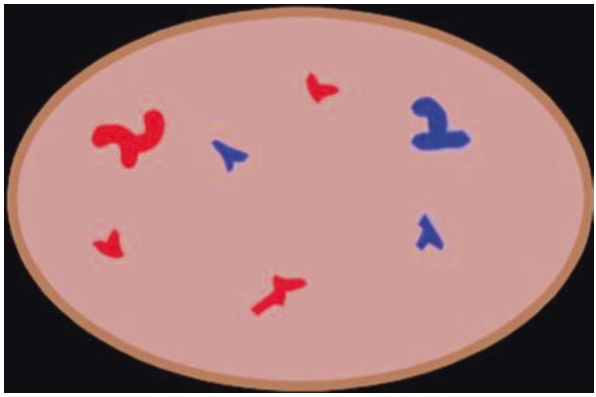

Fig. 7.8 Internal vascularization, when vessels (sometimes more than one) are identified inside the lesion, the most common finding in malignant neoplasms

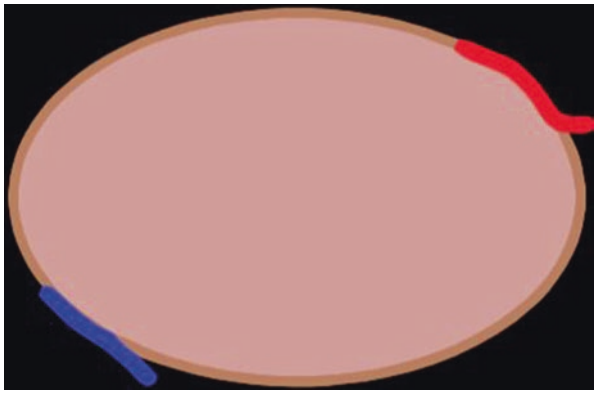

Fig. 7.9 Peripheral vascularization, when vessels are found surrounding the lesion, more common in inflammatory processes and benign solid masses

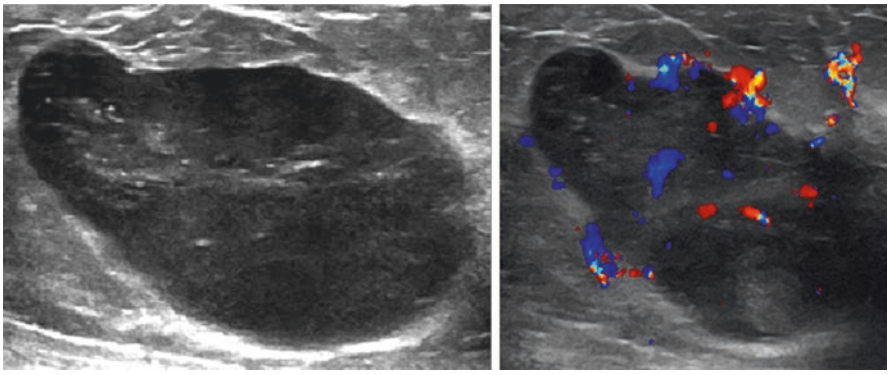

Fig. 7.10 New, solid, hypoechoic, oval, and circumscribed mass, with peripheral and central vascularization, and branched vessels on color Doppler. Patient underwent a percutaneous biopsy and was diagnosed with adrenal carcinoma metastasis

7.4 Elastography

Ultrasound elastography is an established method for characterization of focal lesions in the breast and can be used to measure tissue stiffness with the potential to improve specificity in the diagnosis of breast masses. There are two forms of elastography available: strain (SE) and shear wave (SWE).

This technique assesses tissue elasticity, which is the tendency of tissue to resist deformation with an applied force, or to return to its original shape after removal of the force [9–11].

Obtaining a good grayscale image is essential before changing to the elastography mode since SE and SWE images are often generated based on raw data from grayscale images.

Ultrasound elastography has 86.5% sensitivity, 89.8% specificity, and 88.3% diagnostic accuracy in the differentiation of benign from malignant solid breast masses [12].

Elastography is a useful complementary tool for undetermined breast lesions categorized as BI-RADS 4A or BI-RADS 3 or for cystic lesions but cannot avoid investigation if ultrasound features are clearly suspicious.

Some benign lesions can be poorly deformable, such as fibrous fibroadenomas or scars. The presence of implants can also change the strain of breast tissue around the implant, complicating elastography assessment.

The bull's eye cyst pattern can be seen with lesions that appear solid and suspicious on B-mode imaging. It occurs because of the fluid movement, and there is no correlation between images.

In ACR BI-RADS, the elastography findings are divided into:

(a) Stiff or hard.
(b) Intermediate.
(c) Soft, and this relationship is made with adjacent adipose tissue.

7.4.1 Strain Elastography

In this technique, a normal stress is applied to tissue (gentle compression or natural movement such as heartbeat, vascular pulse, or breathing), and the normal strain is measured. Under an equal amount of stress, a stiff region experiences less strain than the surrounding soft tissue.

For breast imaging, the region of interest (ROI) should extend anterior-posteriorly from the subcutaneous fat tissue to the pectoralis muscle, excluding the thoracic cage, and the width should be adjusted to keep the lesion of interest within 25% of the ROI width [13].

The information obtained with strain elastography provides qualitative information (hard, intermediate, soft).

Tsukuba Scoring System

A color-coded scoring system has been proposed by Itoh et al. [12], most commonly used for SE. The strain in lesion tissue is displayed in a color-coded image. The scoring system assigns a score from 1 to 5 (Fig. 7.11) with the risk of malignancy increasing from 1 to 5 (Fig. 7.12):

The risk of malignancy increases from 1 to 5.

7.4.2 Shear Wave Elastography

In contrast to strain imaging, SWE employs a higher intensity pulse to generate shear waves in the parallel or perpendicular dimensions.

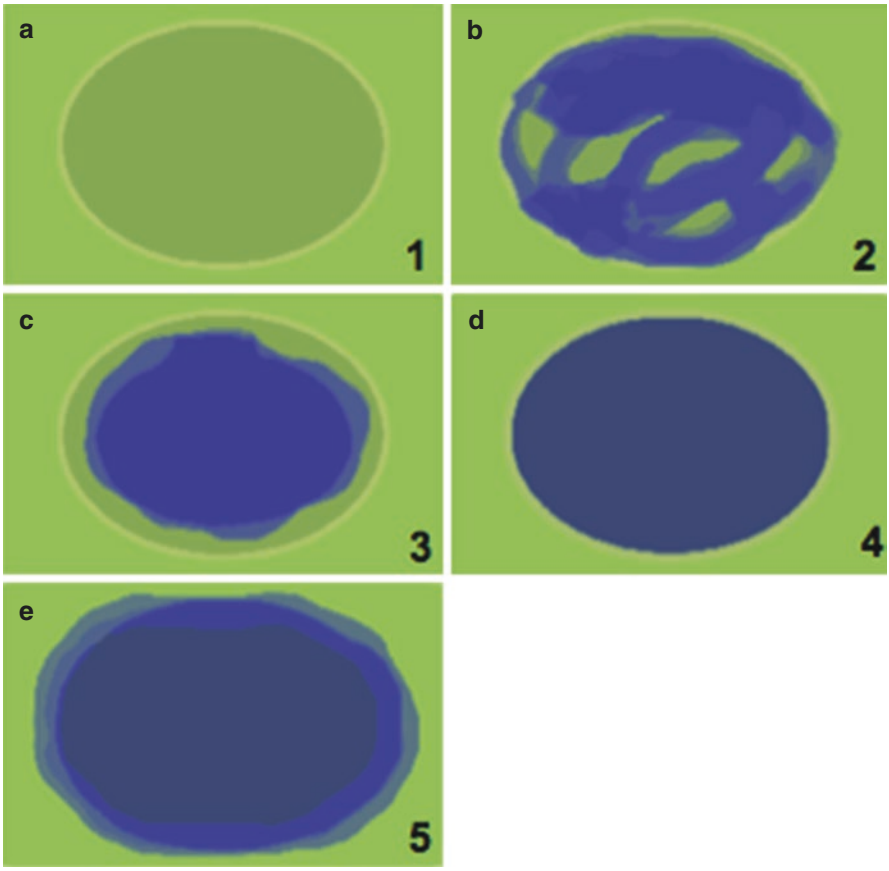

Fig. 7.11 (**a**) Score 1: complete deformability of lesion. (**b**) Score 2: most of the lesion is deformable although there are areas which are not deformable. (**c**) Score 3: presence of stiff area in center with peripheral deformability of lesion. (**d**) Score 4: no deformability throughout the entire lesion only. (**e**) Score 5: no deformation throughout the entire lesion or in adjacent tissue

