Breast Ultrasound 101: Back to the Basics

Belinda Zaparinuk R.T.(M)BS,CBEC,FNCB
Senior Consultant, Mammography Educators

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Breast Ultrasound 101

- Anatomy
- Core Knowledge
- Image Review – Correlation – Triangulation
- Positioning
- Scanning Techniques
- Knobology
- Physics of Ultrasound
- Scanning Protocols
- Documentation
- Ergonomics
- Test Your Knowledge

2

Theory

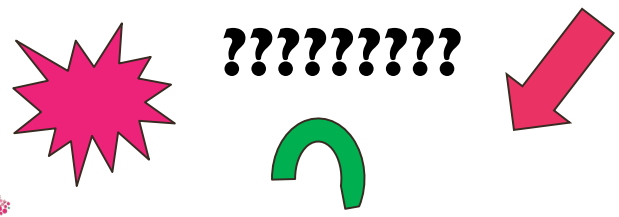
To ensure all breast tissue has been interrogated in a **standardized method, that can be replicated**.

- Screening Method
- Diagnostic Method

3

Reality

Imaging is not consistent, not standardized and is user dependent… WHY????



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ANATOMY

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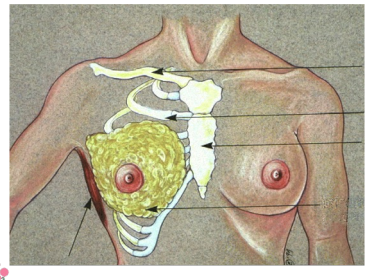
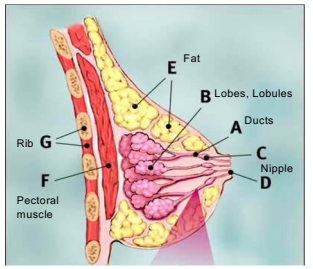
Anatomy





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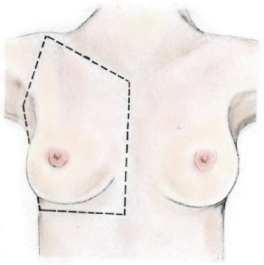
Anatomy

Perimeter:

The sternal notch, to tip of the clavicle, the sleeve of the axilla, the lateral chest wall, to the inframammary ridge to the midline of the chest, back to the sternal notch.



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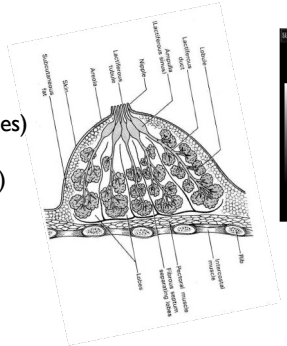
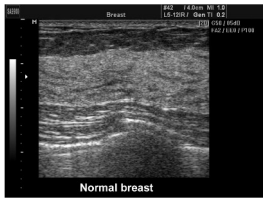
Anatomy

- Skin
- Subcutaneous fat
- Cooper ligaments
- Superficial mammary fascia
- Breast parenchyma (ducts/lobules)
- Retromammary fat
- Pectoralis muscle (major/minor)
- Ribs
- Pleura





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Anatomy

- **SKIN- Hyper**echoic
- **FAT, SUB-Q FAT- Hypo**echoic (**Reference Tissue**) Appears lobulated with a surrounding thin echogenic rim
- **FIBROGLANDULAR PARENCHYMA** (most variable)
  - Can appear homogeneous or heterogeneous (uniformly) or a combination of both
  - Can appear **Iso**echoic in lactation
  - TDLU's can sometimes be identified
  - Ducts when collapsed appear as thin echogenic line (hypoechoic zone)
  - Conspicuity changes with age, and can accumulate and appear as dilated tube up to 5mm

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Anatomy

Reference Tissue
FAT

- **Fat** in the breast appears dark gray, unlike in other areas of the body
- **FAT** is **Iso**ehoic
- Darker than **FAT** is **Hypo**echoic – usually lesion of concern
- Brighter than **FAT** is **Hyper**echoic or echogenic – usually lesion is benign
- Intramammary lymph nodes with a fatty hilum will still appear echogenic

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CORE KNOWLEDGE

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Core Knowledge

Breast density composition is defined by four categories, which consist of the following:

- A – Almost entirely fatty
- B – Scattered areas of fibroglandular density
- C – Heterogeneously dense
- D – Extremely dense

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Core Knowledge

- The breast composition categories are assigned value by a visual estimation of fibroglandular-density tissue within the breast
- The assessment of the volume of attenuating tissue in the breast is to help indicate the relative possibility that a lesion could be obscured by normal breast tissue and that the sensitivity of the examination may be compromised by dense breast tissue

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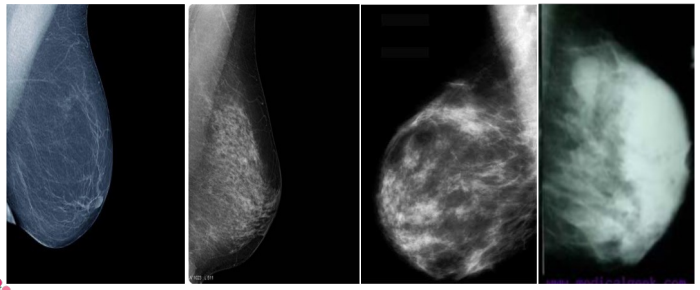
Core Knowledge



