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REVIEW ARTICLE

Breast Ultrasound: Pitfalls, Tricks, and Tips. An Approximation for Radiologists in Training

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ABSTRACT

Breast ultrasound diagnostic performance depends not only on the operator's experience but also on the correlation of the results with other modalities. Therefore, a strong understanding of the acquisition technique and imaging optimization and the potential pitfalls in interpreting these studies is essential for achieving an adequate diagnosis. However, the trainees' exposure to image optimization and ultrasound physics may be limited, impacting the quality of the examinations. Therefore, this review aims to provide an approach to breast US acquisition and interpretation, highlighting and illustrating tips for avoiding misinterpretations, mainly for trainees.

Keywords: Ultrasonography, Mammary; Breast Neoplasms; Radiology

Introduction

Breast ultrasound (US) is a widely recognized and available diagnostic imaging modality, both interactive and dynamic. However, its diagnostic performance depends not only on the operator's experience but also on the correlation of the results with other modalities. Therefore, a strong understanding of the acquisition technique and imaging optimization and the potential pitfall in interpreting these studies is essential for achieving an adequate diagnosis. However, trainees' exposure to image optimization and clinically relevant ultrasound physics may be limited, impacting the quality of their examinations.

This review aims to provide an approach with thirteen essential concepts of the breast US acquisition and interpretation, highlighting and illustrating tips for avoiding misinterpretations, mainly for trainees.

Equipment and transducers (1)

The first step is choosing the right transducer; higher-frequency (i.e., 15 MHz) have a better spatial resolution optimizing the axial and lateral spatial resolution, and lower-frequency (i.e., 7,5 MHz) have better depth penetration with poor spatial resolution [1,2]. Whereas the former is helpful in breasts less than 3 cm in thickness or for superficial lesions, the latter is for posterior or deep lesions and breasts larger than 3 cm in thickness [3].

Patient positioning (2)

Two are the recommended positioning: *supine*, the arms bent behind the head to evaluate medial-located lesions, and *oblique half-sided*, the ipsilateral arm elevated to assess the lateral lesions and the axilla.

The areas of interest include the breast parenchyma, infraclavicular, sternal, submammary, and peripheral lateral regions *(Figure 1)*. Scan should be performed in radial and antiradial clockwise patterns on transverse and sagittal planes [3].

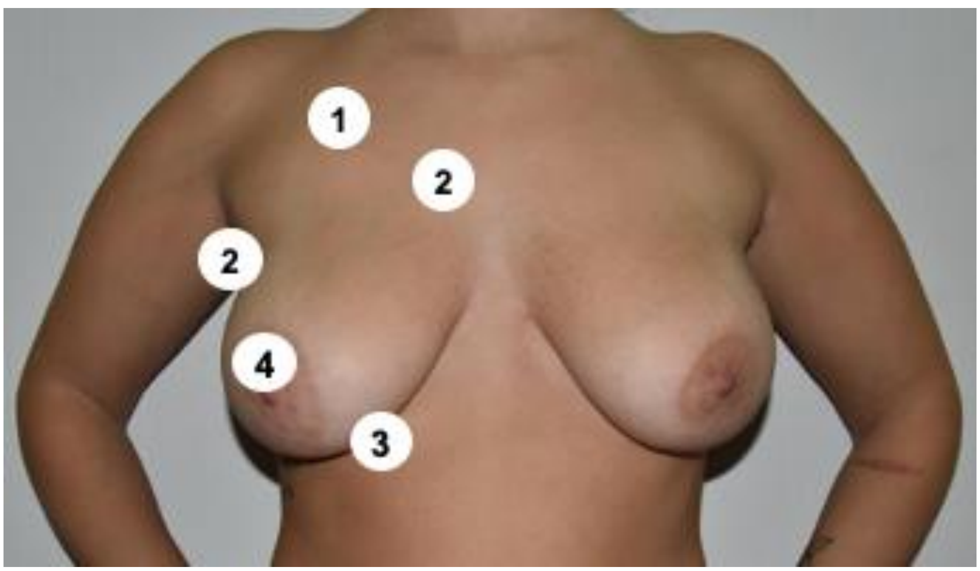

Figure 1. Areas to evaluate in breast US: (1) infraclavicular; (2) sternal and lateral; (3) submammary grove; (4) retro areolar.

Transducer positioning (3)

The recommended positioning is *perpendicular*, continuously from the submammary groove to the axillary tail, and *orthogonal* for areas of particular interest, by exerting a variable pressure to assess the lesion compression and behavior. A tip for evaluating skin or subcutaneous superficial lesions is using higher frequencies and applying gel generously *(Figure 2)* [3].

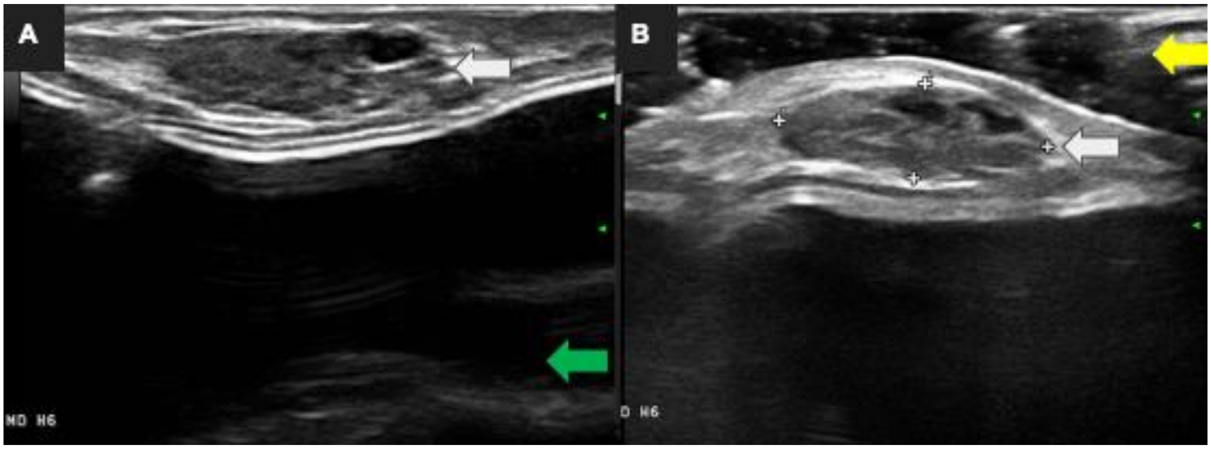

Figure 2. A tip for evaluating superficial lesions: applying a gel coat. (A) Shows a superficial lesion (white arrow) in prosthetic reconstruction (green arrow) at 6 o'clock position underneath the scar. (B) After applying a gel coat (yellow arrow) the lesion is seen as an oily cyst.

Transducer compression and lesions compressibility (4)

Whereas the normal fatty tissue modifies its thickness with manual compression and does not deform the surrounding tissue, a lesion has a mass effect and rough edges with the surrounding tissue [4] (Figure 3). Also, changing the scan plan and seeing continuity with the surrounding tissue differentiates between a lesion and a pseudo-lesion due to Cooper's ligaments' prominent shading [5]. The same applies to the nipple and areolar complex acoustic shadow, which hinders subareolar region lesions visualization; this can be overcome by changing the transducer angle and slightly pushing the nipple to the side [4]. Finally, it should be remembered that lesions tend to flatten on US and stretch in mammograms [3].