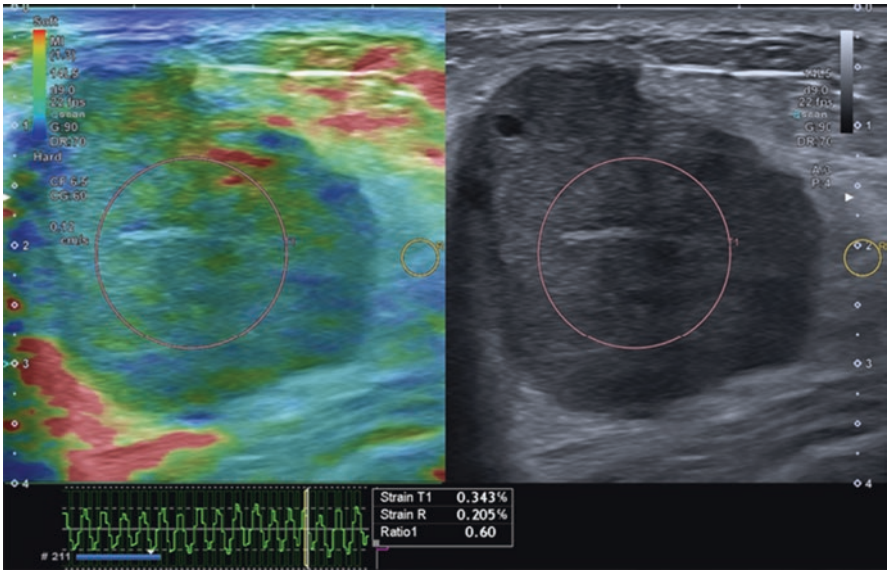

Fig. 7.12 Solid, hypoechoic, irregular, and microlobulated lesion on the grayscale B-mode image (right). Color mapping SE image (left) showing the same lesion shaded in blue color (hard lesion in the color scale used)

With the use of light transducer pressure, automatic transient pulses can be generated by the US probe, inducing shear waves transversely oriented in the tissue. The system captures the speed of these shear waves, which move faster in hard tissue compared to soft tissue.

To measure the elasticity quantitatively in SWE for breast lesions, the most common practice is to place a 2- to 3-mm circular ROI over the stiffest part of the lesion, including the immediately adjacent stiff tissue or halo [14].

Shear wave elastography provides quantitative information because tissue elasticity can be measured in meters per second or kilopascals, a unit of pressure. A value of over 80 kPa or velocity results of over 2 m/s are considered suspicious (Figs. 7.13 and 7.14).

7.5 Automated Breast Ultrasound

Automated breast ultrasound (ABUS) is used as a supplement to mammography for screening in asymptomatic women with dense breasts. It is an effective screening modality with diagnostic accuracy comparable to that of handheld ultrasound (HHUS) [10, 15].

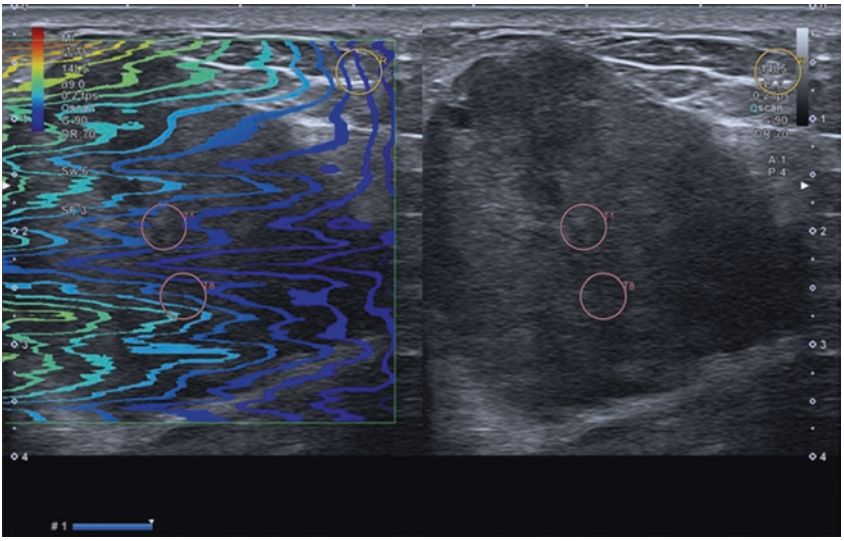

Fig. 7.13 Solid, hypoechoic, irregular, and microlobulated lesion on the grayscale B-mode image (right), poorly deformable in color-mode SWE (left)

	Speed[m/s]		Elasticity[kPa]		Dispersion[(m/s)/kHz]		
	Average	SD	Average	SD	Average	SD	Depth[cm]
1	6.14	1.45	104.8	45.4	***	***	1.4
2	7.51	0.74	139.8	46.0	***	***	1.2
3	3.70	1.06	45.0	21.7	***	***	1.7
4	5.61	1.17	95.1	37.6	***	***	2.3
5	8.18	0.58	111.0	68.2	***	***	1.2
6	3.50	0.76	38.8	16.3	***	***	2.2
7	4.49	1.45	64.3	32.1	***	***	2.6
8	7.94	0.56	139.1	60.9	***	***	0.9
9	4.48	0.56	61.5	15.3	***	***	1.6
10	5.54	0.94	95.3	32.8	***	***	2.4
11	5.10	0.80	80.2	23.9	***	***	2.0
12	5.16	0.64	81.4	18.8	***	***	2.1
R	1.78	0.09	9.3	0.9	***	***	0.7
Mean	5.32		82.0		***		
SD	1.77		36.8		***		
Median	5.16		81.4		***		
IQR	2.73		54.7		***		

Fig. 7.14 Velocities measured in the lesions are very high (>3 m/s), which suggests a malignant lesion

ABUS consists of a US scanner and special stationary device with a transducer, which moves automatically in a scan box. The slice thickness is adjustable from 0.5 mm to 8.0 mm, and up to 448 axial slices are acquired [10, 15].

The sequence of the technique consists of three steps: patient positioning, image acquisitions, and interpretation of data.

The patient lies down in the supine position with the ipsilateral hand raised above the head. A rolled towel is placed under each shoulder to help stabilize the breast with the nipple pointing to the ceiling. A hypoallergenic lotion is spread out evenly on the breast with an additional amount on the nipple area. A nipple marker is placed in every examination for accurate correlation of the reformatted views.

The exam is performed in anteroposterior, medial, and lateral views routinely and in the superior or inferior view additionally in cases of large breasts. Image acquisition in six views takes approximately 10–15 min.

The optimal image quality should be guaranteed for screening. However, the image quality and ultrasonic resolution diminish with poor contact, marked shadowing due to fibrotic breasts, and artifacts.

ABUS presents some limitations such as inability to assess vascularity and tissue elasticity and exclusion of axillary regions from the field of view. ABUS screening is also limited by its high recall rate and biopsy rate with low positive predictive value (PPV), similar to HHUS screening.

The most common artifacts in ABUS are:

(a) Corrugation, which is due to respiratory motion; this artifact can be avoided when women breathe calmly and do not speak or cough.
(b) Dropout shadowing deep to the skin, caused by insufficient lotion application and extreme compression.
(c) Nipple shadow and reverberation artifacts frequently occurred with ABUS.
(d) Skip artifacts present as a transverse anechoic line at the location of change in tissue stiffness due to a mass and can be used to detect isoechoic masses.
(e) In the study by Vourtsis and Kachulis [13], a "zigzag" sign was produced by disruption of the scanning process in 61.5% of women with palpable lesions.

Studies have shown that ABUS is a standardized and reproducible imaging modality that surmounts the limitations of HHUS, while offering valuable impact in the detection of breast lesions, and differentiates malignant from benign lesions, with a high inter-observer reliability [10, 13, 15, 16].

7.6 Correlation with Other Imaging Methods

When looking for a lesion initially identified on mammography or MRI, careful correlation must be made with the depth of the lesion and surrounding anatomical structures.

The location of the lesion can be affected by the patient's position, which differs during mammography, US, and MRI exams (Figs. 7.15 and 7.16).

