Breast Ultrasound: Improving Your Skills & Patient Care

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Objectives
- Discuss **US techniques** available for image optimization.
- Review & compare the US appearances of **benign & malignant masses**.
- Describe the **use of US** in evaluating abnormal findings on physical exam & imaging.
- Discuss the role of US in **supplemental cancer screening**.

Introduction
- Breast US was first introduced in the 1950's.
- It has become an **essential tool** in breast imaging.
- It is both an **adjunct & a complement** to mammography & MRI.
- Currently, it is the primary imaging modality to guide **interventional breast** procedures.

Optimal Ultrasound Techniques
- Patient anxiety
- Patient positioning

Optimal Ultrasound Techniques
- Operator dependent
- Real-time scanning
  - Lesion mobility
  - Location
  - Relationship to adjacent structures
  - Direct assessment of a palpable lesion

What Type of Transducer?
- **ACR VII. EQUIPMENT SPECIFICATIONS**
  - Breast ultrasound should be performed with a high-resolution real-time **linear array scanner** operating at a center frequency of at **least 10 MHz and preferably higher**.
    - Other transducers may be utilized in special circumstances.
What Type of Transducer?

- **ACR**: In general, the **highest frequency capable of adequate penetration to the depth of interest** should be used.
- For evaluating **superficial lesions**, scanning through a thin stand-off device or thick layer of gel may be helpful in offsetting the transducer face from the uppermost layer of skin, to bring it into the focal zone of the transducer.
- Focal zones should be electronically adjustable

**Gray-Scale Imaging**

- **Linear array transducer**!
  - 12-5 MHz is commonly used
  - 17-5 MHz may be used:
    - **High frequency transducer provides excellent spatial resolution**
      - Better "shades of gray"
      - Margin resolution
      - Lesion conspicuity versus background
    - **Cost**: Decreased penetration due to attenuation of the beam (>3cm)

**Gray-Scale Imaging**

- **Depth** – pectoralis muscle visualized along with the posterior FOV
- **Gain** – fat is a mid shade of gray at all levels
- **Time Gain Compensation** – adjusts image brightness at different depths to compensate for attenuation of the US beam

**Gray-Scale Imaging**

- **Mammographic/MRI lesion**
  - Correlate with lesion size, depth, location & distance from nipple
  - Correlate with surrounding tissue
    - Is the tissue around the lesion entirely fat or fibroglandular tissue?
      - Should be the same on ultrasound

**Male Breast Cancer**

- **0.7% of all breast cancers**
  - Infiltrating ductal tumors most common
    - All ductal subtypes have been described
    - DCIS without invasive disease < 5%
    - Paget’s disease has been reported
    - Infiltrating lobular uncommon
- **Mean age at diagnosis = 67 yr**
  - Uncommon in men < 40 yr old
  - Stage for stage similar prognosis as females
  - Axillary adenopathy in 50% at presentation
2nd Look US

Gray-Scale Imaging

• Palpable lesion
  – Any imaging correlation? Over age 30…
  – Under age 30, pregnant or lactating?

• The examiner should palpate the lesion & then place the US transducer directly over the mass.
  – Supine
  – Upright: Kleenex box

Gray-Scale Imaging

• Adjust depth

• Multiple focal zones improves resolution at multiple depths simultaneously
  – Decreases frame rate

• If a single focal zone is used, it should be centered at the level of interest

Example – Focal Zone(s)

Remember!

• Gain settings, focal zone selections & fields of view should be optimized to obtain high-quality images!

Spatial Compounding

• Utilizes electronic beam steering to acquire multiple images obtained from different angles within the plane of imaging
  – Decreases frame rate
**Spatial Compounding**
- Real echoes from returning structures are enhanced, providing improved contrast resolution
  - Lesion margins
  - Posterior borders
  - Calcifications
- Artifactual echoes are reduced
  - Speckle
  - Posterior acoustic enhancement
  - Posterior acoustic shadowing

**Speckle Reduction**
- Real-time post-processing
- Enhances contrast resolution
- Improves margin definition
- Complementary to spatial compounding
  - Can be used at the same time!

