

BREAST ULTRASOUND

David V. Schacht MD MPH

I have no financial relationships
to disclose

ROLE OF ULTRASOUND IN BREAST IMAGING

- Diagnosis
 - Differential cysts from solid masses
 - Differentiate benign from malignant masses
- Screening
 - Women at high risk who can't have MRI
 - Dense breast parenchyma (separate discussion)
- Imaging guidance for breast interventional procedures

DIAGNOSIS

- ACR BI-RADS-US First Edition 2003
- Most recent printed ACR BI-RADS atlas 2025 Edition is available to purchase at [ACR.org](https://www.acr.org). The eBook is also available
- US Section Reference for this talk including images:

Leung, JWT, Baker, JA, Hooley, R, Loving, VA, Raelyea, JA. Ultrasound. In: ACR BI-RADS v2025 Manual. Reston, VA American College of Radiology; 2025

Updated BI-RADS Structure

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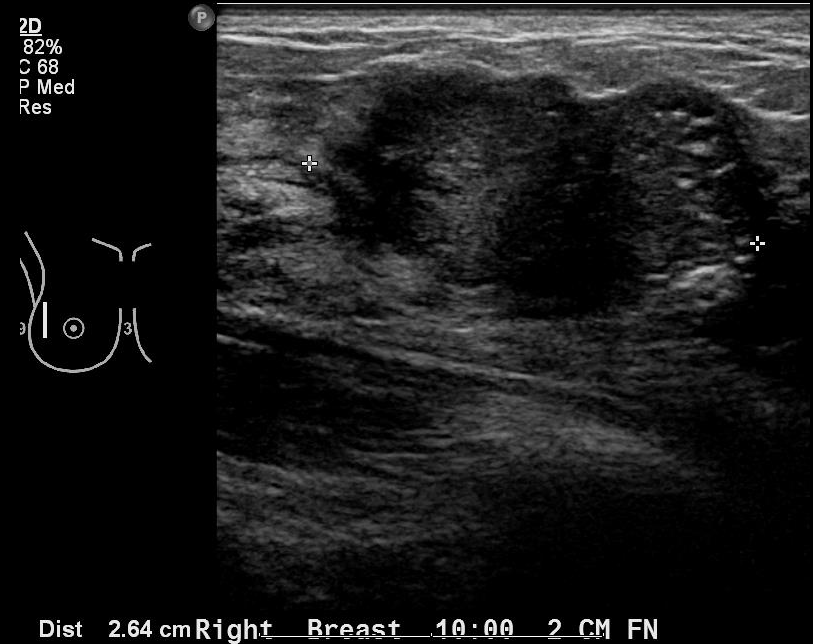
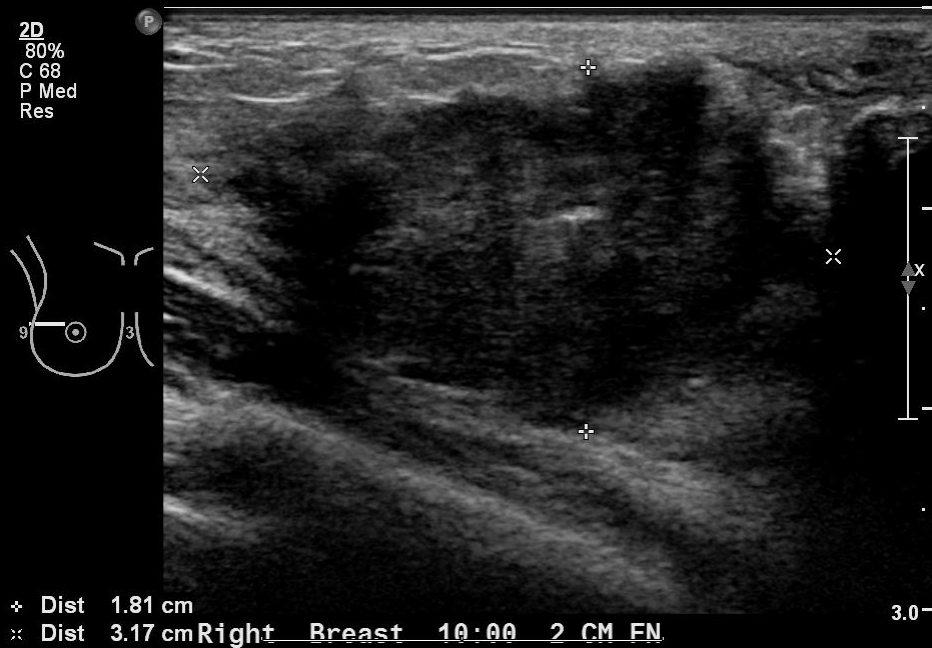
ANATOMY

- Helpful reminders regarding anatomy and US:
 - Normal breast skin thickness on US is up to 2 mm, except at areola
 - Imaging immediately behind the nipple requires a significant gel layer or oblique angled imaging
 - Depth of lesion can influence differential and management
 - Ex: Fat necrosis can at times be given BIR 2 in the subQ tissues
 - Normal lymph nodes in the breast and axilla have cortical thickness of 3 mm or less

IMAGE QUALITY

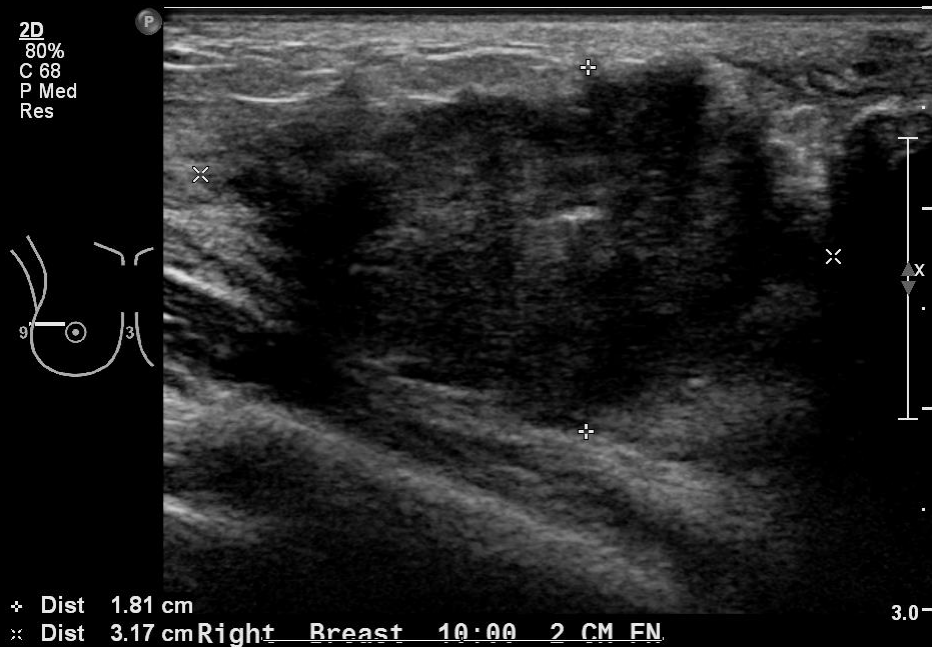
- Operate at at least 12 MHz
 - For high contrast and spatial resolution
 - At the expense of depth of penetration
 - Rare to have more than several cm of tissue when patient supine
- Compress appropriately in order to minimize artifacts such as shadowing (grayscale) and lack of vascularity (Doppler)

LABELING AND MEASUREMENT REMINDER



Round to the nearest whole hour and whole CM

LABELING AND MEASUREMENT REMINDER

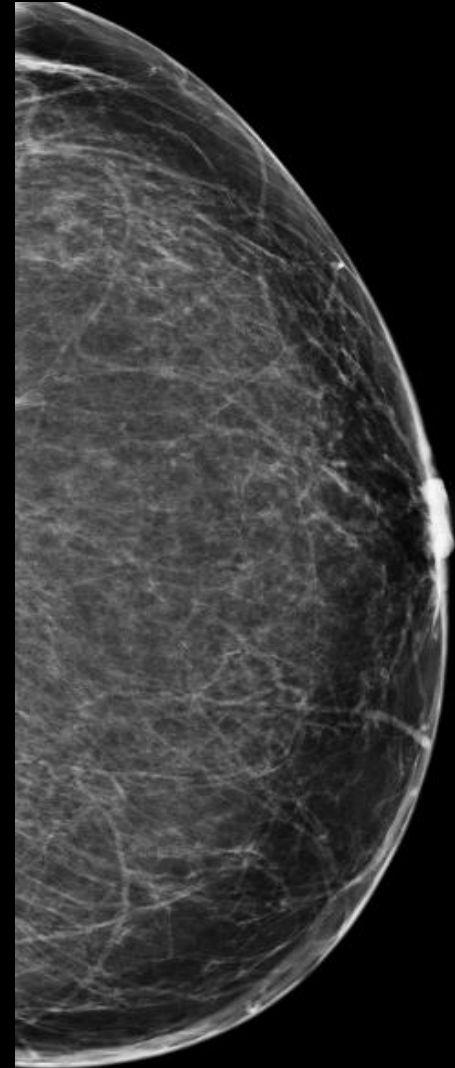
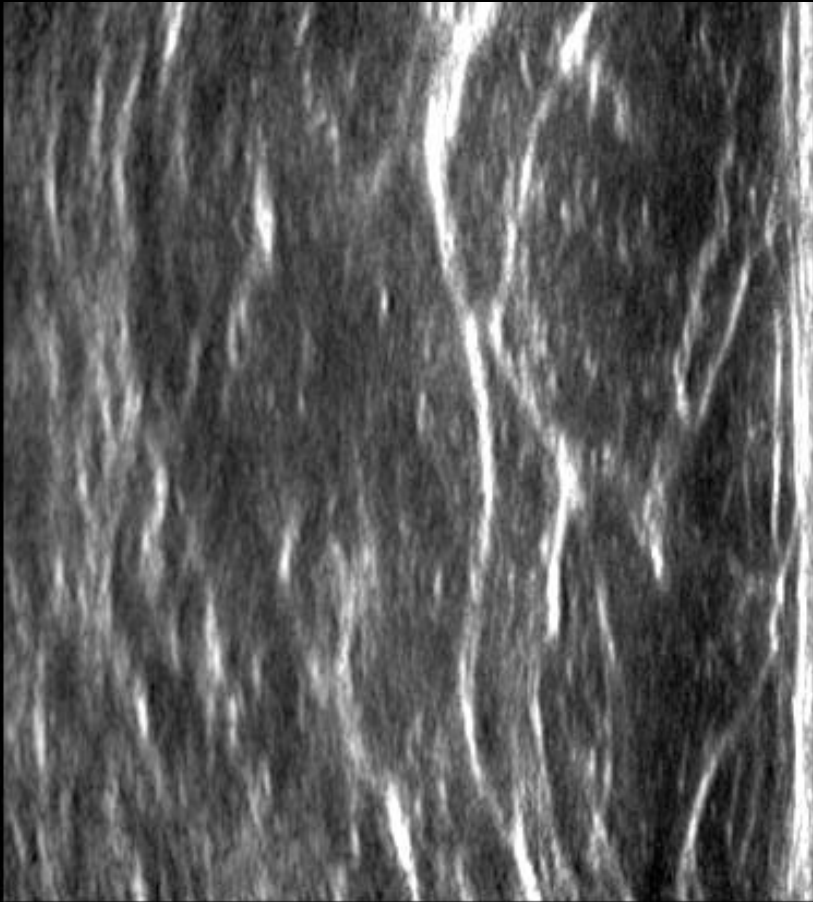


- Six images
 - 3 each: long/trans or radial anti-radial
 - Finding alone
 - With measurements
 - With Doppler
- Capture the longest size and then orthogonal measurements rounded to nearest mm or 0.1 cm (be consistent within a report)
- Measurement should include the echogenic rind, when present

BIRADS: TISSUE COMPOSITION

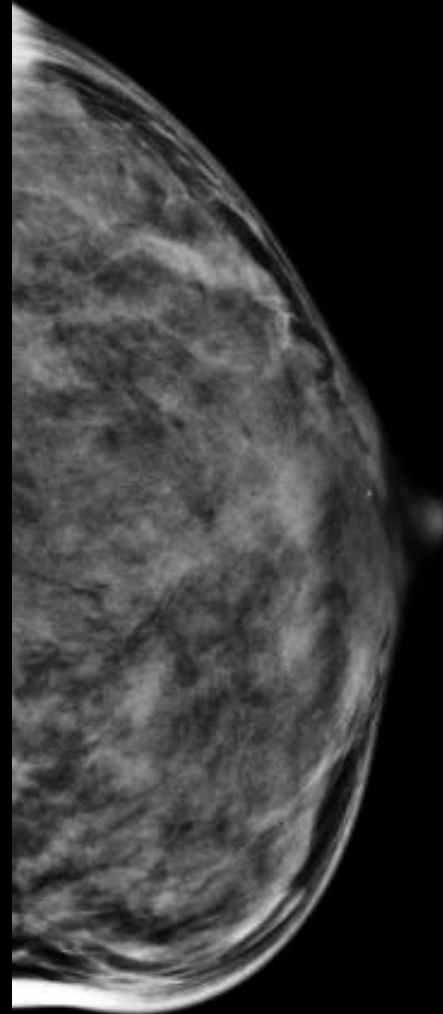
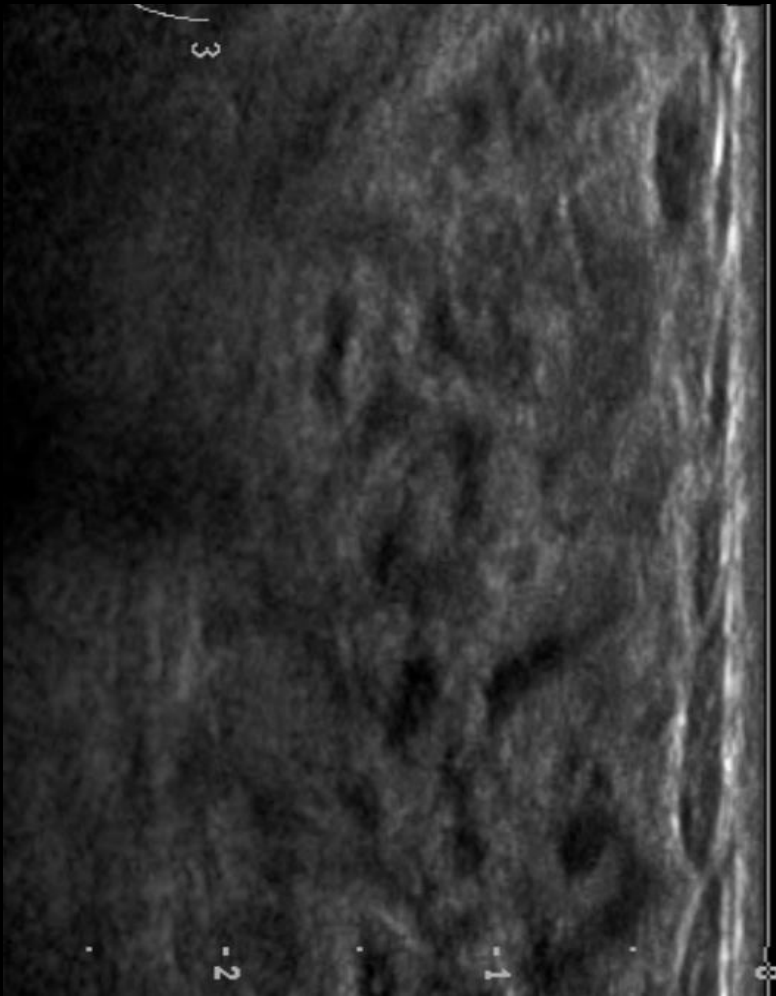
- For use primarily in the screening realm
- Tissue Pattern:
 - Homogeneously fat
 - Homogeneously fibroglandular
 - Heterogeneous tissue composition
- Glandular Tissue Component:
 - Minimal, Mild, Moderate, Marked

TISSUE PATTERN: FAT



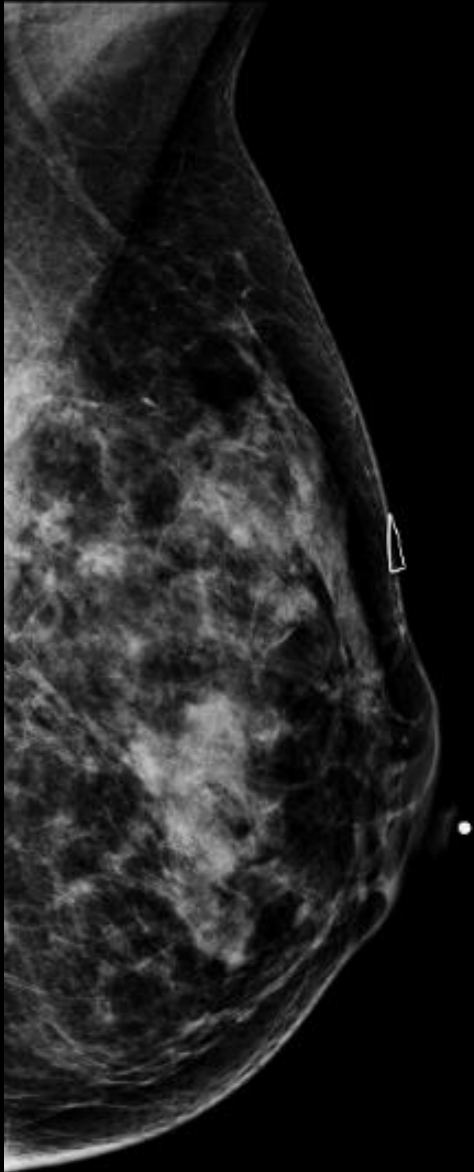
Only thin echogenic lines amidst fat lobules

TISSUE PATTERN: FIBROGLANDULAR



Thick zone of echogenic tissue beneath a small layer of subcutaneous fat

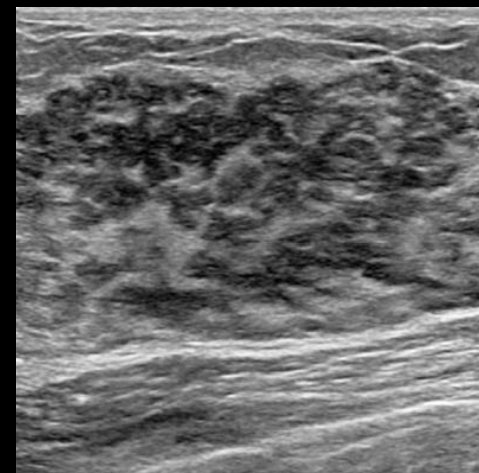
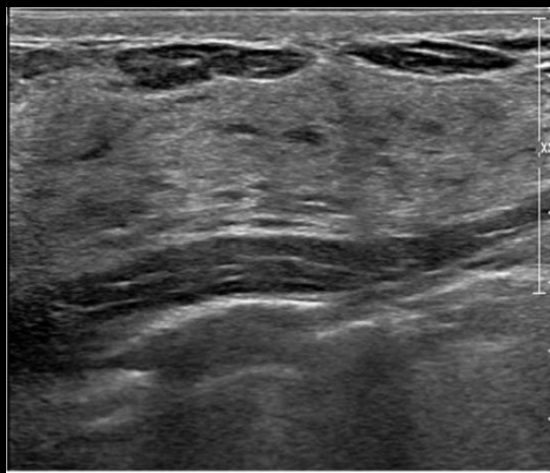
TISSUE PATTERN: HETEROGENOUS



A Combination of the two, and can be confounding in the screening setting

GLANDULAR TISSUE COMPONENT

- A risk factor for future cancer similar to density on mammo
- Amount of intermixed TDLUs (hypo) within echogenic stroma
- Minimal, mild, moderate, marked (spectrum shown)



FEATURE ANALYSIS-MASSES

- Multiple features should be used, but most important for US are: SHAPE, MARGINS, ORIENTATION, ECHO PATTERN
- Combined multiple features are the best predictors for differentiating benign vs. malignant cancers
- Do not select just one feature: parallel does not always mean the mass is benign