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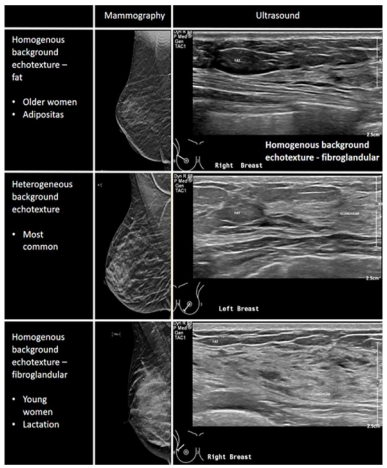

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Core Knowledge

- This allows the patient and her doctor to better assess her risk of developing breast cancer
- Other factors include age, family history, previous breast
- biopsies, and gene mutations
- 50% of all women undergoing screening mammography have dense breasts

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Core Knowledge

- Mammography is the foundation
- The standard of care is that mammography along with ultrasound provides comprehensive imaging
- If an area presses out, it is still recommended to document with ultrasound

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Core Knowledge

- Ultrasound alone does not provide the complete interrogation of the breast
- It can be a starting point for imaging women under 30 and pregnant women, but mammography may be needed

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Core Knowledge

- Approximately 75% of breast cancers occur in women who have no family history of the disease and are not high-risk
- One in six breast cancers occur in women ages 40-49

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Core Knowledge

- It is important to be familiar with breast pathology because it indicates the relative risk of developing an invasive breast cancer
- Pathology helps to determine the plan of care
- Pathology assists in the tumor characteristics to determine neoadjuvant treatment

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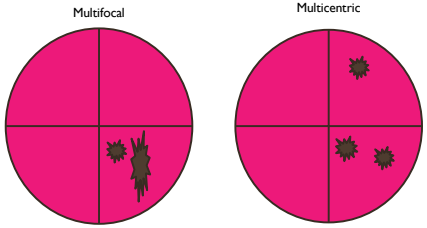
Core Knowledge

Breast cancer can be multifocal and multicentric.



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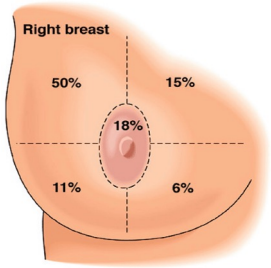
Core Knowledge



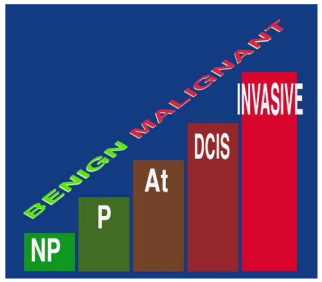


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IMAGE REVIEW – CORRELATION – TRIANGULATION

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Image Review – Correlation – Triangulation

Look at the patient's breasts.

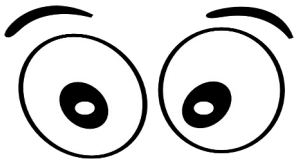

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Image Review – Correlation – Triangulation

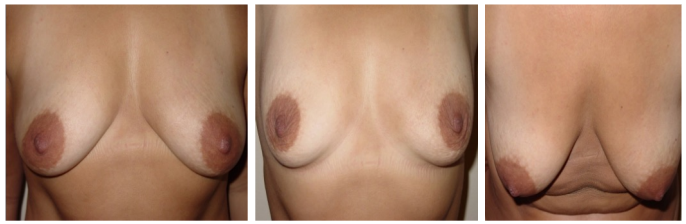

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Image Review – Correlation – Triangulation

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Image Review – Correlation – Triangulation

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Image Review – Correlation – Triangulation

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Image Review – Correlation – Triangulation



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Image Review – Correlation – Triangulation

How we view the anatomy is always changing, but the anatomy itself always presents the same.

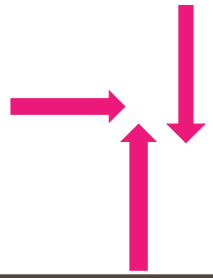
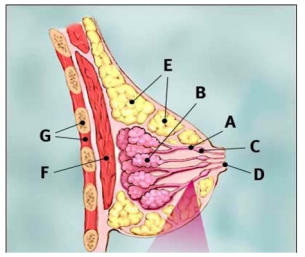

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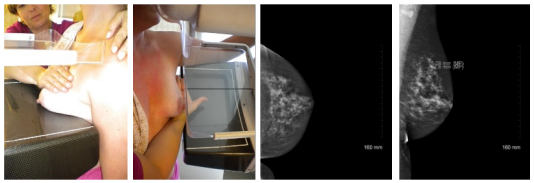
Image Review – Correlation – Triangulation

Mammography:

- Craniocaudal (CC) view: 0 degrees
- Mediolateral Oblique (MLO) view: 45 degrees



