Imaging Guided Percutaneous Breast Biopsy

Objectives
- State rationale for performing image guided biopsies
- List steps to accurate and safe performance of image guided biopsy
- Describe pitfalls in performing image guided biopsy

The challenge of breast cancer detection
- In US, 275,000 new cases each year, 41,000 deaths
- Nearly 1 million breast biopsies performed each year
- Mammography PPV 20-25%
- Ultrasound PPV 10%
- Important to minimize morbidity

Percutaneous Breast Biopsy
- Accurate pathologic diagnosis
- Minimally invasive
  - Minimizes surgery
    - no surgery if benign
definitive lumpectomy if malignant
- Minimizes morbidity, patient inconvenience
- Biopsy devices
  - 14 G automated core needle biopsy
  - Directional vacuum assisted biopsy device

Importance of Image Guided Percutaneous Biopsy
- Nonpalpable screening detected findings
  - Image guidance required to target finding for biopsy
- Palpable findings
  - Palpation alone may not target the mass from overlying parenchyma
- Image guidance
  - Precisely targets the abnormality for palpable or non-palpable masses

Accuracy
14 Gauge core needle, 1352 cases (2008)
- 98.5% sensitivity
- False negative 1.6% (all identified prospectively)
- 6% were high risk lesions requiring excision (31% upgraded at excision)

Sensitivity of 14 G biopsy

Youk et al, Radiographics 2007

<table>
<thead>
<tr>
<th>Study/Year</th>
<th>No. of Cases</th>
<th>No. of Cancers Seen at Core Biopsy</th>
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<tr>
<td>Parker et al 1993 (2)</td>
<td>54</td>
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<td>Iversen et al 1998 (3)</td>
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<td>56 (97)</td>
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<td>Stahl et al 2001 (5)</td>
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<td>Marnier et al 2002 (10)</td>
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<td>Berg et al 2003 (11)</td>
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<td>Selmeier and Brem 2005 (12)</td>
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<td>Bachetser et al 2005 (13)</td>
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*Numbers in parentheses indicate reference numbers. Numbers in parentheses indicate percentage.

Methods of Guidance for Percutaneous Biopsy

- Palpation
- Mammography
  - Grid
  - Stereotactic
- Ultrasound
- MRI

Establishing a Breast Percutaneous Biopsy Program

- Clinical protocols
  - Patient selection (medications, tolerance)
  - Abnormality selection
  - Modality for image guidance
  - Pathology correlation and recommendations
  - Patient notification and follow-up instructions
  - Practice audit

The Breast Percutaneous Biopsy Program

- Administrative protocols
  - Consent form
  - Pre-biopsy instructions
  - Post-biopsy instructions
  - Scheduling protocols
  - Specimen handling
  - Record keeping
  - Quality assurance

The Breast Percutaneous Biopsy Program

- Modalities for image guidance
  - Depends on available equipment
  - Ultrasound
    - High resolution linear transducer, minimum 10MHz
  - Stereotactic
    - Upright add-on
    - Dedicated prone unit
  - MRI
    - Breast coil with localizing device, biopsy needle

History of percutaneous biopsy

- By 1914, needle aspiration biopsy used for lung and lymph nodes
- With increased use of mammography:
  - 1970’s: Stereotactic device introduced
  - 1980’s: Automated core biopsy guns, paired with US and stereotactic imaging
Fundamentals

- Technique of biopsy
  - Operation of biopsy device is simple for any image modality
- Image guidance for biopsy
  - Evaluating location of biopsy device relative to target is challenging for all modalities
  - Correct image interpretation guarantees that correct area is sampled
  - Requires high level expertise in ability to interpret the modality used for guidance

Fundamentals of image guided biopsy

- Indirect (Image guidance) vs. direct visualization
- Requires expertise in the imaging modality
- Concerns of image guided biopsy:
  - Are you actually seeing the area of concern?
  - Did you aim the needle appropriately?
  - Did the needle subsequently sample the right area?