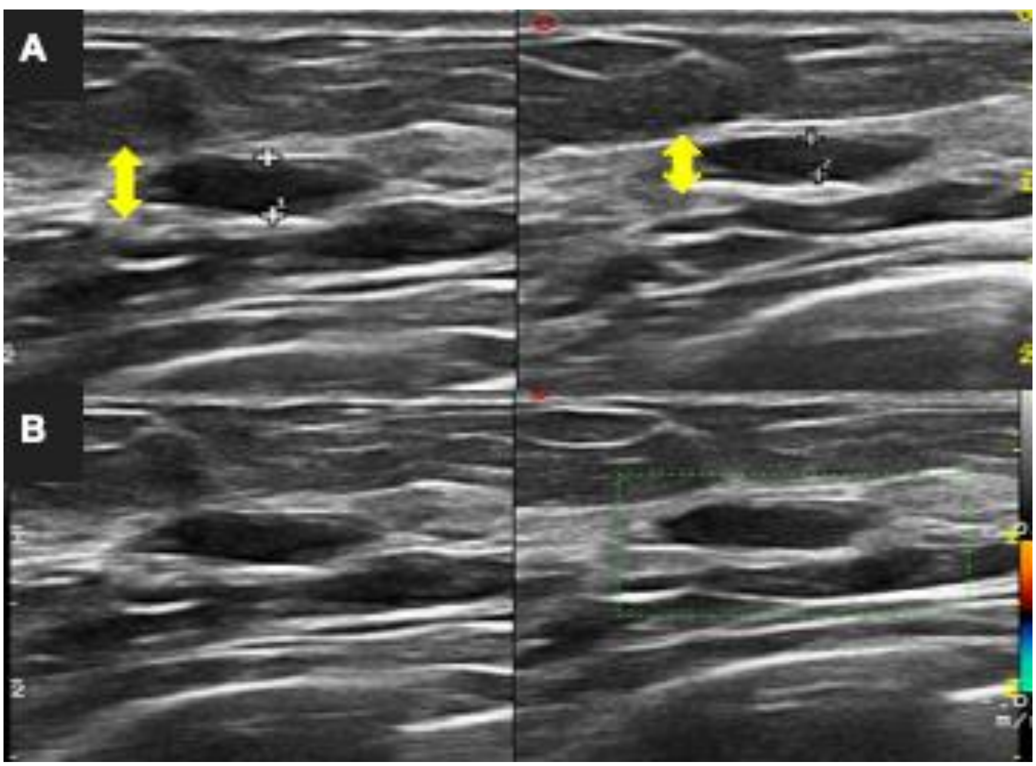

Figure 3. Evaluating the lesion compressibility. (A) Shows how manual compression modifies the thickness of a fatty lobe (yellow arrow), reinforced by the absence of Color Doppler flow inside the lesion (B).

Establishing lesion localization and echogenicity (5)

US should include the entire mass in multiple planes, measurement, clock time position, and distances to posterior pectoral plane and nipple; images should be with and without calipers to assess margins [6].

American College of Radiology recommends setting the echogenicity in relation to the subcutaneous fatty tissue [7] in mid-level gray, and fat in the pre mammary area should demonstrate the same echogenicity as the mammary parenchyma and retromammary area [2,3,7]. Most solid masses are hypoechoic, while the skin, Cooper ligaments, and fibrous tissue are echogenic and simple cysts are anechoic [3]. Skin and subcutaneous fat are highly reflective, intraparenchymal fatty tissue is hypoechogenic, and breast parenchyma and fibrous tissues and Cooper's ligaments are hyperechoic structures [1].

Adjusting parameters in the US (6)

First, check the field of view to breast size; trapezoidal and panoramic have a wider field of view [2].

Secondly, modify the depth to include the entire breast. The beam's focus should be 1 to 2 cm from the skin to evaluate the mammary area [2]. Then, the *focal area* should be placed at the lesion level or just below it (*Figure 4)* [2,3].

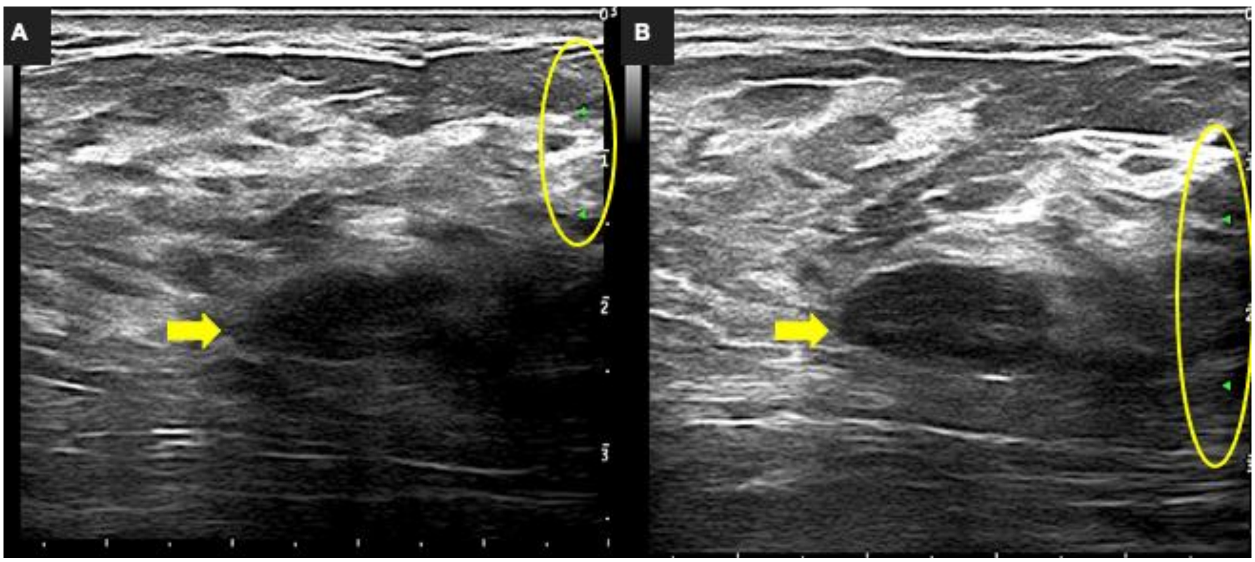

Figure 4. The focal area is the beam narrowest part with the highest lateral resolution and should be placed at or slightly below the area of interest. (A) Shows how an incorrectly positioned focal (circle) area blurs the lesion margin (arrow), whereas (B) the correctly set (circle) allows a better definition (arrow).

Thirdly, set the following parameters to assign the iso-echogenicity standard of fat tissue [3]:

**Time gain compensation curve* should gradually increase with increased depth and match the fatty tissue in all the breast depths [6] *(Figure 5)*.