MASSES

- A mass occupies space and should be seen in two projections
- Masses can be distinguished from normal anatomic structures, such as ribs or fat lobules, using two or more projections and real-time scanning
- They should have real shape (unlike non-mass lesions)

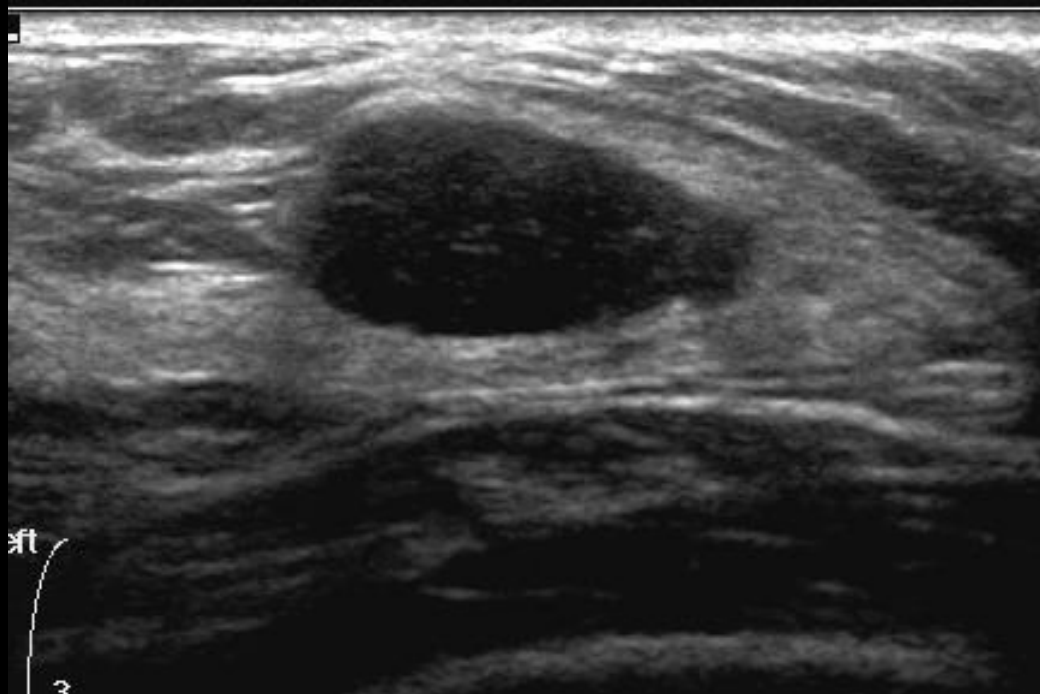


BIRADS MASSES-SHAPE

- Oval: elliptical or egg-shaped
- Round: spherical, ball shaped, circular, or globular
- Irregular: neither round nor oval
- Lobulated: Like Oval but with a few indentations

BIRADS MASSES-SHAPE

- Oval: elliptical or egg-shaped; may include 2 or 3 undulations
- Round: spherical, ball shaped, circular, or globular
- Irregular: neither round nor oval
- Lobulated: Like Oval but with a few indentations



Shape: Oval



Shape: Round

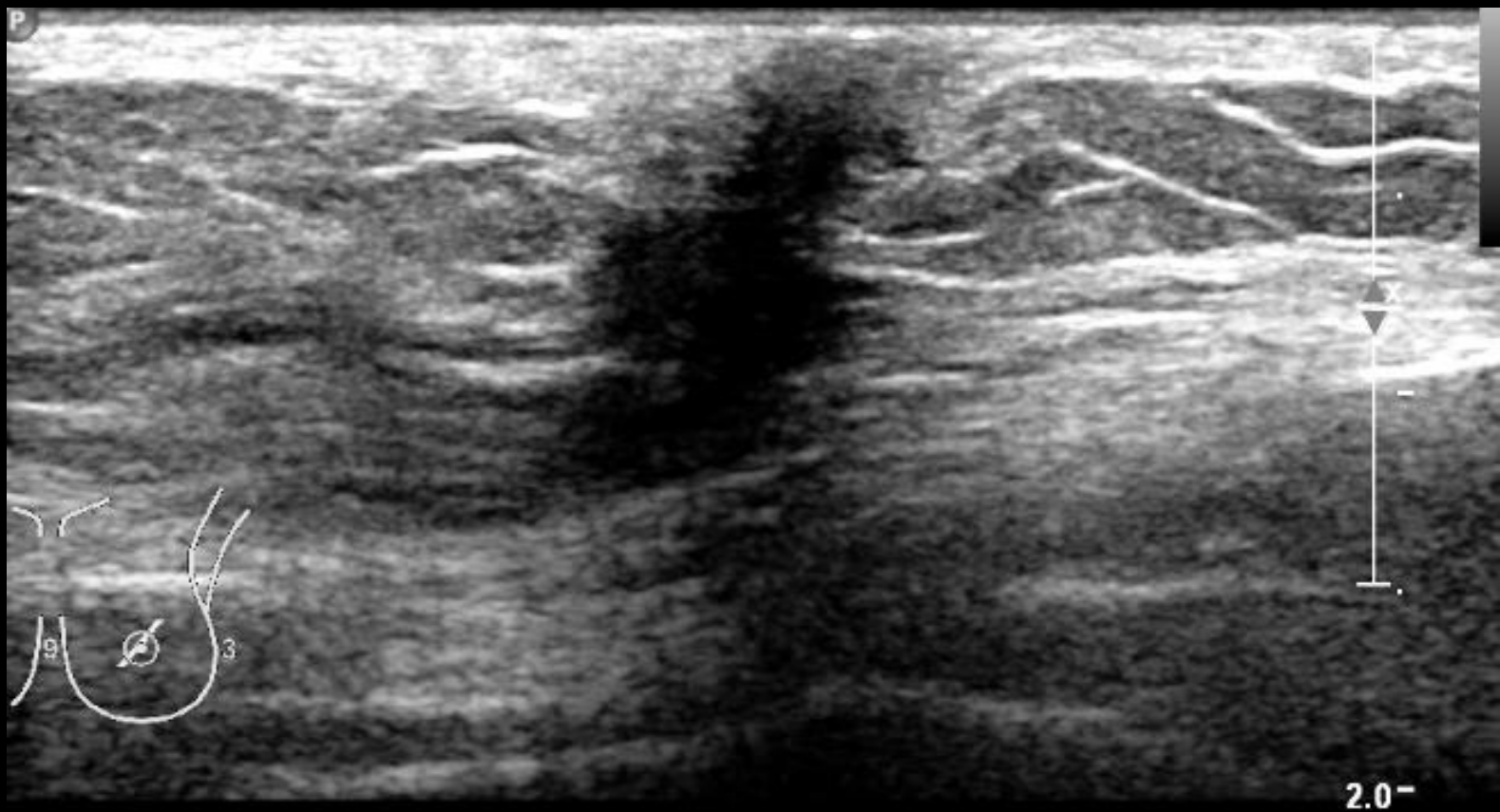
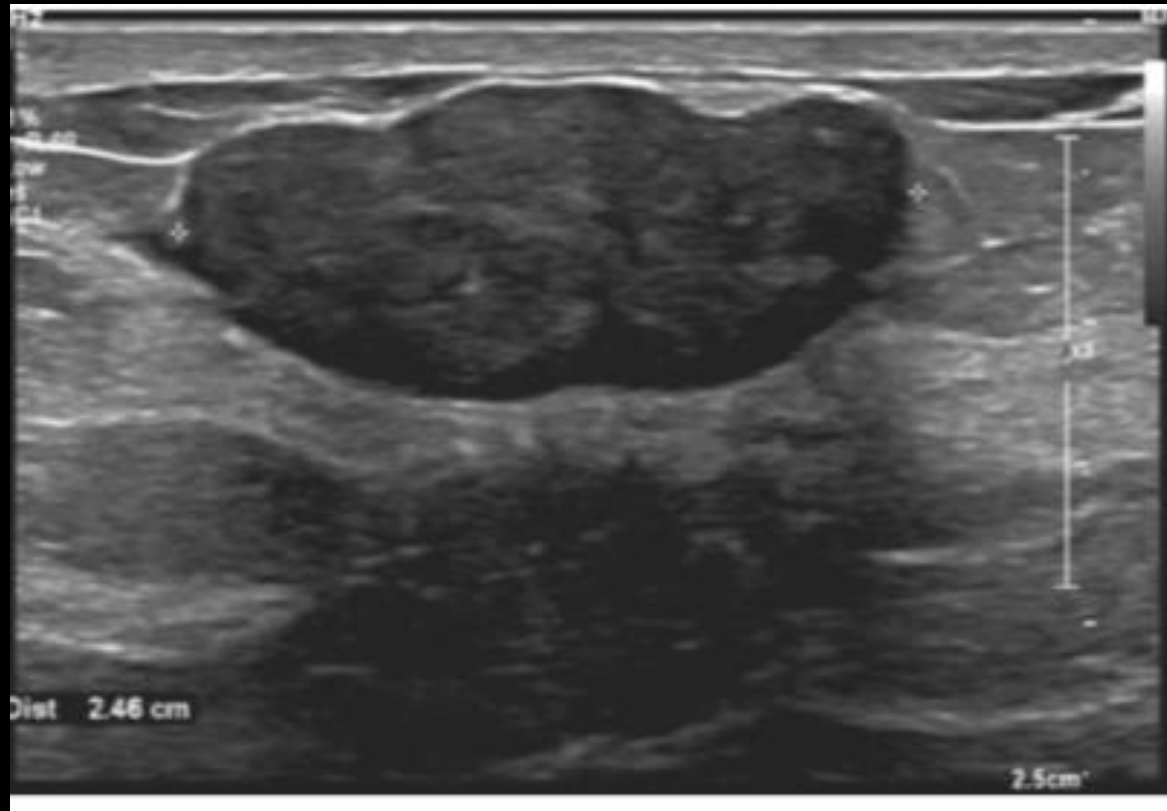


Image Time 11

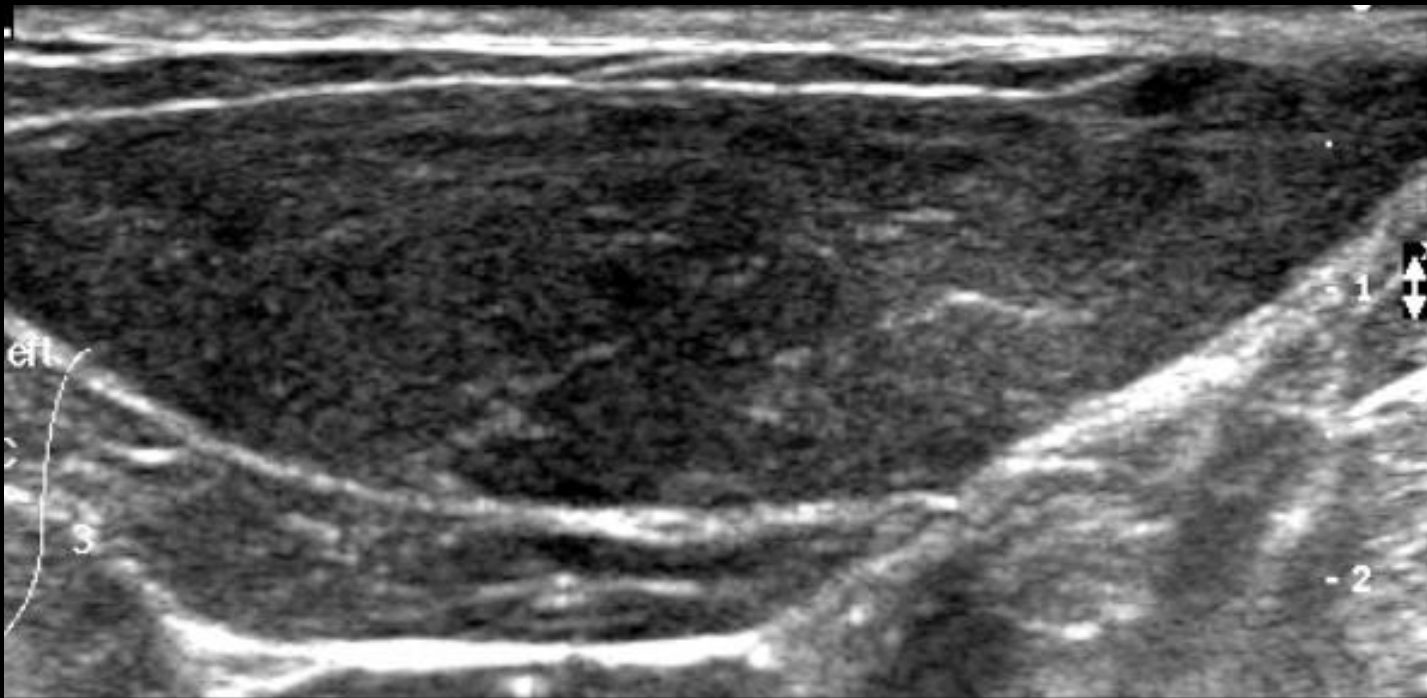
Shape: irregular



Shape: lobular

BIRADS MASSES-MARGINS

- Circumscribed: well defined, smooth, distinct rim, of the ENTIRE surface of the mass



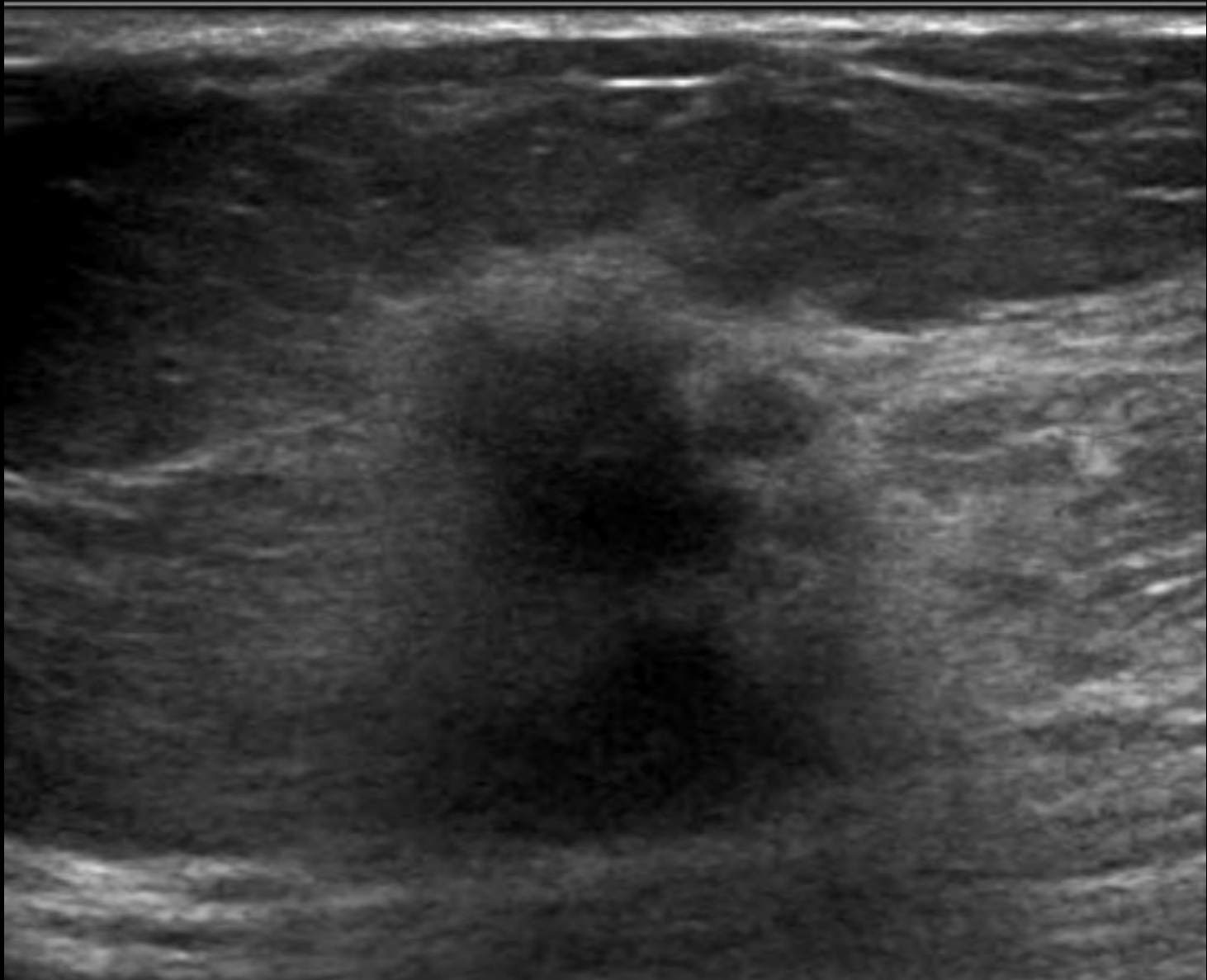
***IDC subtypes can be very benign looking: medullary (younger) mucinous (older)

MASSES-MARGINS

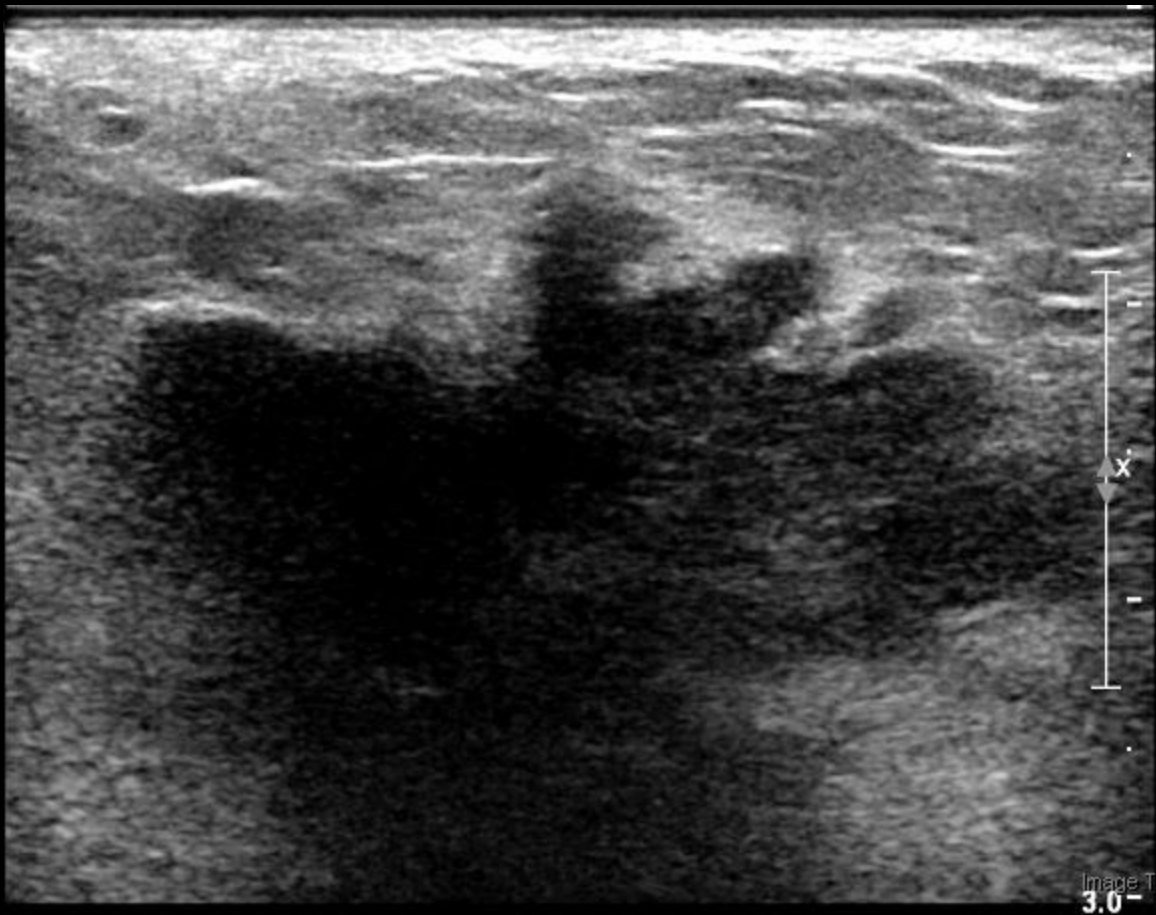
- NOT CIRCUMSCRIBED:
 - Indistinct: poorly defined (includes echogenic rim)
NOT irregular which is a shape
 - Angular: sharp corners or acute angles
 - Microlobulated: more than 3 undulations
 - Spiculated: sharp lines projecting from the mass

