Introduction

Ultrasound (US)-guided interventional breast procedures, including fine-needle aspiration (FNA), core needle biopsy (CNB), and preoperative wire localization, are safe, accurate, and routinely performed for lesions visualized on US. US guidance is usually preferred over mammography and magnetic resonance (MR) because of shorter procedure times, real-time visualization, increased patient comfort, easy access to all parts of the breast including the axilla, and lack of ionizing radiation or intravenous contrast. For beginners and trainees, the use of a turkey breast phantom can be a useful teaching tool. A thorough understanding of the indications, relative contraindications, technique, and postprocedure management of US-guided procedures is essential for optimal patient outcomes.

US of Breast Masses

Breast US is used to better characterize masses detected on physical examination, mammography, or MR imaging. Most cystic and solid masses can easily be differentiated using a high-resolution linear transducer of 12-5 to 17-5 mHz. Simple cysts are benign anechoic masses with a thin imperceptible wall, up to a single thin septation, and enhanced through transmission. Complicated cysts are hypoechoic with no internal vascularity and may exhibit indistinct margins or lack posterior acoustic enhancement or both. Complicated cysts are very common and have a very low malignancy rate ranging from 0%-0.8%. Most can be classified as BI-RADS 3, requiring short-interval follow-up.

Benign and malignant solid masses can both be well differentiated on sonography. Benign US features include oval shape, parallel orientation to the skin, and well-circumscribed margins, which usually do not require biopsy, even if palpable. Suspicious US features include spiculated or angular margins, ductal extension, microlobulations, marked hypoechogeticity, posterior acoustic shadowing, and a nonparallel orientation to the skin. If a mass exhibits both cystic and solid components, including thickened walls, internal septations, or internal vascularity, it should be classified as a complex mass. Abnormal intramammary or axillary lymph nodes may also be identified on US. Such lymph nodes may have a thickened or an eccentrically bulging cortex with a diminished fatty hilum. In addition, using high-resolution transducers, US can identify calcifications, particularly if within a cluster >10 mm in size or located within a hypoechoic mass or ductlike structure.

US-Guided Biopsy Procedures

Most benign-appearing masses generally do not require tissue sampling and can be safely managed with short-interval
follow-up imaging. Occasionally, a benign-appearing cyst or mass may be aspirated or biopsied if the patient is symptomatic or if definitive proof that a new mass identified on mammography or MR definitively correlates with a benign-appearing mass seen on US. However, if a suspicious mass is identified on US, percutaneous image-guided biopsy should be readily performed.

Preprocedure Protocol
Before any US-guided procedure, the procedure, including its risks and benefits, should be carefully explained to the patient and signed consent should be obtained. Possible risks including pain, bleeding, infection (<1%), marker clip migration (if used), and possible repeat biopsy or surgical excision for discordant, high-risk, or malignant lesions are discussed.

Patient allergy and anticoagulation history should be reviewed and documented. Policies regarding preprocedural antithrombotic use (including aspirin, warfarin, clopidogrel, and daily nonsteroidal anti-inflammatory drugs) vary across institutions. In a recent study by Chetlen et al, no clinically significant hematoma was identified in 617 women undergoing a variety of breast CNB procedures. In this study, the incidence of hematoma formation was 3.6% for smaller 12- or 14-gauge needles, which was significantly lower than 29.5% seen with larger 9-gauge needles. Patients taking daily aspirin were at highest risk for postbiopsy hematoma, and among 13 women taking warfarin, 2 developed a postprocedural hematoma. For some patients, the risk of discontinuation of anticoagulation therapy may be great and should be done so at the discretion of the referring physicians in consultation with the physician performing the procedure and hospital policy.

When FNA is performed, the patient is informed of the possibility of requiring CNB in case the FNA is unsuccessful owing to very thick cyst contents or the presence of a solid mass. Moreover, FNA procedures are virtually free of complications. However, patients may occasionally experience bruising or tenderness over the region. Free-hand (nonimage guided) aspirations are performed less frequently and have a 0.01%-0.3% risk of pneumothorax.

The lesion to be biopsied is re-evaluated by US, with special attention to any nearby structures, including the pectoralis muscle or vessels, and the optimal needle approach is selected. With the arm relaxed behind the head, the patient should usually be scanned in the supine position for medially located lesions or the semielixible position for laterally located lesions. The skin should be cleansed with Betadine or other sterile skin solution and the breast is draped with sterile towels. The US probe should be cleansed with Betadine or enclosed with a sterile cover. Sterile gel, Betadine, or alcohol should be used as a coupling agent, although gel contamination of the sample should be avoided if cytologic analysis is to be performed as it can mimic mucin. These procedures require a clean, semisterile field, although the biopsy needle and skin insertion should remain sterile throughout.