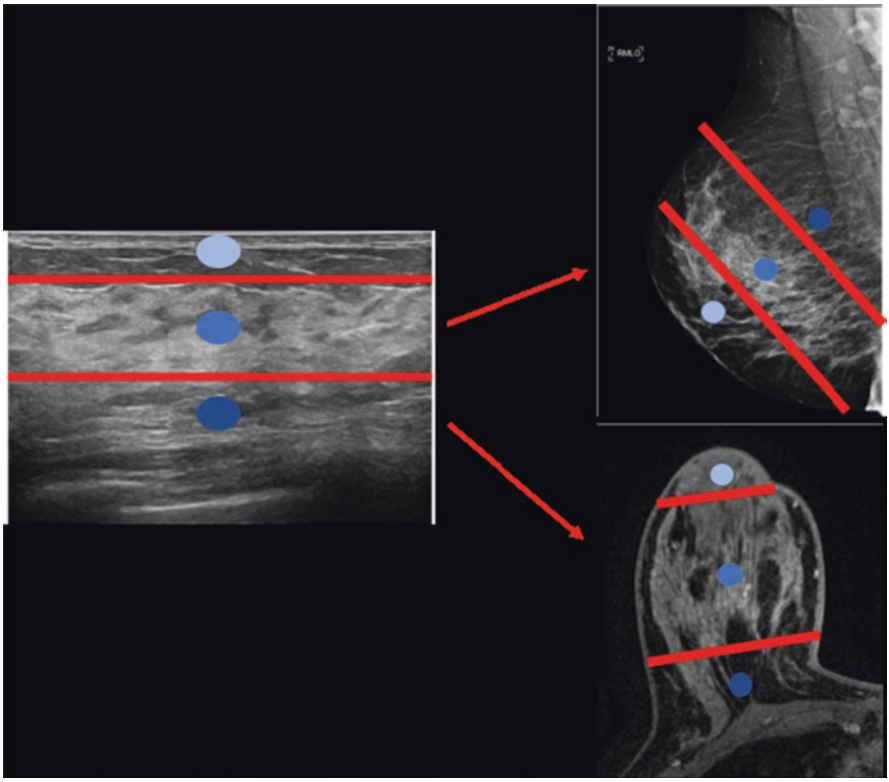

Fig. 7.15 When performing the correlation with mammography and MRI, take into account location (superficial, medium, and deep thirds), dimensions, shape, and margin

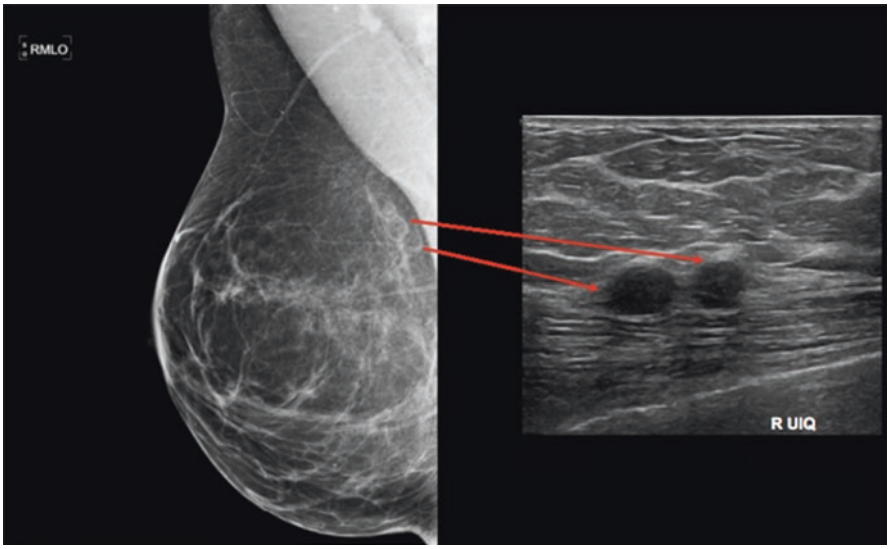

Fig. 7.16 Oily cysts in the posterior third of the right breast seen on mammography and their correspondence in the ultrasound study, next to the pectoral muscle

If a mass identified on mammography or magnetic resonance imaging is completely surrounded by adipose or fibroglandular tissue, on US, it must also be surrounded by hypoechoic tissue or echogenic fibroglandular tissue, respectively.

Lesions detected by MRI images are usually hidden in mammography, but many can be detected with the US. Along with the additional characterization of a lesion detected by MRI, US can be used to guide the intervention toward lesions initially detected in MRI (Fig. 7.17).

Likewise, careful attention is needed to the region of clinical interest when examining a palpable abnormality to ensure that the correct area is scanned. The examiner should place a finger on the palpable abnormality and then position the transducer directly over the region.

7.7 Exam Documentation

According to ACR BI-RADS®, the documentation must contain the breast that is being studied, the laterality, and the place of the "body mark," thus reducing any errors in laterality and quadrant (Fig. 7.18).

When documenting findings, the adjustment of focus and gain and frequency must be made and must contain images with and without measures to allow the evaluation of margins in still images. The location should be noted in laterality, quadrant, and/or clock face notation on the breast [9].

The size of the lesion should be measured in three dimensions, first reporting the longest diameter and the rest in the orthogonal plane (Figs. 7.19 and 7.20). The measurement can be made in millimeters or centimeters, rounding to just one decimal place [7].

In the presence of multiple cysts, documentation of the largest cyst in each breast and the measurement of its largest dimension can be made. In the presence of a normal lymph node, the same documentation can be performed.

Measure the longest axis (1) and perpendicular to the first (2). The third measure (3) should be taken from a plane orthogonal to the first image.

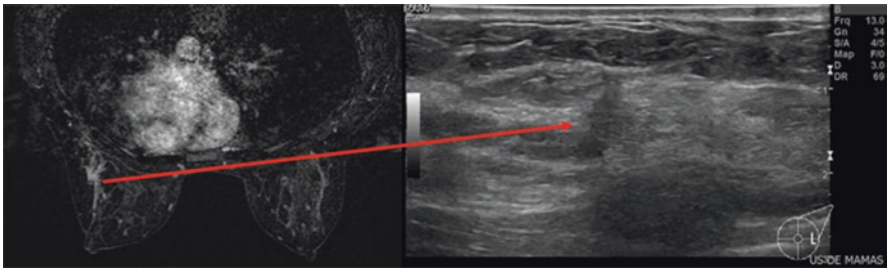

Fig. 7.17 Non-mass enhancement associated with architectural distortion in the posterior third of the outer quadrants of the left breast in the mammary zone (surrounded by fibroglandular tissue) and its ultrasound correspondence ("second-look" ultrasound)

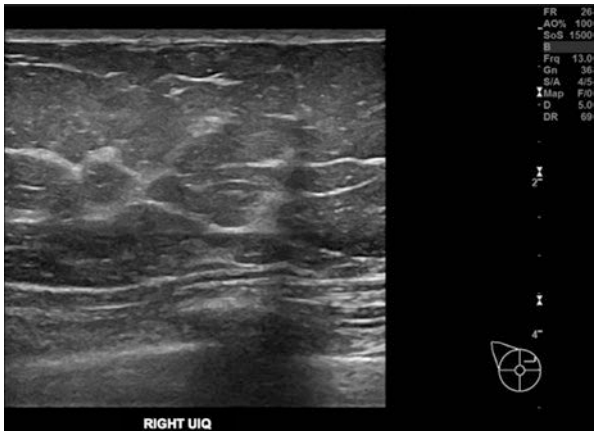

Fig. 7.18 US documentation with laterality, quadrant, and body mark

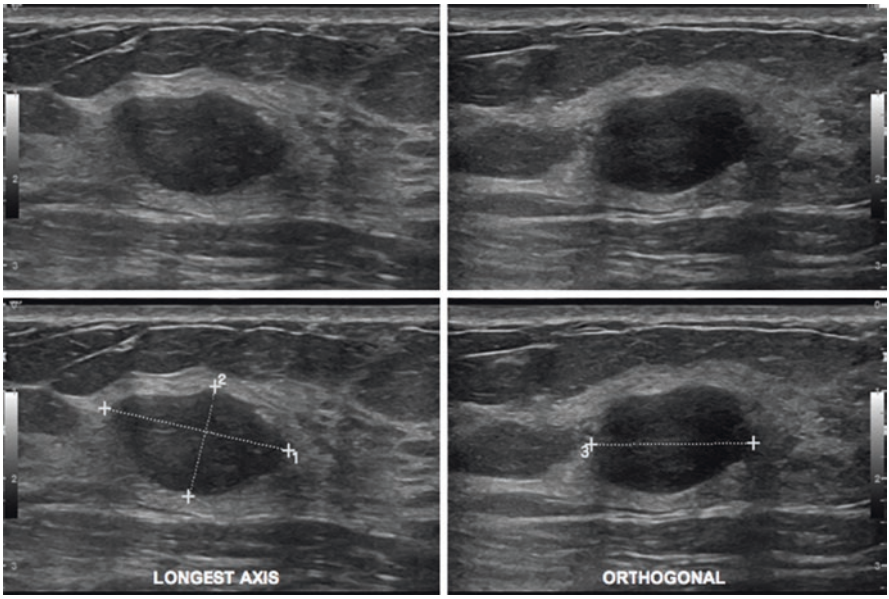

Fig. 7.19 Mass documentation in two plans without and with measures

The distance between the papilla and the lesion, and from this to the skin, is useful information and easy to identify by any operator, facilitating eventual localization during surgery and for evolutive control (Fig. 7.21).

A color Doppler/power Doppler image is recommended to assess the vascularization of the documented lesion (Fig. 7.22).

The documentation on breast screening without changes should contain the four quadrants and the retroareolar region.