MASSES-MARGINS

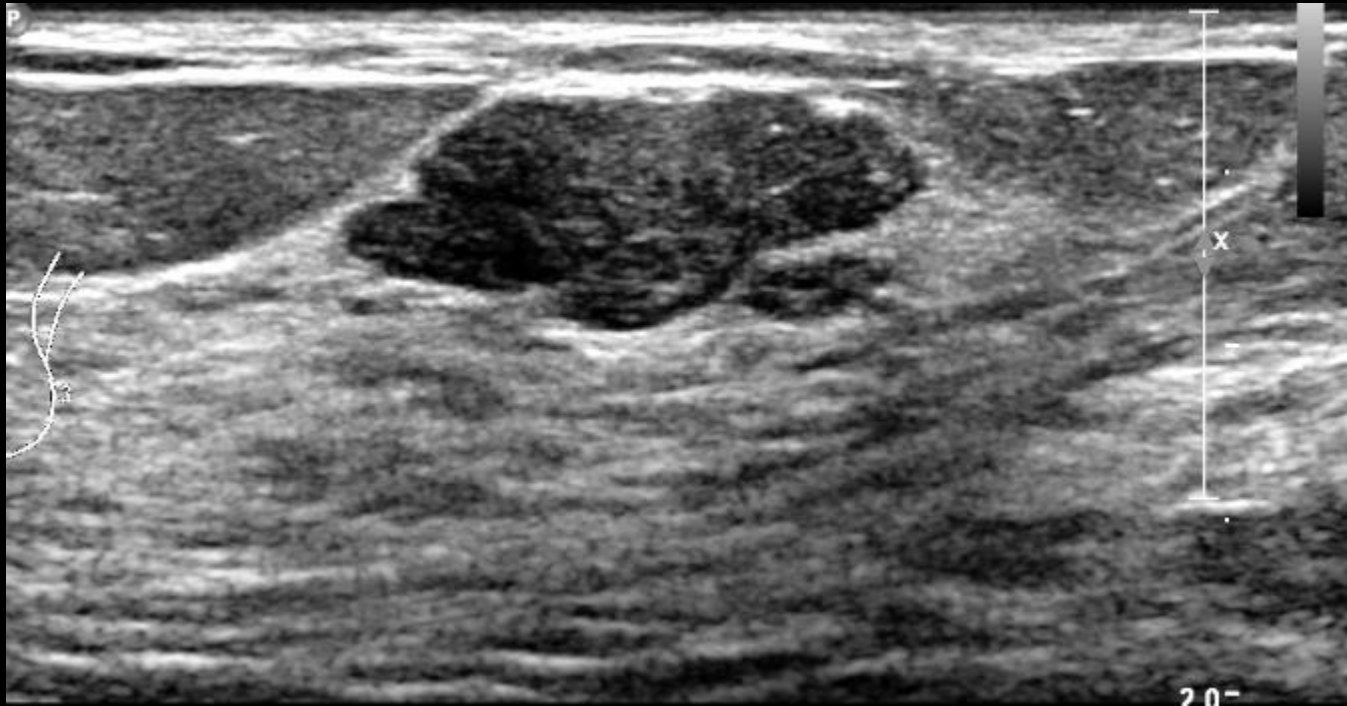
- NOT CIRCUMSCRIBED:
 - Indistinct: poorly defined (includes echogenic rim)
NOT irregular which is a shape
 - Angular: sharp corners or acute angles
 - Microlobulated: more than 2-3 mm “short cycle”
undulations or ripples
 - Spiculated: sharp lines projecting from the mass



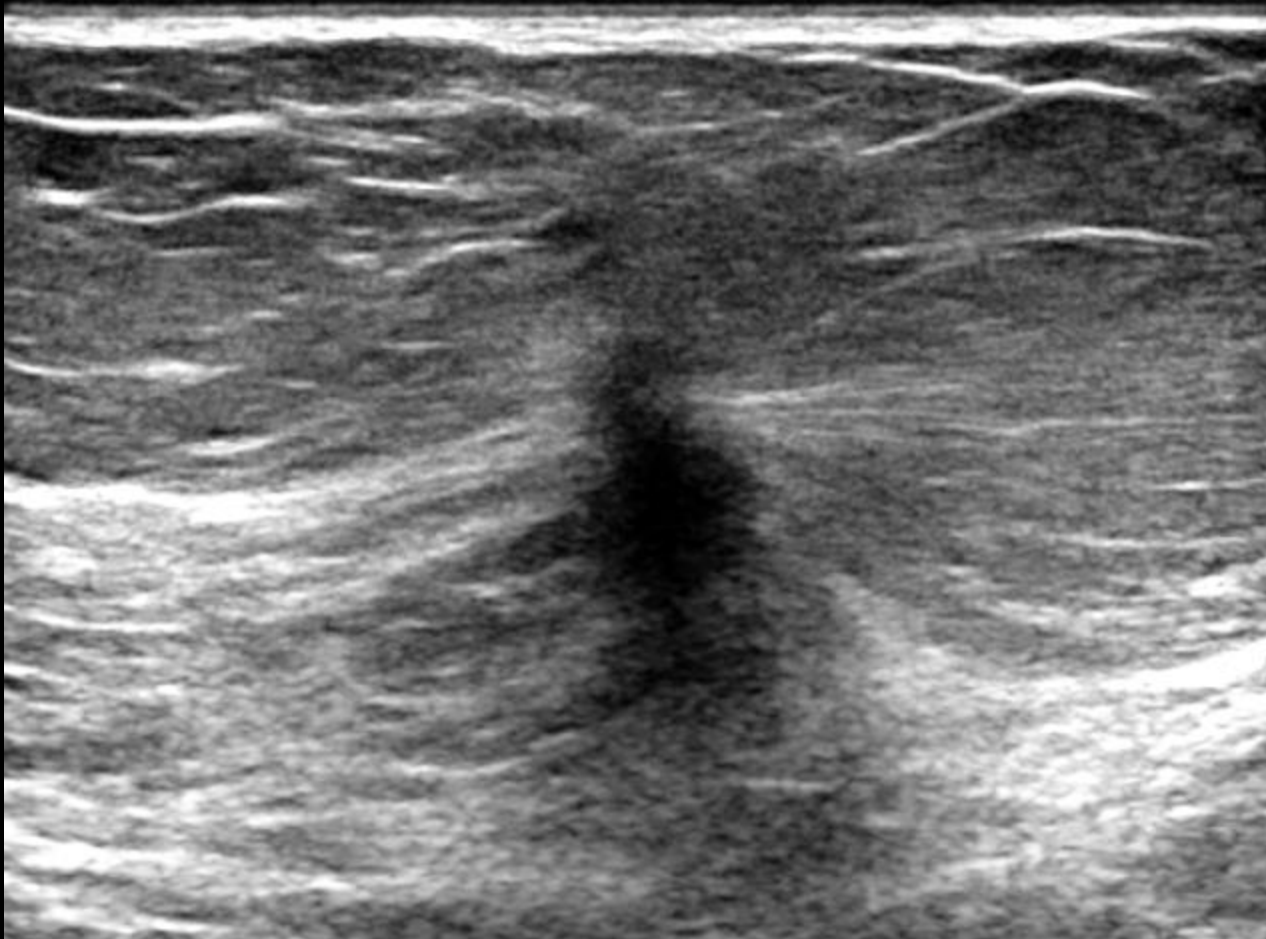
Margins: Indistinct with Echogenic Halo



Margins: angular



Margins: microlobulated



Margins: Spiculated

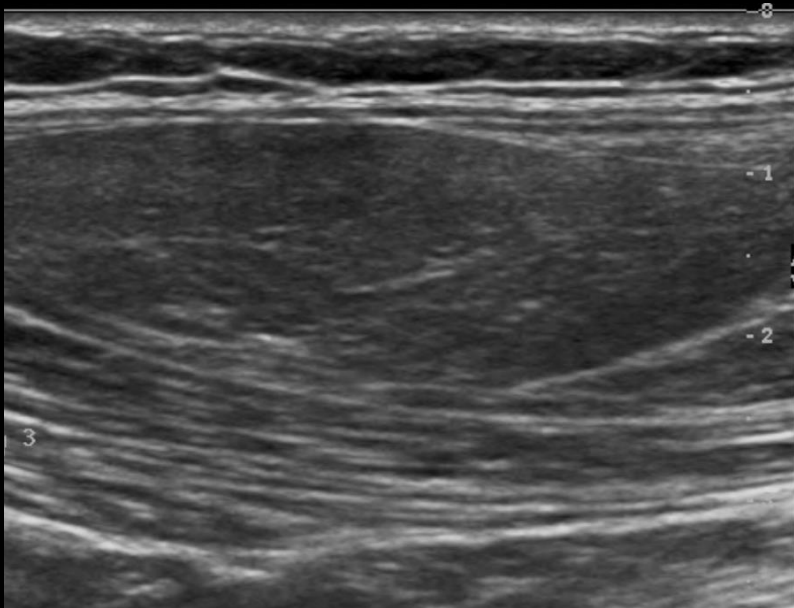
MASSES-ORIENTATION

PARALLEL: long axis of lesion in alignment with the skin line (horizontal or wider than tall) pushes towards benign

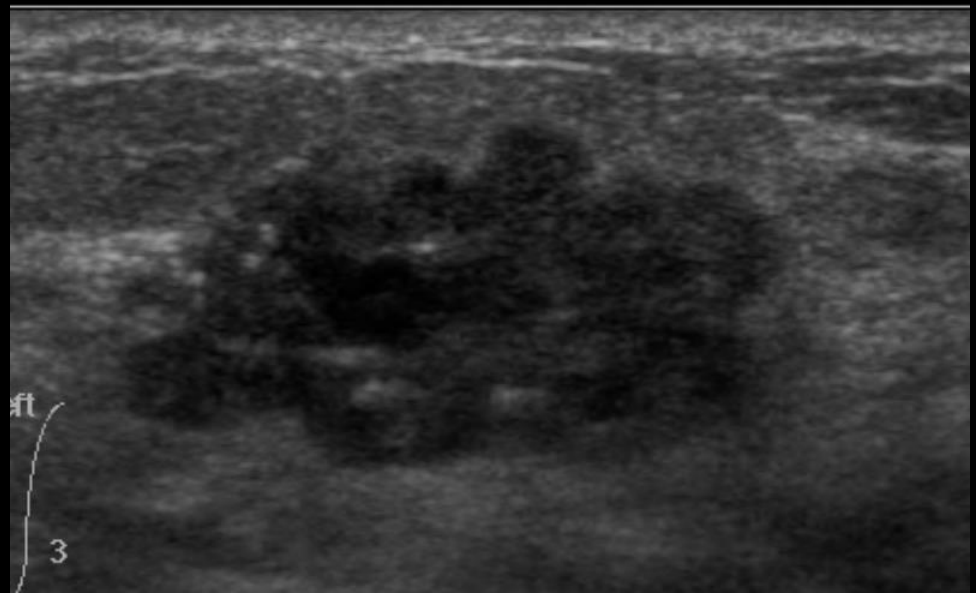
DDx: FA, CA, Cyst, Sebaceous Cyst, Lipoma