Pathology Correlation

- Pathology findings must be concordant with imaging findings
- Pathology correlation requires confidence in targeting during the biopsy
- Discordant findings suggest sampling error
  - In other words, biopsy missed the lesion
- Supports need to confirm imaging assessment of targeting during biopsy

Pathology Correlation

- Confirming appropriate sampling during biopsy
  - Stereotactic biopsy for calcs:
    - Radiograph tissue samples
    - Confirm that pathologist sees adequate calcs
  - Ultrasound guided biopsy:
    - Evaluate needle position in mass during biopsy

Preparation for Needle Biopsy

- Pre-biopsy screen for:
  - Anticoagulant use
  - Bleeding disorder
  - Allergies/sensitivities

Preparation for Needle Biopsy

- Obtain informed consent
  - Describe procedure
    - describe alternative diagnostic methods
    - describe known complications
      - Bleeding, infection
      - High risk lesion requiring excision
      - Sampling error
    - allow patient to ask questions
Prepare the procedure tray

• Skin cleansing solution
• Sterile drape
• Sterile probe cover
• Sterile gel or iodine solution as coupling agent

Local Anesthesia

• 1% lidocaine or xylocaine (lidocaine and epinephrine)
• deliver anesthetic
  • 1-3cc superficially at needle insertion site, 25 g needle
  • 10 cc along anticipated biopsy track, 20 g spinal
  • Image during injection of anesthetic (for US bx)
    - Confirm adequate approach
    - Observe changes in appearance of target

Clip Placement

• To mark site of biopsy
  • For future localization in cases of malignancy
  • To define area of biopsy for future follow-up imaging
• To mark site of cancer treated with neoadjuvant chemotherapy
• Gel based/titanium visible on US, mammo, and MRI

Post-Biopsy Care

• Manual compression after each sampling
• Steri-strip on skin nick
• Pressure dressing
• Ice pack
• Avoid strenuous activity for 24 hours
• Watch for excessive bleeding, pain, fever

Methods of Guidance for Percutaneous Biopsy

• Palpation
• Mammography
  • Grid
  • Stereotactic
• Ultrasound
• MRI

Stereotactic Biopsy
Principles of Stereotactic Targeting

• Stereology
  – Determining 3-D information from planar 2-D views
• Parallax
  – Apparent shift from a reference object

Principles of Stereotactic Targeting

• Stereotactic scout view
  – Confirm that the abnormality is in field of view
• Stereotactic pairs
  – Precisely identify a specific target on each view
  – Shift of target from midline determines depth from reference point

Stereotactic Scout and Pairs

Principles of Stereotactic Targeting

• Coordinate systems
  – Provide location in three dimensions
  – Systems use either Cartesian coordinates or Polar coordinates

Cartesian Coordinates

Cartesian system (Lorad)

- Defines a target by distances from 3 axes x, y, z, that intersect at right angles
- X = left-right, y = up-down, z = depth
- Distance from reference point given in mm
- Familiar and intuitive, errors easy to identify and correct

Principles of Stereotactic Targeting

• Accuracy of stereotatic biopsy depends on accuracy of targeting
  – How well can you interpret the stereotactic scout view and stereo pairs?
  – Abnormality selection: a focal structure must be identifiable on these three views
  – High likelihood of inaccurate targeting:
    – Soft tissue masses, scattered uniform calcifications
**Procedure for Stereotactic Biopsy**

- Obtain stereotactic scout view
  - Confirm that the abnormality is in field of view
- Obtain stereotactic pairs
  - Precisely identify a specific target on each view
- Prepare biopsy site
  - Cleanse, anesthesia, skin nick
- Needle to pre-fire position, obtain stereo pairs
  - Abnormality at needle tip
- Fire needle, obtain tissue samples
- Confirm adequate sampling

**Technical Considerations**

- Compressed breast thickness must be > 3 cm (check film)
- Abnormality must be able to be placed in window (deep lesions may not be possible)
- Subareolar abnormalities cannot be adequately compressed
- Abnormality must be visible on digital magnified image
Procedure for Stereotactic Biopsy - Scout