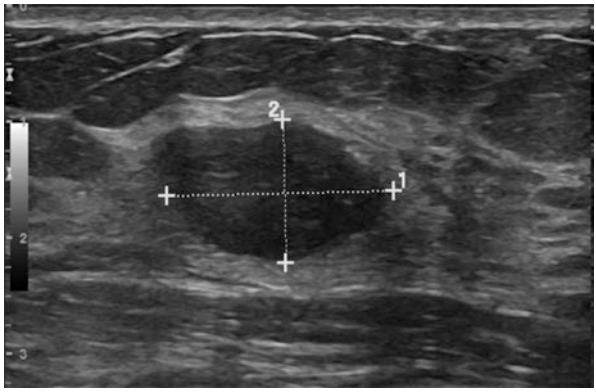

Fig. 7.20 Incorrect measurement, not respecting the largest axis of the lesion

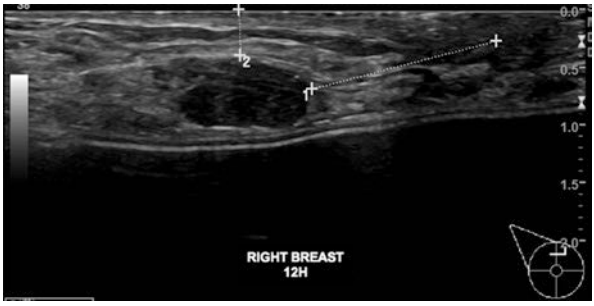

Fig. 7.21 Distance between the mass and the papilla (1) and the skin (2)

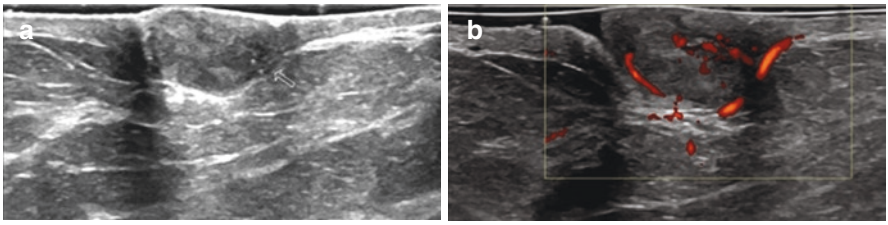

Fig. 7.22 Isoechoic mass that is difficult to characterize in B mode (**a**), but well delimited with the use of power Doppler (**b**)

Axilla documentation is not mandatory under the American College of Radiology (ACR) but can be performed as a courtesy when performing breast exams.

The ultrasound evaluation of breast implants must be performed in two separate steps, with adjustments of focus, gain, and depth for the evaluation of the parenchyma and later for the evaluation of the implant (Figs. 7.23 and 7.24).

7.8 BI-RADS® Lexicon

1. Breast composition
   Can be homogeneous background – fat or fibroglandular or heterogeneous background echotexture (Figs. 7.25, 7.26, and 7.27).

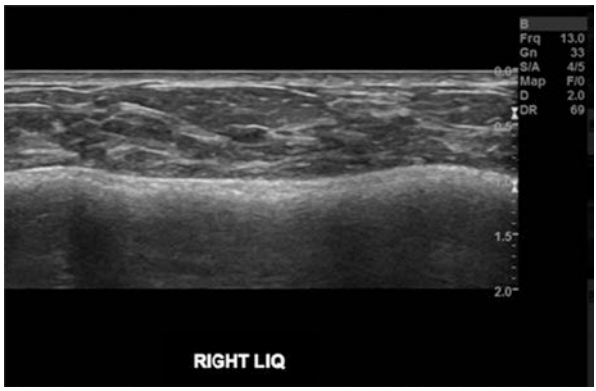

Fig. 7.23 Adjustment of focus and depth for evaluation of the breast parenchyma

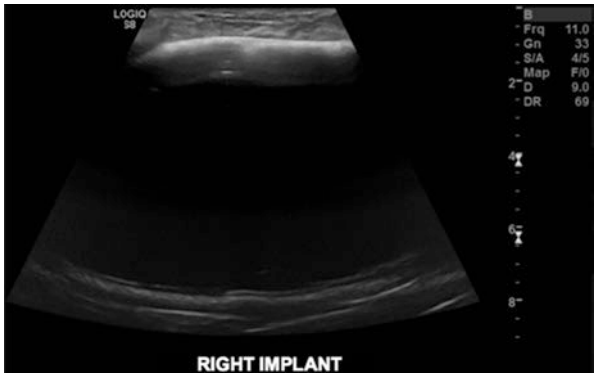

Fig. 7.24 Adjustment of focus and depth for evaluation of the implant

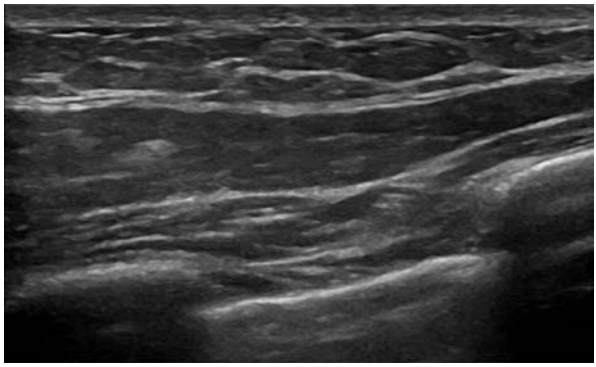

Fig. 7.25 Homogeneous background echotexture – fat

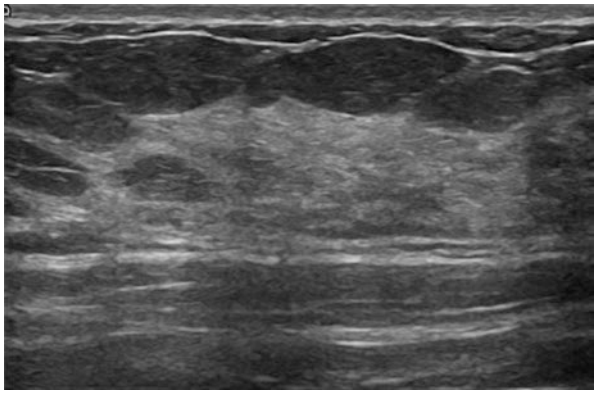

Fig. 7.26 Homogeneous background echotexture – fibroglandular

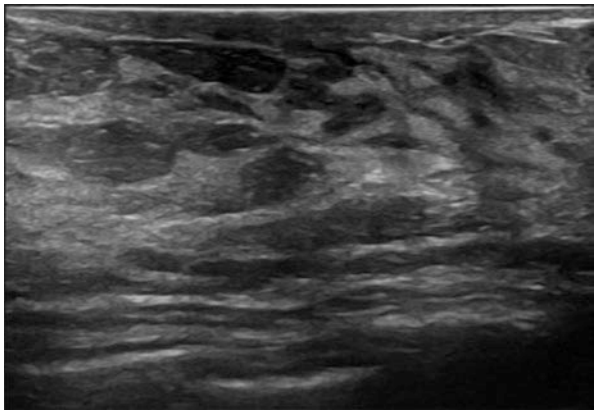

Fig. 7.27 Heterogeneous background echotexture

2. The characteristics of a mass that must be evaluated and included in the report include:

   (a) Shape
   Shape can be oval, round, or irregular (Figs. 7.28, 7.29, and 7.30).
   (b) Margin
   Can be circumscribed or non-circumscribed (indistinct, angular, microlobulated, or spiculated) (Figs. 7.31, 7.32, 7.33, 7.34, and 7.35).
   (c) Orientation (in relation to the skin surface)
   Parallel or non-parallel (Figs. 7.36 and 7.37).
   (d) Echogenicity
   Can be anechoic, hyperechoic, hypoechoic, isoechoic, complex cystic solid, or solid, heterogeneous (Figs. 7.38, 7.39, 7.40, 7.41, 7.42, and 7.43).
   (e) Posterior features