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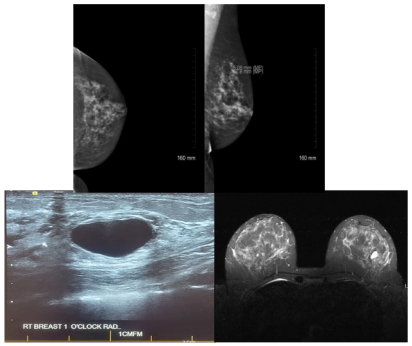

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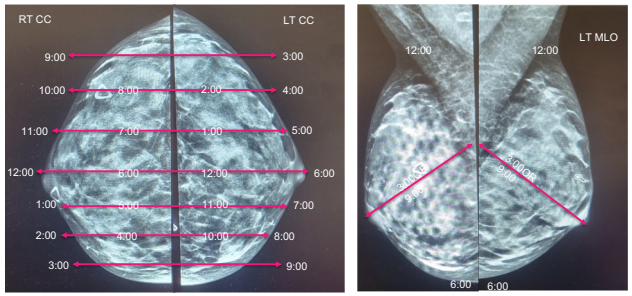

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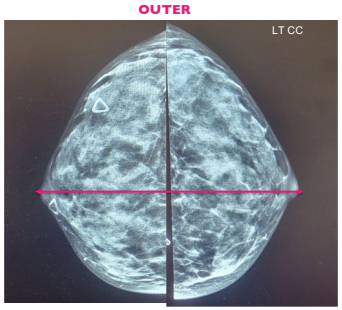

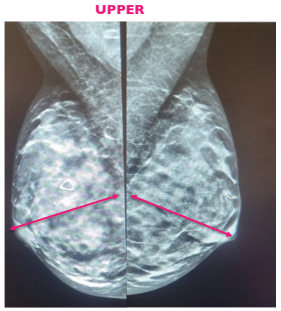

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Image Review – Correlation – Triangulation

- If the Area of Concern (AOC) is seen in one view only, a 90-degree lateral (LM/ML) can help determine if the AOC is located in the medial breast
- "Muffins Rise… Lead Sinks"

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Image Review – Correlation – Triangulation

- O'clock is determined by the location of the AOC on the CC view
- The quadrant is determined by the MLO, either the AOC is above the nipple (upper) or below the nipple (lower)

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Image Review – Correlation – Triangulation

When correlating findings found on prior breast imaging modalities, the operator performing handheld scanning should correlate the size, location of lesions and match the type and arrangement of tissues surrounding the lesion in order to reduce the likelihood of misregistration.

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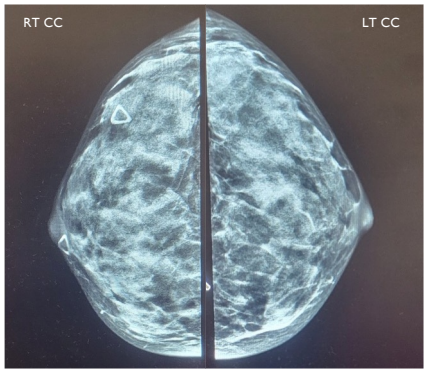
Case #1



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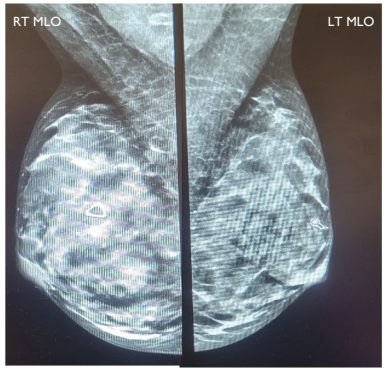

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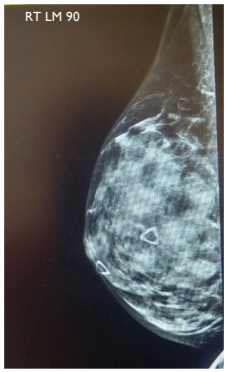

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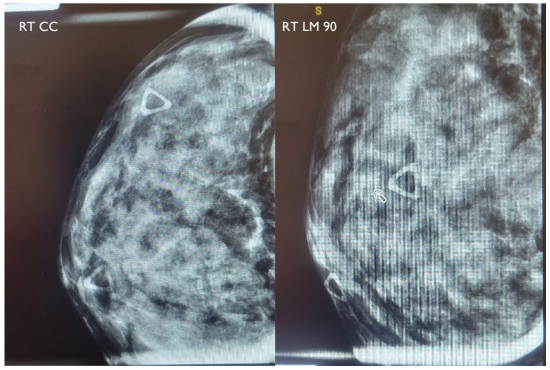

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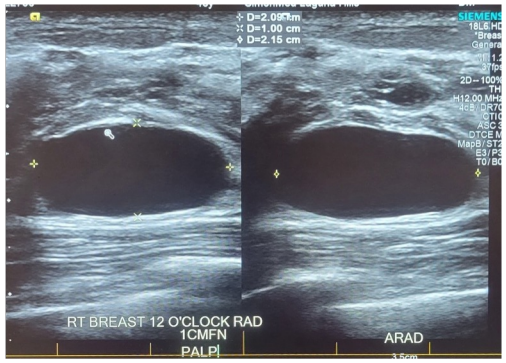