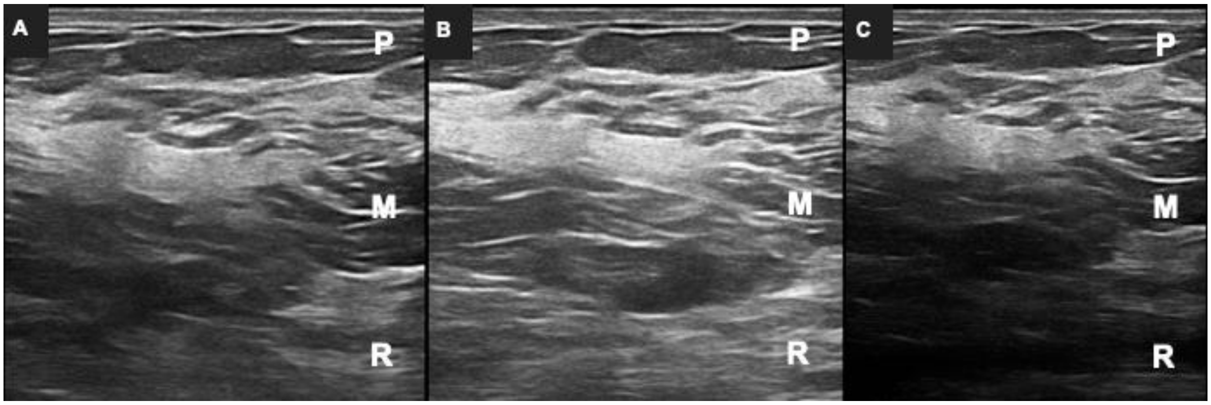

Figure 5 The fatty tissue at all breast tissue depths should be set at midlevel gray echogenicity. From cranial to caudal, there are three zones: pre-mammary (P), mammary (M), and retro-mammary (R). (A) Echogenicity is adjusted correctly. The quality could be poor as in (B) if the gain setting is too high and the fat lobes will appear too bright, or as in (C) if the gain setting is too low and the fat lobes will appear dark gray.

**Grayscale gain setting* (brightness) determines the return signal amplitude. Spurious echoes can be displayed in a simple cyst resembling a complex cyst or solid mass if it is too high. If gain is too low, a solid mass can appear as a cyst (*Figure 6)* [2].

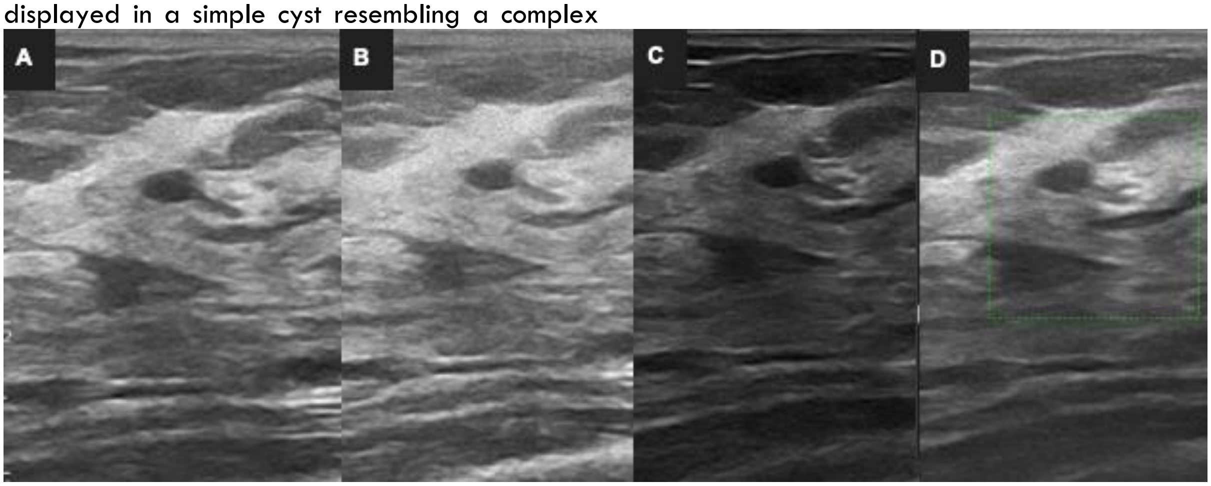

Figure 6. Variations in grayscale allow differentiating cystic from solid lesions. A) Demonstrates an appropriate gain. B) Shows if the gain is high, the lesion may be misinterpreted as solid. C) Shows if the gain is low, the lesion may be misinterpreted as cystic. D) Doppler evaluation demonstrates the absence of vascularization. The lesion was interpreted as a cystic with low-level internal echoes (Bi-Rads 2).

**Dynamic range* (optimal: 55-70 dB) is the number of shades of gray. A higher will allow perceiving subtle differences, and a lower will increase image contrast [2] (Figure 7).

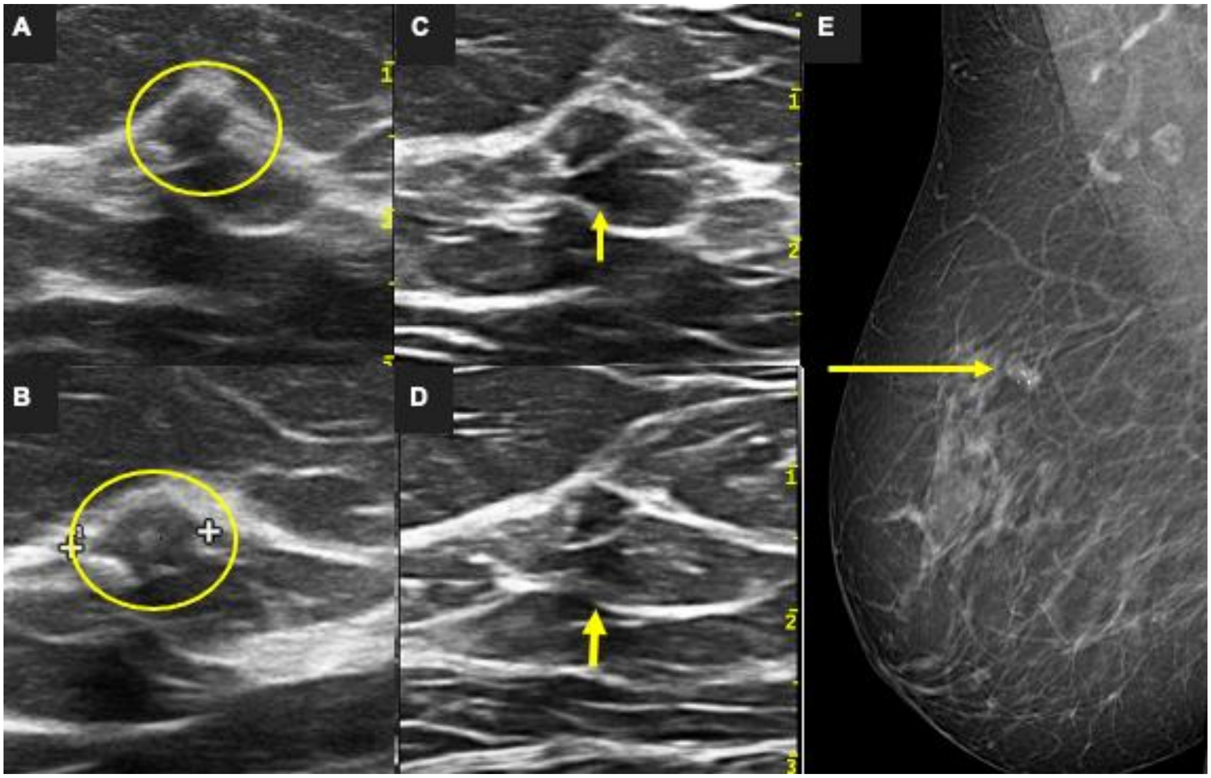

Figure 7. Variations in dynamic range influence lesion delineation. A) and B) show a larger dynamic range that generates a smoother image (circles). C) and D) show a reduction of the dynamic range that will cause a steeper gradient in the image contrast, allowing a better view of the nodule associated with calcifications (arrows). E) The mammographic mass is represented as an oval isoechoic mass in the middle portion of the breast with associated calcifications (arrow).