PARALLEL ORIENTATION

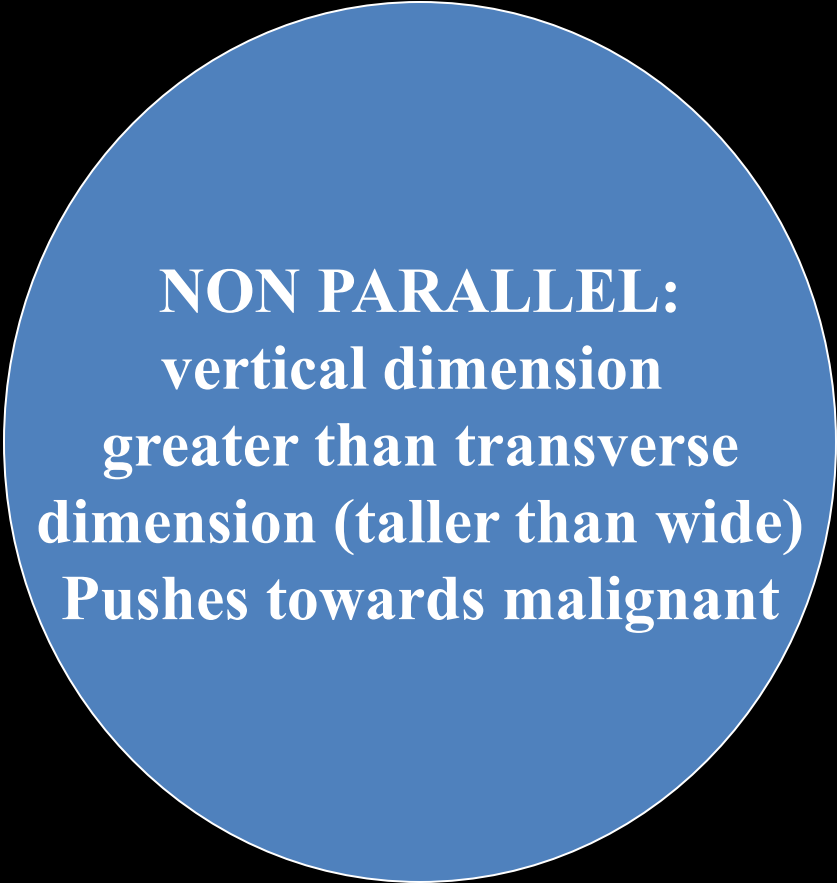
Benign lipoma



Invasive ductal carcinoma



MASSES-ORIENTATION

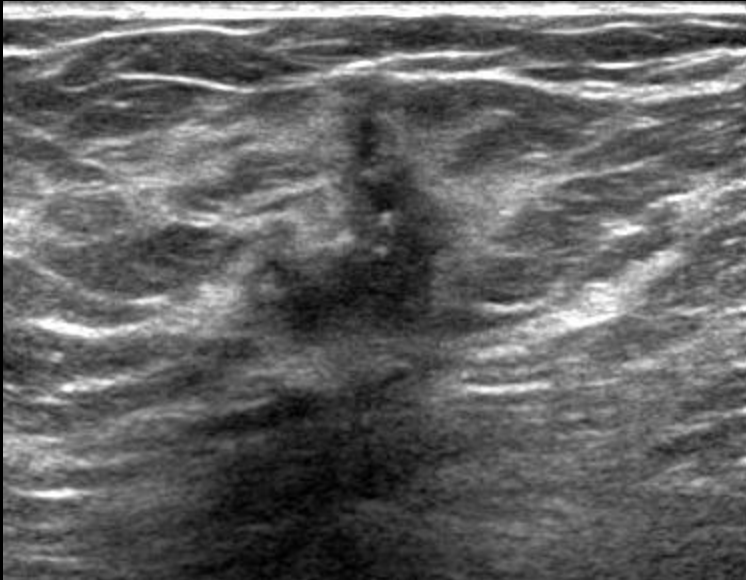


**NON PARALLEL:
vertical dimension
greater than transverse
dimension (taller than wide)
Pushes towards malignant**

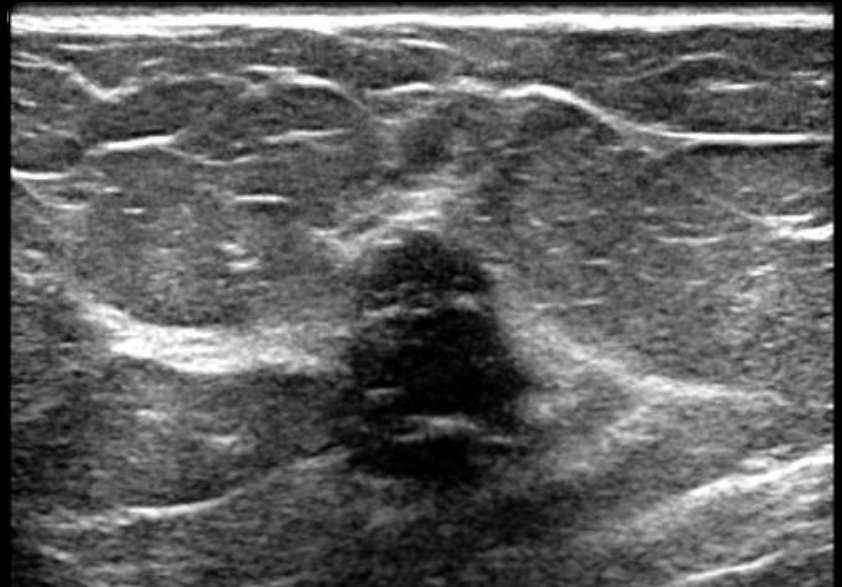
DDx: CA, FA, Cyst

NON-PARALLEL ORIENTATION

Malignant-IDC/DCIS

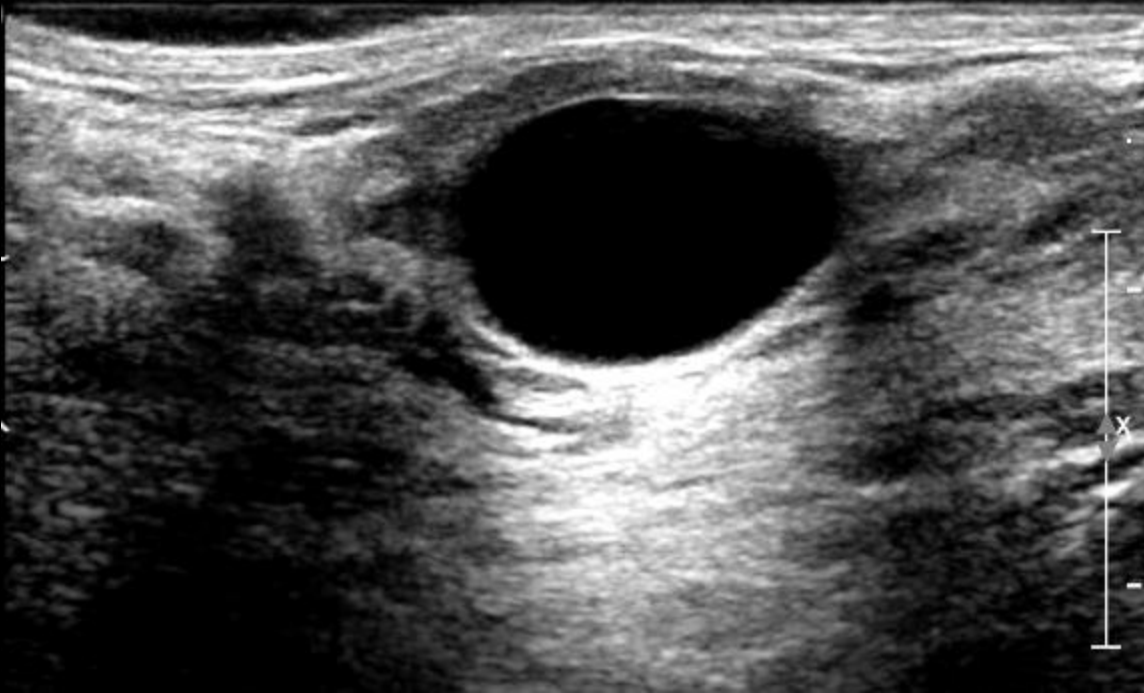


Benign- fibroadenoma

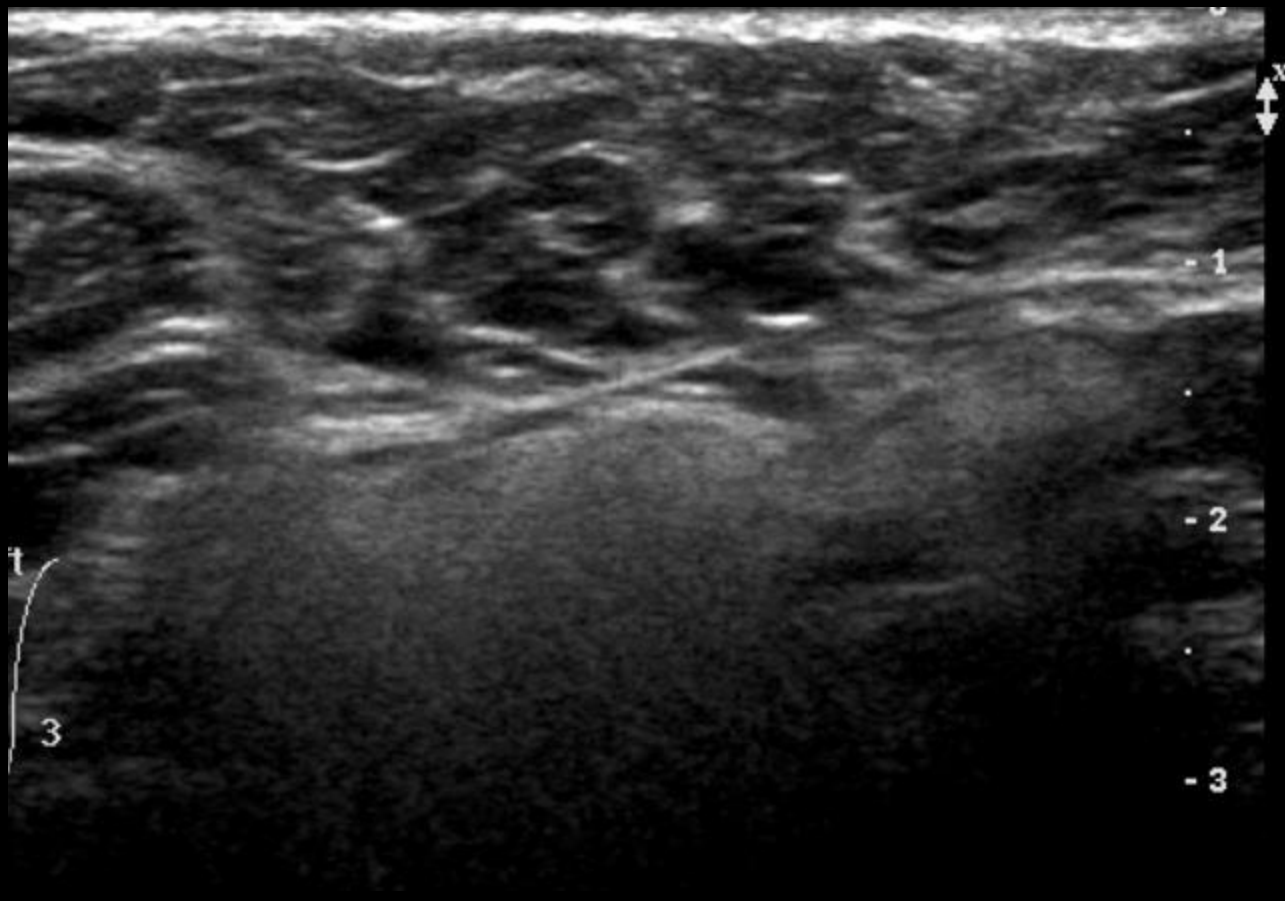


MASSES-ECHO PATTERN

- **Anechoic**: without internal echoes; simple cysts usually.
 - The rare triple negative may look very near anechoic but should have other suspicious features
- **Hyperechoic**: increased echogenicity relative to fat or equal to fibroglandular tissue
 - Typically benign presuming other benign features are present
- **Mixed Solid and Cystic**
- **Hypoechoic**: relative to fat, low-level echoes throughout; Most masses including cancers, complicated cysts and FA fall here
- **Heterogeneous**: portions are hyperechoic and portions are hypo- or isoechoic to fat (NO CYSTIC COMPONENT)
- **Isoechoic**: Same as subQ fat



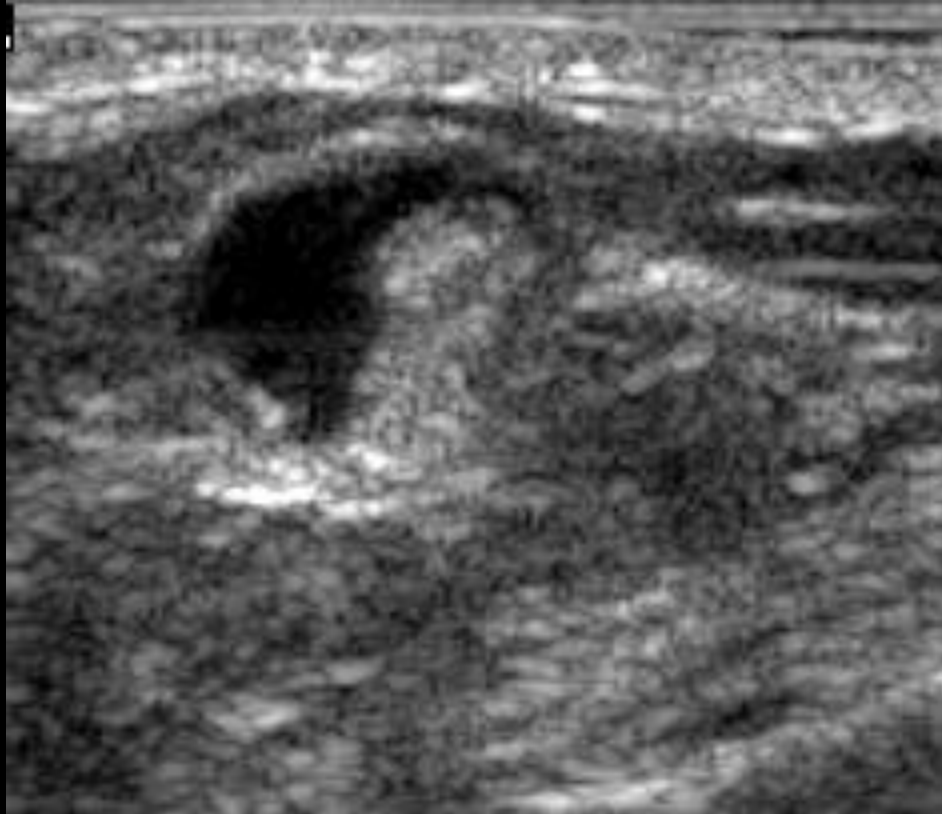
Echo Pattern: anechoic



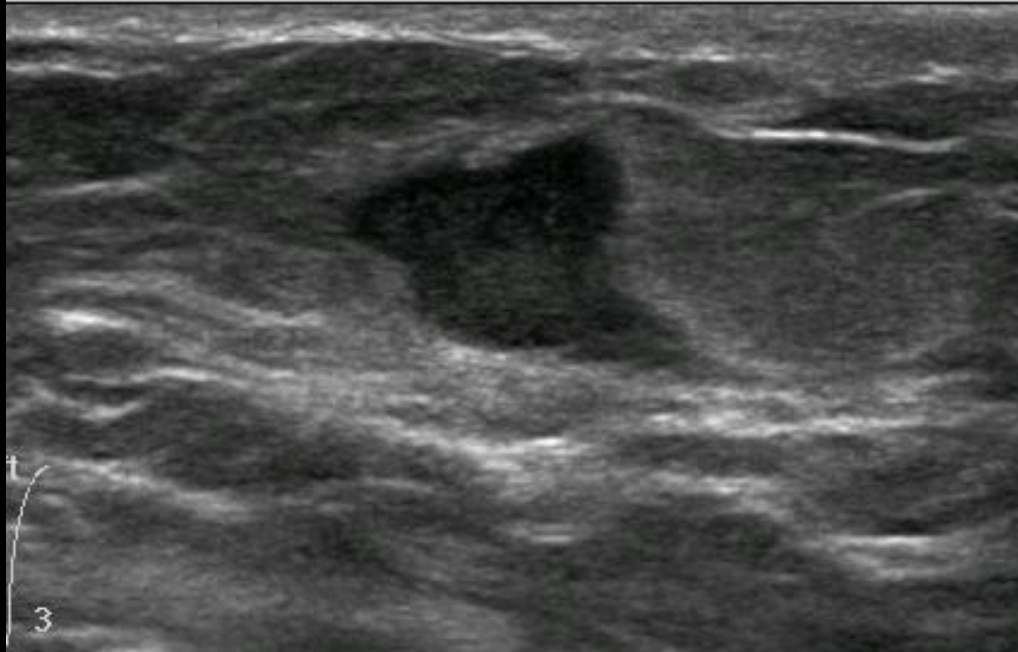
Echo pattern: hyperechoic

ECHO PATTERN: MIXED SOLID AND CYSTIC

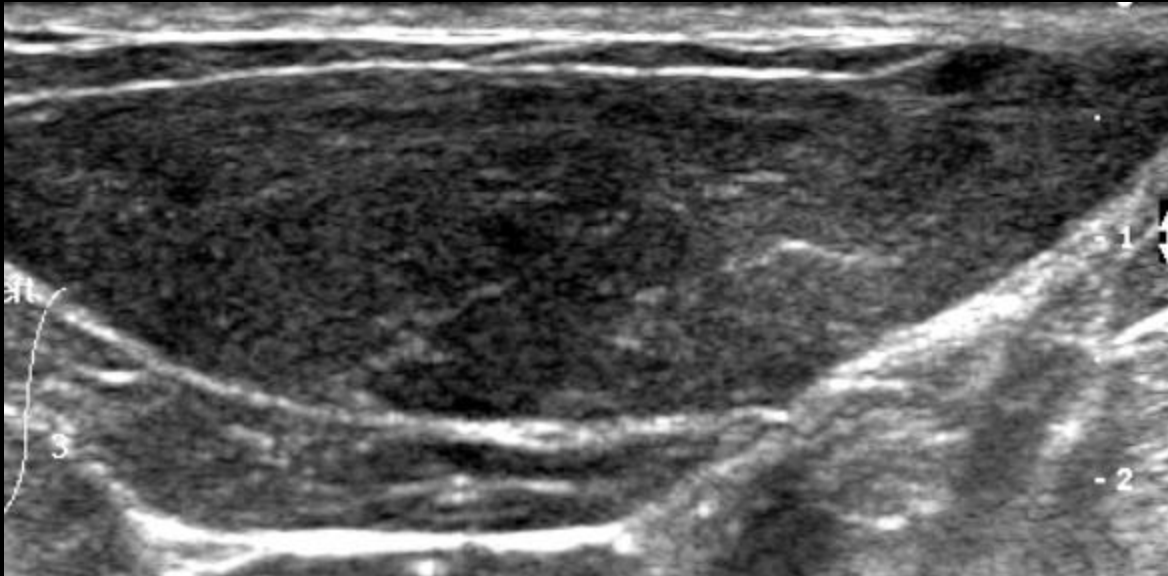
- Contains both anechoic (cystic) and echogenic (solid) components
- New BiRads emphasizes that it is the solid component that drives management
- DDX:
 - Intracystic carcinoma
 - Spectrum of papillary lesions
 - Hematoma and oil cysts
 - Galactocele
 - Hemorrhagic cysts
 - Abscesses



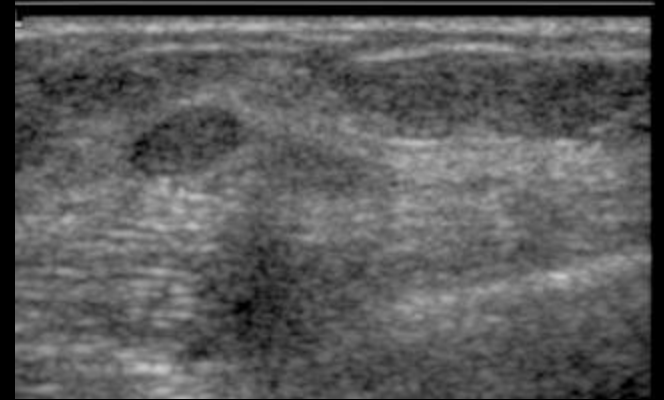
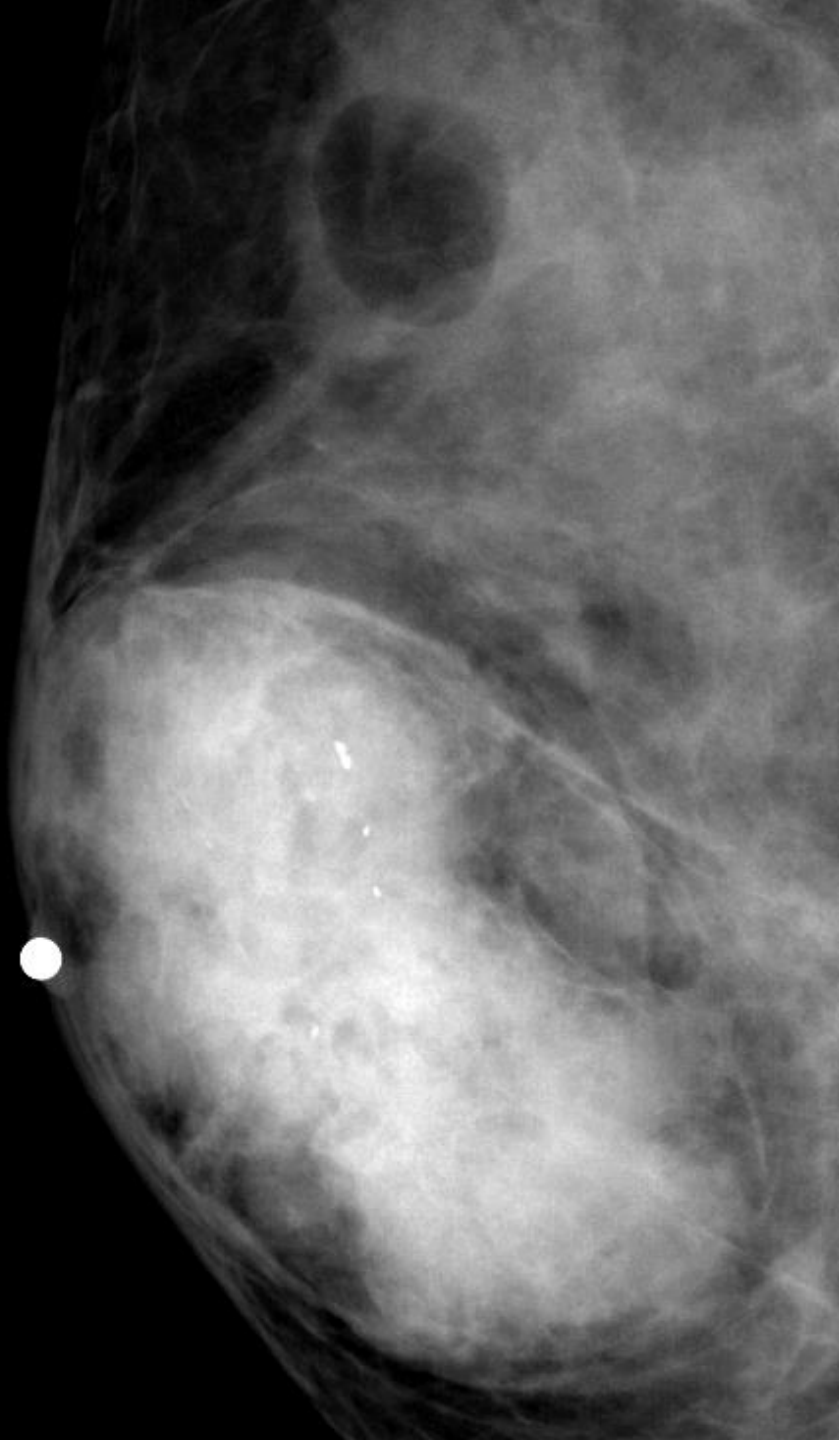
Echo pattern: Mixed Solid and Cystic