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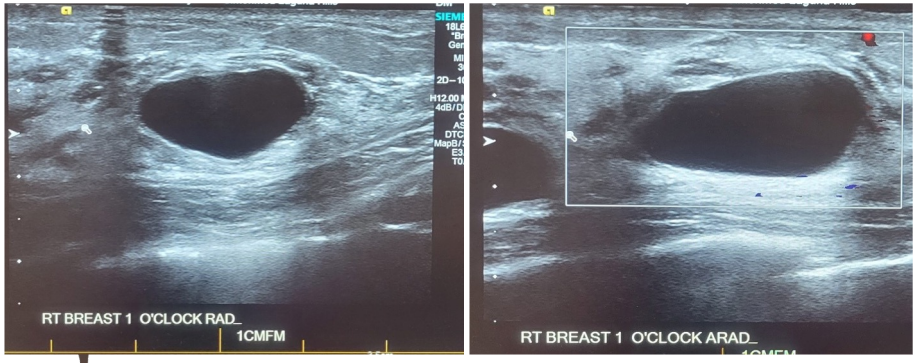

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Case #2

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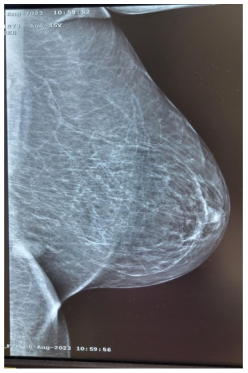
Case #2



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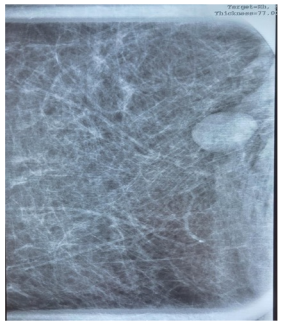
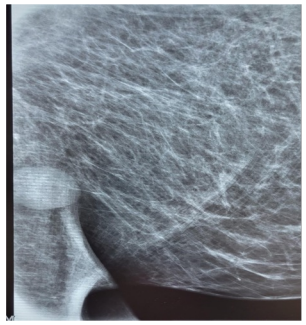


RT CC MAG



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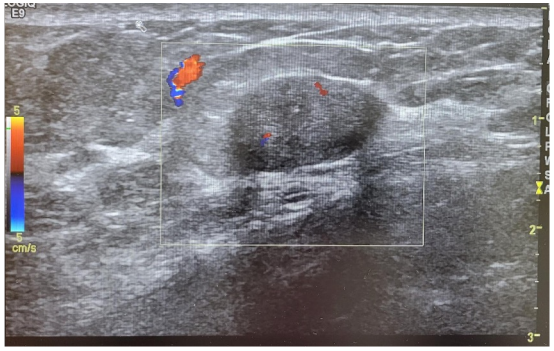

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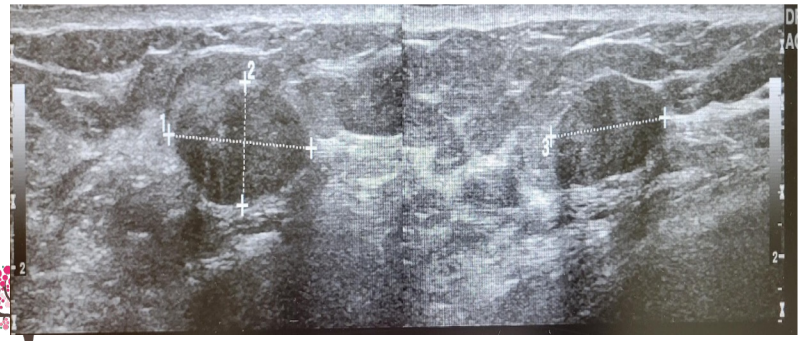

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POSITIONING

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Positioning

- Patient should be rolled into a Cahan position to reduce thickness of the breast and evenly distribute breast tissue
- This position helps in the imaging of the upper outer quadrants of the breast

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Positioning

The arm should be raised above the head:

- This elongates the pectoralis muscle and allows for better mobilization of the breast
- Even when the patient is rolled back to supine position to complete imaging of inner quadrants of the breast

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SCANNING TECHNIQUE

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Scanning Technique

It is recommended that breast US to be performed with **7MHz- 15MHz (or higher)** resolution, real time, linear array transducer.

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Scanning Technique

- To **survey** the breast completely, Sagittal and Transverse scans are recommended
- Supplemental Radial and Anti-Radial scans ensure entire breast structures are interrogated

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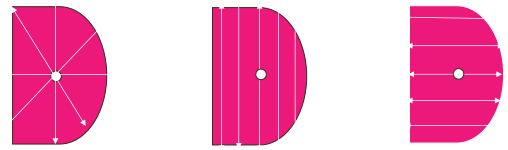
Scanning Technique

- Scanning in three directions while applying a firm, even compression, provides a good interrogation of the breast
- Then document in orthogonal views