**Harmonic tissue imaging* makes the beam narrower, improving the resolution [7,8], and reducing artifacts such as reverberation and comet tail artifacts [8].

Doppler color and Power Doppler (9)
Currently, it is not mandatory in BI-RADS [9]. Visualizing a vessel on the periphery and inside a mass and adjacent tissue is normal. Contrarily, common malignancy signs are tortuous vessels with irregularity in their branches (central, penetrating, branched) and unordered intratumoral vessels [7,10] (Figure 8). Also, Doppler can help in the calcifications' characterization as echogenic foci with the scintillation artifact [3,5] *(Figure 9)*.

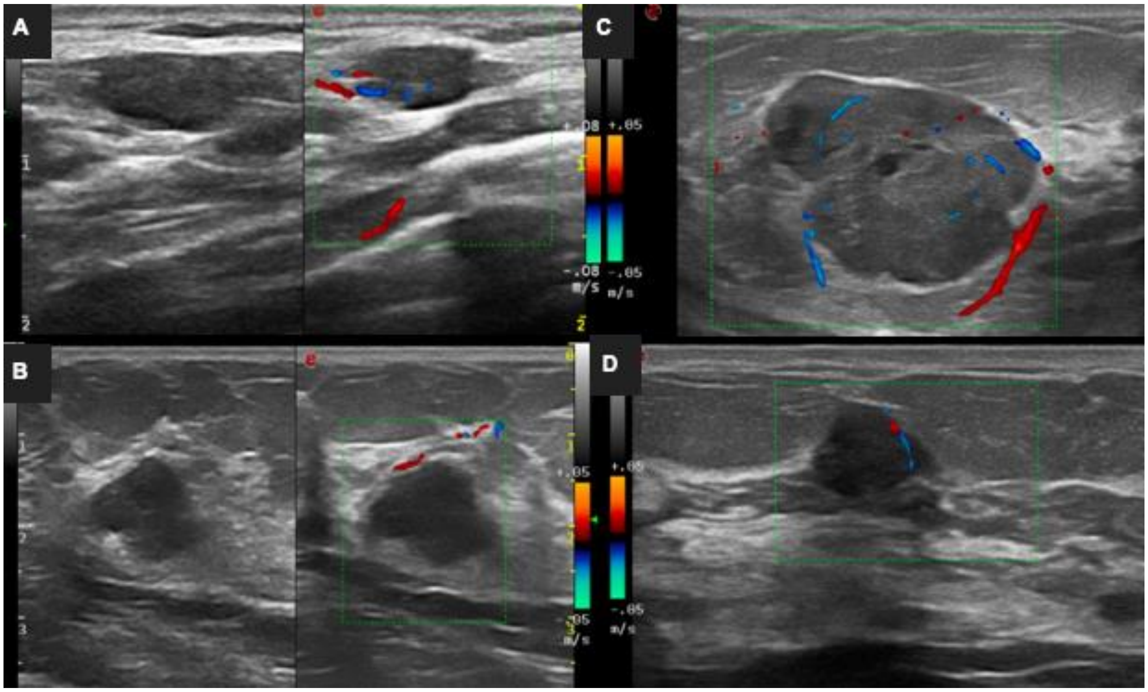

Figure 8. A parallel artery and vein can be seen throughout all the images (A, B, C, and D) in the center and the periphery of the mass, suggesting a benign etiology.

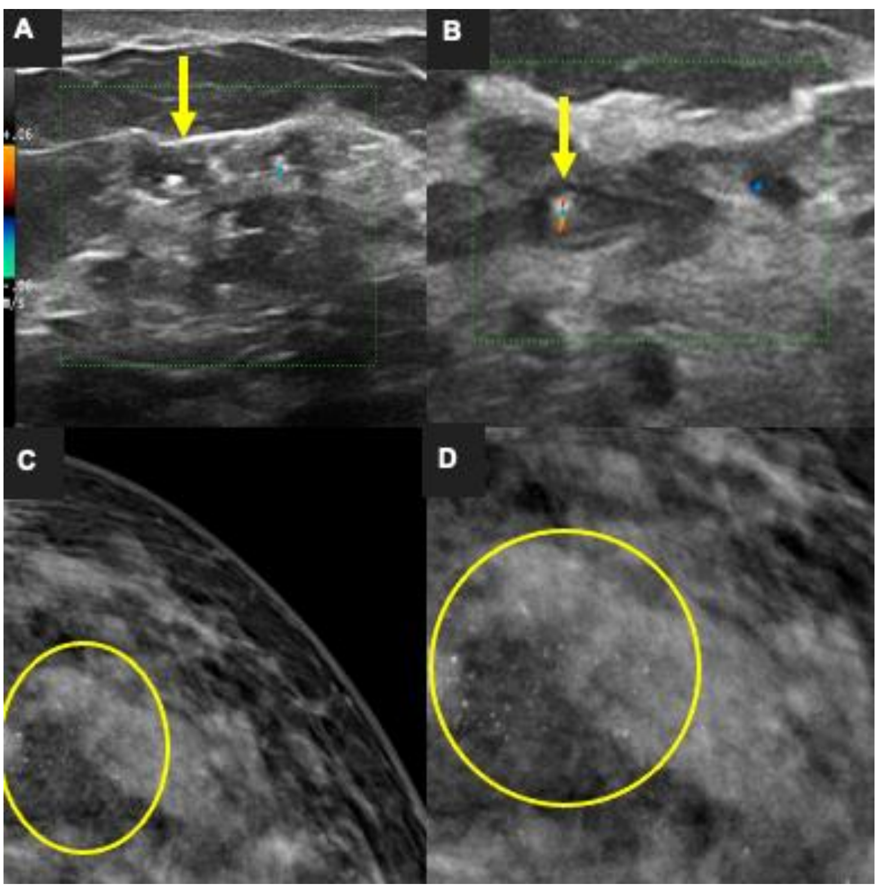

Figure 9. (A, B) US Color Doppler images demonstrate small clustered microcysts, containing tiny echogenic foci and scintillation artifact (arrows) that confirms the presence of microcalcifications in correlation with the mammographic finding (C and D, CC view and spot view, respectively).