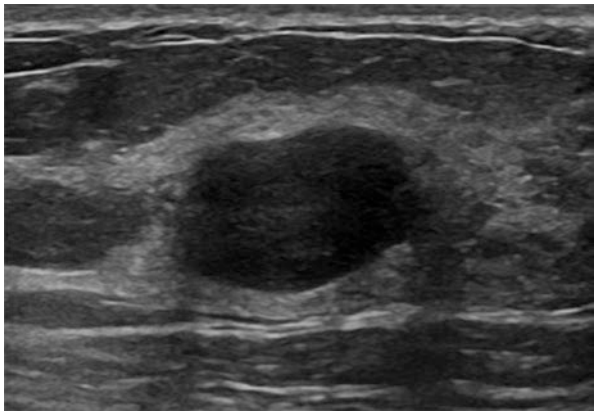

Fig. 7.28 Oval

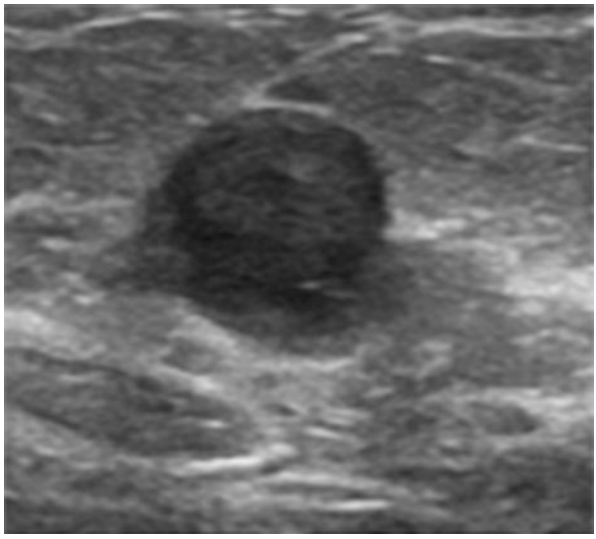

Fig. 7.29 Round

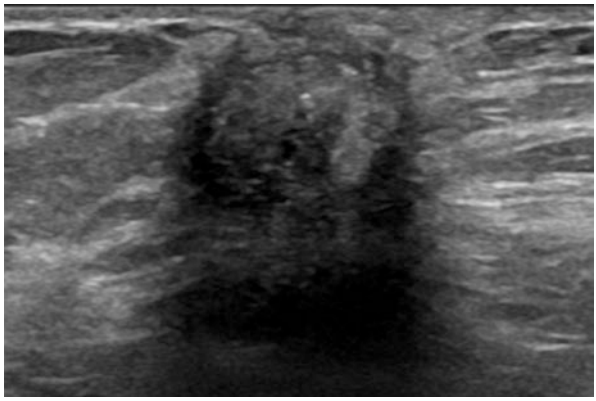

Fig. 7.30 Irregular

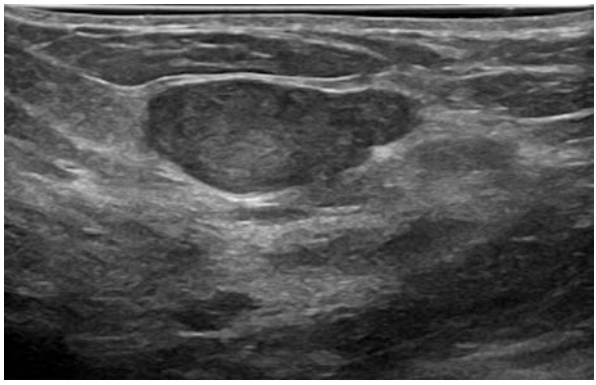

Fig. 7.31 Circumscribed

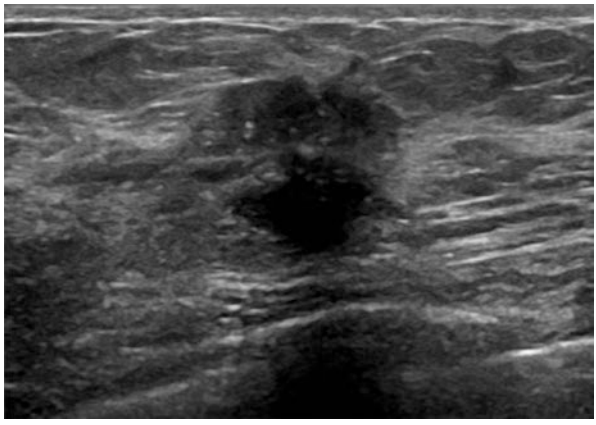

Fig. 7.32 Non-circumscribed – indistinct

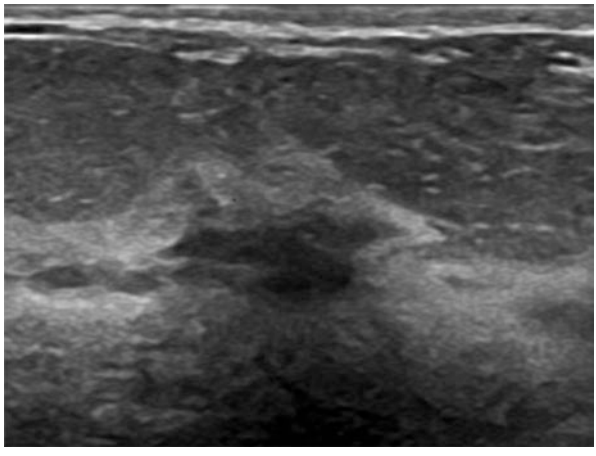

Fig. 7.33 Non-circumscribed – angular

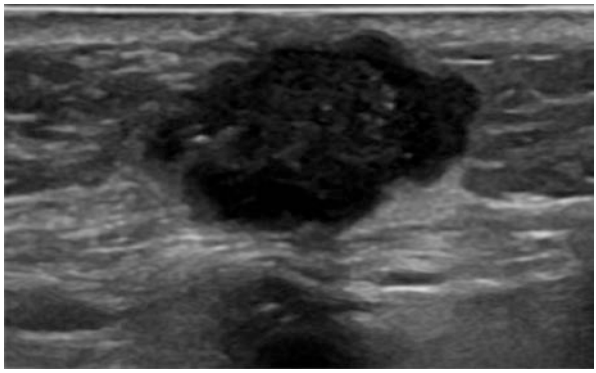

Fig. 7.34 Non-circumscribed – microlobulated

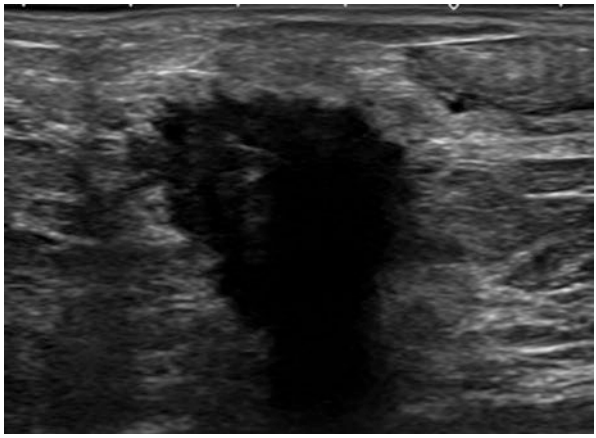

Fig. 7.35 Non-circumscribed – spiculated

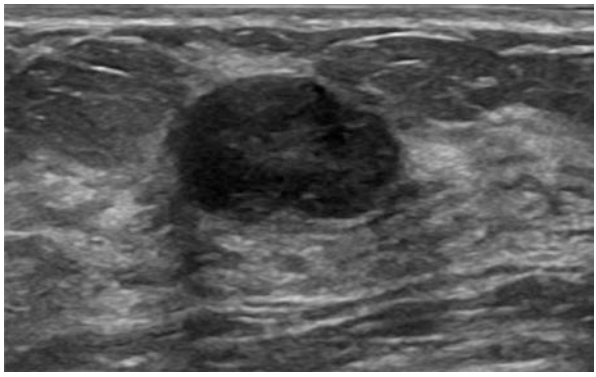

Fig. 7.36 Parallel

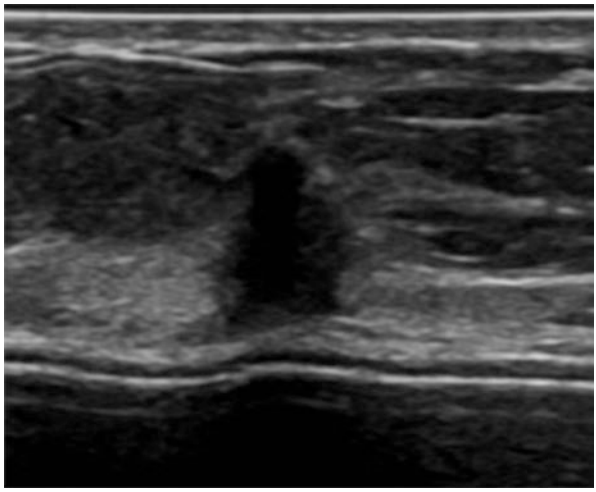

Fig. 7.37 Non parallel

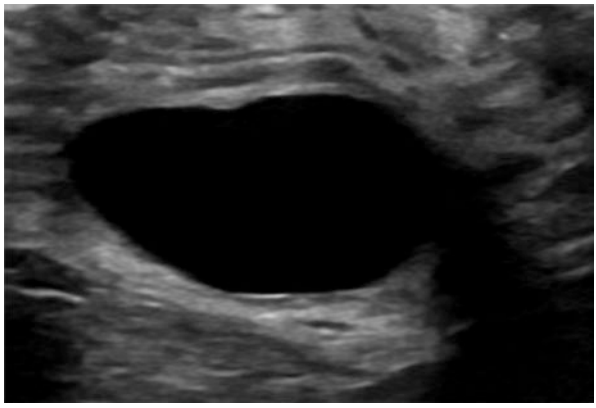

Fig. 7.38 Anechoic

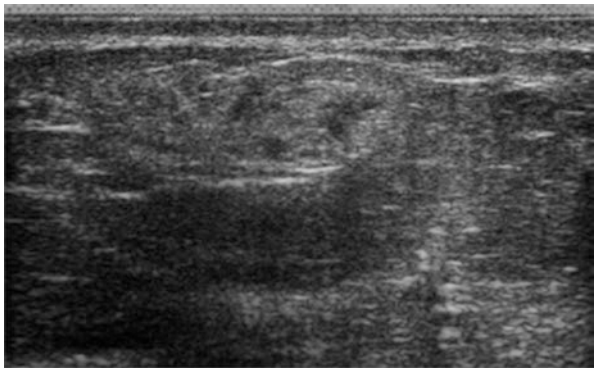

Fig. 7.39 Hyperechoic

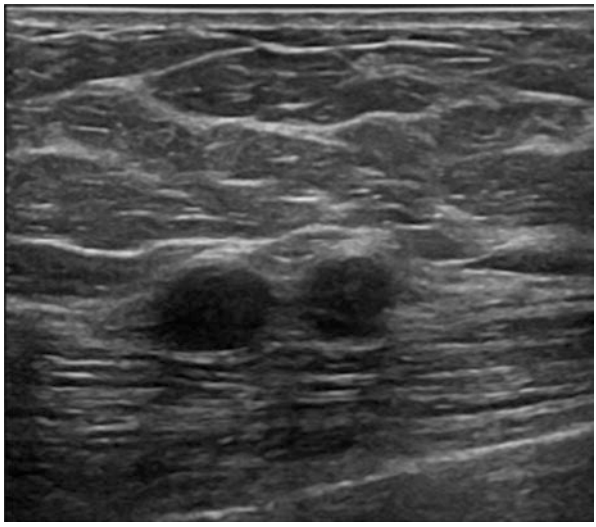

Fig. 7.40 Hypoechoic

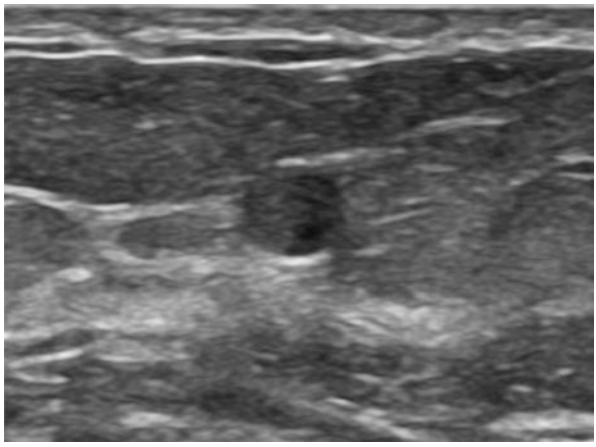

Fig. 7.41 Isoechoic

No posterior features, enhancement, shadowing, or combined pattern (Figs. 7.44, 7.45, and 7.46).

3. Calcifications
   Can be in a mass, outside a mass or intraductal (Figs. 7.47, 7.48, and 7.49).
4. Associated findings
   (a) Architectural distortion (Fig. 7.50).
   (b) Ductal changes (Fig. 7.51).
   (c) Skin changes
      (i) Skin thickening (Fig. 7.52).
      (ii) Skin retraction (Fig. 7.53).