Technique and Patient Management
Before needle insertion, local anesthetic should first be given using a 25-gauge needle. This should be performed with US guidance as a “practice run” to simulate the course of the biopsy needle. Care should be taken to avoid injection of excessive amounts of anesthetic, as this may obscure a lesion, particularly if small and subtle. Lidocaine HCl 1% is commonly used (with optional buffering with 8.4% sodium bicarbonate in a 10:1 ratio to decrease patient “burning” sensation) and 1-3 mls are administered subcutaneously, under US guidance, including a raised skin wheal. Subsequently, 3-10 mL of local anesthetic (depending on the gauge of the biopsy needle being used) or deep anesthetic (1% lidocaine HCl with epinephrine 1:100,000 for CNB) is infused within the tissue surrounding the lesion along the expected needle trajectory.

US-guided procedures require a high-resolution US system and a high-frequency linear array probe > 12.5 MHz for optimal needle visualization. Spatial compounding and multiple focal zones also improve needle visualization. Attention to probe-needle-lesion alignment is essential. The probe and breast should be stabilized using pressure from the heel and fifth finger of the hand holding the transducer (Fig. 1). The lesion should be centered in the image. The needle should be aligned along the long axis of the needle and best visualized when < 30° and parallel to the probe face and chest wall and perpendicular to the US beam, so that the number of reflected echoes is maximized. If the needle is not well visualized, small alternating movements of needle or transducer should be made with the needle directed toward the lesion; simultaneous movement of both the probe and the needle should be avoided as this limits needle visualization. The needle tip should always be visualized and directed away from any large vessel or the chest wall. Orthogonal image planes perpendicular to the needle shaft may be used to document the echogenic “dot” of the needle within the targeted lesion.

US-Guided FNA
US-guided FNA is most often indicated for symptomatic or complicated cysts or both, which can occasionally mimic the US appearance of a solid mass and may require US-guided FNA for diagnosis. US-guided FNA with a post-aspiration mammogram may be performed for definitive proof that a cyst seen on US correlates with a new or suspicious mass identified on mammography. FNA of solid masses is generally not preferred because of decreased sensitivity and an insufﬁcient sampling rate of up to 10%. US-guided FNA is typically performed with a 21- or 18-gauge 2.5-in needle and a 10- or 3-mL syringe. In the authors’ experience, longer needles are not required even for posterior lesions in large breasted women because a nonparallel needle approach can be safely applied (Fig. 2). A preaspiration image should be obtained documenting the appropriate lesion is to be aspirated, followed by local anesthesia. Some cysts may be difficult to aspirate and in these cases, several attempts to puncture both the anterior and posterior cyst wall should be
performed using a single insertion with an 18-gauge needle. Although most cysts can be completely evacuated using this technique and require only routine follow-up imaging, occasionally a complicated cyst with very thick contents may be incompletely drained. In these cases, short-interval follow-up US in 6 months is prudent.

If the aspirate fluid is white, yellow, or greenish black in color, it can be discarded and the patient reassured the cyst was benign. If the fluid is bloody or if the patient is at high risk for breast cancer or at the patient’s or referring physician’s request, the aspirate may be sent for cytologic analysis. Cytology of cyst contents may be acellular or include proteinaceous debris, apocrine cells, macrophages, or old blood. If suspicious, atypical, or mucinoid findings are found on cytology, rebiopsy or excision is warranted. In these cases, if the cyst was completely evacuated, follow-up US in 4-6 weeks should be performed as malignant cystic lesions should recur and can be rebiopsied. Alternatively, a postbiopsy marker clip can also be deployed at the aspiration site of a suspicious cyst. When cyst aspirations are performed for symptomatic relief, patients should be advised of the possibility of cyst reaccumulation.
US-Guided CNB

US-guided CNB is most commonly performed using automatic or semiautomatic needles or vacuum-assisted devices (Fig. 3). Needles smaller than 14 gauge are not commonly used as they are associated with decreased diagnostic accuracy.10-13 Single-use, sterile packed, plastic, automatic spring-loaded devices with an integrated needle are preferred for most lesions as they are easy to use and cost-effective. These devices usually have a 22-mm throw with a 2-cm sample notch and usually use a 2-step firing mechanism: the inner needle with the sampling trough enters the lesion rapidly followed by the outer cutting cannula. Because the needle must be removed to retrieve each sample, repetitive insertions are necessary, although an optional 13-gauge coaxial trocar or cannula is available to facilitate multiple needle insertions.

Abnormal lymph nodes may be biopsied with CNB or FNA, although CNB is preferred because it is more accurate14 and unlike FNA, hormone receptor status and immunohistochemistry can be obtained with core samples. If lymphoma is suspected, core samples should be placed in saline or RPMI-1649 for flow cytology, as well as formalin.

Color Doppler interrogation is essential before US-guided biopsy of any suspicious axillary lymph node. If CNB is to be performed, the open trough technique should be used to avoid damage to adjacent vessels or nerves (Fig. 4). The decision to confirm metastases in a suspicious axillary lymph node ipsilateral to a newly diagnosed breast cancer is controversial, but can be performed if requested by the surgeon.