Correlating US and mammography (10)

To US appropriate localization, it is essential to localize the quadrant, depth, and distance to the nipple and the calcifications or lesions in mammograms [5,11,12], especially in CC view [3] (F*igure 10 and 11*). Also, placing a skin marker during US will help localize the lesion on a mammogram [5,6].

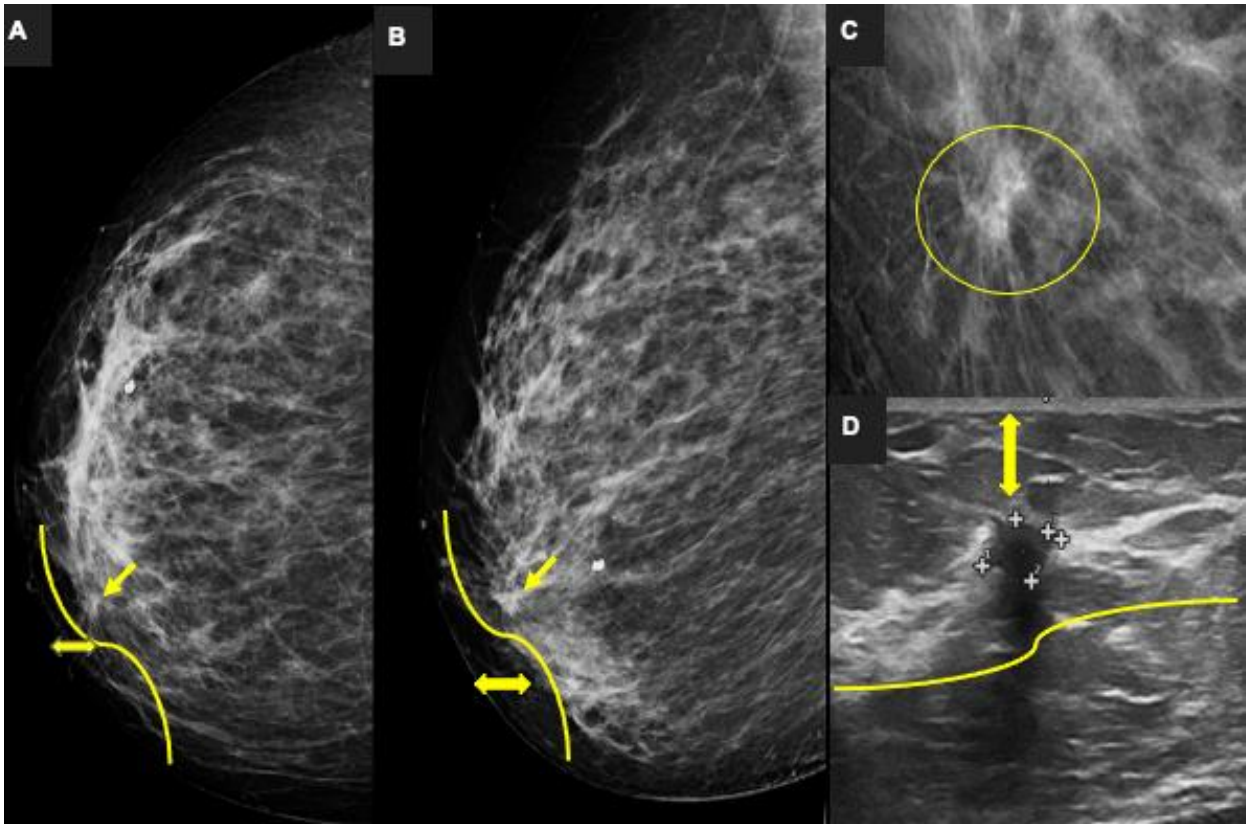

Figure 10. (A) CC view of a screening mammogram revealed a small focal asymmetry in the lower internal quadrant of the right breast (arrow). (B) Corresponding lesion on the medial-lateral-oblique view (MLO). (C) CC spot view identified a focal asymmetry (circle). (D) US reveals a suspicious mass at 10 o'clock (arrow). Histopathology: invasive ductal carcinoma.

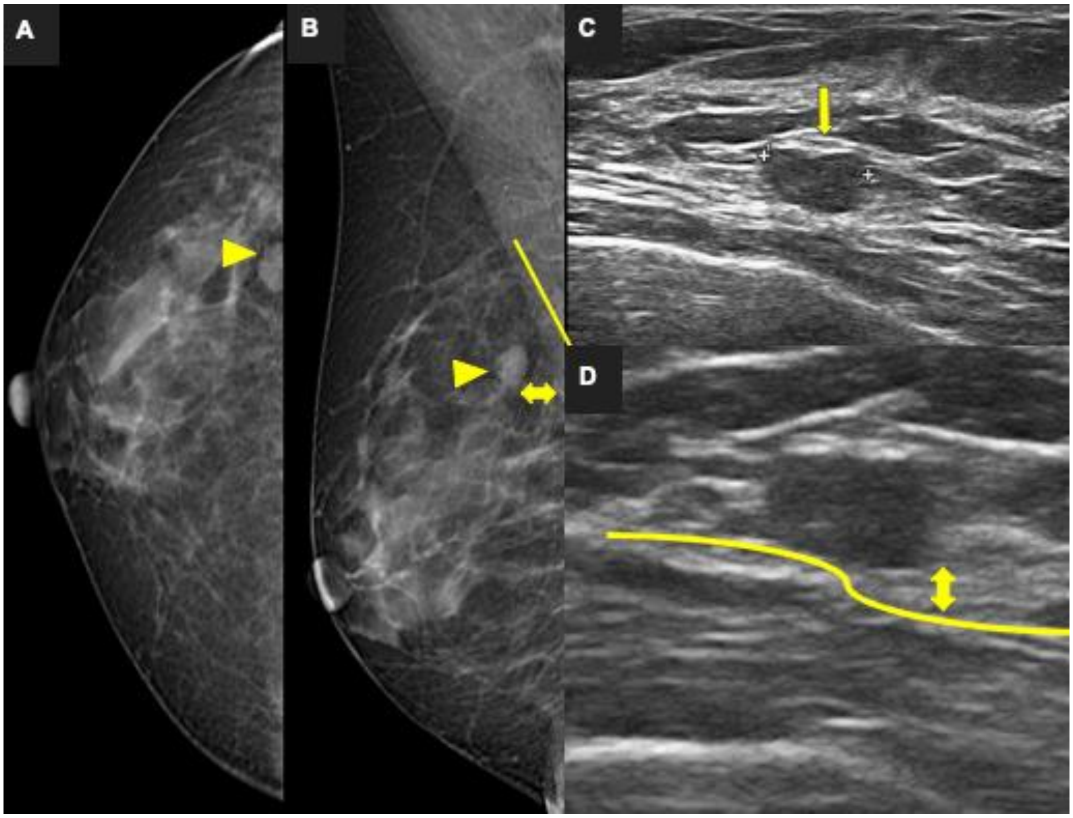

Figure 11. Posterior location of a breast lesion. CC (A) and MLO (B) views show a 1 cm lobular isodense mass (arrowhead) in the posterior section of the breast. On US transverse (C and D), the mass is depicted as an oval microlobulated isoechoic mass (arrows) in the posterior section of the breast, adjacent to the pectoral muscle.