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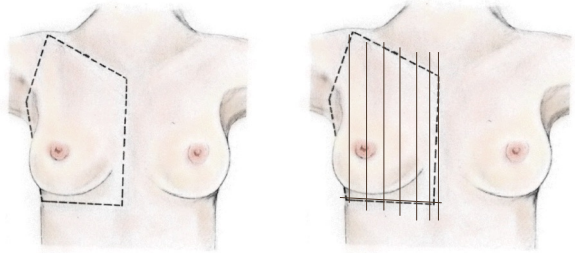
Scanning Technique



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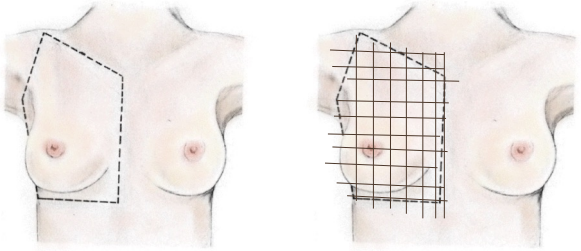
Scanning Technique



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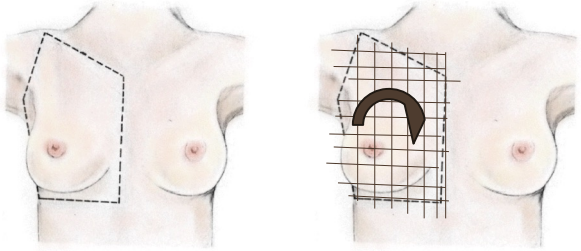
Scanning Technique



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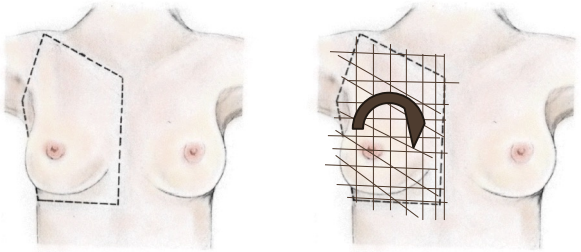
Scanning Technique



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Scanning Technique

Transducer Angle

- It should be parallel to the sub-Q fat/glandular tissue and the chest wall
- This improves visualization of acoustic interfaces and keeps the beam perpendicular
- This is the plane where most lesions grow

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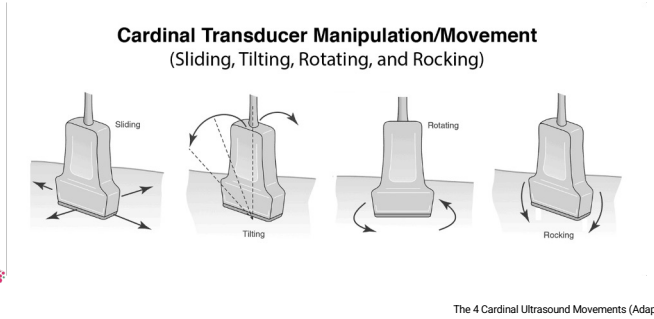
Scanning Technique



The 4 Cardinal Ultrasound Movements (Adapted from Ramsingh 2018

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Scanning Technique

- Rock it, Roll it… side-to-side, back-and-forth
- On curved surfaces, it aids in keeping the perpendicular interface of the transducer
- Aids in ultrasound-guided biopsies to help keep the needle perpendicular to the transducer (to visualize it) while keeping the needle parallel to the chest wall (to avoid pneumothorax and implant rupture)

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Scanning Technique

- Gel is your friend
- Apply even, firm compression

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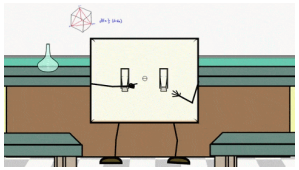
Scanning Technique

- Scanning with the lights on
- Our best work is done in the dark!



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Scanning Technique

Common Mistakes:

- Reading only the report, not reviewing images

OR

- Looking at the images and not reading the report

Review images, review the report… it's a must!!!!

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KNOBOLOGY

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Knobology

Recommendation:

- Agree to agree
- Set it and leave it alone
- All machines have same settings

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Knobology

Field of View (FOV):
Controlled by image depth, it must be optimized to see the detail of the breast.

FOCAL ZONE

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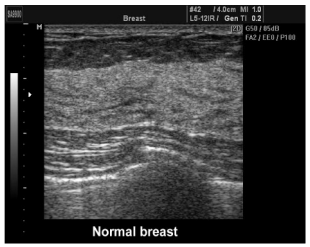
Knobology

Settings should be adjusted at the center of the breast; this allows the breast to appear uniformly bright in near and far fields.



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Knobology

If the field of view is too large, information can be compressed or stacked at the top of the image.

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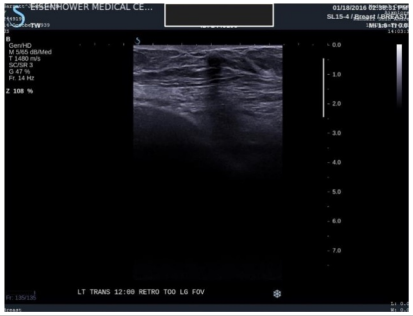
Knobology

Field of view is too large.



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Knobology

If the field of view is too small, important information deep to your image will be not seen.

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Knobology

Field of view is too small.

