What the Physicist needs to Know and Do in Stereotactic Breast Biopsy

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Educational Objectives

• SBB role in breast cancer management
• SBB Technologist and Physicist QC
• VAB localization accuracy details
• Image quality and dose in SBB
• Brachytherapy application

To make a definitive diagnosis about whether a breast abnormality is benign or malignant, a biopsy must be performed.

80% are benign

Breast Cancer Diagnosis and Biopsies

Category 3
Probably Benign Finding

- anxious patient
- strong family history of breast cancer
- compliance with a recommendation for 6-month follow-up is unlikely

Category 4
Suspicious Abnormality

- can differentiate those patients requiring surgical management from those who can be managed using clinical and mammographic follow-up

Category 5
Highly Suggestive of Malignancy

- used preoperatively to confirm diagnosis and expedite surgical planning and therapy

Indications for Breast Biopsy

Breast Biopsy Options

Vacuum Assisted Core Needle Breast Biopsy
Core Needle Breast Biopsy
Open Surgical Breast Biopsy

Minimally Invasive
- Stereotactic x-ray guided
- Ultrasound guided

Invasive

Minimally Invasive Advantages
- Outpatient procedure
- Local anesthesia: No post-procedure disability
- Improved cosmesis: No stitches
- Eliminates distortion of breast tissue that might make interpretation of a mammogram difficult
- Permits optimal preoperative planning when there is a definitive diagnosis of cancer
- Lower cost

Indicated Targets for SBB

Mammographic Abnormalities including
- Solid, spiculated, nonpalpable Mass
- Suspicious Micro-calcifications
- Solid, circumscribed Mass that is dominant (usually larger than 1 cm)
- Architectural distortion
- Asymmetry

Trends in SBB Usage:

INCREASING?
- Use of CAD makes calcs more suspicious
- Reimbursement, self-referral?

Figure 3. Plot shows the stereotactic (11-gauge) vacuum-assisted core biopsy rates per 1000 screening examinations for each calendar quarter.
Success Trend in SBB Usage:

DECREASING?
- Overcall?
- Desired goal is 25-40% of recommended biopsies be malignant (PPV)

Accuracy of SBB:

“Accuracy” means correlation with surgical biopsy and depends on several issues:
- Sampling localization accuracy
- Sample volume size
- Type of cancer

Accuracy of SBB - Localization:

Sampling Localization Accuracy depends on:
1. Image quality
   - QC item
2. Mechanical accuracy of unit
   - QC item
3. Skill of operator
   - Training and experience

Accuracy of SBB - Sample Size:

Correlation with surgical biopsy improves with sample volume size:
Accuracy of SBB - Cancer Stage:

Accuracy is lower for ADH than for DCIS

- ie, there may be "upstaging" at surgery from ADH to DCIS

NOT Breast Cancer

Normal

Ductal Hyperplasia

Atypical Ductal Hyperplasia (ADH)

Accuracy of SBB:

Radiologist's Bottom line:

- "SBB is equivalent to surgical biopsy in accuracy"

Surgeon's Bottom line:

- "SBB results are often upstaged at surgery"
**QC Testing Needs**

<table>
<thead>
<tr>
<th>Mammography</th>
<th>Stereotactic Breast Biopsy</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Image quality</td>
<td>• Image quality</td>
</tr>
<tr>
<td>• Patient dose</td>
<td>• Sampling accuracy</td>
</tr>
<tr>
<td></td>
<td>• Patient dose</td>
</tr>
</tbody>
</table>

**QC Testing Recommendations for SBB Units**

- ACR Practice Guideline
- ACR SBB accreditation
- State requirements (not MQSA!)
- Manufacturer’s recommendations
- Technologist & Physicist QC
  Components in each category above

**ACR Practice Guideline**

"ACR Practice Guideline for the Performance of Stereotactically Guided Breast Interventional Procedures" - effective 10/05

- QC testing same as ACR accreditation
- Establishes Qualified MP as one who meets MQSA requirements

**ACR Accreditation QC Testing Recommendations**

- ACR SBB QC manual
  - Full description of tests
  - Sample report forms
- All MP’s should have a copy
How to Order Manual

- ACR.org > ACR Store > Quality and Safety > QC Manuals > Stereotactic Biopsy

- Stereotactic Breast Biopsy Quality Control Manual

- Product Code: P-SBQCM
  Price: $57.50

State Requirements for SBB

- MQSA does not apply to SBB units
- Some states have implemented their own requirements

Manufacturer QC Testing Recommendations

- Manufacturer may recommend tests specific to the unit.