Second-look US after MRI (11)

It is a targeted examination after an MRI to possibly allowing a US-guided biopsy, which is less costly, more broadly available, and comfortable [13-15]. The patient positioning on MRI is ventral decubitus, whereas in US is supine. The subcutaneous fat, glandular tissue, and subglandular fat on MRI correspond to the US's anterior, middle, and posterior zones [14,15] *(Figure 12)*.

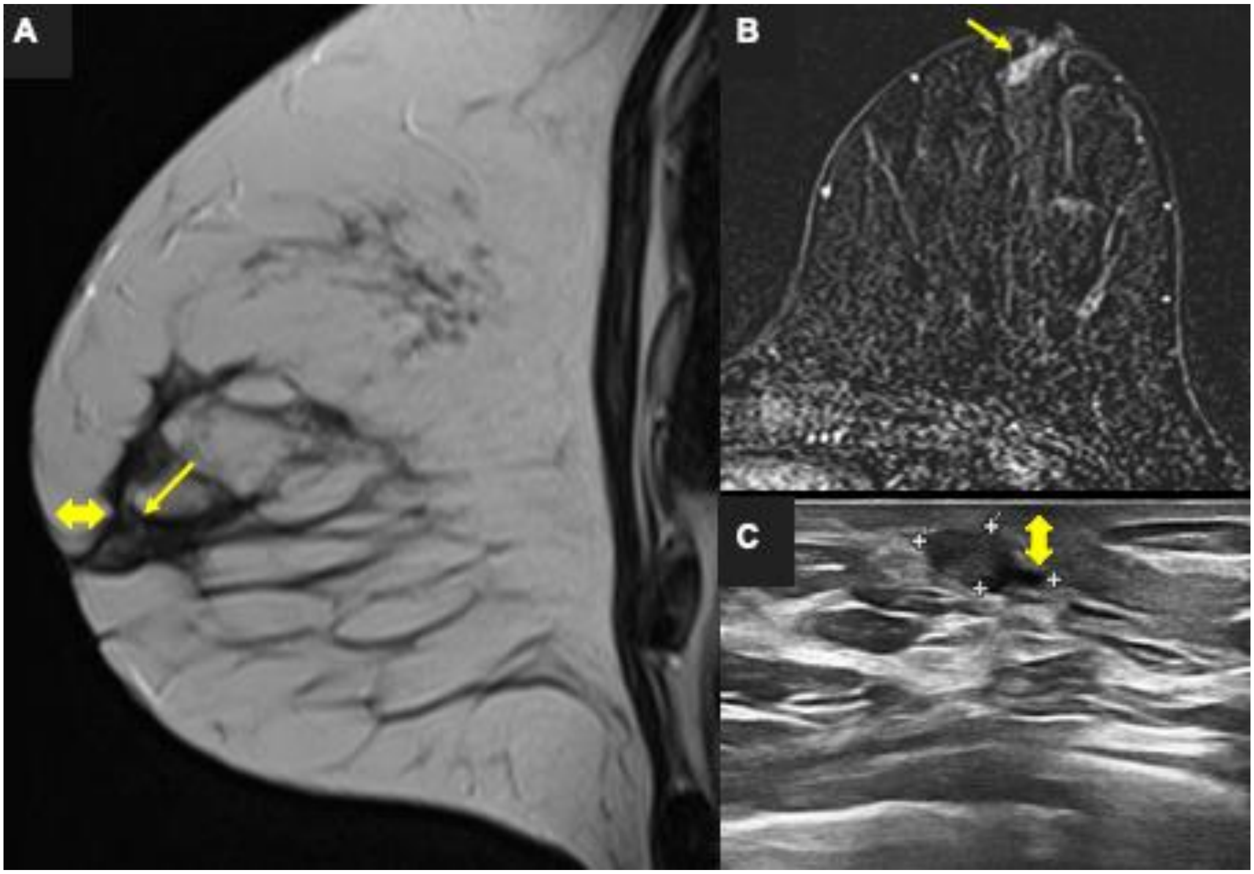

Figure 12. (A) MRI Sagittal T2-weighted image shows a nodule within the duct (arrow) in the retroareolar region of the right breast. (B) T1 fat-saturated post-contrast subtraction image demonstrates a linear enhancement (arrow). (C) Second look US confirms the presence of an intraductal hypoechoic lesion in the retroareolar region without vascularization at Doppler (arrow). Histopathology: intraductal papilloma with atypia.

Since a missing MRI-US correlation does not exclude malignancy, it is advisable doing a US-guided biopsy of an MRI-discovered lesion [15]. Some innovations such as real-time virtual sonography, which can synchronize US and MRI images in real-time [16], are trying to overcome limitations.

Non-mass findings (12)

Currently not included in Bi-RADS, it is an identifiable altered echotexture area that does not conform to a mass shape (incidence: 1% - 5.3%), most caused by DCIS and ILC. An MRI non-mass enhancement may correlate with UD non-mass findings [17] (*Figure 13)*