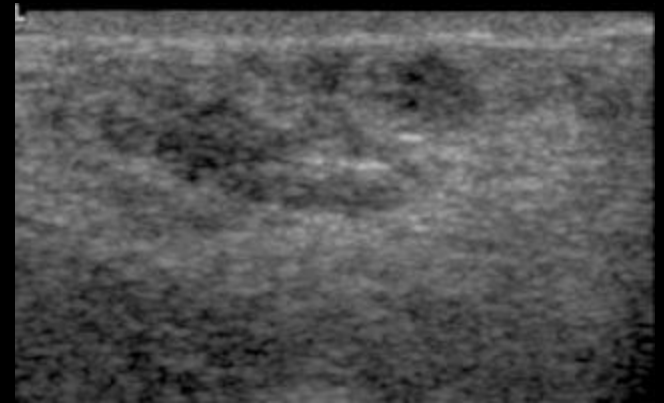
Echo pattern: hypoechoic



Echo pattern: isoechoic



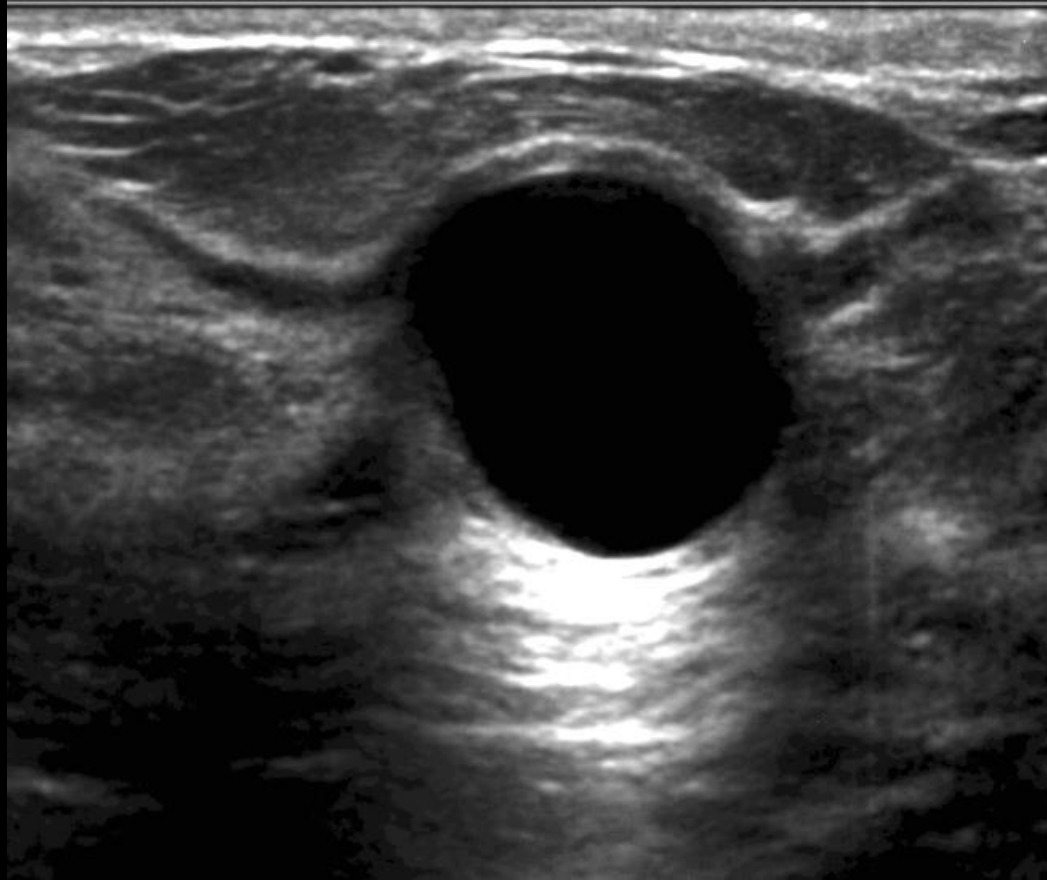
Echo pattern: hypoechoic



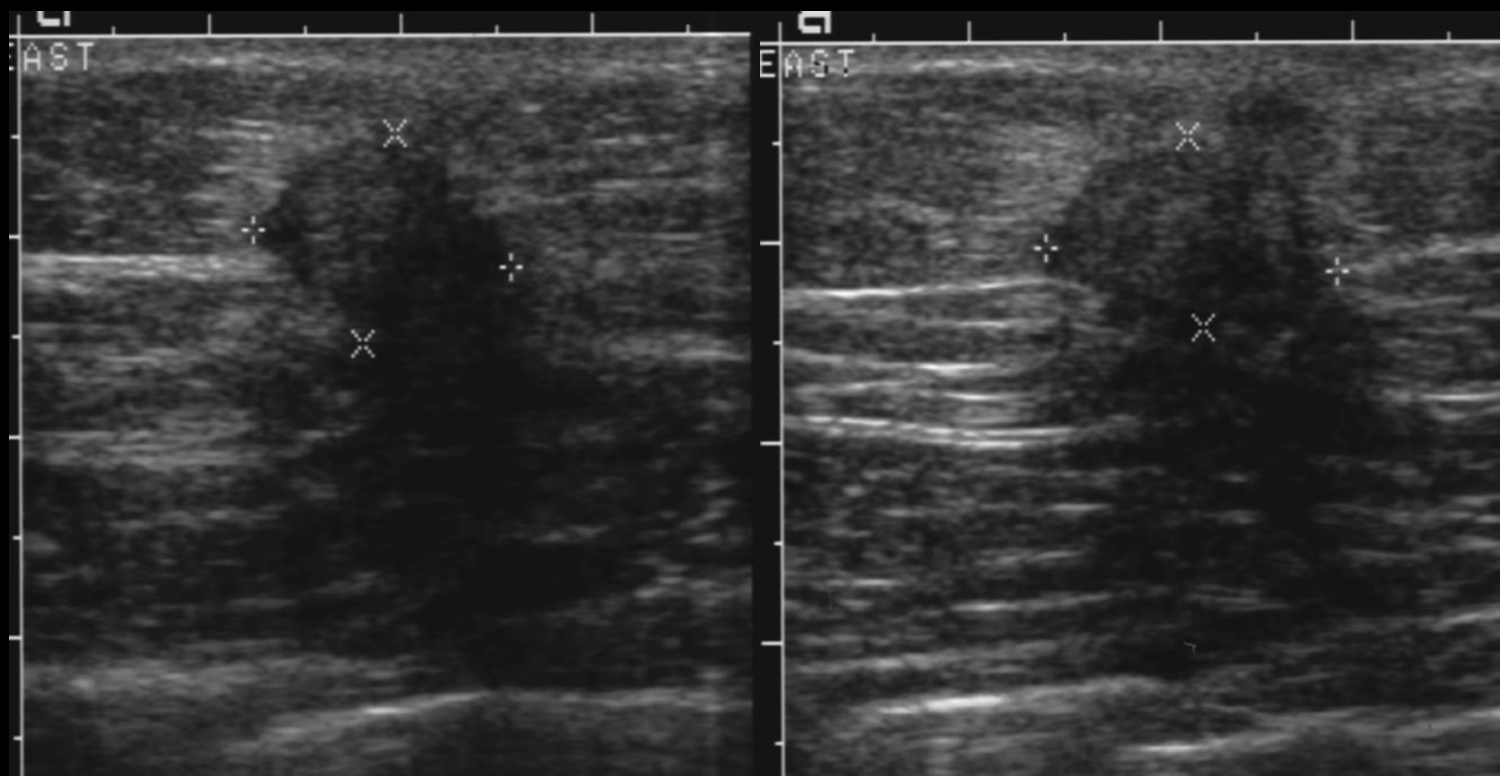
Echo pattern: heterogeneous

MASSES-POSTERIOR ACOUSTIC FEATURES

- No posterior acoustic features
- **Enhancement**: more echogenic posterior to the mass; criterion for simple cyst
- **Shadowing**: posterior attenuation; fibrosis, postoperative scars, fibrous mastopathy, cancers (especially lobular)



Posterior acoustic features: enhancement



Posterior acoustic features: shadowing

NON-MASS LESIONS

- New category added to the 2025 Manual
- Recognizes that not all abnormalities on US will have the features of a mass
- Is distinct from normal tissue, seen in 3 planes, but cannot be described using the mass features previously discussed of margin and shape
- Distribution: Focal, Linear, Segmental, Regional
- Echo pattern: Hyperechoic, Hypoechoic or Heterogeneous
- Posterior features: Shadowing, Enhancement or none
- Certain associated features are shown to increase odds of malignancy:
 - Calcifications
 - Distortion
 - Hypervascularity
 - Shadowing
 - Duct Extension
- Correlation with other modalities is critical

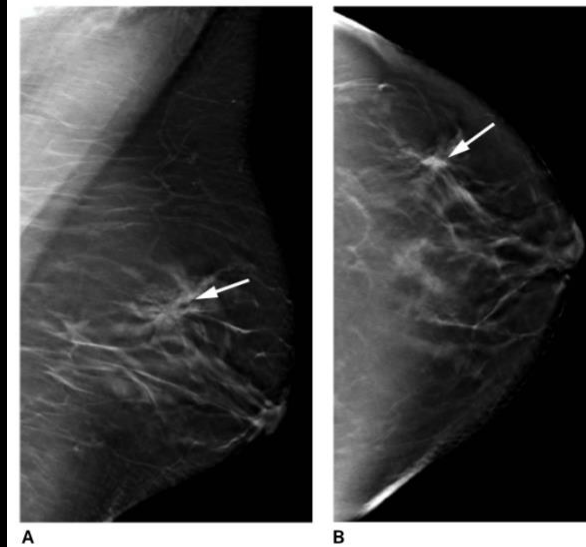
NON-MASS LESIONS:

- A. Architectural Distortion on 2 views
- B and C. Focal non-mass lesion with posterior shadowing and duct extension

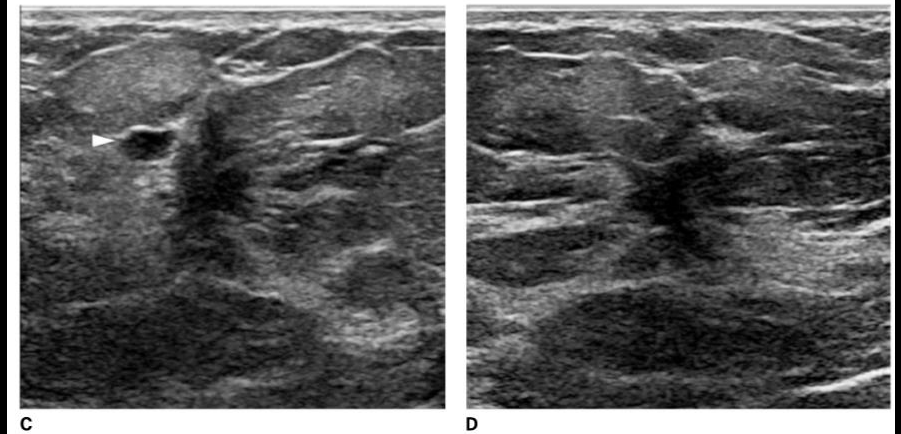


NON-MASS LESIONS:

A, B. Architectural Distortion on mammography

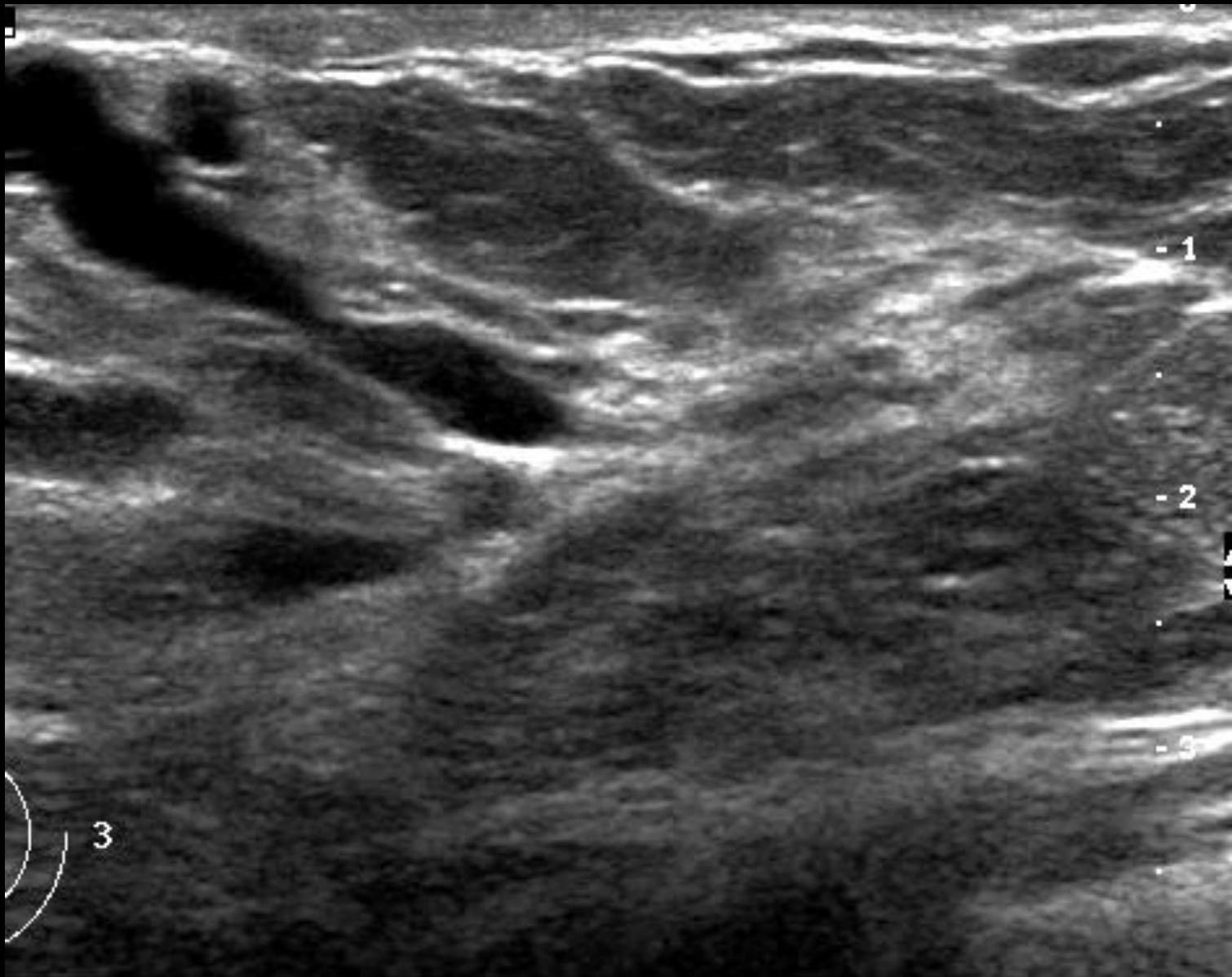


C, D. Focal non mass lesion on US with associated distortion

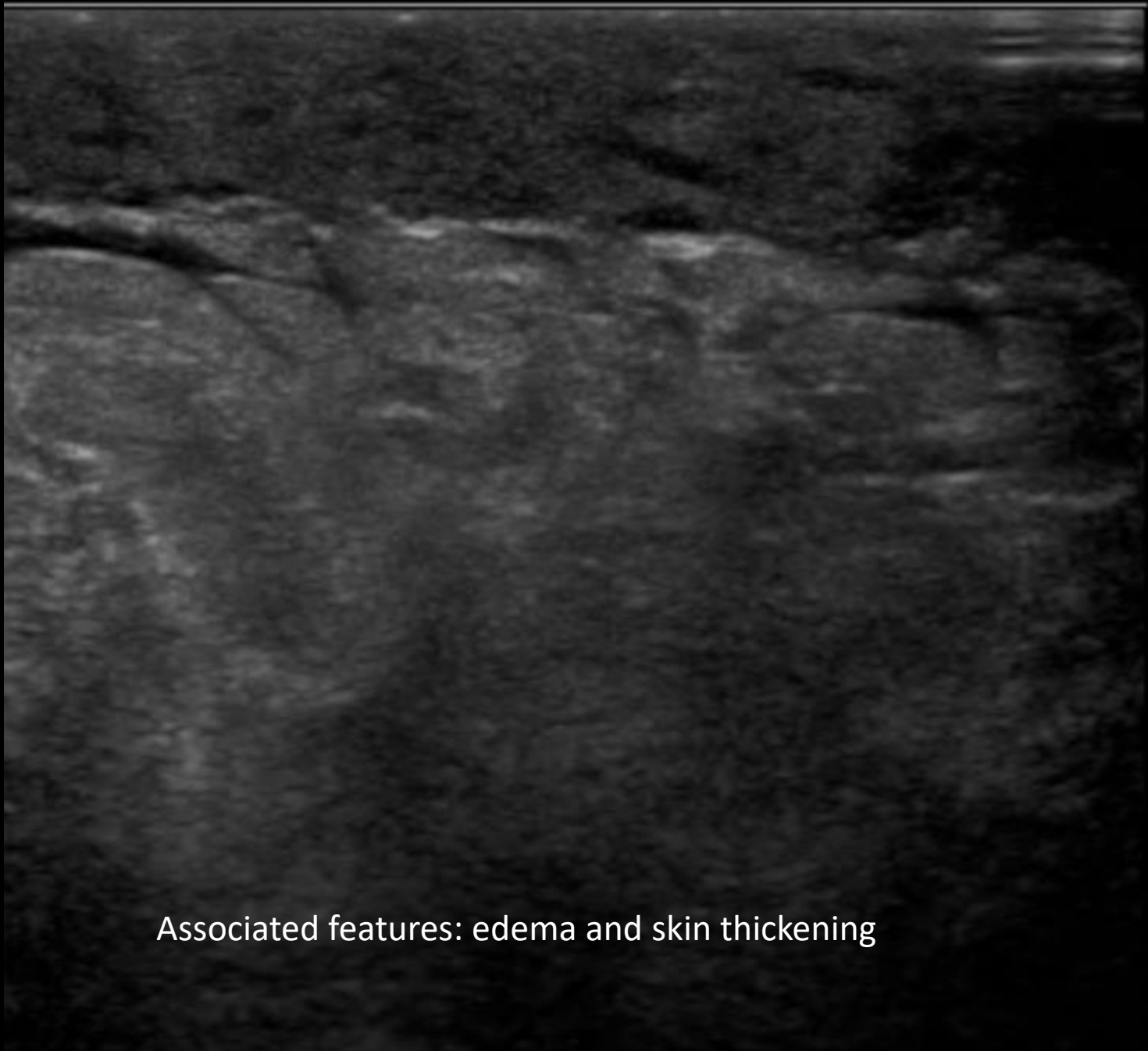


ASSOCIATED FEATURES

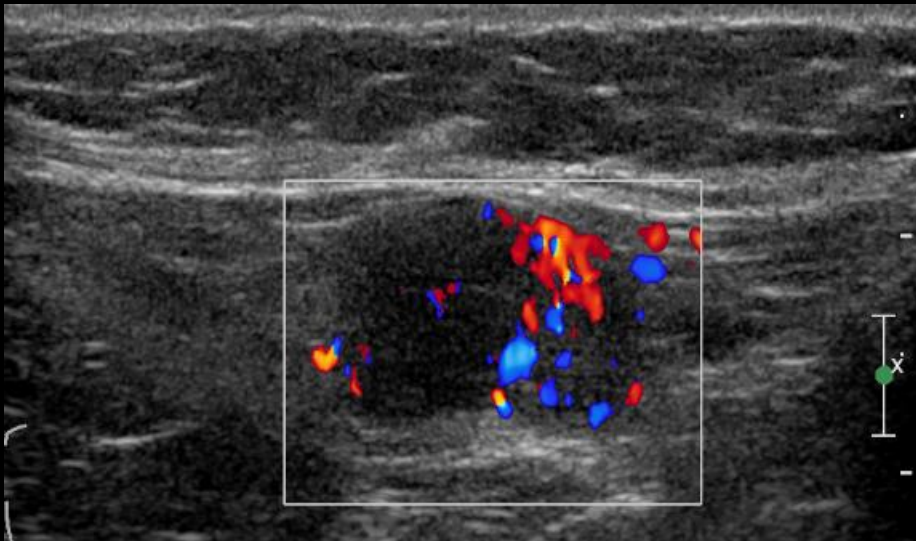
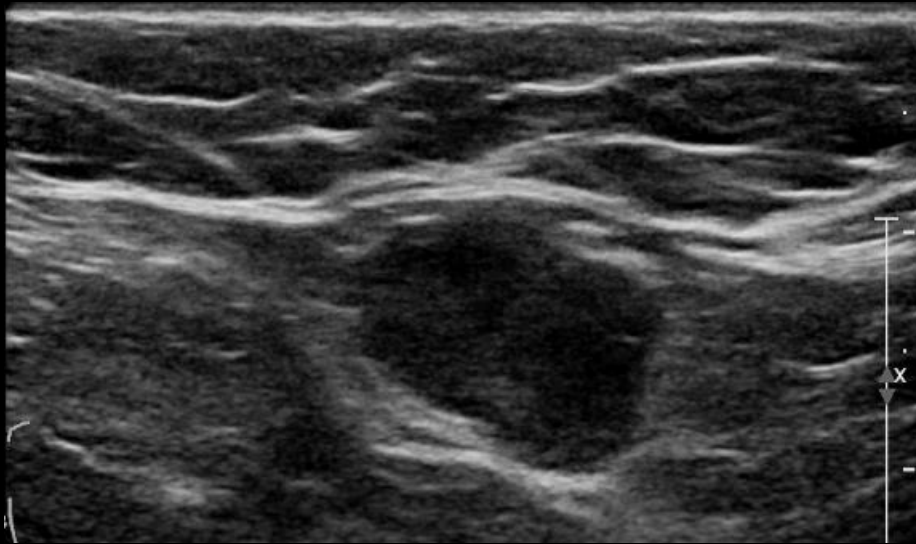
- Echogenic Pseudocapsule: Thin and surrounds entire mass, usually Bir2
- Echogenic Rind: Poorly defined and thick, increased suspicion, often Bir4
- Architectural distortion: disruption of normal anatomic planes; critical to look for on ABUS screening studies (esp coronal images)
- Duct changes: abnormal caliber and/or arborization
- Skin changes
 - Skin Thickening: focal or diffuse thickening of skin more than 2mm (except in periareolar area and lower breast)
 - Skin retraction: skin surface is concave or ill defined and pulled in
- Edema: increased echogenicity of surrounding tissue and reticulation
- Vascularity
 - Absent
 - Internal Vascularity
 - Vessels in rim
- Elasticity assessment
 - Soft
 - Intermediate
 - hard



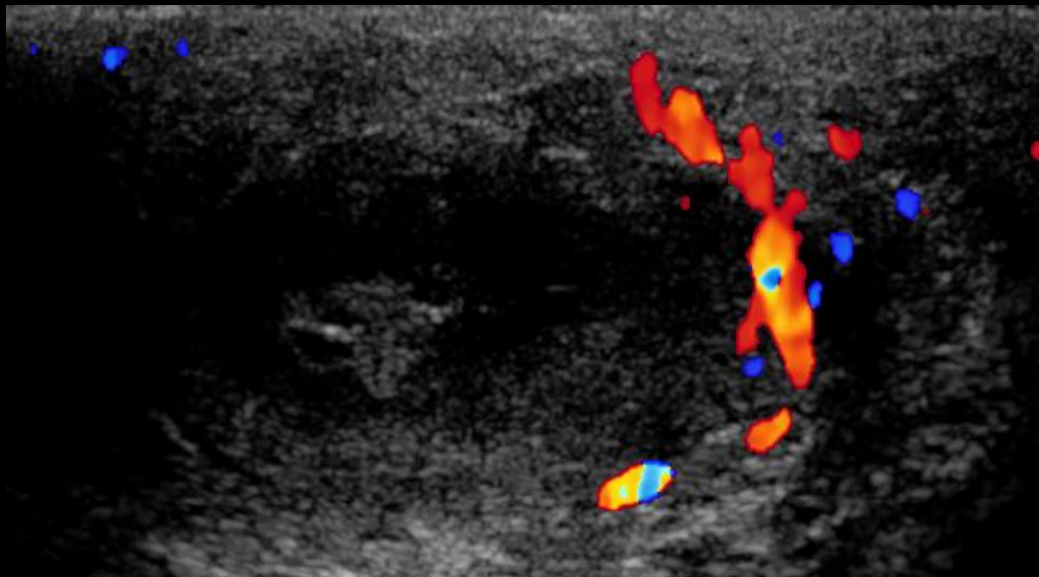
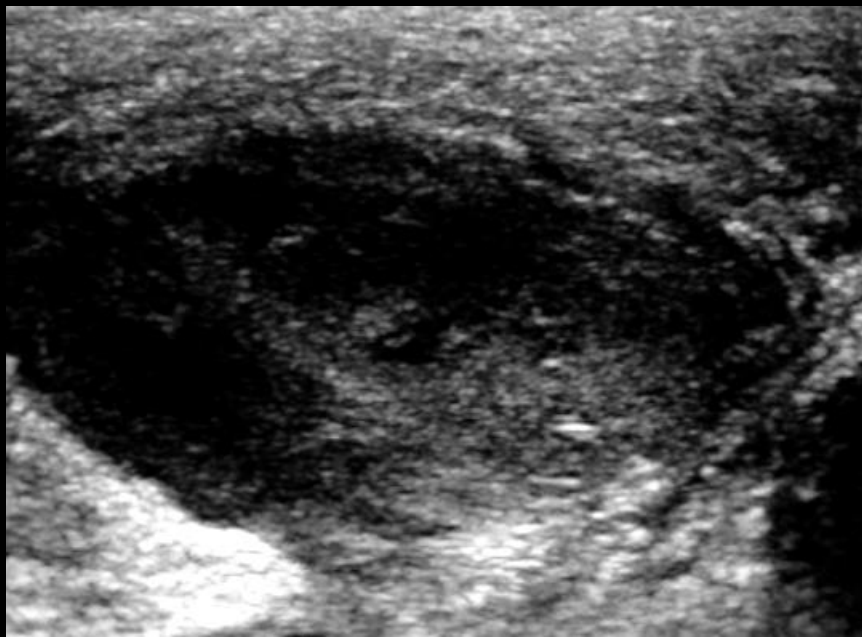
Associated features: ducts



Associated features: edema and skin thickening



Associated features: internal vascularity



Associated features: Vascularity –vessels in rim-Abscess

OK...But what should we do?