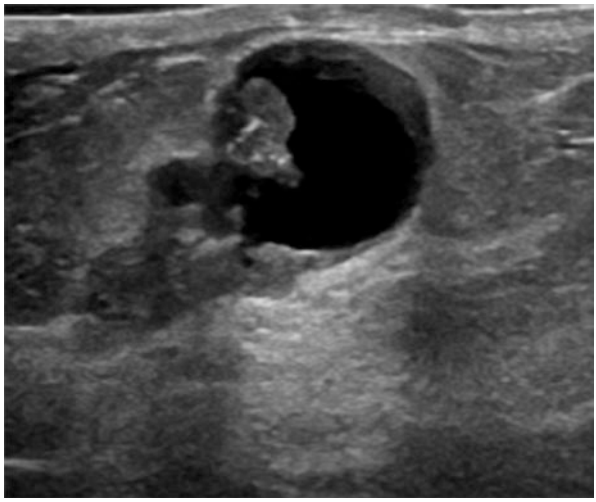

Fig. 7.42 Complex cystic solid

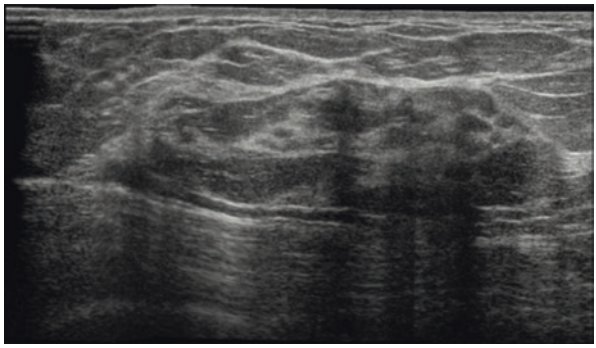

Fig. 7.43 Solid, heterogeneous

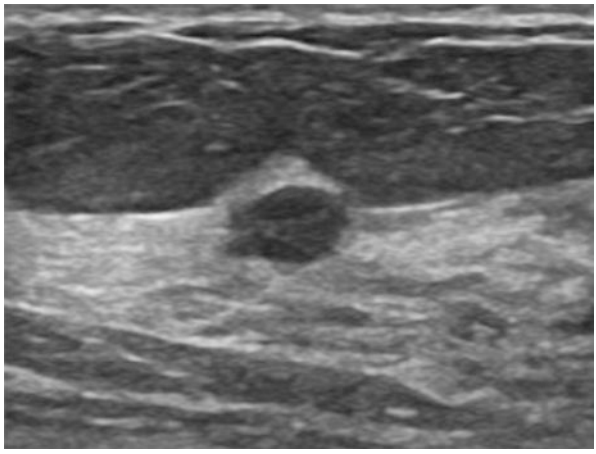

Fig. 7.44 No posterior features

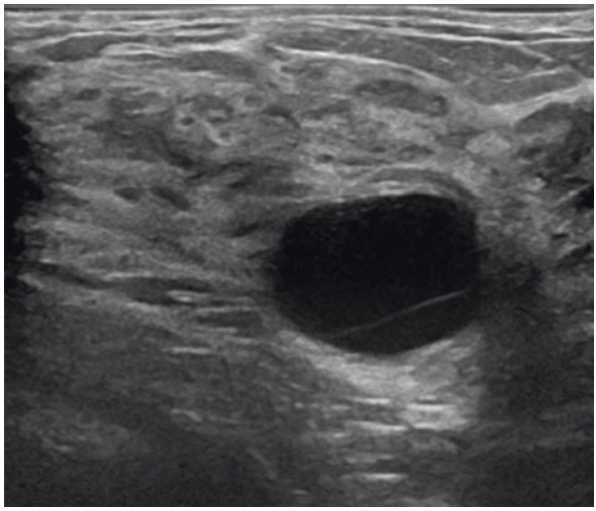

Fig. 7.45 Enhancement

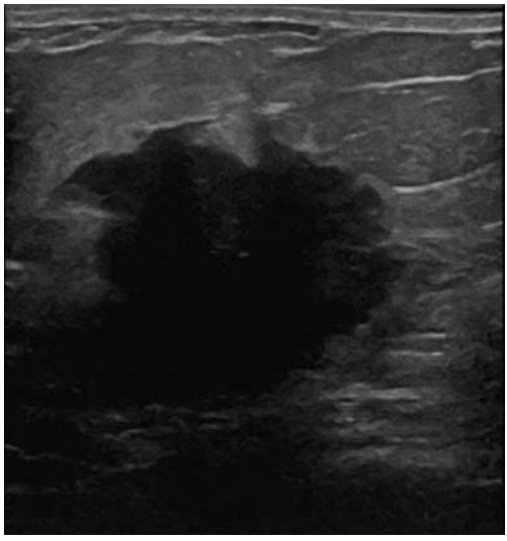

Fig. 7.46 Shadowing

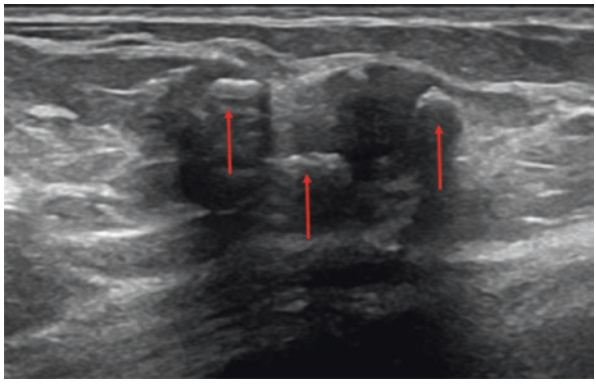

Fig. 7.47 Calcifications in a mass

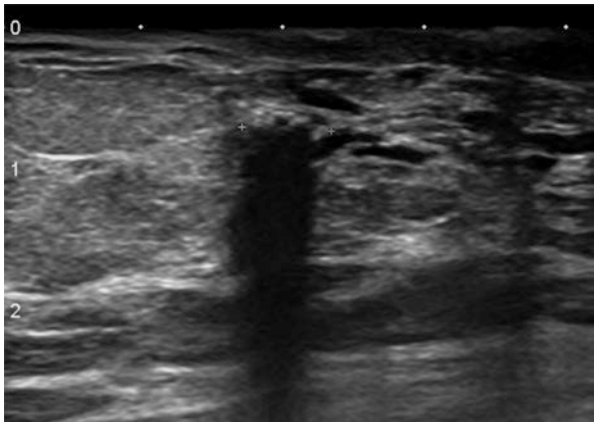

Fig. 7.48 Calcifications outside of a mass

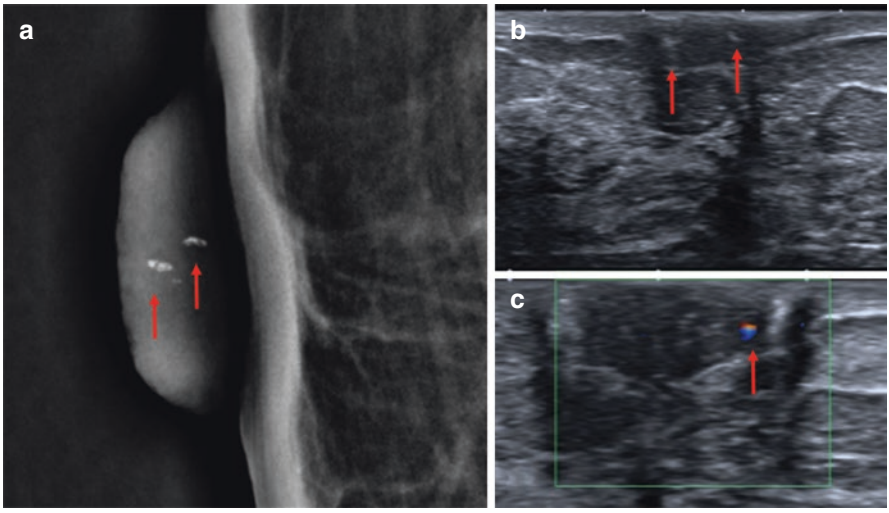

Fig. 7.49 A 75-year-old patient undergoing breast cancer screening. Linear calcifications on the right papilla on mammography (**a**). US shows hyperechoic foci within the papilla (**b**). In color Doppler (**c**), these foci have a "twinkle" artifact

(d) Edema (Fig. 7.54).
(e) Vascularity

(i) Absent
(ii) Internal vessels
(iii) Vessels in rim

(f) Elastography assessment

(i) Soft
(ii) Intermediate
(iii) Hard

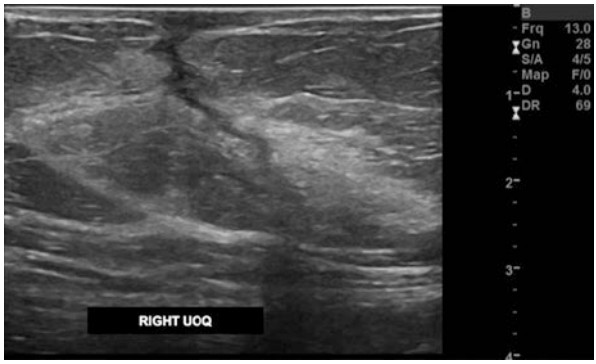

Fig. 7.50 Architectural distortion after breast conservation surgery