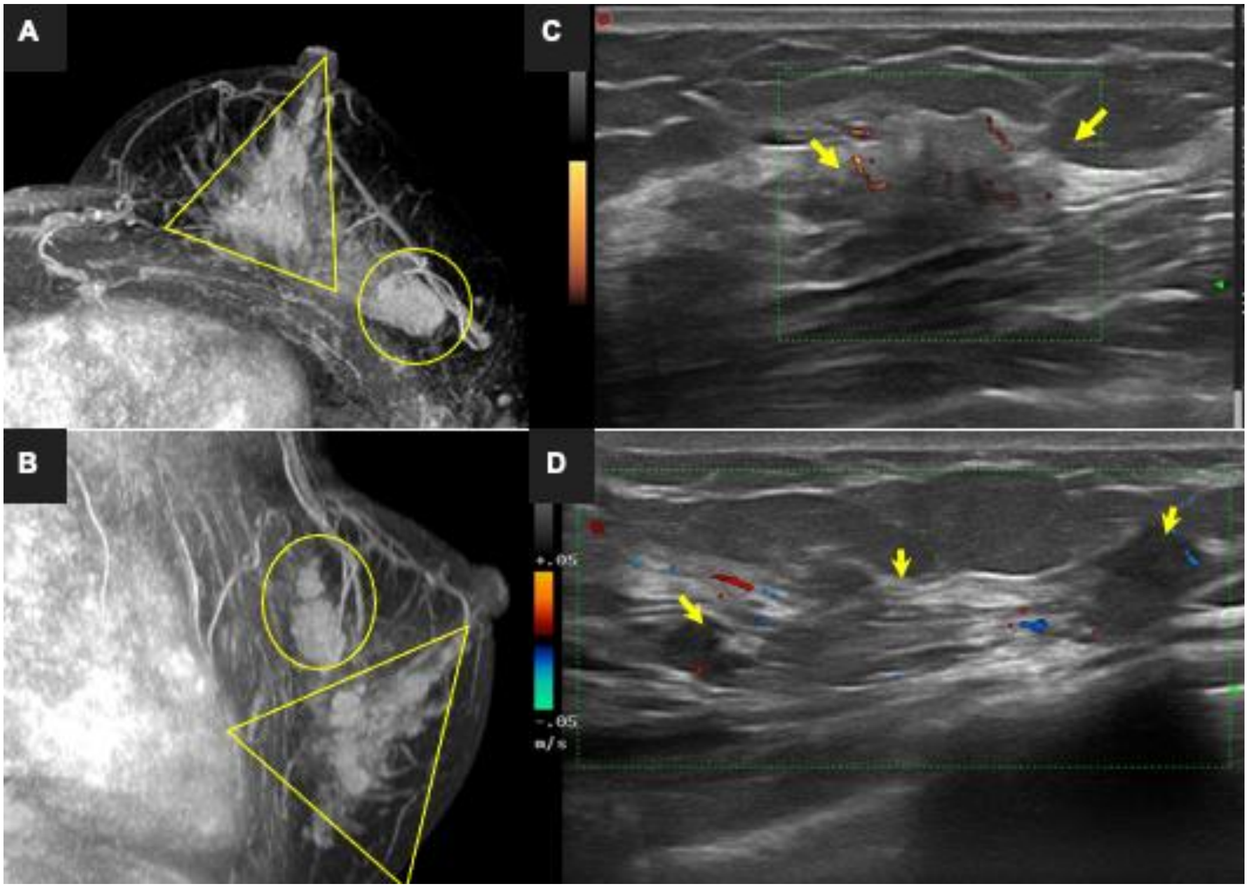

Figure 13. Non-mass findings on US correlate with MRI non-mass enhancement. Axial (A) and sagittal (B) contrast enhanced MIP projections of MRI show a focal non-mass enhancement (circles) in the upper outer quadrant of the left breast and a segmental non-mass enhancement at the 6 o'clock position in the same breast (triangles). (C) Focus US shows a focal finding without a corresponding mass seen as a hypoechoic area (arrows) in the upper outer quadrant and (D) shows a linear hypoechoic non-mass finding (arrows) at the 6 o'clock position. Histopathology: invasive ductal carcinoma in both locations.

Breast implants and ruptures (13)

It is essential to know the implant type and previous exchanges. The field of view should cover the implant altogether. A tip is placing focal areas in different levels and splitting the screen to use the contralateral side as a reference [18]. A normal implant is anechoic and exhibits a smooth contour outlined by a trilaminar-elastomer-covered fibrous capsule (Figure 14), and also can have radial folds representing elastomer cover invaginations [18].

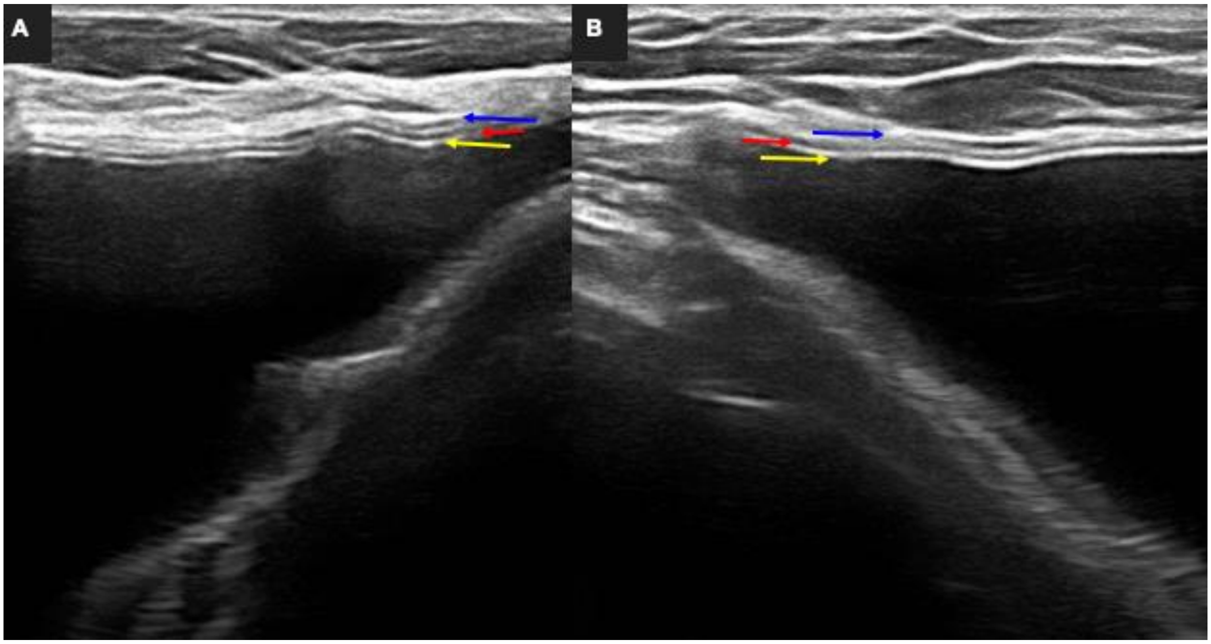

Figure 14. Complex trilaminar-elastomer-covered fibrous capsule. The external echogenic line corresponds to the outer surface of the capsule (blue arrow), the median echogenic line represents a fusion of two echogenic lines that correspond to the inner surface of the capsule and the outer surface of the elastomer cover (red arrow), and the internal echogenic line corresponds to the internal surface of the elastomer (yellow arrow).

"Keyhole", "subcapsular line", and "stepladder" are classic signs of *intracapsular* rupture. The silicone begins to settle inside the vertex of a radial fold and expand it, giving a "keyhole" appearance. The extruded silicone fits the fibrous capsule within the intracapsular space, causing a sheet-like separation "subcapsular line". As the silicone continues to escape, the elastomer shell progressively invaginates, producing thin echogenic lines "stepladder, "[18]. A mimicker of it is the implant impurities (*Figure 15),* creating spurious echoes (avoid it by comparing with the contralateral implant).