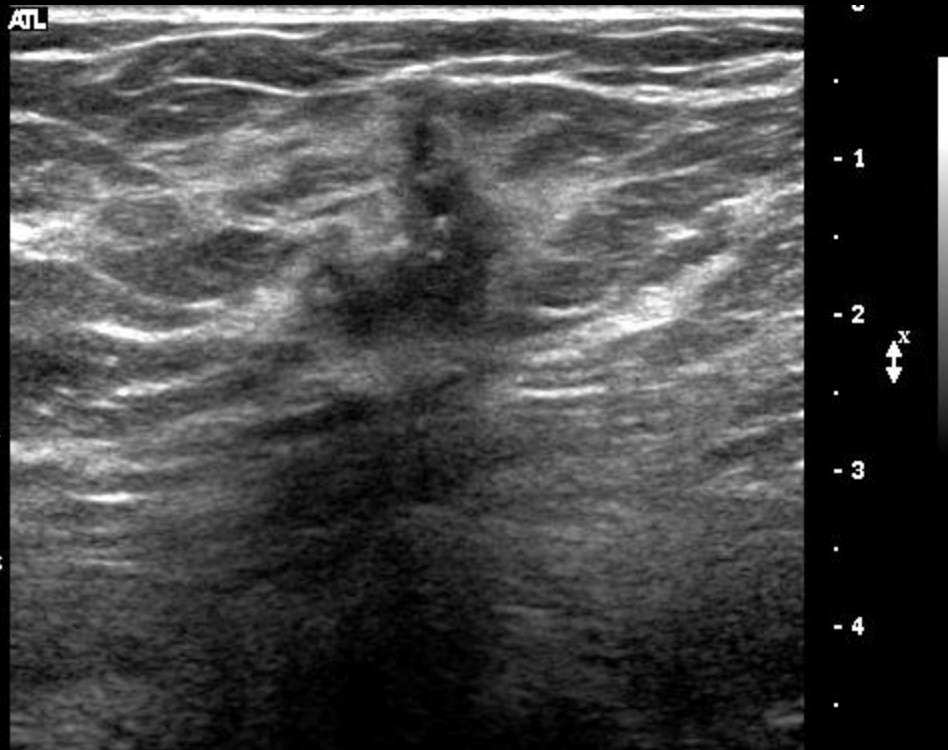
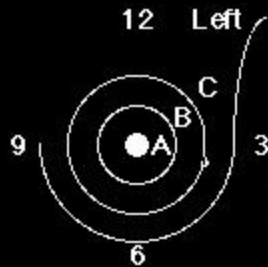
Management

- Use a combination of all visualized features to make a recommendation for follow up/management.

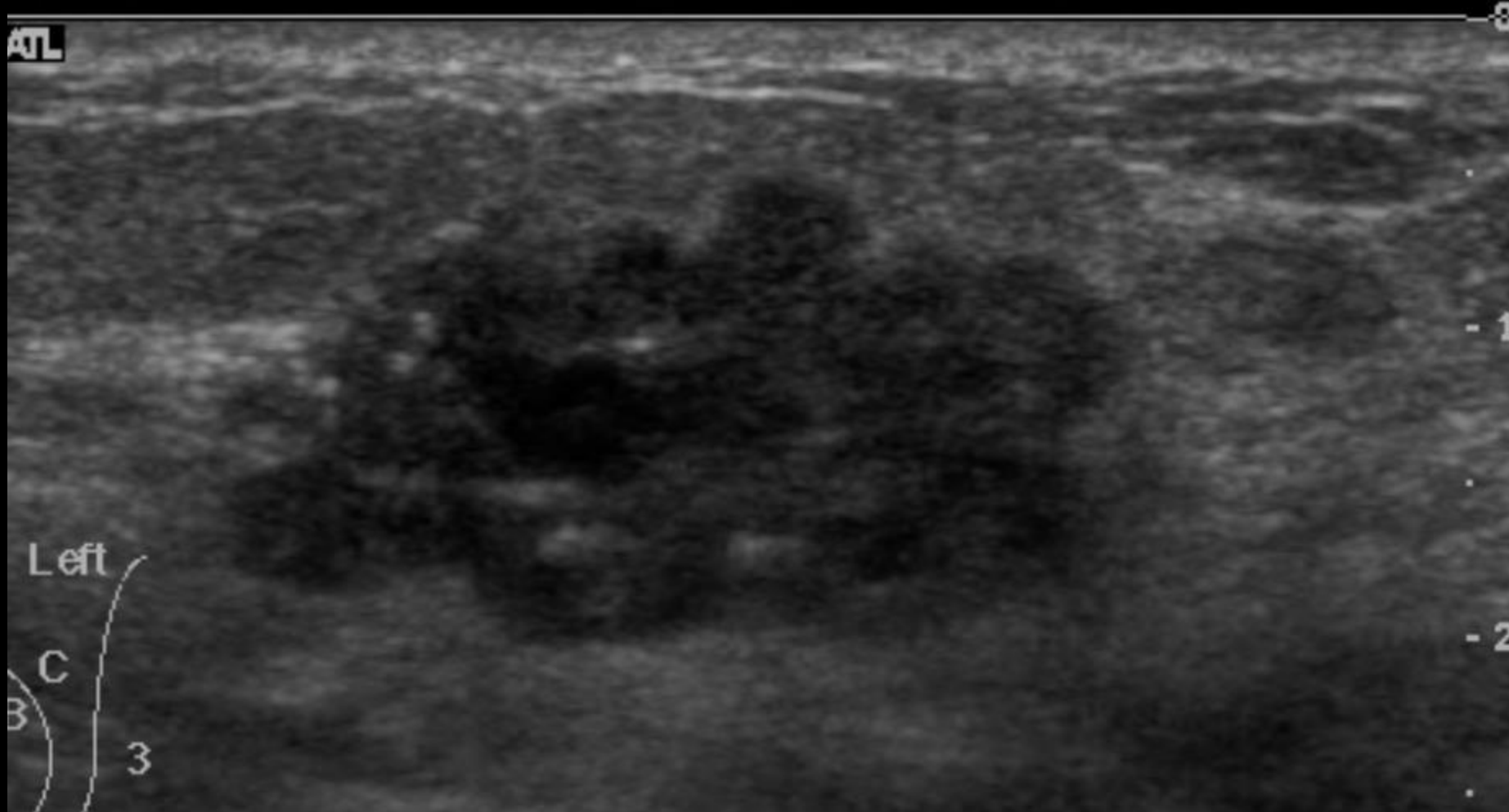
A couple examples:

- USE ALL CHARACTERISTICS!

Map 5
iSCAN/C 4
Persist Off
2D Opt:FSCT
Fr Rate:Surv
SonoCT®
XRes™



Orientation: not parallel
Margins: Not circumscribed (angular)
Posterior features: shadowing
Calcifications



Orientation: parallel

Shape: Irregular

Margins: Not circumscribed (microlobulated)

Calcifications

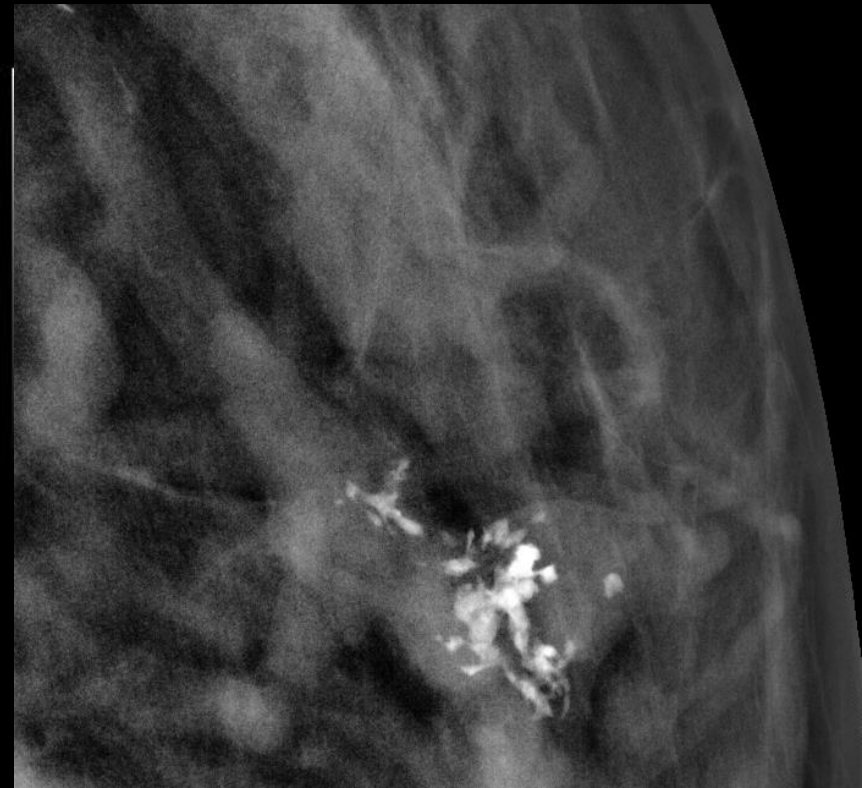
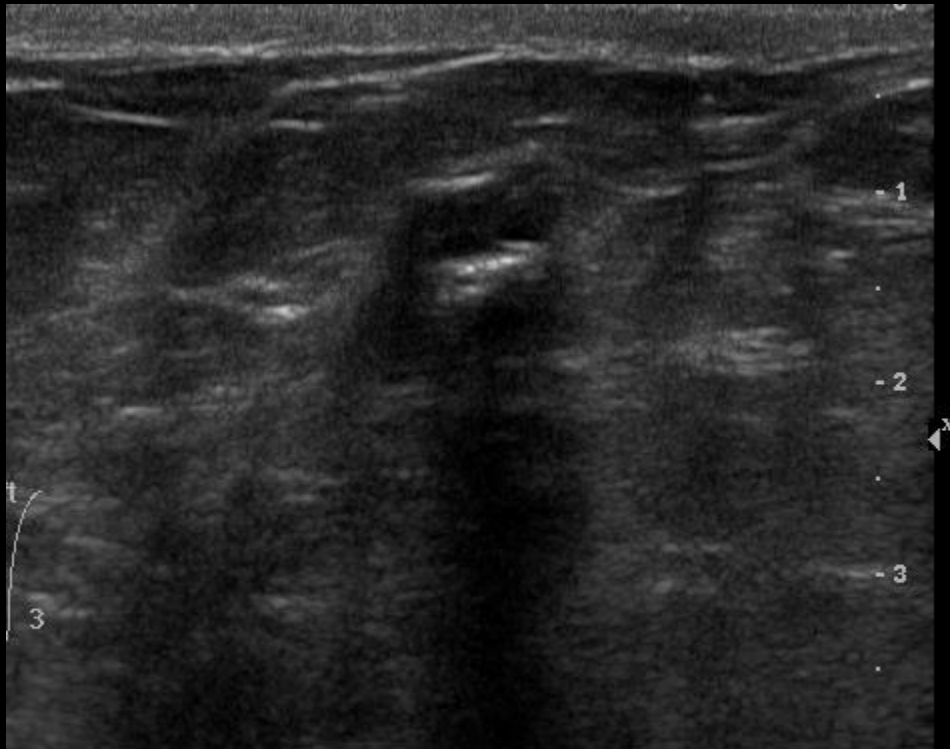
CALCIFICATIONS

- Calcifications are poorly characterized with US but can be recognized as echogenic foci, particularly when in a mass
 - Calcifications in a mass
 - Calcifications outside a mass
 - Intraductal calcifications
 - Association with non-mass lesions
- Think about locations where US guided biopsy is a better option than stereo!

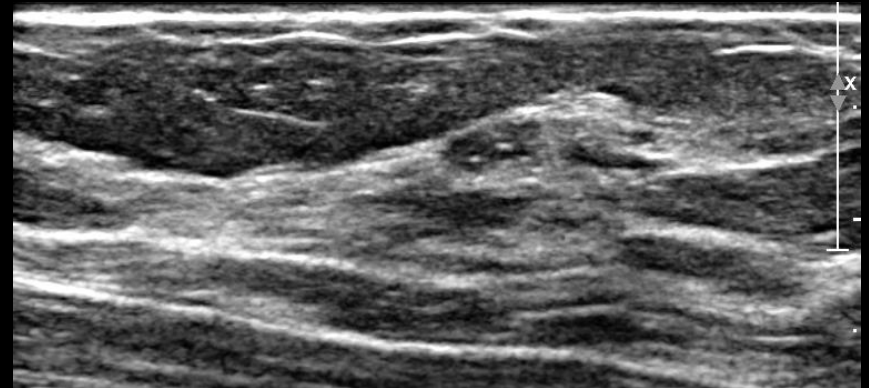
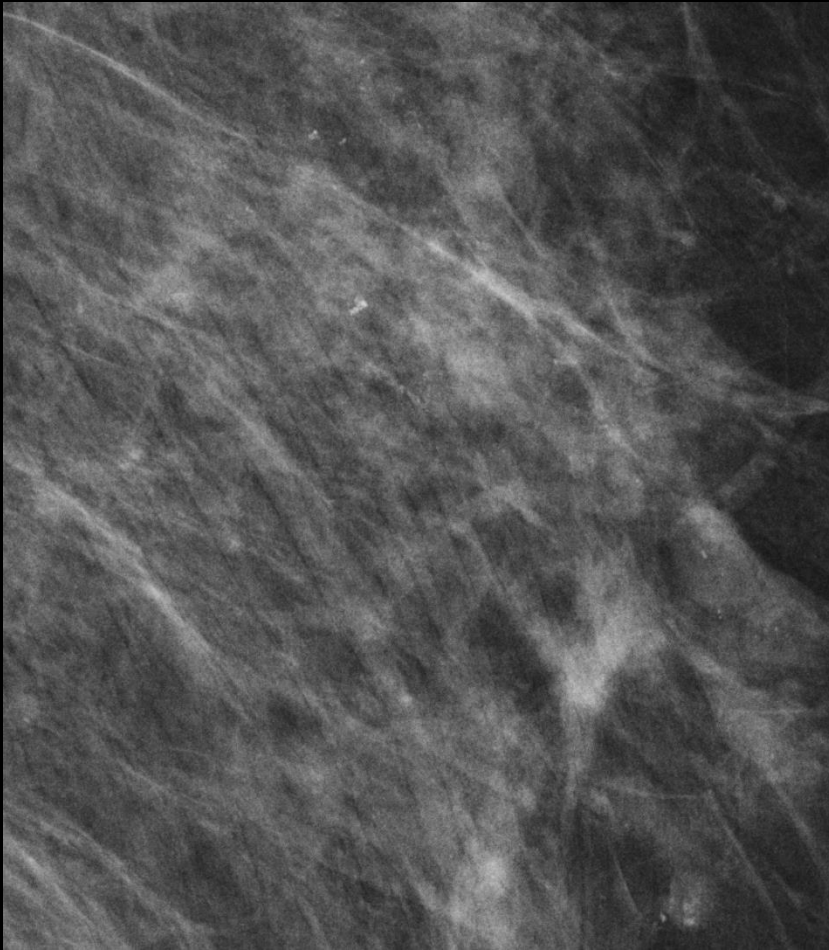
CALCIFICATIONS

- Macrocalcifications: more than 0.5 mm in size, cause acoustic shadowing
- Microcalcifications: in or out of a mass, less than 0.5 mm in size, too small to attenuate the US beam

CALCIFICATIONS



CALCIFICATIONS

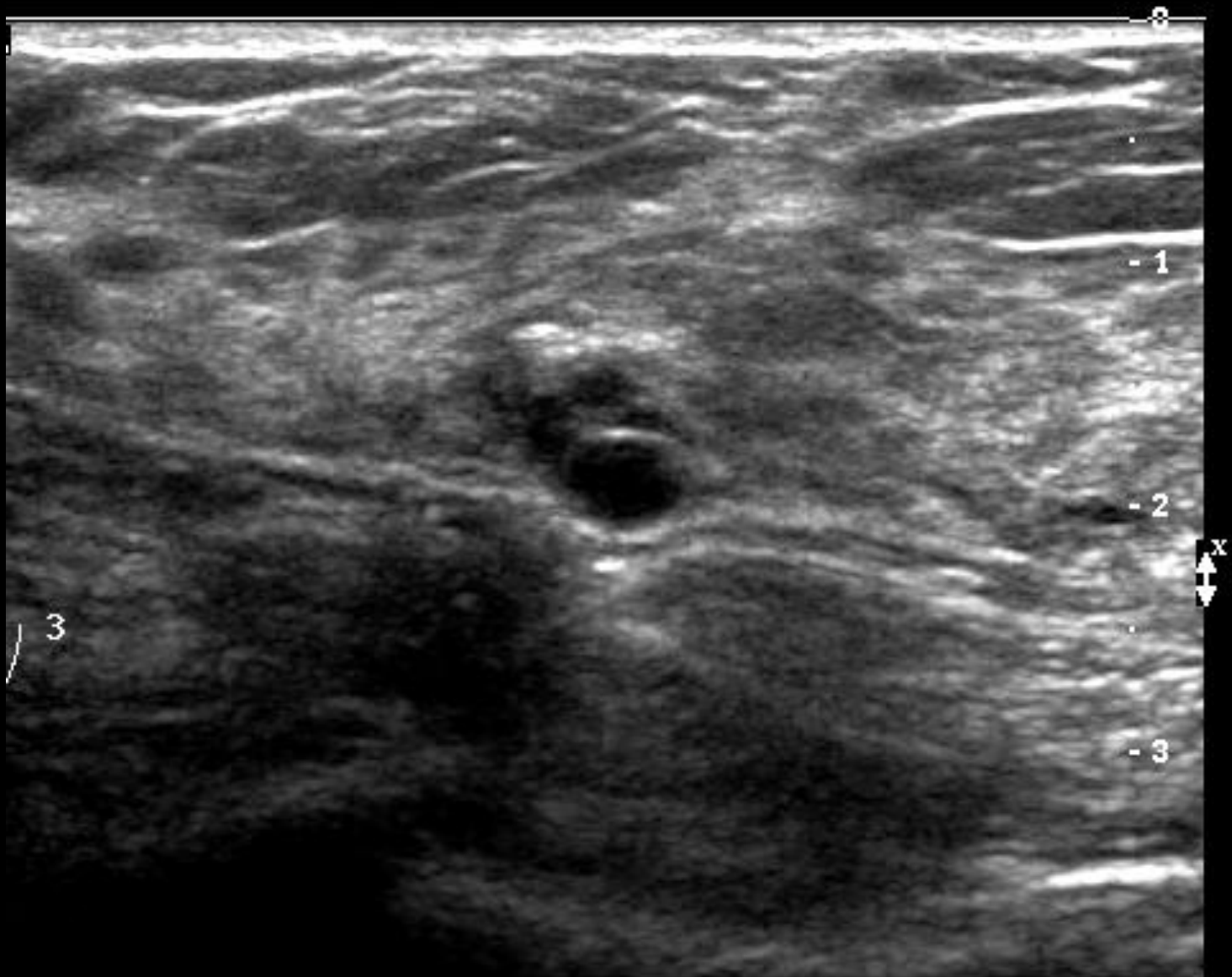


SPECIAL CASES

- Simple Cyst
- Clustered microcysts
- Complicated cyst
- Mass in or on skin
- Foreign body
- Implants
- Post surgical
- Vascular abnormalities
 - AVMs
 - Mondor disease
- Post traumatic
- Fat necrosis
- Abscess