Technologist QC Tests

- Reviewed by physicist
- Physicist must know how to perform tests to properly review
Technologist Daily QC

Localization accuracy in air
< 1.0 mm sphere

Lorad requires Z=0 alignment before each patient

Technologist Weekly QC

• Track phantom object scores
• Track AEC mAs
• Track system gain (ROI)
• Artifacts

Minimum Passing Phantom Image Object Scores

<table>
<thead>
<tr>
<th></th>
<th>ACR-MAP</th>
<th>ACR-MAP</th>
<th>Mini-Phantom</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Screen/film</td>
<td>SBB Digital</td>
<td>SBB Digital</td>
</tr>
<tr>
<td>Fibers</td>
<td>4.0</td>
<td>5.0</td>
<td>3.0</td>
</tr>
<tr>
<td>Specks</td>
<td>3.0</td>
<td>4.0</td>
<td>3.0</td>
</tr>
<tr>
<td>Masses</td>
<td>3.0</td>
<td>3.5</td>
<td>2.5</td>
</tr>
</tbody>
</table>
Technologist Monthly QC

1. Hardcopy output quality
   - Print SMPTE or stored Phantom Image
   - Measure OD in consistent locations
   - Compare hardcopy with monitor

2. Visual checklist
   - Lights, switches, motion, accessories
   - Opportunity to document items needing repair

Technologist Semi-Annual QC

1. Compression force

2. Repeat analysis
   - Count repeated and rejected images by category and tabulate
   - Document analysis and corrective action
   - Repeat rate will typically be higher than for mammography

Ongoing QA

Medical audit:
- # of cancers diagnosed
- # of complications needing treatment
- # and reason for repeated biopsies
- Rate of compliance with recommended follow-up in women with benign SSB results

Physicist’s Annual Survey

1. SBB Unit Assembly Evaluation
2. Collimation Assessment
3. Focal Spot / System Limiting Resolution
4. kVp Accuracy and Reproducibility
5. Beam Quality Assessment (HVL)
6. AEC / Manual Exposure Assessment
7. Image Receptor Uniformity
8. Breast ESE, AGD, AEC Reproducibility
9. Image Quality Evaluation (phantom)
10. Artifact Evaluation
11. Localization Accuracy
1) Unit Assembly Evaluation:

Key Items for SBB:
- Mechanical and safety
- Breast thickness indicator accuracy
- Needle holder and guides assure 1 mm accurate support.
- Operator technique charts posted

2) Collimation Assessment:

a. X-Ray Field should extend beyond Image Receptor on all 4 sides
b. X-ray Field should extend < 5 mm beyond image receptor on any side
c. Does the biopsy window align with the image field of view?

Lorad Collimation Assessment: Digital Image

- Measure visible diameter of coin with TOOLS/CALIPERS.
- Anterior missing image is 19.0 - 17.6 = 1.4 mm
- Should be <5 mm
BUT... How about the X-Ray Field?

CHEST WALL

Film behind steel compression paddle does not show full extent of x-ray field.

2 Exposures on Same Cassette:
1 with paddle; 1 without

Shows: 1) x-ray field too large
2) not centered to biopsy window

3) System Resolution Test:

- Need to measure in BOTH:
  - 512 matrix
  - 1024 matrix

- Need to measure BOTH:
  - Parallel to A-C axis
  - Perpendicular to A-C

Must ZOOM Image:

Typical with this Test object (Lorad): 5.6 lp/mm (512 mode)
Test object (Lorad): 7.1 lp/mm (1024 mode)
4, 5) kVp and HVL Tests:

- Can make exposures without digital acquisition from generator console
- HVL measurement thru biopsy aperture, ie, through hole in paddle
  - HVL > kVp / 100

6) AEC or Manual Exposure Assessment:

- Evaluate signal (ROI) using clinical technique for 4, 6, 8 cm phantom.
  - Performance Criteria (ACR):
    - 6, 8 cm ROI value should be within 20% of 4 cm.
    - exposure time should be <2 sec

Lorad Manual Exposure Recommendation:

- Performance Criteria (Lorad):
  - ROI signal = 4000 in 512 mode
  - ROI signal = 6000 in 1024 mode
- No AEC – Technique chart critical

Lorad Manual Exposure Assessment:

<table>
<thead>
<tr>
<th>Phantom</th>
<th>Matrix</th>
<th>kVp</th>
<th>mAs</th>
<th>Digital signal at image center</th>
<th>% Difference from 4 cm</th>
</tr>
</thead>
<tbody>
<tr>
<td>4 cm</td>
<td>512</td>
<td>66</td>
<td>216</td>
<td>3899</td>
<td>-1%</td>
</tr>
<tr>
<td>6 cm</td>
<td>512</td>
<td>29</td>
<td>273</td>
<td>3660</td>
<td>-21%</td>
</tr>
<tr>
<td>8 cm</td>
<td>512</td>
<td>32</td>
<td>322</td>
<td>3086</td>
<td>-21%</td>
</tr>
<tr>
<td>4 cm</td>
<td>1024</td>
<td>85</td>
<td>192</td>
<td>3176</td>
<td>-12%</td>
</tr>
<tr>
<td>6 cm</td>
<td>1024</td>
<td>32</td>
<td>266</td>
<td>3407</td>
<td>-12%</td>
</tr>
<tr>
<td>8 cm</td>
<td>1024</td>
<td>34</td>
<td>350 (max)</td>
<td>2462</td>
<td>-38%</td>
</tr>
</tbody>
</table>

Source: Lorad/Trex/Hologic Applications Support
Fischer AEC Exposure Recommendation:

- **Performance Criteria (Fisher):**
  - ROI signal = 1800 – 2000 (Standard)