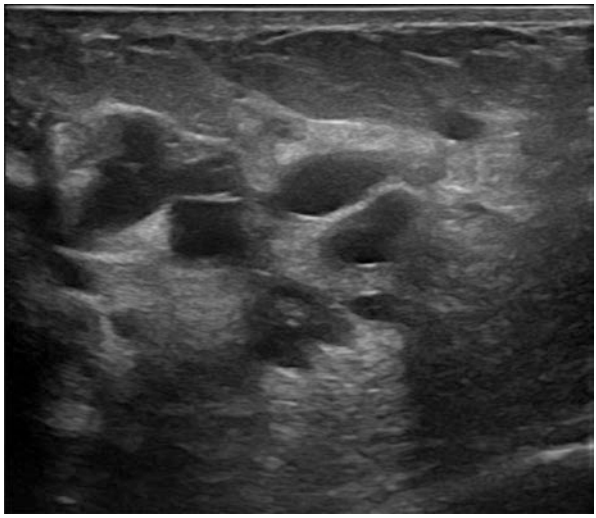

Fig. 7.51 Duct ectasia

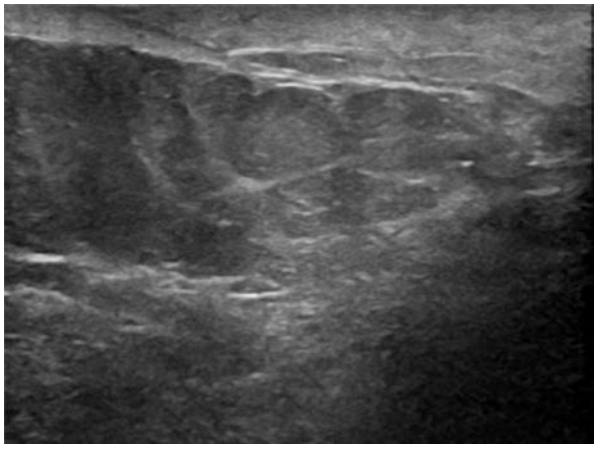

Fig. 7.52 Skin thickening

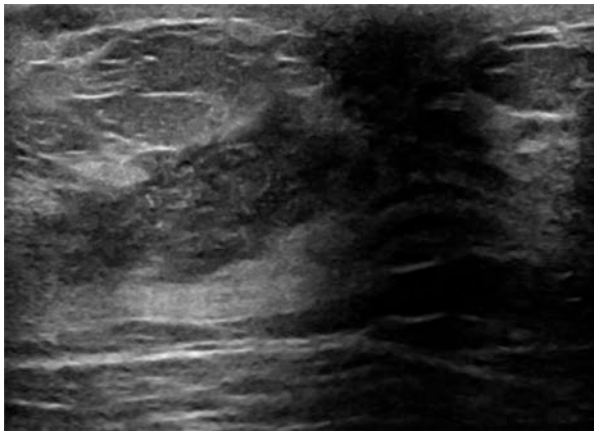

Fig. 7.53 Nipple retraction secondary to an irregular mass

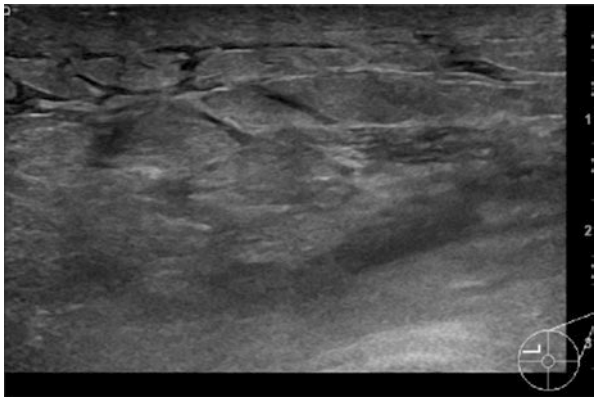

Fig. 7.54 Skin and parenchymal edema

5. Special cases

   (a) Simple cyst (Fig. 7.55).
   (b) Clustered microcysts (Fig. 7.56).
   (c) Complicated cyst (Fig. 7.57).
   (d) Mass in or on skin (Fig. 7.58).
   (e) Foreign body, including implants (Fig. 7.59).
   (f) Lymph nodes: intramammary, axillary (Fig. 7.60).
   (g) Vascular abnormalities (Fig. 7.61).
   (h) Postsurgical fluid collection (Fig. 7.62).
   (i) Fat necrosis (Fig. 7.63).

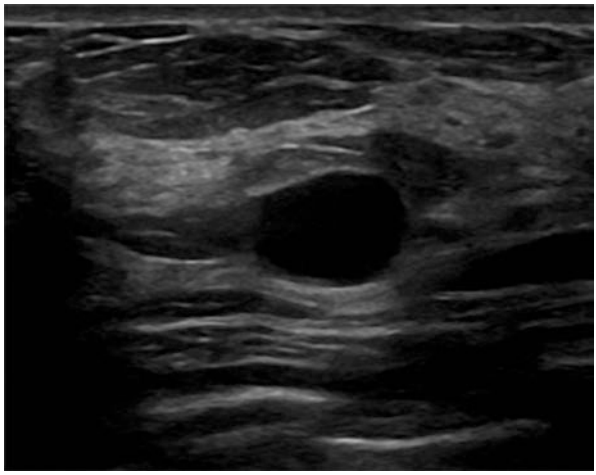

Fig. 7.55 Cyst

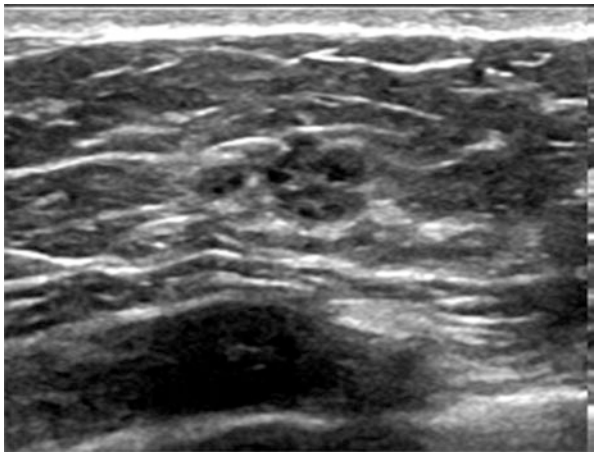

Fig. 7.56 Clustered microcysts

7.9 Report and Assessment

The preparation of the ultrasound report must contain the indication of the exam, the breast composition, a brief description of the lesion according to ACR BI-RADS, comparison with previous exams, final impression, and recommendation.