US-Guided Vacuum-Assisted Procedures

US-guided directional vacuum-assisted biopsy (US-VAB) is an alternative to automated CNB. Compared with automated US-CNB, usually performed with a 14-gauge needle, US-VAB uses vacuum suction and often larger 14- to 7-gauge probes to remove significantly more tissue. Despite the use of a different biopsy device, the procedure, associated risks, and follow-up management are otherwise identical to automated CNB.

US-VAB is generally used for very small or subtle lesions, architectural distortions without a definite underlying mass, suspicious calcifications, intracystic mural nodules, or intraductal masses (Fig. 5). US-VAB confers several advantages including a single insertion, directional sampling, and retrieval of larger tissue cores. Single-use disposable vacuum-assisted devices are available, but these require multiple insertions for each specimen obtained. Although currently not the standard of care, there is increasing interest in using US-guided vacuum-assisted devices for complete excision of probably benign palpable lesions, such as fibroadenomas, in women who desire complete removal. In these cases, surgical removal can be replaced with US-VAB, particularly for lesions < 1 cm in size. Several studies have demonstrated complete removal of lesions, in up to 94% of cases,15,16 with low rates of residual masses. Successful excision of intraductal masses in women with worrisome nipple discharge has also been shown, with resolution of associated nipple discharge in 87% of patients.17

US-Guided Preoperative Localization

A variety of needle and wire apparatus exist, including those with nonretractable or retractable hook wires. Nonretractable wires are advantageous because the risk of movement during patient transport to the operating suite is minimized. Retractable wires are advantageous
because they can be easily repositioned multiple times to achieve accurate placement. Regardless of needle or wire choice, all are available in multiple lengths to facilitate accurate depth placement, although in most instances, a 5-cm needle is adequate. Using US guidance, the needle is inserted entirely through the lesion and the tip of the needle placed approximately 1 cm beyond the lesion margin. The wire is deployed through the hollow needle shaft with the thick portion of the wire within the lesion and the hook placed beyond the lesion (Fig. 6). Post-procedure US images and mammograms in the craniocaudal and mediolateral projections are performed if there is a mammographic correlate or at the surgeon’s preference. Annotated US images or mammography images or both of the properly position wire are provided to the surgeon.

Following excision, specimen x-ray can be performed to document lesion and wire retrieval. If the lesion is not seen mammographically, sonography of the specimen placed in a saline bath, using a probe cover, can be performed. The final report is not issued until the pathology is reviewed. If the lesion excised was previously biopsied percutaneously,
the prior biopsy site should be present and included in the pathology report.

US-guided radioactive seed localizations can now be performed using an I-125 seed placed up to 4-5 days before surgery via an 18-gauge needle. However, most breast imagers still perform US-guided wire localization for preoperative guidance and excision of a suspicious lesion or biopsy-proven cancer identified on US.

**Challenges**

Biopsy of deep or very posterior lesions can be challenging because there is a risk of vascular injury, pneumothorax, damage to a cosmetic implant, or possibly missing the lesion altogether. This can be partially solved by making an incision >1 cm from the edge of the probe centered over the lesion. When the needle is inserted, it can be initially directed at a steep angle and immediately “scooped” to maintain a parallel orientation with respect to the chest wall. Another solution is to “raise” the lesion by slowly injecting the anesthetic posterior to the target. Likewise, superficial lesions can be pushed deeper by injecting anesthetic immediately beneath the skin. Because of increased sensitivity, retroareolar masses should be anesthetized adequately and an oblique needle approach should be used, if possible, to avoid firing the needle directly beneath the nipple-areolar complex. In these difficult cases, sampling the lesion using the “open trough technique” should be considered to eliminate rapid firing of the needle. This allows more precise needle placement within the lesion.

Occasionally, a small or subtle lesion would be difficult to visualize after the initial core sample is obtained. This may be secondary to associated hemorrhage, edema, or air introduced by the biopsy device. In most cases, the biopsied region can still be identified and additional sampling and biopsy marker clip placement can still be performed. Additionally, it may be difficult to optimally place a needle adjacent to a lesion if surrounded by very dense breast tissue. In such cases, the use of a vacuum-assisted device is desirable and the needle may be deployed proximal to the lesion several times until the biopsy device is used to “make” a track to reach the target.

**Summary**

US-guided breast intervention is a safe, accurate, and efficient choice for image-guided breast procedures. With ever improving high-resolution US equipment, more lesions would be amenable to US-guided biopsy, FNA, localization, and other interventional procedures. For
example, more lesions are being detected with screening whole-breast US, which historically has a low positive predictive value of 6%-18%. Therefore, high threshold for biopsy should be considered for many masses, which often have a low index of suspicion when detected on screening US. Early studies also demonstrate that probably benign masses seen on screening US can be managed with 12-month (rather than 6-month) follow-up imaging. Alternatively, a lower threshold for US-guided biopsy should be considered for women in high-risk categories for breast cancer, as malignancies in this subpopulation may have a benign US appearance. Future studies and technological advances should continue to improve the diagnostic performance of breast US and US-guided interventional procedures.

References