Stereotactic Breast Biopsy

*Design and Testing*

Robert J. Pizzutiello, Jr., F.A.C.M.P.
Upstate Medical Physics, Inc.
716-924-0350
Overview

- What is a SBB?
- Purpose of ACR-SBBAP
- Requirements for accreditation
- Technologist’s QC Tests
- Medical Physicists QC Tests
Detection vs. Diagnosis

Detection
- BSE
- Physician Physical Exam
- Mammography
- Ultrasound

Tissue Diagnosis
- Biopsy
- Cytology
- Histology
SBB- Imaging and Dose Considerations

- Localization (not detection) of abnormalities
- Limited numbers of “normals”
- Complex background
- Microcalcifications, masses
- Limited FOV needed
- Radiation risk to selected “at risk” population
SBB X-ray Systems

- Dedicated prone units: similar to Diagnostic Mammography Units
- Smaller FOV required, 16° target angle
- Light Field may be replaced by two illuminating lamps
- SID may be longer
- AEC may or may not be available
Types of SBB Equipment

- Dedicated prone tables
- Add-on stereo units
- Screen-film imaging
- Digital Image receptors
The CCD Image Receptor

- Charge-Coupled Device
- An integrated circuit (chip) silicon wafer
- About the size of a postage stamp
- Converts light into electronic image
CCD Image Receptors

- 5cm x 5cm FOV CCD, typical
- LoRad DSM (below) 5 cm x 5 cm
- GE Senovision (right) 8 cm x 8 cm
Higher Film Contrast means less tolerance for exposure variation.
Conventional x-ray exposure creates an aerial image

Intensifying screen converts latent x-ray image to visible light image

Minify light image to CCD size

Readout CCD to computer

Display, manipulate, archive digital image
Optical coupling/mirror system

Light *reflection* from phosphor
2:1 fiberoptic taper demagnification
Light transmission through phosphor
Digital Image Quality

- Contrast
- Blur
- Noise
- Artifacts
- Dose
Factors Affecting Breast Dose

- kVp, mAs
- exposure time (film only)
- breast thickness
- breast composition (dense or fatty)
- multiple exposures

- digital image processing does NOT affect dose
- optical density of film (if hardcopy is used) does NOT affect dose
To Minimize Breast Dose

- Develop and maintain a good technique chart
- Obtain manufacturer’s suggested techniques
- Evaluate image quality at different mAs values (Technologist and Medical Physicist)
- Moderately higher mAs will reduce image noise, but increase dose
- Insufficient mAs will produce a noisy (grainy) image, but can be made to appear “well exposed” with window/level control
- Excessive mAs images may also appear “OK” with window/level adjustment
- Minimize retakes
Principle of Stereotactic Localization

- 2-D localization - planar view
- 3-D localization - triangulation needed for depth coordinate
Our first exposure to Stereo Localization Techniques
How many pins are left?
The origin of the $15^\circ$ stereo shift?
Methods of Imaging
Guided Breast Biopsy

- Ultrasound guided, hand-held needle
- Stereotactically guided core biopsy
  Not visible on ultrasound
  Localize with millimeter precision
Core Biopsy
ACR-SBBAP History

- Committee convened Fall, 1995
  Develop professional standards
  Develop SBBAP materials for facilities
- Pilot program 1st quarter, 1996
- Announced at ACR Breast Cancer Meeting (April, 1996)
- Reviewers trained
ACR-SBBAP

- Modeled after ACR-MAP
- 1996 vs. 1987
- Personnel qualifications
- Equipment performance
- QC
- Procedure verification (through clinical image evaluation)
- Image quality (phantom images)
- Dose
Personnel Qualifications
Medical Physicist

- Board Certification or alternate requirements
- 15 hours CE in Mammo Physics every 3 years
- < 6/1/97
  - 3 hands-on SBB MP Surveys, or
  - 1 hands on SBB MP Survey under guidance of Qualified SBB MP
- > 6/1/97
  - 1 hands-on SBB MP Survey under guidance
- At least 1 SBB MP Survey per year
- 3 hrs CE in SBB Physics every 3 years
Physician Qualifications

Collaborative vs. Independent Practice Model

In a collaborative practice, the patient derives the benefit of consultation and collaboration from the radiologist and surgeon (or other physician) working together.