Procedure for Stereotactic Biopsy

Procedure for Stereotactic Biopsy

Fundamentals of Ultrasound Guided Percutaneous Biopsy of the Breast

Ultrasound Guided Biopsy - Advantages

- Utilizes existing equipment
- Quick procedure (20-30 minutes total room time)
- Comfortable position for most patients
- Accesses masses that are inaccessible to or invisible on mammography
- Disadvantage: Significant learning curve
  - Requires excellent sonographic skills (both scanning and interpretation) and hand-eye coordination

Ultrasound Guided Biopsy

posterior lesion difficult to approach on mammography easily accessible with ultrasound
Ultrasound Guided Biopsy: Implants

Precise aim with US guidance

Biopsy devices

- **14 G Automated core needle**
  - **Advantages**
    - Less expensive
    - No bulky equipment
  - **Disadvantages**
    - May need more specimens to ensure sampling
    - Therefore possible longer procedure time

- **Vacuum-Assisted**
  - **Advantages**
    - Larger cores
    - Complete sampling in fewer passes
    - Shorter procedure time
  - **Disadvantages**
    - May remove entire lesion

14G automated core needle

US Guided Vacuum Assisted Biopsy

Relative Size of Specimens

11 g vacuum assisted vs 14 g core biopsy specimens

Position biopsy device within or under target image target within biopsy aperture during sampling
Technique of tissue acquisition

14 G automated core needle

Vacuum assisted biopsy device

Preparation for Needle Biopsy

• Pre-scan the patient
• Determine the best approach
  - Consider
    • Location of lesion
      Relation to chest wall
    • Tissue density/firmness
      Approach from periphery usually traverses less glandular tissue
    • Comfort
      Yours and hers!

Patient Positioning

• Supine or semi upright, flat or oblique
• Ipsilateral arm raised over head
• Change position to achieve best approach
  • Area of interest should be
    As flat as possible
    As accessible as possible
    As ergonomic as possible
• Make patient as comfortable as possible

Ultrasound Guided Biopsy Technique

• Patient position to facilitate sonographic approach and patient comfort
• Identify abnormality
• Pick approach based on safety, ergonomics
• Prepare skin site, anesthesia, make skin nick
• Position needle, acquire tissue
• Confirm needle position in mass post-fire

Core Biopsy Technique: Aesthetics

• Consider location of skin nick
  • periareolar
  • avoid upper inner quadrant
• Minimize size of skin nick
• Cosmetically acceptable scars
  • follow contour of Langer’s lines
Image while administering deep lidocaine

- Observe approach
- Observe post lidocaine appearance
- Confirm adequate infiltration of biopsy track
- Manipulate lesion

Fundamentals: Positioning and approach of needle

Early technique

Transverse Approach

Standard, safer approach

Longitudinal Approach

Positioning of the Needle: Longitudinal approach

- Entire length of needle should be visible
- Needle path ideally approaches a parallel course relative to chest wall
  - To best visualize the needle
  - To avoid chest wall trauma and pneumothorax

Steps to a successful biopsy: 14 G automated core needle

- Image target
- Aim at target
- Deploy device
  - Fire gun (automated core needle)
- Confirm post fire location
  - Most accurate assessment with 2 views: long axis and orthogonal views
- Acquire tissue
Image target: Plan approach

Note dimension on sag vs. trv view: pick approach with bigger target

Aim at target

Deploy device

Aim at target

Aim; Deploy device

Post-Fire: mass and tissue will shift
Re-assess position of needle in 2 views

Difficult to confirm needle in mass in long axis
Short axis view confirms needle in mass
After biopsy device is deployed and location confirmed

- Remove needle
- Remove specimen from needle
- Place specimen in formalin container
- Repeat for desired number of specimens
  - Number depends on assessment of adequacy of sampling on each post fire image
- Hold pressure (5-10 minutes)
- Steri strips on skin nick; gauze pressure dressing or elastic wrap

Steps to a biopsy:
Directional vacuum assisted device

- Image target
- Aim at target
- Deploy device
  - Confirm post deployment location
  - Most accurate assessment with long axis and orthogonal views
- Open specimen chamber
- Acquire tissue