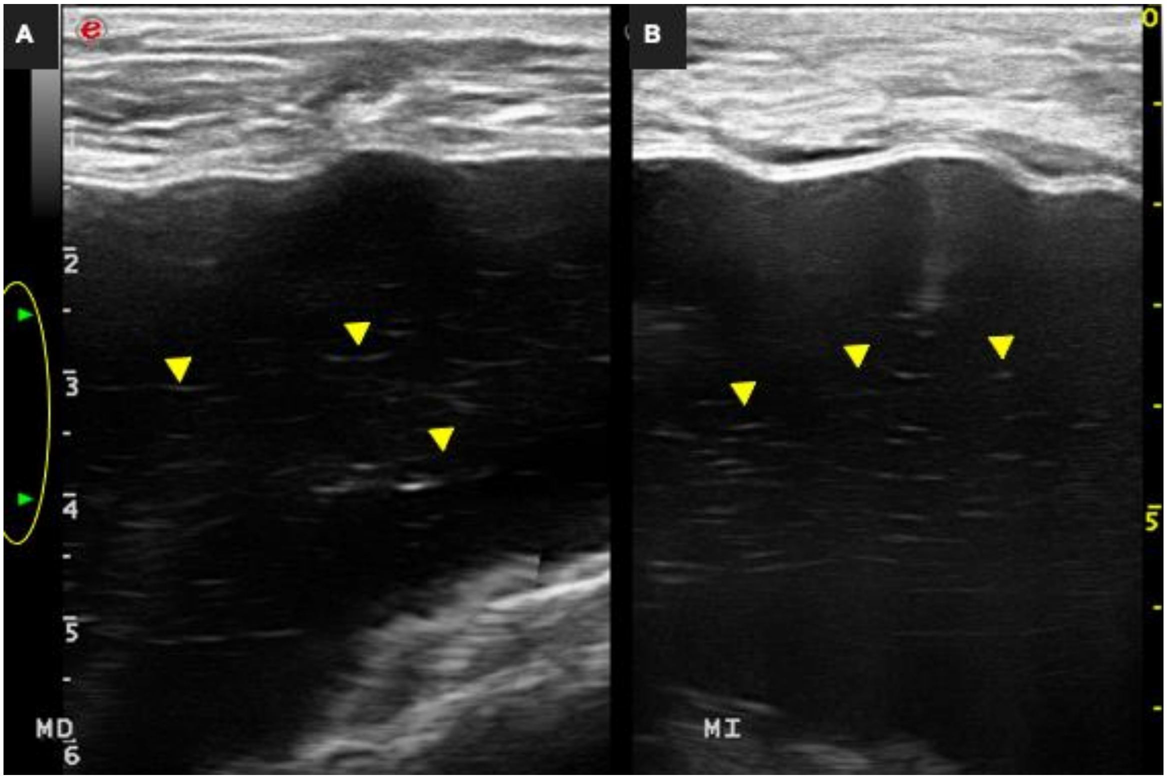

Figure 15. Spurious echoes within the silicone implant mean, in most cases impurities, or that the silicone gel began to solidify over time. To assess questionable artifacts in internal echogenicity, two split-screen images are usually helpful. When evaluating implants, the focal area should be located at the height of the implants (circle on A).

Reverberation artifact, a band of increased echogenicity paralleling the capsule-shell complex, is commonly seen along the implant margin, and be minimized by using lighter compression or possibly harmonic imaging. Echogenic lines within the implant that do not parallel the capsule-shell complex should raise suspicion for rupture [18].

The most frequent sign of extracapsular rupture is the "snowstorm," representing free silicone inside the parenchyma with variable echogenicity. Tips for identification are mammography and correlation with the history of replacement or free silicon injection. Also, it can be delineated in axillary adenopathy due to gel bleeding in progress, but not necessarily suggesting rupture [18].

Conclusion

US quality depends on the operators' experience and knowledgeability. US good technical practices, accurate scanning, and correlation with mammography and MRI allow for a more optimal diagnosis of breast lesions.

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Informed consent: it was waived for this retrospective investigation by the IRB as this study was of minimal risk, and data were deidentified.

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References

1. Athanasiou A, Tardivon A, Ollivier L, Thibault F, El Khoury C, Neuenschwander S. How to optimize breast ultrasound. *Eur J Radiol*. Jan 2009;69(1):6-13. doi:10.1016/j.ejrad.2008.07.034
2. Carpentier B, Hayward J, Strachowski L. Enhancing Your Acoustics: Ultrasound Image Optimization of Breast Lesions. *J Ultrasound Med*. Jul 2017;36(7):1479-1485. doi:10.7863/ultra.16.09018
3. Hooley RJ, Scoutt LM, Philpotts LE. Breast ultrasonography: state of the art. *Radiology*. Sep 2013;268(3):642-59. doi:10.1148/radiol.13121606
4. Baker JA, Soo MS, Rosen EL. Artifacts and pitfalls in sonographic imaging of the breast. *AJR Am J Roentgenol*. May 2001;176(5):1261-6. doi:10.2214/ajr.176.5.1761261
5. Uematsu T. Ultrasonographic findings of missed breast cancer: pitfalls and pearls. *Breast Cancer*. Jan 2014;21(1):10-9. doi:10.1007/s12282-013-0498-7
6. Wang LC, Sullivan M, Du H, Feldman MI, Mendelson EB. US appearance of ductal carcinoma in situ. *Radiographics*. Jan-Feb 2013;33(1):213-28. doi:10.1148/rg.331125092
7. Kim MJ, Kim JY, Yoon JH, et al. How to find an isoechoic lesion with breast US. *Radiographics*. May-Jun 2011;31(3):663-76. doi:10.1148/rg.313105038
8. Anvari A, Forsberg F, Samir AE. A Primer on the Physical Principles of Tissue Harmonic Imaging. *Radiographics*. Nov-Dec 2015;35(7):1955-64. doi:10.1148/rg.2015140338
9. Mendelson EB B-VM, Berg WA, Whitman GJ, Feldman MI, Madjar H, et al. ACR BI-RADS ultrasound. In: D'Orsi CJ SE, Mendelson EB, Morris EA, ed. *ACR BI-RADS Atlas: Breast Imaging Reporting and Data System*. 2013.
10. Vilagran M, Del Riego J, Palaña P, et al. Parallel vessels as a predictor of benignity in solid breast masses. *Breast J*. Mar 2019;25(2):257-261. doi:10.1111/tbj.13190
11. Park JM, Franken EA, Jr. Triangulation of breast lesions: review and clinical applications. *Curr Probl Diagn Radiol*. Jan-Feb 2008;37(1):1-14. doi:10.1067/j.cpradiol.2007.09.001
12. Park JM, Yang L, Laroia A, Franken EA, Jr., Fajardo LL. Missed and/or misinterpreted lesions in breast ultrasound: reasons and solutions. *Can Assoc Radiol J*. Feb 2011;62(1):41-9. doi:10.1016/j.carj.2010.09.002
13. Candelaria R, Fornage BD. Second-look US examination of MR-detected breast lesions. *J Clin Ultrasound*. Mar-Apr 2011;39(3):115-21. doi:10.1002/jcu.20784
14. Leung JW. Utility of second-look ultrasound in the evaluation of MRI-detected breast lesions. *Semin Roentgenol*. Oct 2011;46(4):260-74. doi:10.1053/j.ro.2011.08.002
15. Spick C, Baltzer PA. Diagnostic utility of second-look US for breast lesions identified at MR imaging: systematic review and meta-analysis. *Radiology*. Nov 2014;273(2):401-9. doi:10.1148/radiol.14140474
16. Ando T, Ito Y, Ido M, et al. Pre-Operative Planning Using Real-Time Virtual Sonography, an MRI/Ultrasound Image Fusion Technique, for Breast-Conserving Surgery in Patients with Non-Mass Enhancement on Breast MRI: A Preliminary Study. *Ultrasound Med Biol*. Jul 2018;44(7):1364-1370. doi:10.1016/j.ultrasmedbio.2018.03.001
17. Choe J, Chikarmane SA, Giess CS. Nonmass Findings at Breast US: Definition, Classifications, and Differential Diagnosis. *Radiographics*. Mar-Apr 2020;40(2):326-335. doi:10.1148/rg.2020190125
18. Seiler SJ, Sharma PB, Hayes JC, et al. Multimodality Imaging-based Evaluation of Single-Lumen Silicone Breast Implants for Rupture. *Radiographics*. Mar-Apr 2017;37(2):366-382. doi:10.1148/rg.2017160086