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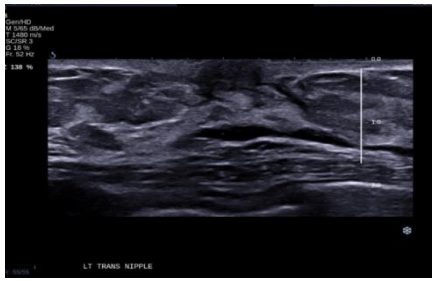
Knobology

Field of View = Correct Depth



Skin

Pre-pectoral fascia

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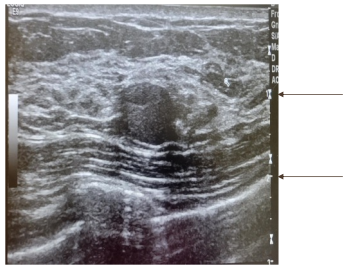
Knobology

Depth is indicated on the monitor by a line of cm markers.



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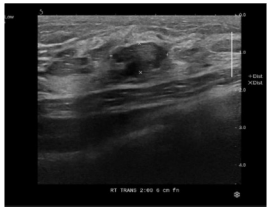
Knobology

Search with a larger FOV and narrow it down when characterizing a lesion.



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Knobology

Too high of gain, causing the image to be too bright, which creates artifactual noise that affects the contrast resolution.

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Knobology

Overall Gain: too low gain, the image is too dark and real echoes can be missed.

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Knobology

The goal is to display the maximum levels of grays, which creates a wide or high dynamic range.

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Knobology – Calipers

- Measure what is real
- If in doubt, mark the skin

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Knobology – Calipers

- Lesions should be measured in at least two dimensions and documented in two planes
- Images documented, require with and without calipers
- If suspicious of malignancy, the axilla is to be interrogated and documented accordingly

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Knobology – Calipers

- To make the caliper measurement, record the dimensions to include the longest dimension
- Acquire one view in the scan plane demonstrating the longest dimension, which may not correspond to the two orthogonal views

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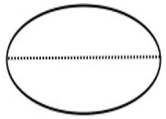
Knobology – Calipers

Note that the scan plane of the lesion's longest diameter may be in any plane.



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Knobology – Doppler

- Brightness indicates the velocity of blood cells
- Brighter shades of color = higher velocities of blood cells
- Mean velocity is calculated by color doppler

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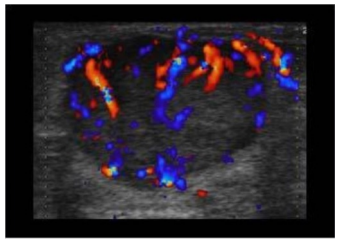
Knobology – Doppler

BART – Blue Away Red Towards



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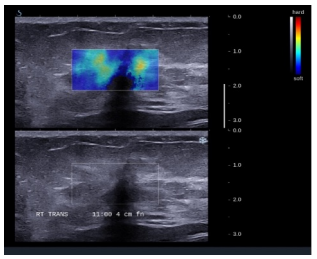
Knobology – Elastography

Used to perform breast mass evaluation and characterization.



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Knobology – Elastography

- Can increase the specificity in differentiating benign versus malignant breast masses
- Benign lesions compress with transducer pressure and malignant lesions displace the breast tissue without changing in height
- The color scales should be annotated to denote hardness or softness when using elastography

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Knobology – Harmonic Imaging

- Improves quality of the displayed image which is of suboptimal quality
- The harmonic frequency travels through the body with less beam distortion

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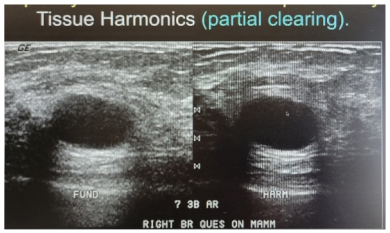
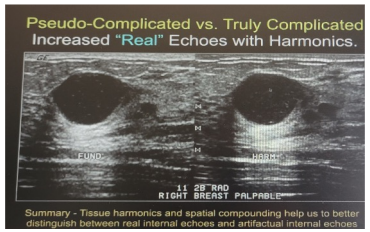
Knobology – Harmonic Imaging





Source: Dr. Tom Stavros

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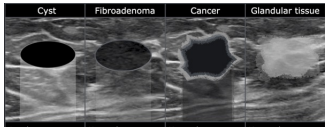
Knobology – Pathology

Cyst	Fibroadenoma	Cancer	Glandular tissue
			
Anechoic pattern	Hypoechoic	Hypoechoic	Hyperechoic
Oval or round shape	Most common: • oval or round Less frequent: • lobulated	Most common: • irregular shape Less frequent: • round or oval	Locally prominent glandular tissue
Circumscribed margin	Circumscribed margin	Margin is not circumscribed: • Indistinct • angular • microlobulated • spiculated	
Horizontal orientation	Horizontal orientation	Vertical orientation	
Posterior Enhancement	Sometimes minimal posterior enhancement	Frequently posterior shadowing	No feature
No calcifications	May have gross calcifications	May have small calcifications in or outside mass	No