SPECIAL CASES: Today's focus

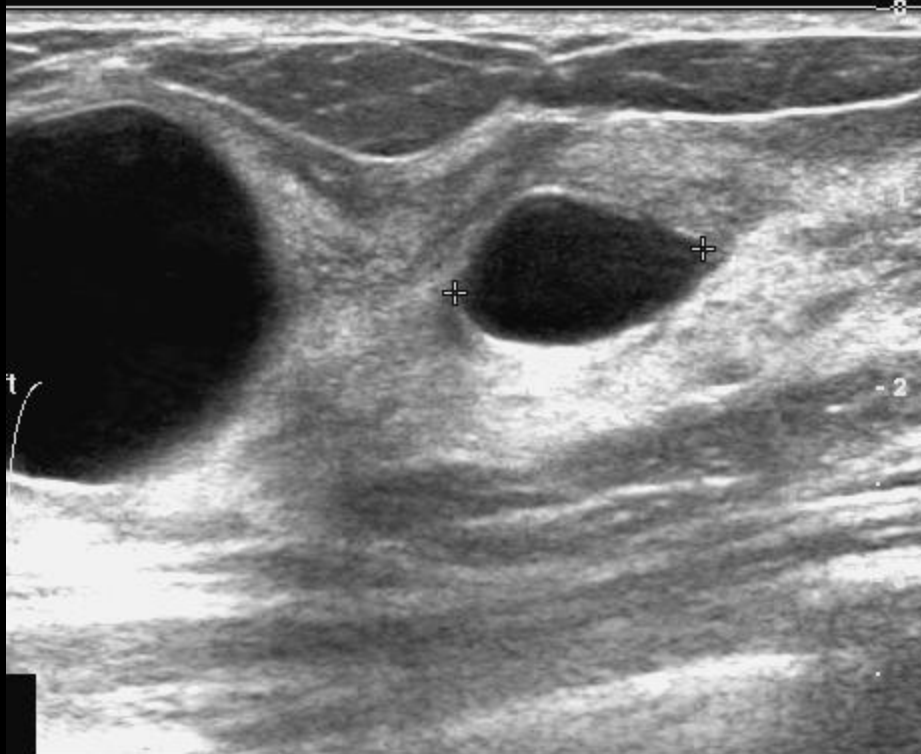
- Clustered microcysts
- Complicated cyst
- Mass in or on skin
- Mondor disease
- Postsurgical fluid collection
- Fat necrosis



Special cases: clustered microcysts – Recommendation often for Bi-Rads 2 but occasionally 3 or 4 depending on context

SPECIAL CASES

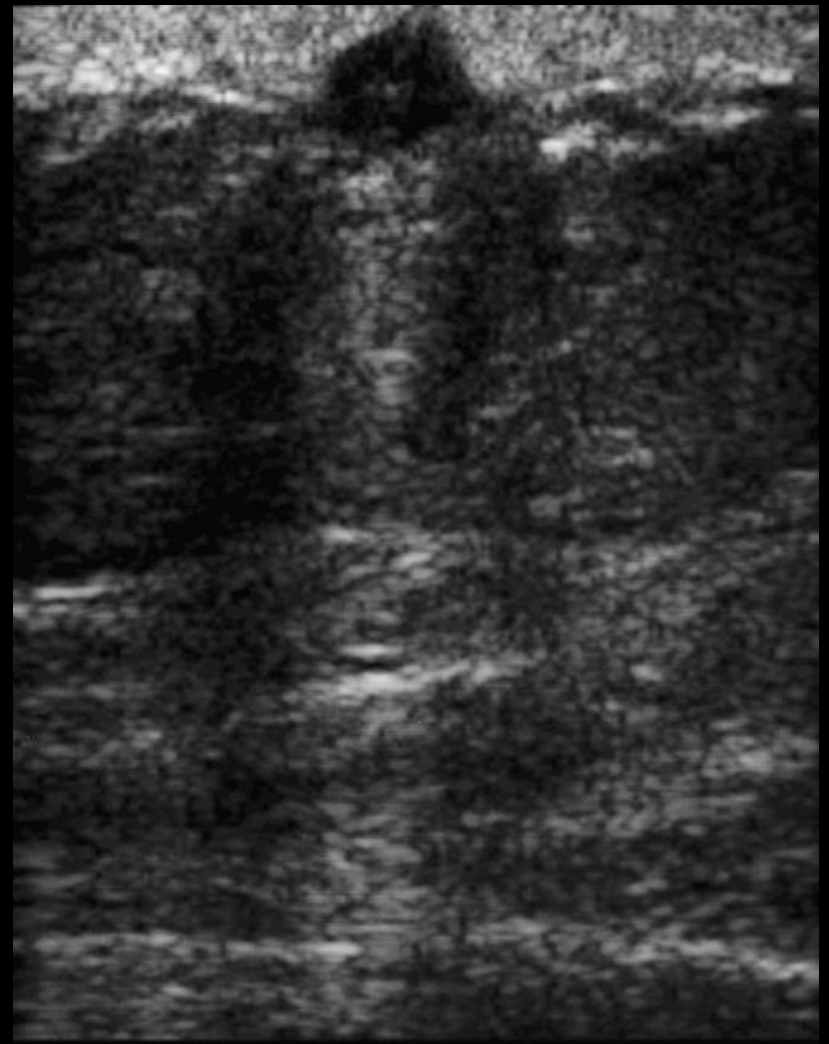
- Complicated cysts: homogeneous low-level internal echoes, may have a layered appearance, may contain brightly echogenic material that scintillate, no discrete solid component (see mixed solid and cystic mass)



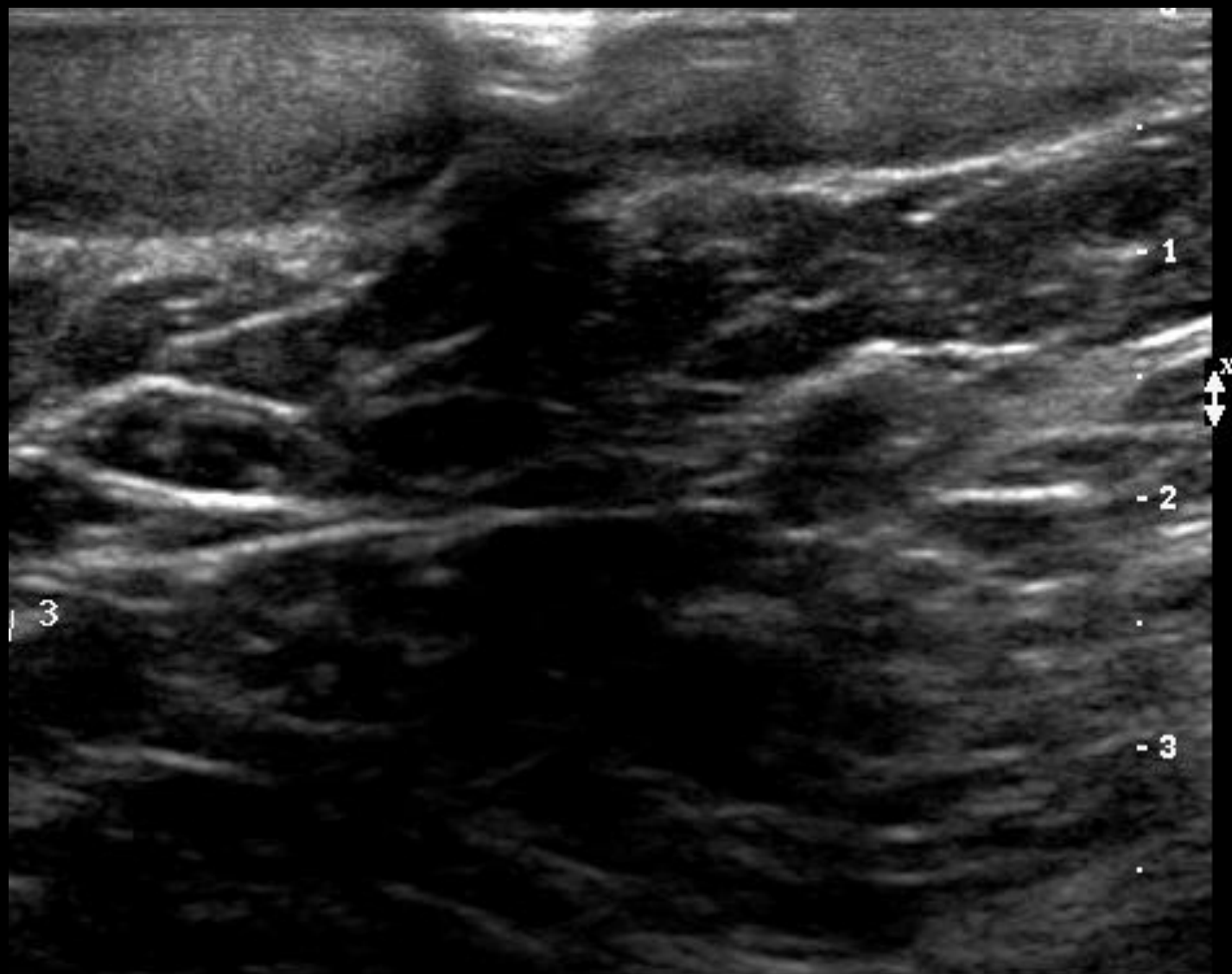
Special cases: complicated cyst
Usually BiRads 2 (versus mixed solid and cystic mass, usually 4)

SPECIAL CASES

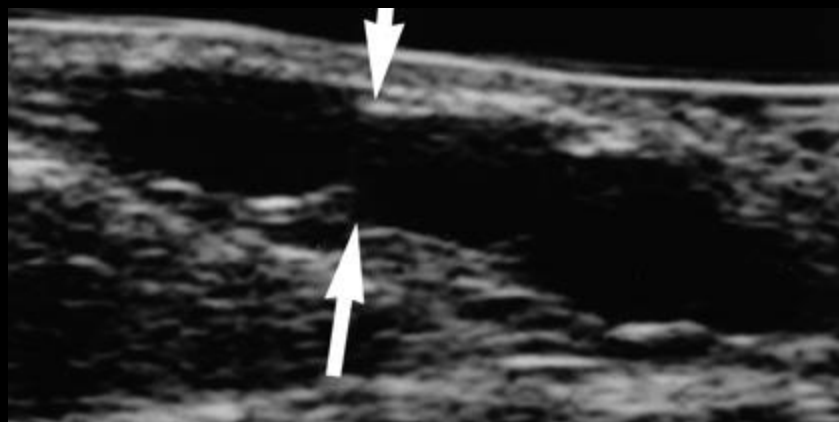
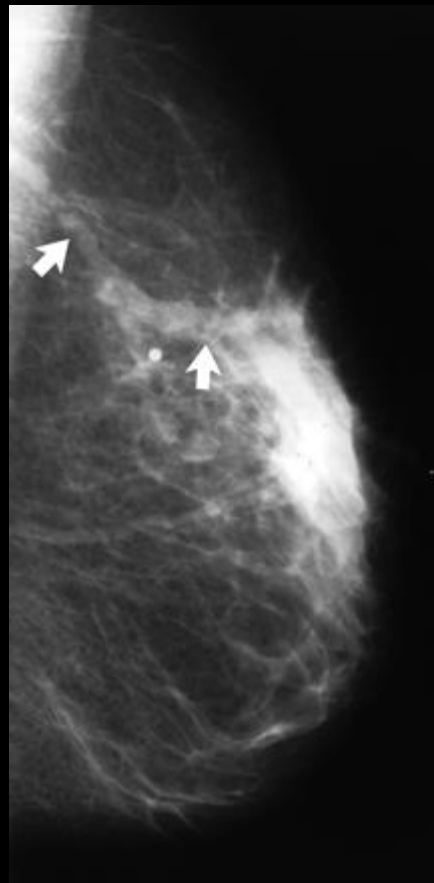
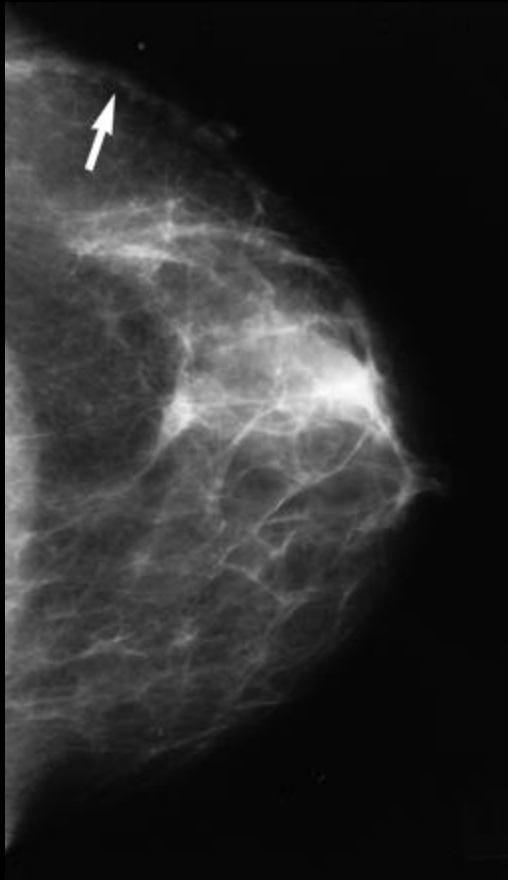
- Mass in or on skin: sebaceous or epidermal inclusion cysts, keloids, moles, neurofibroma and accessory nipples; mass has to be partially within the thin echogenic bands of skin
- Often can appreciate the “claw sign” indicating the layer of origin is the skin



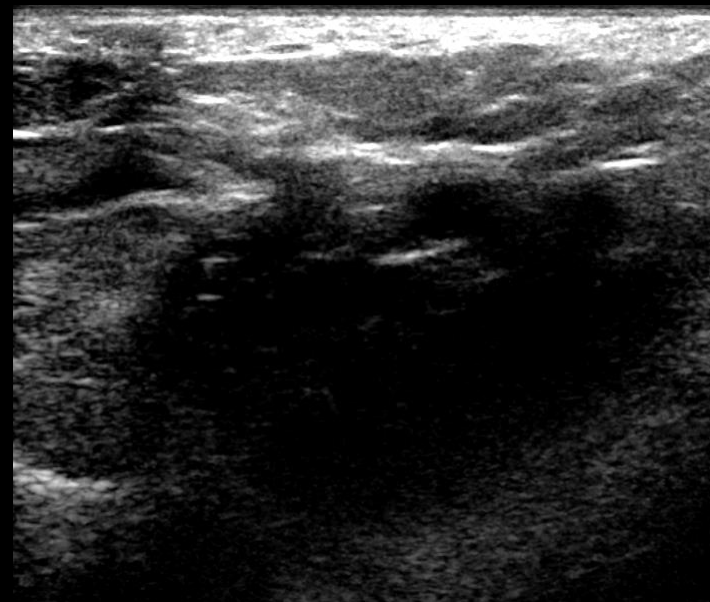
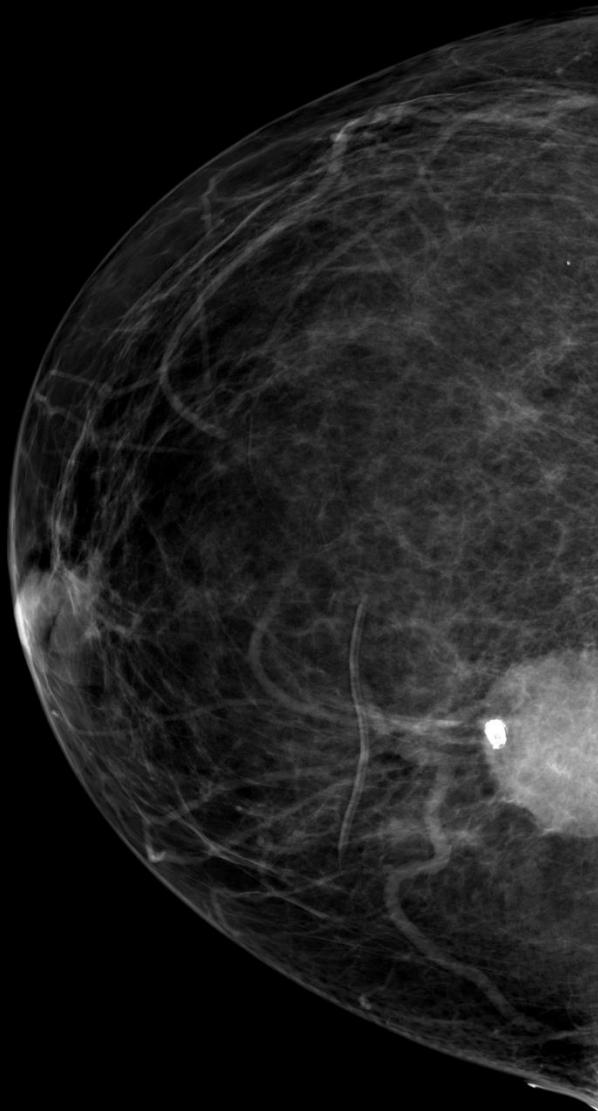
Special case: skin mass (sebaceous cyst)