Where a radiologist or surgeon (or other physician) are practicing independently, the expertise in the diagnosis and management of breast disease of an individual physician may provide the patient with an equivalent benefit.
Physician Credentials

- Mammograms
- SBB
- Training, Experience
- Category I SBB courses
- QA
- Radiation Physics Training
- Supervision of RT and MP
- Post biopsy recommendations
- Lesion identification at time of biopsy
Approximate Status
September, 1998

- 377 facilities applied
- 278 facilities accredited
- 382 units applied - active
- 105 units applied - pending
- 182 units accredited on initial attempt
147 units with deficiencies on initial evaluation

<table>
<thead>
<tr>
<th>Description</th>
<th>Count</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clinical only</td>
<td>62</td>
<td>(42%)</td>
</tr>
<tr>
<td>Clinical in combination</td>
<td>34</td>
<td>(23%)</td>
</tr>
<tr>
<td>Phantom only</td>
<td>31</td>
<td>(21%)</td>
</tr>
<tr>
<td>Phantom in combination</td>
<td>4</td>
<td>(3%)</td>
</tr>
<tr>
<td>Dose</td>
<td>16</td>
<td>(11%)</td>
</tr>
</tbody>
</table>

96 units passed after re-application
The latest word...

- No longer accepting optical disk or diskette. Hard copy images only.
- FDA will implement regulations mandating accreditation of facilities if they do not comply voluntarily
- Check TLD technique (10% failure rate for dose)
- QC Manual available early 1998
## QC Tests Common to Mammography and SBB Minimum Testing Frequencies

<table>
<thead>
<tr>
<th>Test</th>
<th>Mammo</th>
<th>SBB</th>
</tr>
</thead>
<tbody>
<tr>
<td>Darkroom Cleanliness</td>
<td>Daily</td>
<td>D (SF only)</td>
</tr>
<tr>
<td>Processor Quality Control</td>
<td>Daily</td>
<td>D (SF only)</td>
</tr>
<tr>
<td>Screen Cleanliness</td>
<td>Weekly</td>
<td>W (SF only)</td>
</tr>
<tr>
<td>Viewboxes &amp; Viewing Conditions</td>
<td>Weekly</td>
<td>W (SF only)</td>
</tr>
<tr>
<td>Phantom Images</td>
<td>Weekly</td>
<td>Weekly</td>
</tr>
<tr>
<td>Visual Checklist</td>
<td>Monthly</td>
<td>Monthly</td>
</tr>
<tr>
<td>Repeat Analysis</td>
<td>Quarterly</td>
<td>Quarterly</td>
</tr>
<tr>
<td>Analysis of Fixer Retention</td>
<td>Quarterly</td>
<td>Q-(SF only)</td>
</tr>
<tr>
<td>Darkroom Fog</td>
<td>Semi-annually</td>
<td>S - (SF only)</td>
</tr>
<tr>
<td>Screen-Film Contact</td>
<td>Semi-annually</td>
<td>S - (SF only)</td>
</tr>
<tr>
<td>Compression</td>
<td>Semi-annually</td>
<td>Semi-annually</td>
</tr>
</tbody>
</table>
# QC Tests Unique to SBB

## Minimum Testing Frequencies

<table>
<thead>
<tr>
<th>Test</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Zero Alignment Test (only on some units)</td>
<td>Before each patient</td>
</tr>
<tr>
<td>Localization Accuracy Test (in Air)</td>
<td>Daily</td>
</tr>
<tr>
<td>Phantom Image Quality Test</td>
<td>Weekly</td>
</tr>
<tr>
<td>Hardcopy Output Quality</td>
<td>Monthly</td>
</tr>
<tr>
<td>(if hard copy is produced from digital data)</td>
<td></td>
</tr>
<tr>
<td>Visual Equipment Check</td>
<td>Monthly</td>
</tr>
<tr>
<td>Repeat Analysis</td>
<td>Semi-annually</td>
</tr>
<tr>
<td>Compression Force Test</td>
<td>Semi-annually</td>
</tr>
</tbody>
</table>
## An overview of the QC Tests Unique to SBB (Radiologic Technologist)

<table>
<thead>
<tr>
<th>Test</th>
</tr>
</thead>
<tbody>
<tr>
<td>Zero Alignment Test</td>
</tr>
<tr>
<td>(only on some units)</td>
</tr>
<tr>
<td>Localization Accuracy Test (in Air)</td>
</tr>
<tr>
<td>Phantom Image Quality Test</td>
</tr>
<tr>
<td>Hardcopy Output Quality</td>
</tr>
<tr>
<td>(if hard copy is produced from digital data)</td>
</tr>
<tr>
<td>Visual Equipment Check</td>
</tr>
<tr>
<td>Repeat Analysis</td>
</tr>
<tr>
<td>Compression Force Test</td>
</tr>
</tbody>
</table>
Zero Alignment Test