**Harmonic Imaging**
- Relies on filtering the multiple higher harmonic frequencies (multiples of the fundamental frequencies)
  - The ultrasound pulse is distorted as it travels through the non-linear (to sound) breast tissue
  - Thus, creating harmonic frequencies
- The returning US signal contains both the original fundamental frequency & its multiples, or harmonics
- Allows the higher frequencies to be selected & used to create the gray-scale images
  - By not using the lower frequency echos, this reduces reverberation/internal echoes in lesions (cysts)
  - Improves lateral resolution & may improve contrast resolution
**Speed of Sound**

- Speed of sound in **tissue** = 1540 m/sec
- Speed of sound in **fat** = 1430-1470 m/sec
- *Speed of sound imaging* is available on most US units and is an optional adjustment depending on what type of tissue is being scanned: fat, dense tissue or mixed fat/tissue of the breast

**Imaging of a Mass**

- Radial/anti-radial
  - Transverse/longitudinal
- Acquire images in 2 planes **without and with caliper measurements**
  - Measure to the margin of the mass
    - Include the echogenic halo of a mass (cancer)
    - Longest horizontal x AP x orthogonal horizontal

**Examples**

- [Illustration of imaging techniques](image)
- [Examples of imaging results](image)
Lesion Annotation
- Right breast
- 2 o’clock
- Radial/anti-radial
- 3 cm from the nipple
  - Not fingers from nipple

Extended FOV
- Applying a pattern recognition
- Helpful in measuring large lesions
- Location of lesions
- Surgical planning

Doppler Ultrasound
- Color
- Power – more sensitive to low-flow volumes
- Quantitative spectral – wave form
- Both malignant & B9 lesion features overlap
- Cyst vs. solid
- Abscess

Elastography
- Measure the tissue stiffness
  - Potential to improve specificity
- Lesions deeper than 2 cm are less accurately characterized
- No universal color-coding standard

Elastography
- Strain
  - More operator dependent
  - Requires gentle compression with the ultrasound probe
  - Causes tissue displacement (strain)
    - Decreased in harder tissue
    - Quantitative information
      - Strain ratios: Lesion/background
      - Malignant lesions tend to have higher ratios
  - Shear-wave
    - Less operator dependent
    - Based on the principle of acoustic force
    - Transient pulses – cause transversely oriented shear waves in the tissue
    - Captures of the velocity of the shear waves
      - Travel faster in hard tissue
      - Measured in meters/sec or kilopascals

Elastography - Strain
- Score 1
- Score 2
- Score 3
- Score 4
- Score 5
- Benign
- Malignant
Elastography – Shear-wave

B9 & Malignant Lesions

- Oval shape
- Circumscribed margin
- Hypoechoic/Iso-echoic
- Parallel to chest wall
- Absence of any malignant features

Cyst

Solid Mass

Calcifications

Clinical Practice
Imaging Findings

- Asymptomatic patient
  - Mammogram
  - MRI Screening
- Symptomatic patient
  - Diagnostic mammogram
  - Diagnostic MRI
  - Palpable mass
  - Pain
  - Discharge

BI-RADS

- Introduced in 2003 for US
- New addition for 2014 – 5th edition

BI-RADS

- Tissue composition (screening only)
  1. Homogeneous background echotexture – fat
  2. Homogeneous background echotexture – fibroglandular
  3. Heterogeneous background echotexture

BI-RADS - Mass

- Shape
  - Oval
  - Round
  - Irregular
- Orientation
  - Parallel
  - Not parallel
- Margin
  - Circumscribed
  - Not circumscribed
  - -Indistinct
  - -Angular
  - -Microlobulated
  - -Spiculated
- Echo pattern
  - Anechoic
  - Hyperechoic
  - Complex cystic and solid
  - Hypoechoic
  - Isoechoic
  - Heterogeneous
- Posterior features
  - No posterior features
  - Enhancement
  - Shadowing
  - Combined pattern
- Calcifications
  - Calcifications in a mass
  - Calcifications outside of a mass

BI-RADS - Mass

- Associated features
  - Architectural distortion
  - Duct changes
  - Skin changes
    - Skin thickening
    - Skin retraction
  - Edema
  - Vascularity
    - Absent
    - Internal vascularity
    - Vessels in rim
  - Elasticity assessment
    - Soft
    - Intermediate
    - Hard