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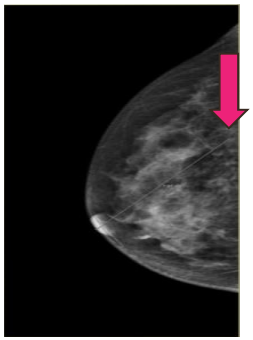
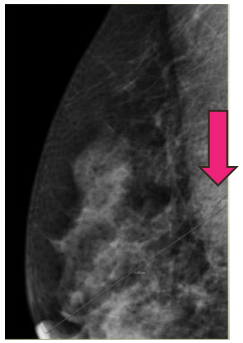
Knobology – Calcifications





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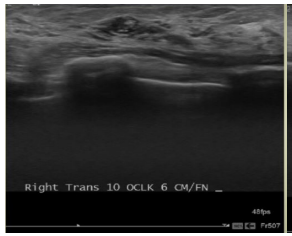
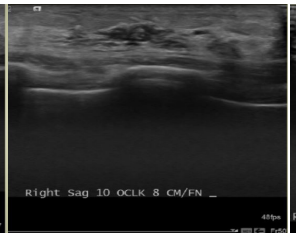
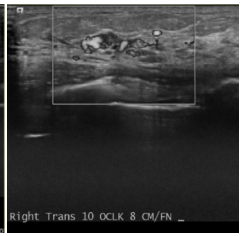
Knobology – Calcifications







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PHYSICS OF ULTRASOUND

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Physics of Ultrasound

- To understand the relationship of the speed of sound, the frequency of the sound wave and the wavelength in image acquisition
- Frequency affects the resolution of the image (use 12.5mHz or higher)
- Resolution and frequency are equally proportional but can affect depth penetration
- Axial resolution is best with higher frequency transducers
- Lateral resolution is determined by the width and focus of the beam
- Focal zones should be at the level of the lesion or at most 1cm superficial or deep to the anterior or posterior margins of the AOC

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Why is Breast Ultrasound so complicated?

- Imaging is not consistent
- No standardized protocols
- User dependent

Why not apply the same principles from Mammography to Ultrasound?

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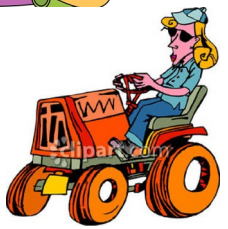
We know how to get there…

… but not the same route.



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SCANNING PROTOCOLS

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Scanning Protocols

- Scanning protocols: Screening vs Diagnostic
- Standardized scanning technique
- Create consistency, continuity and accountability

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Scanning Protocols

- Standardized imaging protocols allow for image reproducibility, accountability and provide measurable information
- Staff understand that imaging requirements improve patient flow, productivity and work environment

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Scanning Protocols

RAD A

RAD B

100

Scanning Protocols

Radiologists on board with standardized imaging protocols:

- Reduce interruptions and confusion
- Hold accountability
- Empowers staff
- Improve patient flow and productivity

HAPPY RADIOLOGIST = HAPPY STAFF

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Scanning Protocols

Tech/Rad Review

DATE:	TECH	RAD	PATIENT MRN#
REVIEWER:			

TECH	PASS	FAIL	N/A	RAD	PASS	FAIL	N/A
LATERALITY							
CMFN							
2 PLANES							
LOCATION							
CALIPERS							
DOPPLER							
PROTOCOL							
MISC							
CORRECTIVE ACTION:				CORRECTIVE ACTION:			

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Scanning Protocols

Quality Watch is the super user, provides the education to new staff, maintains the compliance and provides the measurable information.

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DOCUMENTATION

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Documentation

Communication along with Image and Report Review is essential for continuity of care.

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Documentation

- Reports need specific information regarding location in the breast, distance from the nipple and what type of abnormality needs to be imaged
- Additional imaging should be specific

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Documentation

- Reports that say additional imaging with ultrasound is not specific
- Specific reports, along with annotated AOC on images aid in the triangulation between modalities (Mammo, US, MRI)
- Also needed if patients go to another facility for work-up
- Vital, especially with teleradiology communication

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Documentation

- Specific documentation from the technologist with accurate and complete history taking is important
- If working in an environment where the patient is passed onto another department for imaging, strong communication is important along with accurate documentation
- Work sheets, history sheets and instant messaging is vital for continuity of care for the patient, the staff and the radiologist

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Documentation

- The facility name and location
- Examination date
- Patient's first and last name
- Identification number and/or date of birth
- Anatomic location including side (left/right)
- Orientation of transducer in orthogonal views
- CMFN
- O'clock

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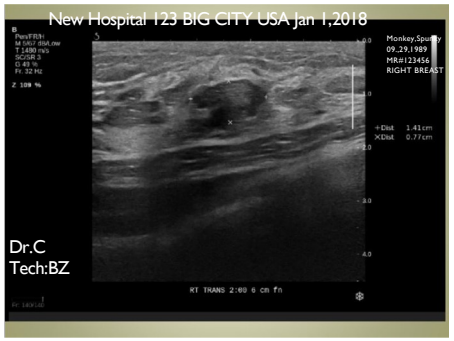
Documentation