The report should conclude a summary of relevant US findings with a final assessment using BI-RADS® US categories 1–6 and the phrases associated with them.

If report of a US examination is integrated with a concurrently mammographic examination, the combined final assessment should reflect the highest likelihood of malignancy assessed by the two exams [7].

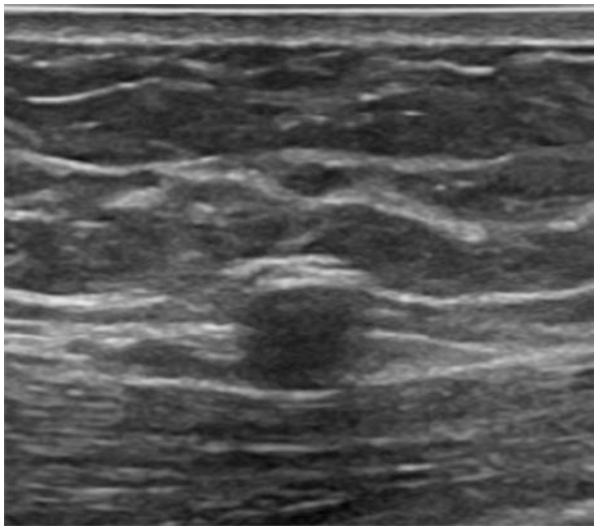

Fig. 7.57 Complicated cyst

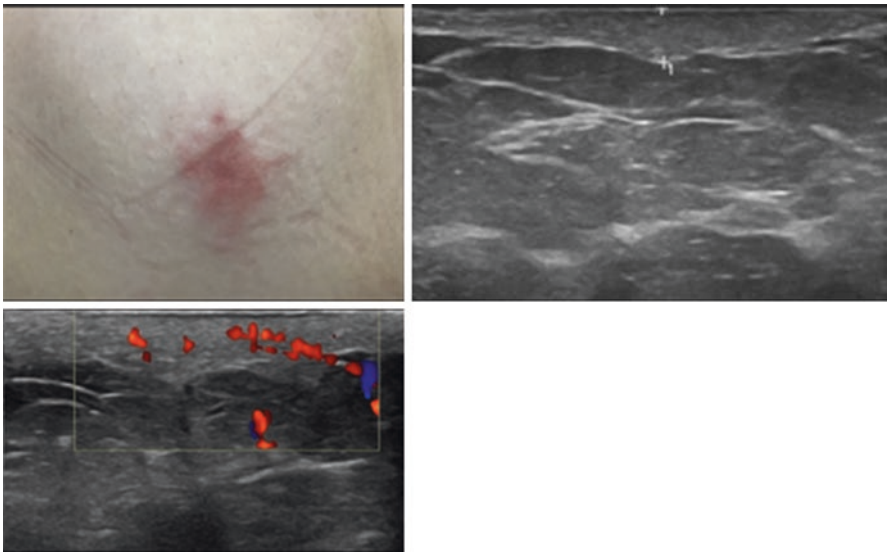

Fig. 7.58 Skin lesion. Ultrasound demonstrates skin thickening with increased vascularity

7.9.1 BI-RADS® Categories

1. Category 0: incomplete – need additional imaging evaluation.
2. Category 1: negative – 0% likelihood of malignancy – routine screening is recommended.

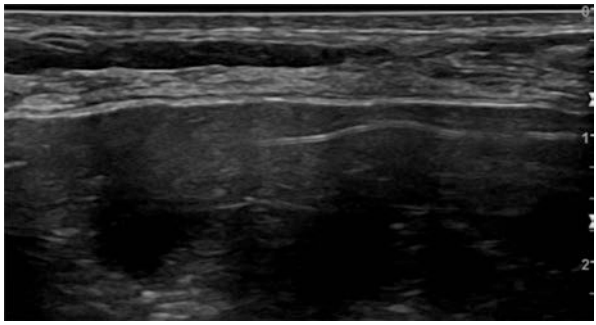

Fig. 7.59 Breast implant rupture

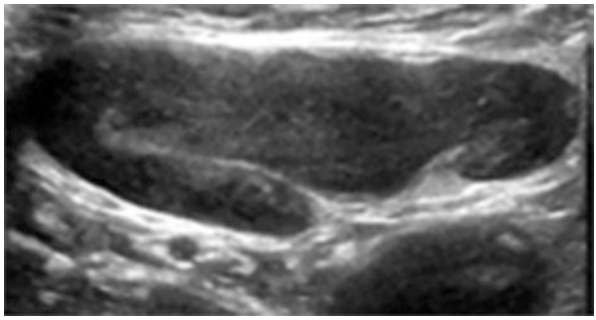

Fig. 7.60 Abnormal lymph node

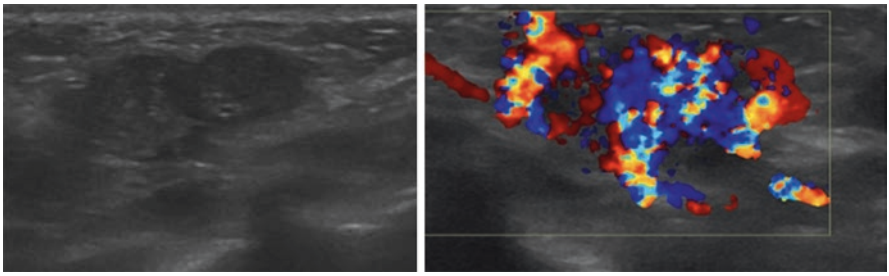

Fig. 7.61 An 8-month-old with circumscribed, hypoechoic, and heterogeneous mass in the upper outer quadrant of the left breast. Color Doppler shows high flow in the entire lesion with a vascular pedicle, consistent with arteriovenous malformation

3. Category 2: benign – 0% likelihood of malignancy – routine screening is recommended.
4. Category 3: probably benign – ≤2% likelihood of malignancy – follow-up is recommended (6 months, 12 months, 24 months, optional 36 months).
5. Category 4: suspicious – >2% but <95% likelihood of malignancy – tissue sampling is recommended.

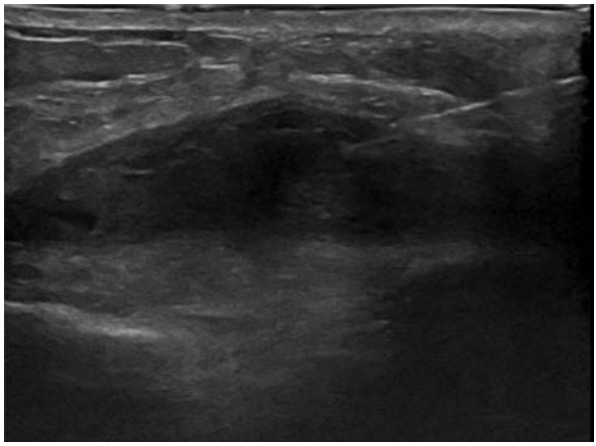

Fig. 7.62 Postsurgical fluid collection

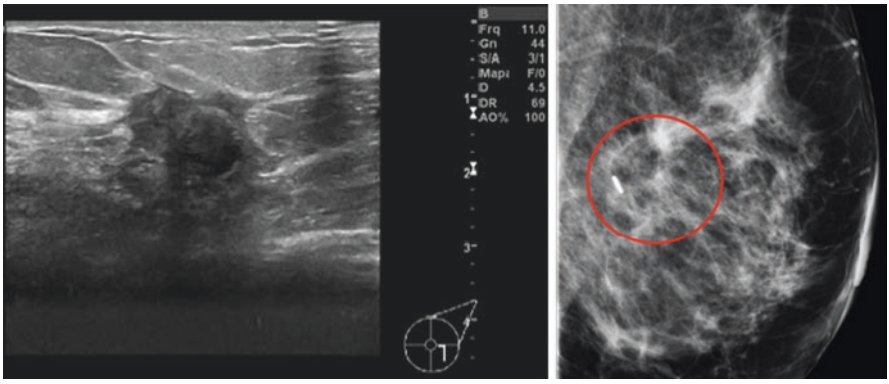

Fig. 7.63 Irregular mass in a patient with a history of surgical manipulation, requiring further evaluation with mammography. The correlation with mammography showed that it was steatonecrosis

BI-RADS subdivides category 4 assessments by likelihood of malignancy into categories 4A (>2% to ≤10%), 4B (>10% to ≤50%), and 4C (>50% to <95%).

6. Category 5: highly suggestive of malignancy – ≥95% likelihood of malignancy – tissue sampling is recommended.
7. Category 6: known biopsy-proven malignancy – surgical excision when clinically appropriate.

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