- Perform before each patient
- Verify that zero coordinate is accurate
- Assures that stereotactic unit is not improperly installed
Localization Accuracy

- Closed loop system test
- Position needle to a known coordinate
- Digitize position of needle tip
- Targeting software calculates position of needle tip
- Coordinates should be identical
- ± 1.0 mm sphere
Phantom Image Quality Evaluation

Fiber Diameters (mm)
- 1.56
- 1.12
- 0.89
- 0.75
- 0.54
- 0.40

Speck Diameters (mm)
- 0.54
- 0.40
- 0.32
- 0.24
- 0.16

Mass Diameters (mm) 2.00, 1.00, 0.75, 0.50, 0.25
Phantom Image Quality Evaluation

Nuclear Associates Digital Mini Phantom

Mammography Accreditation Phantom
<table>
<thead>
<tr>
<th></th>
<th>ACR Accreditation</th>
<th>NA Digital</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fibers</td>
<td>1.56</td>
<td>x</td>
</tr>
<tr>
<td></td>
<td>1.12</td>
<td>x</td>
</tr>
<tr>
<td></td>
<td>0.8</td>
<td>0.93</td>
</tr>
<tr>
<td></td>
<td>0.75</td>
<td>0.74</td>
</tr>
<tr>
<td></td>
<td>0.54</td>
<td>0.54</td>
</tr>
<tr>
<td>Specks</td>
<td>0.54</td>
<td>0.54</td>
</tr>
<tr>
<td></td>
<td>0.4</td>
<td>x</td>
</tr>
<tr>
<td></td>
<td>0.32</td>
<td>0.32</td>
</tr>
<tr>
<td></td>
<td>0.24</td>
<td>0.24</td>
</tr>
<tr>
<td></td>
<td>0.16</td>
<td>0.2</td>
</tr>
<tr>
<td>Masses</td>
<td>2</td>
<td>x</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>0.75</td>
<td>0.75</td>
</tr>
<tr>
<td></td>
<td>0.5</td>
<td>0.5</td>
</tr>
<tr>
<td></td>
<td>0.25</td>
<td>0.25</td>
</tr>
</tbody>
</table>
## Minimum Passing Phantom Image Scores

<table>
<thead>
<tr>
<th></th>
<th>ACR-MAP</th>
<th>Accreditation Phantom</th>
<th>Mini-Phantom</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Screen/film</td>
<td>Digital</td>
<td>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>
Phantom Imaging: a common avoidable failure

- NAD Digital Mini Phantom
  1st image (image quality)
  2nd image (TLD)
- Mammo Accreditation Phantom
  4 images for image quality
  5th image for TLD
- OK to window/level digital images
- Use grid (or not) per clinical technique
Hardcopy Output Quality

- Laser or multifORMAT camera
- Evaluate SMPTE Test Pattern, if available
- Record window width, level
- Produce hardcopy
- Measure OD at 4 consistent locations
- Record and monitor for consistency
Visual Checklist

- Use ACR checklist or equivalent
- Lights, switches, motion, accessories
- Customize for your machine/room
- Documentation (date, initials)
Repeat Analysis

- Count repeated and rejected film by category and tabulate
- Include a log of images repeated, but *not* discarded
- Overall repeat rate should be < 5%
- Document *analysis* and *corrective action* - even if your repeat rate is low
Compression Force

- Bathroom scale or compression gauge
- Measure maximum compression in manual and power modes
- The scale should read 25-40 pounds in automatic mode
- Documentation
# Additional Technologist’s QC Tests (Screen-Film only)

<table>
<thead>
<tr>
<th>TEST</th>
<th>FREQUENCY</th>
</tr>
</thead>
<tbody>
<tr>
<td>Darkroom Cleanliness processor QC</td>
<td>Daily</td>
</tr>
<tr>
<td>Screen Cleanliness</td>
<td>Daily</td>
</tr>
<tr>
<td>Viewboxes &amp; Viewing Conditions</td>
<td>Weekly</td>
</tr>
<tr>
<td>Fixer Retention Analysis</td>
<td>Weekly</td>
</tr>
<tr>
<td>Screen-Film Contact Darkroom Fog</td>
<td>Quarterly</td>
</tr>
<tr>
<td></td>
<td>Semi-Annually</td>
</tr>
</tbody>
</table>
SBB Annual Medical Physics Survey