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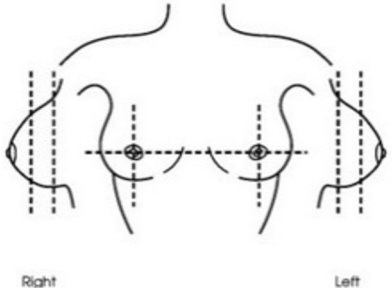
Documentation

Allows for reproducible images:

- Moles-◯
- Scar- ෴
- Palpable lump-△
- Pain- □



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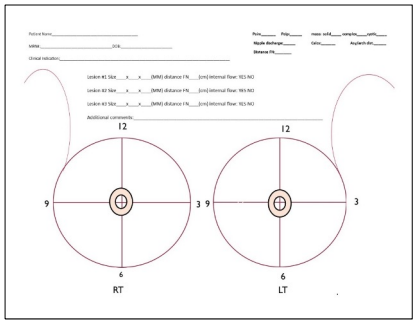
Documentation



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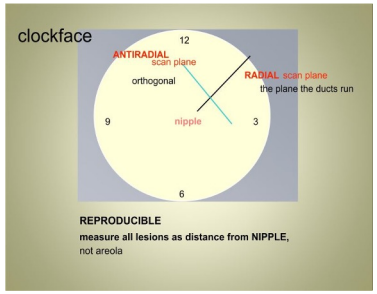
Documentation

The Why = Reproducible



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The Key to Consistency

- Set protocol
- Implement standardization
- Document Laterality, Orientation, O'clock and CMFN
- Scan follow-up on the same machine
- Have settings the same on all machines

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ERGONOMICS

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Ergonomics

Roughly 80% of sonographers have musculoskeletal-related injuries:

- 1 in 5 have a career ending injury
- 5 years before experiencing pain on average

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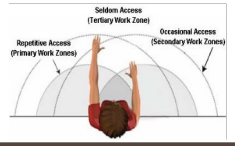
Ergonomics

There is a certain perimeter that the worker can perform in, without overextending for a long period of time:

- This is known as the Primary Work Zone, Secondary Work Zone, and the Tertiary Work Zone
- Understanding this workspace will help with your ergonomics



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Ergonomics

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Ergonomics

(A)

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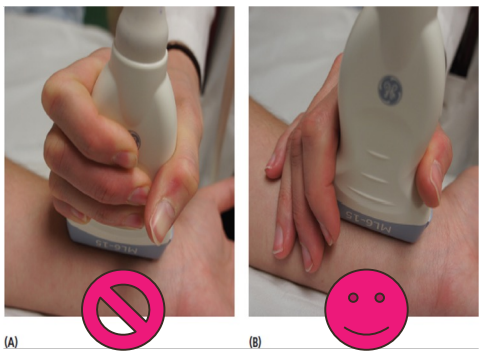
Ergonomics



(A) (B)

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Ergonomics

- Chair or stool adjusted to you
- Monitor at eye level
- Machine within proper reach
- Feet flat or supported
- Move the patient close to you
- Adjust height of bed if possible
- Flip the patient

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TEST YOUR KNOWLEDGE

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Test Your Knowledge

- 55 yr old female Caucasian
- Hx MVA 5 yrs ago
- No fm hx ca breast or other cancers
- Recent weight loss 55 lbs
- C/o palp lump rt breast x 5 yrs
- No bx, surg, HRT, meds
- Nulliparous, 14 menstrual, 50 menopause

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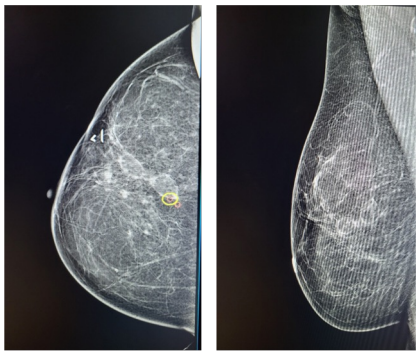
What do you see?



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What do you see?

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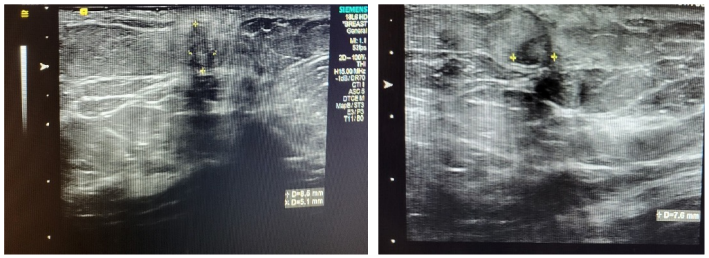
What do you see?



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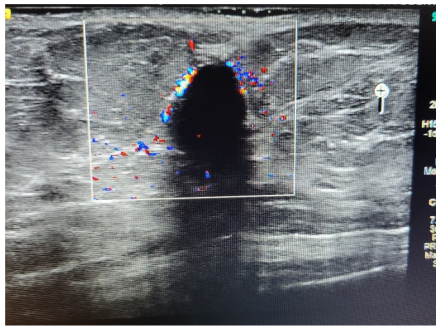
What do you see?



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What YOU see, image, and document makes a difference of finding something early or late.

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Quality Breast Imagers

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