Image target:
Plan approach

Place biopsy device within or under mass; check position in orthogonal view

Sample mode

After biopsy device is deployed and location confirmed

- Remove needle
- Remove specimen from needle
- Place specimen in formalin container
- Repeat for desired number of specimens
  - Number depends on assessment of adequacy of sampling on each post fire image
- Hold pressure (5-10 minutes)
- Steri strips on skin nick; gauze pressure dressing or elastic wrap, ice packs
Challenges in US guided breast biopsy

- Visualizing needle
- Lining up needle and target
- Creating and maintaining safe approach along chest wall
- Confirming accurate position after sampling
- Pathology correlation

Helpful hints on visualizing biopsy needle

Further Improvement: Needle Visualization

- Linear objects produce brighter echoes when insonated perpendicular to the US beam

Visualization of 25 g needle in phantom

- Close to parallel to transducer face
- Nearly 90 degrees to transducer face
Lining up the needle with the target

Ideal Needle Placement
Mass successfully targeted

Bird's eye view
Ultrasound image

If your needle is askew...
Look at your hands
Note orientation of needle to transducer

Rotate and position needle under and parallel to the transducer

Needle Askew
Mass missed

Bird's eye view
Ultrasound image

Transducer askew
Mass Missed

Bird's eye view
Ultrasound image
Look at your hands
Note orientation of transducer to target

- Rotate transducer to see mass
- Rotate and position needle under the transducer

Needle and transducer lined up but can’t see needle

- Ultrasound image
- Bird’s eye view
- Transducer is rocked or angled

Pitfall of needle visibility:
Needle track from previous sample, not to be confused with actual needle during next pass

Creating and maintaining safe approach along chest wall

Ideal longitudinal approach
Approach too steep

Supoptimal approach: angle of needle aims at chest wall

Optimal approach angles along chest wall

Difficult suboptimal approach

Needle approach is straighter but still close to pectoral muscle. If this is only available approach, place copious lidocaine under mass to lift it off chest wall
More optimal approach with this region of chest wall

Tricks to maintain safe longitudinal approach while minimizing length of needle course through tissue

Limiting Distance of Needle Excursion

- Think of needle as a lever
- Take advantage of the malleable nature of the breast

Parallel to chest wall but far from mass

Start closer to mass but too steep

Advance part way to mass then lever needle into parallel course
Keep pressing down (gently) till needle is near parallel to chest wall

Then biopsy

Confirming accurate sampling of target

Aim at target

Fire: mass and tissue will shift

Re-assess position of needle in 2 views

Difficult to confirm needle in mass

Confirms needle in mass
Why re-assess needle position?
Pre-fire: perfect position
Post-fire may still miss

Needle motion can shift mass and tissue during firing

Mass shifted to the side when the needle fired
Mass and needle can volume average in US image and appear to be successful biopsy

Need orthogonal view to confirm needle location in mass

Another way to confirm needle in mass: "bent" needle

US image shows needle apparently in mass

Needle next to mass, volume average in image

Pre sample placement  Sample mode

Pathology Correlation for Image Guided Percutaneous Biopsy
Pathology Correlation
• Accurate correlation depends on accurate targeting at time of biopsy
• Pathology result should satisfactorily explain the lesion
• Consider sampling error if pathology does not fit with imaging
• Refer high risk lesions to surgical excision
• Routine follow up for concordant benign

Pathology Correlation
• 6-10% of core needle biopsies require surgical excision
• About 1/3 of high risk lesions are upgraded at surgical excision

High Risk Lesions: Excision Recommended
• Atypical ductal hyperplasia (ADH)
• Atypical lobular hyperplasia and lobular neoplasia
• Radial scar
• Phyllodes tumor
• ± Lobular carcinoma in situ (LCIS)
• ± Papillary lesions

Summary: Image guided percutaneous breast biopsy
• Standard of care for minimally invasive diagnosis of breast abnormalities
• 98.5% sensitivity, 1.6% false negative (compare with surgical excision)
• Requires expertise in image modality and biopsy techniques
• With careful technique and correlation, minimal morbidity for both benign and malignant diagnosis