KELOID

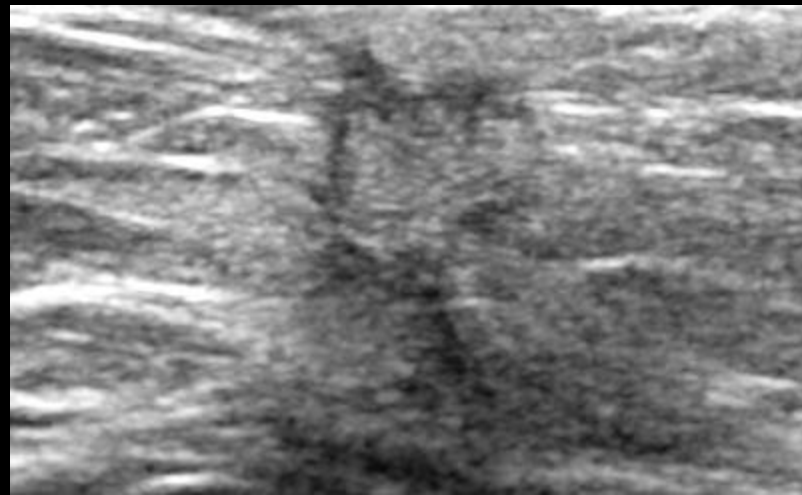
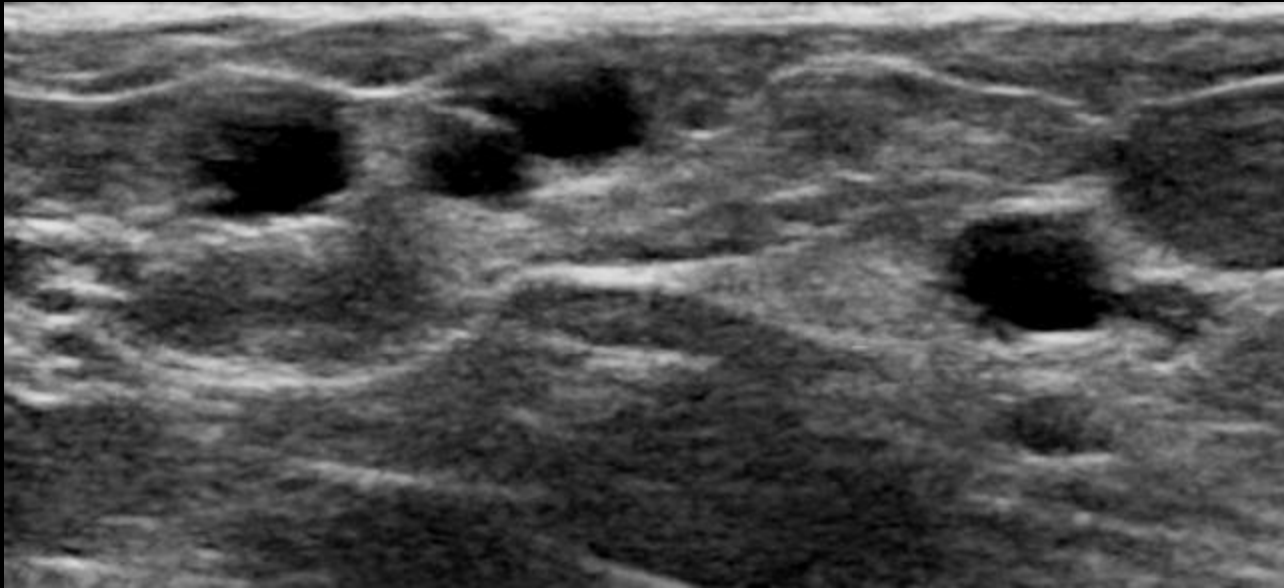


Special cases: Vascular abnormalities Mondor disease



Right Breast 5:00 5 CM FN

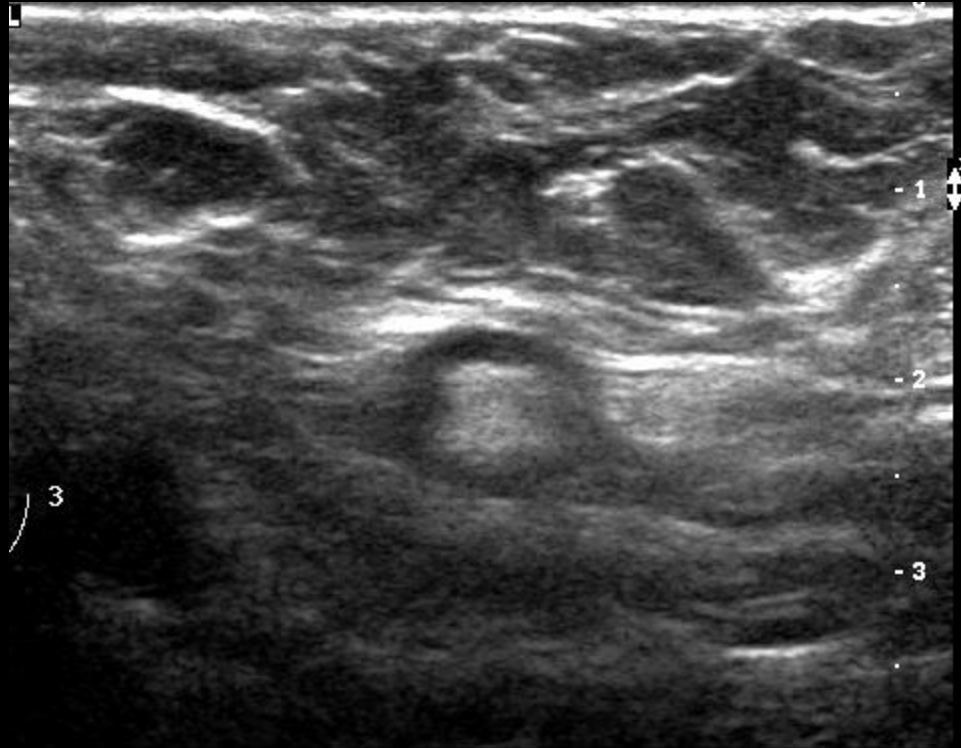
Special cases: postsurgical fluid collection



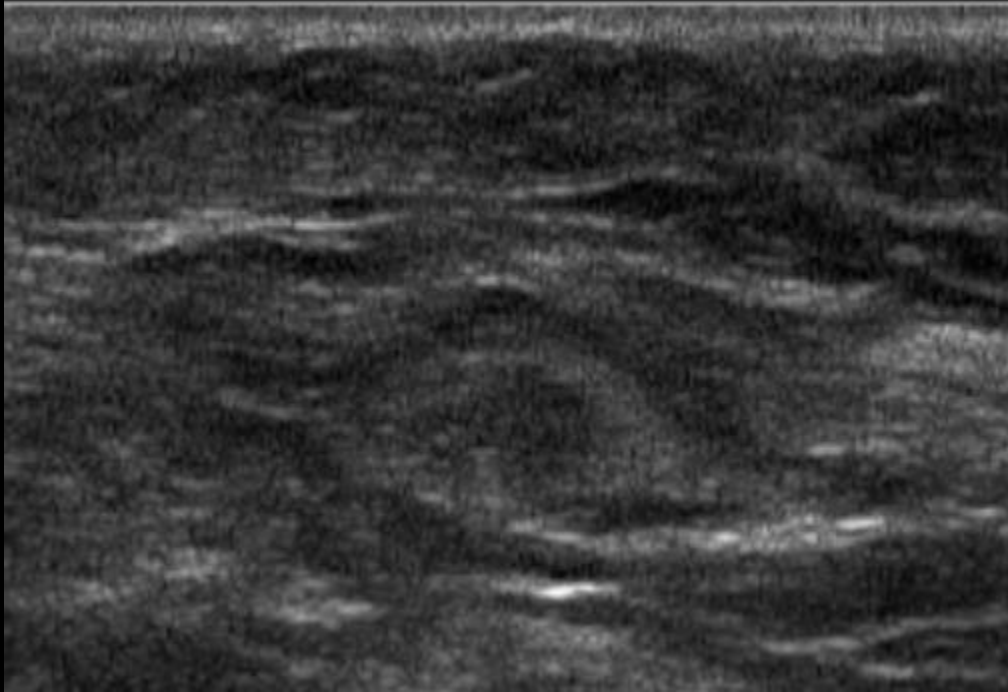
Special cases: fat necrosis
Need clinical history—But be careful, correlate with mammo!

Lymph nodes

- Lymph nodes: may be intramammary or axillary, internal mammary or supraclavicular
- Evaluated overall size, presence/size of a hypoechoic cortex and echogenic fatty hilum
- Doppler flow to the hilum is normal



Intramammary lymph node



Lymph nodes-axillary

BIRADS DESCRIPTORS-ASSESSMENT BASED OF THE HIGHEST LEVEL OF SUSPICION

- 0: Needs additional imaging evaluation
- 1: Negative
- 2: Benign Findings
- 3: Probably Benign Findings; short-interval follow-up suggested
- 4: Suspicious Abnormality; biopsy should be considered
- 5: Highly Suggestive of Malignancy; appropriate action should be taken
- 6: Known Biopsy-Proven Malignancy; appropriate action should be taken

Screening Breast Ultrasound: Past, Present, and Future

Rachel F. Brem¹
Megan J. Lenihan
Jennifer Lieberman
Jessica Torrente

OBJECTIVE. This article discusses breast ultrasound for the detection of breast cancer in the screening environment, as well as strategies for integrating screening breast ultrasound, including automated breast ultrasound.

CONCLUSION. Breast density is an increasingly pertinent issue in breast cancer diagnosis. Breast density results in a decrease in the sensitivity of mammography for cancer detection, with a significant increase in the risk of breast cancer. Ultrasound detects additional cancers.

Breast cancer is the most commonly diagnosed malignancy in women worldwide and is the second leading cause of cancer death in women in the United States [1, 2]. Early detection of breast cancer improves outcomes [3]. Screening strategies for detecting early stage breast cancer are now stratified. Mammography is recommended for women beginning at age 40 years by the American College of Radiology, American Cancer Society, and American College of Surgeons. For the women at highest risk women (i.e., those with greater than 20–25% lifetime risk), annual surveillance with MRI is recommended [4–6]. Preliminary data suggest that high-resolution nuclear medicine imaging, such as breast-specific gamma imaging and molecular breast imaging, may be beneficial in detecting mammographically occult breast cancer in high-risk women [7]. This is notable because an approach to detect mammographically occult breast cancers in women who cannot or will not undergo MRI is now available.

[12]. The decreased ability of mammography to detect breast cancer is a result of the lack of contrast between the “white” breast tissue and the “white” breast cancer visualized mammographically. Not only is mammography limited in women with dense breast tissue, but women with extremely dense breasts also have a 4.7-fold increased risk of developing breast cancer compared with women with fatty-replaced breasts [13]. Cancers detected in women with dense breast tissue are larger and more frequently node positive [14]. There is an 18-fold increased risk of an interval cancer in women with dense breast tissue, with interval cancers having a worse prognosis than screen-detected cancers [13]. Women with dense breast tissue constitute the largest population of “intermediate risk” women—that is, women with a 15–25% lifetime risk of breast cancer. They have the “perfect storm” of decreased mammographic sensitivity and increased risk of breast cancer.

Although ultrasound has long been a mainstay of breast imaging as a diagnostic

Keywords: breast cancer, breast imaging, breast ultrasound, cancer screening, ultrasound

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Screening US: General Picture

Screening breast ultrasound has shown to be an effective tool for detection of small, invasive, predominantly node-negative cancers in women with radiographically dense breasts

Ultrasound can and does detect mammographically occult breast cancer in women with dense breasts

Screening US: General Picture

Detection of additional cancers however is associated with an increased call-back rate and increased false-positive biopsy rate

Limitations of handheld breast ultrasound have restricted its adoption into clinical practice

Other modalities (MRI, CEM) have higher CDR

Screening US: General Picture

Automated breast ultrasound is expected to only become more efficient with development of computer-aided diagnosis/AI systems and increasing familiarity and training with ABUS systems

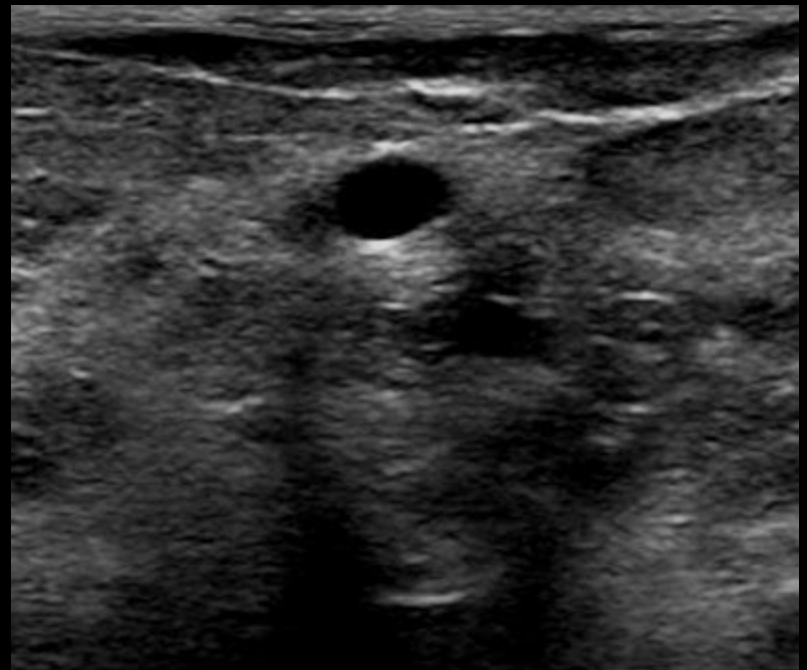
More work is needed to improve the specificity of screening ultrasound and increase its PPV

SOME CASES:

Case 1:



Case 1:



Case 2: Recalled from screening

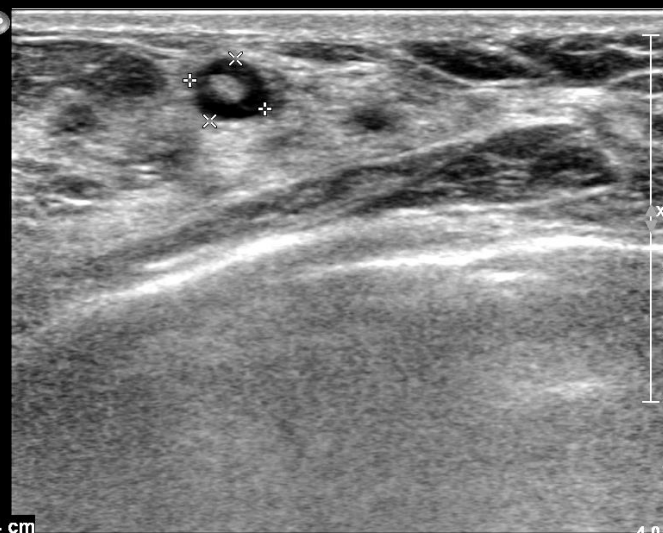


Case 2: Recalled from screening



FK 42HZ
RS

2D
64%
C 58
P Low
Res



M3

✕ Dist 0.614 cm
✕ Dist 0.515 cm

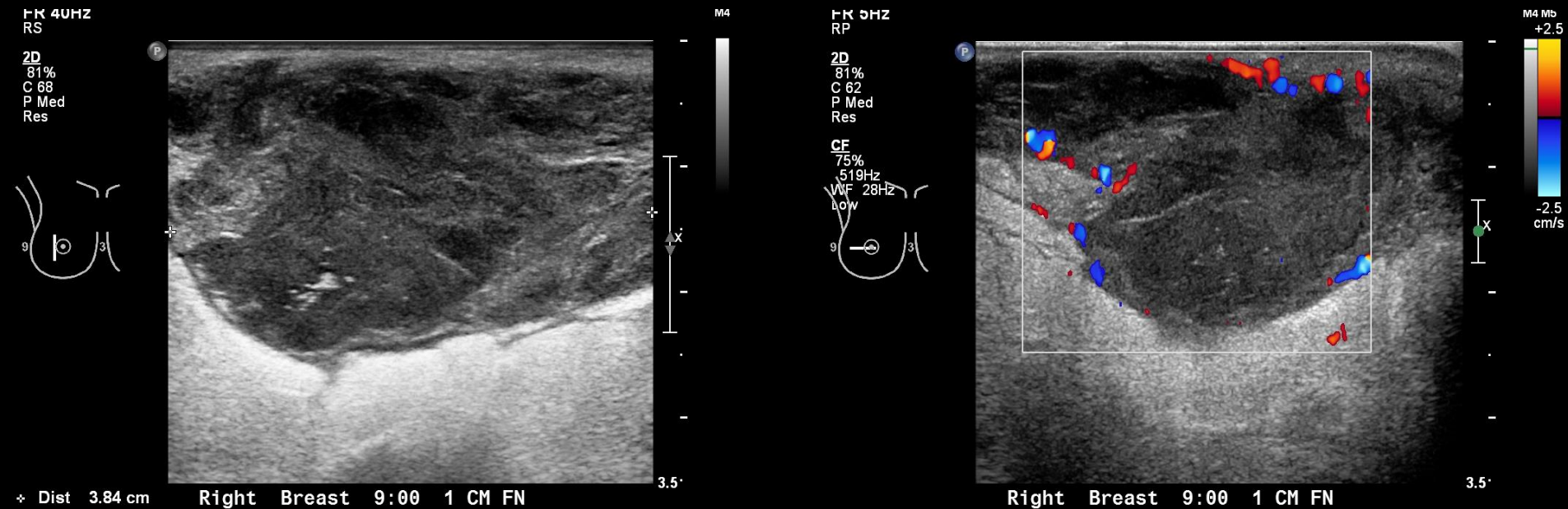
4.0

Case 3: Patient is seen in the ED

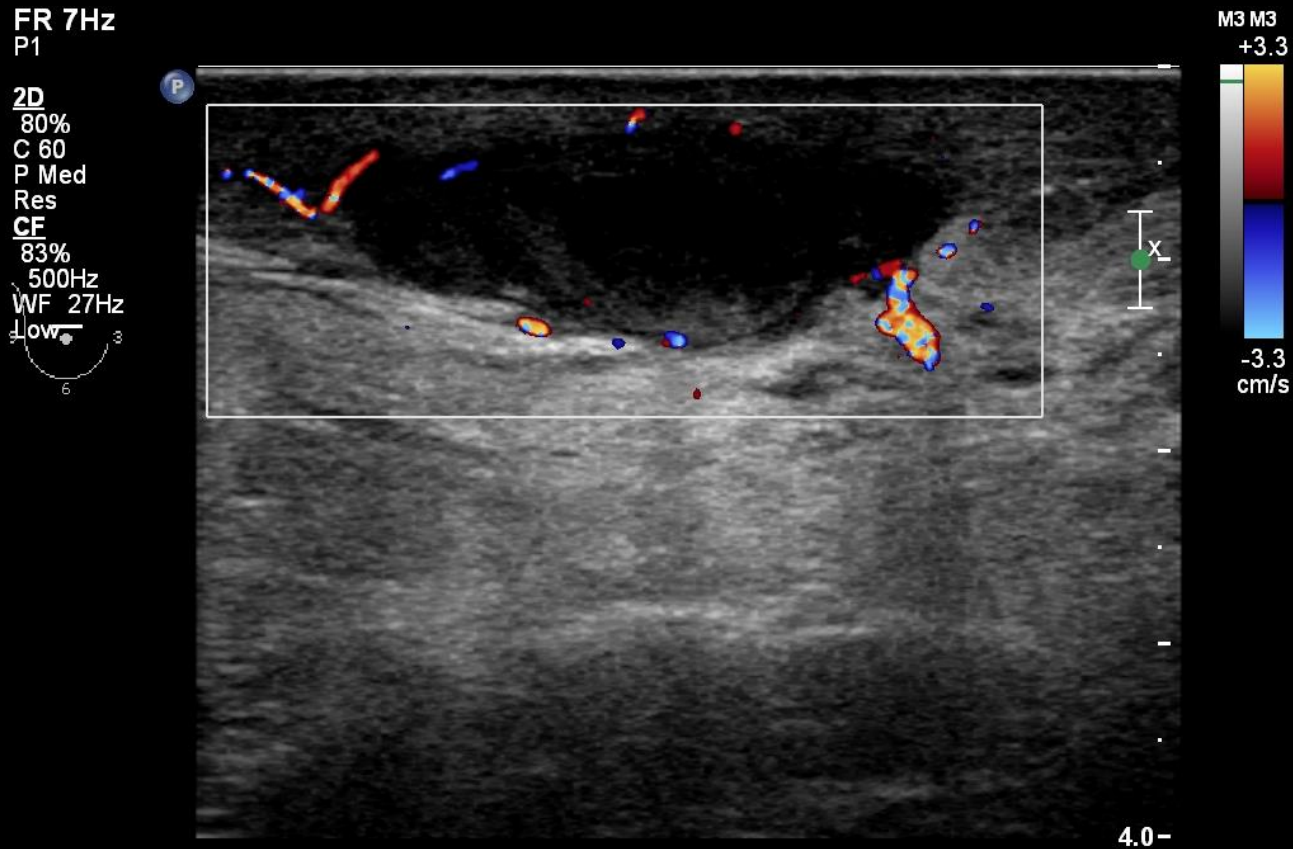


- Right breast size enlarged
- Gas density in breast
- DDx: Inflammatory cancer with necrosis, Abscess

Abscess can contain echogenic/complex fluid



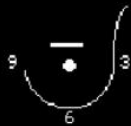
Different patient same diagnosis, more typical looking fluid



Case 4: 31 year old, history of previous fibroadenoma removal. Surgery requests US

RS

2D
66%
C 58
P Low
Res



PALP AREA