BI-RADS – Special Cases

- Simple cyst
- Clustered microcysts
- Complicated cyst
- Mass in or on skin
- Foreign body including implants
- Lymph nodes – intramammary
- Lymph nodes – axillary
- Vascular abnormalities
  - AVMs (arteriovenous malformations)
  - Mondon’s disease
- Postsurgical fluid
- Fat necrosis
**Supplemental Screening**

- High-risk patient
- General patient population
  - Breast density

**Mammography**

- Dense tissue limits sensitivity
  - 30-48% vs. 80-100% in fatty breasts
- Increased risk of cancer

**Ultrasound**

- Not limited by breast density
  - High Sensitivity
- Small hand-held transducer
  - Significant amount of operator subjectivity
  - Variation in breast ultrasound exams
  - Time to perform exam can vary
- Limitations:
  - Missed lesions
  - False-positive findings

**Occult Cancer in Women with Dense Breasts: Detection with Screening US: Diagnostic Yield & Tumor Characteristics**

- 11,220 patients
  - 3,626 patients with dense breasts
  - Normal mammogram & PE
- Physician performed whole breast US
- 11 cancers identified with US alone
  - Prevalence = 0.30%
- Cancer detection rate increased by 17% (from 63 to 74)
- Conclusion: US can depict small, early-stage, occult cancers similar in size & stage to mammographically identified non-palpable cancers.


**Clinical Utility of Bilateral Whole-Breast US in the Evaluation of Women with Dense Breast Tissue**

- 1,862 patients
  - Dense breast negative mammogram and PE
- US or mammography technologist performed study
  - Time of exam: 10 minutes
- 57 biopsies recommended
  - Data only on 51
    - 6 Cancers (cancer detection rate, 0.3%)
- Conclusion: US is useful in detection breast cancer & the cancer detection rate compares favorably with screening mammography.


**Initial Studies**

- Single center
- Supplemental ultrasound increases detection of node-negative invasive breast cancer in women in the 1st prevalence screen
- Increased cancer detection (yield) by 3.5/1000 screened
**ACRIN 6666 Study: Trial of Screening Breast Ultrasound**

**Rationale**

- No randomized controlled trials
- No multicenter studies
- Reproducibility...


**ACRIN - 6666**

- To determine supplemental cancer detection yield of ultrasound & MRI in women at elevated risk for breast cancer
- 2809 high-risk women with dense breasts @ 21 sites
  - 612 also underwent MRI at end of study
- 3 annual screens with mammography & US


**ACRIN - 6666**

- Screening mammogram & ultrasound read independently
- Radiologists did not know the result of the other study
  - Radiologists performed the ultrasound.
- Report & Recommendation……correlation with mammo

**ACRIN - 6666**

- 2662 patients had complete data
- 110 had 111 breast cancer events:
  - 33 (30%) Mammo detected only
  - 32 (29%) US only
  - 26 (23%) by both
  - 9 (8%) by MRI
  - 11 (10%) not detected by any modality


**ACRIN - 6666**

- Additional cancer detection rate:
  - US 4.3 cancers/1000 screens
  - MRI 14.7 cancers/1000 screens.
- 30/32 US detected only cancers were invasive
  - Range 2-40mm (median size 10mm)
  - 26 out of 27 staged were node negative.
- US Biopsy rate = 5% (242 of 4814)
  - 18/242 (7.4%) were cancer


**ACRIN - 6666**

- Conclusion: Addition of screening US or MRI to mammography in women at increased risk of breast cancer resulted in not only a higher cancer detection yield but also an increase in false-positive findings.
Screening US in Patients with Mammographically Dense Breasts: Initial Experience with CT Public Act 09-41

- Retrospective review of data
  - 10/1/2009 through 9/30/10
- Single center - Yale
- Technologists scanned with hand-held transducers
  - **935 patients**
    - 614 low risk
    - 149 intermediate risk
    - 87 high-risk

CT Public Act 09-41: Results

- **75% (701)** BIRADS 1 or 2
- **20% (187)** BIRADS 3 – only 82% (145) returned for F/U
- **5% (47)** BIRADS 4

- **63 aspirations or biopsies**
  - 3 cancers!
  - Less than 1 cm
  - All post-menopausal patients
  - 4.7% (44) false-positive
  - PPV was 6.5%
  - Cancer Detection Rate 3.2/1000

CT Public Act 09-41: Cost

- **Estimated cost**: CT global Medicare reimbursement rates for initial screening, whole-breast ultrasound, F/U, biopsy/aspiration:
  - »$180,802.00
  - »Or
  - »$60,267.00/cancer diagnosed

CT Public Act 09-41: Conclusion

- Technologist-performed hand-held screening breast US offered to women in the general population of dense breasts can aid detection of small mammographically occult breast cancers, although the overall PPV is low.