- **AEC:** Technique chart important for proper kVp

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7) Digital Receptor Uniformity:

- 4 cm lucite or BR-12
- Expose with clinical technique
- Measure SNR = Mean/SD in center and each corner AND suspicious areas

- **Performance Criteria:**
  - Corner SNR’s within 15% of Center SNR

- If SNR not available, use signal

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Digital Receptor Uniformity: Lorad Protocol

- 28 kVp
- mAs for Sig = 4000
- Measure SNR’s at specified locations.
- 32 x 32 pixel ROI – set with trackball.
- Lorad spec +/- 20% of SNR(center)

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Effect of Collimation on Uniformity

- No Biopsy Paddle
  - This is how Lorad calibrates “white field”

- With Biopsy Paddle
  - (x-ray field not well centered to paddle aperture)

- With Biopsy Paddle
  - (After re-centering x-ray field to paddle aperture)
Digital Receptor Uniformity: Fischer Protocol

- Signal uniformity only
- Fischer phantom
- 26 kVp, AEC

8) Average Glandular Dose:
- Depends on matrix size (Lorad)
- Depends on signal (ROI value)
  - Manual technique
  - AEC setting (Low, Standard, High)
- Depends on kVp
  - Do not use same kVp for all thickness!

- Performance Criteria:
  - <300 mrad (3 mGy) for 4.2 cm breast

Effect of mAs on Image Quality and Dose:

28 kVp, 18 mAs, 29 mrad
28 kVp, 70 mAs, 113 mrad
28 kVp, 140 mAs, 227 mrad

9) Image Quality Evaluation:
- 512 and/or 1024 ?
- Site mAs technique
- Site kVp
- Be consistent with technologist test
- Opportunity to show site images at lower dose
10) Artifact Evaluation:

**Typical artifacts:**
- Dust (camera, screen, lens, mirror)
- Pixel defects (dropouts)
- Non-uniformities (light pipe structure, vignetting, linear shading)
  - corrected by white-fielding
- Clipping (dose too high)

On Lorad, “White-Field” is a service procedure:

- Can correct some non-uniformities
- Consists of the average of several exposures on uniform lucite phantom
- Correction formula (Lorad) is:

\[
\frac{\text{Image} - \text{Dark Field}}{\text{White Field} - \text{Dark Field}}
\]

- On Fischer, is a Daily procedure

11) Localization Accuracy:

**(Gelatin Phantom)**

- Technologist test observed by physicist

- **Performance Criteria:**
  a) Pre- and Post-fire images to be as recommended by biopsy device maker
  b) Phantom lesion material is collected by biopsy device
Core Needle Pre-Fire Images: Correct placement for needle:

Core Needle Post-Fire Images: Illustrating “Needle Dive”

How a Vacuum Assisted Biopsy Device Works (Mammotome):

1. Position Probe under Lesion
   - Probe aligned with target

2. Vacuum Tissue into Aperture
   - Cutter rotates and vacuum is applied simultaneously
How a Vacuum Assisted Biopsy Device Works (Mammotome):

3. Transect Tissue

Cutter blade moves forward, tissue is cut

How a Vacuum Assisted Biopsy Device Works (Mammotome):

4. Transection Completed

How a Vacuum Assisted Biopsy Device Works (Mammotome):

5. Transport Tissue

Tissue sample transported to specimen chamber for removal

VAB Probe Positioning:

Pre-Fire Images

Correct Probe Position

+15° +15°
Pre-Fire Pair Fischer:

Post-Fire Images

VAB Probe Positioning:

Correct Probe Position

Pre-Fire Pair Lorad:

Post-Fire Pair Fischer:
Points to Observe during Localization Accuracy Test:

- “Z” zeroing of needle (and X,Y zero)
- “Pull-Back” of needle
- Needle guide close to skin
- Targeting on image, especially for calcs
- Visibility/Marking of alignment hole
- Transmission of coordinates to biopsy gun movable stage

Localization Accuracy: (Gelatin Phantom)

- Biopsy needles are expensive - have site save one for this test.

- Performance Criteria:
  a) Pre- and Post-fire images to be as recommended by biopsy device maker
  b) Phantom lesion material is collected by biopsy device
Breast Cancer Management

- Screening - Mammography
- Diagnosis - U/S, MRI, Biopsy
- Treatment - Surgery, Chemotherapy, IMRT/Brachytherapy

Types of Brachytherapy

- Intracavitary
  - MammoSite
- Interstitial
  - Kuske Grid and Comfort Catheter System

Using SBB Unit for Brachytherapy:

- Breast image with template, AOI drawn around the lumpectomy cavity
- Non-ionic contrast in the lumpectomy cavity with the imaging arm underneath the table clearly defines the target

Template positioned with mild compression
Using SBB Unit for Brachytherapy:

Coordinates chosen For catheter insertion

Using SBB Unit for Brachytherapy:

Brachy Needles inserted

In conclusion.....

• Medical Physicists have an important role in optimizing accuracy in SBB
  - Review technologist QC
  - Perform physics QC survey
  - Optimize image quality & dose

Thank You for Your Attention