- SBB Unit Assembly Evaluation
- Collimation Assessment
- Focal Spot Performance and System Limiting Resolution
- kVp Accuracy and Reproducibility
- Beam Quality Assessment (HVL)
- Automatic Exposure Control System Performance
- Uniformity of Screen Speed or Digital Field
- Breast ESE, AGD, AEC Reproducibility
- Image Quality Evaluation (phantom)
- Artifact Evaluation
- Localization Accuracy
Assembly Evaluation

- Free-standing unit is mechanically stable
- All moving parts move smoothly, without obstructions to motion
- All locks and detents work properly
- Image receptor holder is free from vibrations
- Image receptor is held securely by assembly in any orientation
Assembly Evaluation

- Image receptor slides smoothly into holder assembly
- Compressed breast thickness scale is accurate to ± 0.5 cm, reproducible to ± 2 mm
- Patient or operator is not exposed to sharp or rough edges or other hazards
- Operator technique charts are posted
- Operator protected by adequate radiation shielding
Collimation

- Does the x-ray beam exceed the image receptor?

**Note:** X-rays beyond the digital image receptor will not be seen on the monitor

- Does the biopsy window align with the image field of view?
Performance - System Limiting Resolution

- Line Pair Test Pattern
- Use film to test x-ray machine
- Use CRT image to test “system”
- Technique, clinical kVp
- Scoring the image
  Lines distinct over 1/2 length
kVp Accuracy - Reproducibility

- Verify that actual kVp’s are the same as the indicated kVp’s
- Range of clinical kVp values
- Accuracy within 5%
- Reproducible CV < 0.02
Beam Quality (HVL)

- Thickness of aluminum to reduce radiation exposure by one-half
- Affects contrast and dose
- Used in dose calculation
- Minimum = kVp/100
AEC System Performance

- AEC available on some digital SBB units
- Performance Capability
  
  *Record signal level as function of thickness and technique*

- Monitor exposure time
- Performance Capability (4, 6, 8 cm)
- Provide suggested technique chart
Varying thicknesses of breast equivalent material
Uniformity of Screen Speed or Digital Field

- Image a uniform phantom
- Screen Film systems
  
  *Each cassette produces the same optical density under the same conditions*

- Digital Systems
  
  *Digital detector produces uniform signal values across the field of view*
Phantom Image Quality

- Same procedure as for technologists
- Medical Physicist reviews scoring procedure and checks for consistency
- Uses technique factors for dose determination
Breast Entrance Exposure, AGD

- Data per technique chart
- Measure ESE
- HVL determines DgN
- AGD = ESE * DgN
- AGD < 300 mrad
- Dose and Optical Density
Artifact Evaluation

Unwanted irregularity *not caused* by structures of interest

Causes (Digital)
- Digital Image Receptor

Causes (Screen-Film)
- Lint, dust, static, filter, compression device, grid, BSD, screen, film, cassette, phantom

Common Causes
- Unwanted objects in x-ray beam
Source of Artifacts (Film)

Direction of Film Feed
Source of Artifacts

**Change of orientation**
- Processor related
- Either parallel or perpendicular to direction of travel
- Plus or minus density
- Rollers
- Guide shoes
- Replenishment stream

**No change of orientation**
- X-ray tube
- Filter
- Compression device
- BSD
- Grid (stop motion)
- Cassette
Targeting Accuracy

- Performed annually by technologist under supervision of medical physicist
- Position gel-type phantom
- Image, target and sample
- Result: was the lesion collected?
QC Program Review

For all Technologist QC Tests

- Review procedures
  (ACR SBB-QC Manual)
- Review documentation
- Answer questions
- Written recommendations
Role of the Surgeon in Quality Control

- Understand the importance of QC in SBB
- Assures that personnel remain qualified
- Support QC activities
  - Allow enough time for QC
  - Provide for QC training
  - Periodically check that QC is done as required
- Confer with medical physicist annually
- Assure that follow-up is done if the QC program indicates corrective action is required
- Accreditation
Summary

- What is a SBB?
- Purpose of ACR-SBBAP
- Requirements for accreditation
- Technologist’s QC Tests
- Medical Physicists QC Tests