Moving Forward

- Breast ultrasound scanning requires a small hand-held transducer
- Recent advances in technology have lead to the development of automation
- Automation of ultrasound eliminates operator variation with improved technique standardization

AWBU

- Provides a volume data set of the whole breast in a standardized manner.
- **Short scanning times**
  - 1 minute per scan projection
  - May have AP, Lateral & Medial views of one breast.
  - Extra scan projections may be needed for a larger breast.
Automated Whole Breast Ultrasound

Supplemental Screening
- Tomosynthesis to take over?
- Less patients in subsequent rounds of US screening
- No CPT code
- No for insurance companies

Ultrasound Guided Procedures
- Fine Needle Aspiration/Cyst Aspiration
- Core biopsy
- Marker placement
- Pre-operative needle localization for surgical excision
- Injections for lymphoscintigraphy

Fine Needle Aspiration/Cyst Aspiration

**Indications:**
1. Cyst with debris vs. Solid Mass
2. Abnormal Lymph Node
3. Symptomatic relief of a cyst
4. Aspiration of a cyst to evaluate a finding mammographically – distortion or calcifications

Aspiration - Equipment
- Fine gauge needle – 20 - 25 G
- Syringe +/- tubing
- Aseptic technique
- Local anesthesia
  - Lidocaine
  - Marcaine
  - Saline/Benadryl
Cyst Aspiration

- **Does not aspirate:**
  - Try another needle or larger gauge
  - Core biopsy it!
- **To send or not to send the fluid?**
- **Post-procedure mammogram?**
- **Follow-up?**
- **Complications:**
  - Bruising
  - Bleeding
  - Infection
  - Pneumothorax

*Document!

FNA

- Abnormal lymph node
- Local anesthetic
- 20 gauge needle
- How many passes?
- Pathology present
**US Core Bx - Technique**

- Choose proper distance between the probe edge & planned incision site
  - Superficial mass
  - Deep mass
- Mark site
- *Tip:
  - Proper grip on the transducer

**US Core Bx - Technique**

- Local anesthesia (skin & future needle track)
- Small incision
- Advance the needle to pre-firing position under US guidance
- Needle trajectory along the scanning plane, parallel to the chest wall
- Needle tip at the lesion border and then acquire sample(s)

**How many samples?**
**Pre-fire**

**Document - Procedure**

**Post-fire**

**Vacuum - Assisted Core Biopsy**

**US - Guided Needle Localization**

- **Equipment.**
  - Length of needle – 5 cm
  - One or more needles?

- **Technique.**
  - Shortest distance/same pathway as core
  - Best way to see lesion
  - Aseptic technique
  - Local anesthetic
  - Needle tip in lesion – “shish-kabob”
  - Deploy wire

- **Post-procedure mammogram**
**Post-Procedure Mammogram**

- CC and 90 views
- Label location, distance, & lesion for surgeon

**US - Needle Loc Example**

**Post-Procedure Mammogram**

- **What to do if lesion localized by US was NOT the mammographic lesion?**
  - Let the patient know
  - Re-ultrasound to evaluate for another lesion
  - Mammographically localize the second lesion
  - Inform the surgeon

**Specimen Radiograph**

- Team effort!
- Check if the localization wire is present and it intact?
- **Lesion in the specimen?**
  - Yes/No
  - Margins
  - Ultrasound it if needed
- Let the surgeon know about it immediately:
  - Does he/she need to take more tissue from which margin
**Future Directions**

- More complex transducers
- Faster computer processing
- Post-processing algorithms
- Computer aided detection
- Intravenous US microbubble contrast agents
  - Increase specificity of lesions

**Conclusion**

- Knowledge & understanding of US technology, along with meticulous scanning technique, is imperative for image optimization & diagnosis.

**Conclusion**

- Thank You!
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