Real-time elasticity helps improve breast specificity

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By Anne Tardivon, MD [4]

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Ultrasound has long been an efficient and useful adjunct technique for breast imaging. It is the first modality to be proposed in some situations: if a young or pregnant woman has a palpable mass, for example, or immediately after surgery. Ultrasound is usually performed during the diagnostic workup of masses, if architectural distortion is detected on mammograms, or following mammographic screening in individuals who are at high risk of breast cancer and have dense breast tissue.

Ultrasound's primary role when imaging masses is to determine if the mass is cystic, and hence benign, or solid and potentially malignant. This differentiation is not always easy to make in practice, especially for complicated echoic cysts and lesions that are less than 7 mm in diameter. Characterization of solid masses is based mainly on morphological criteria: shape, spatial orientation, and margins. Interobserver variation can be high, however, especially for lesions that are BI-RADS category 3 (probably benign) or BI-RADS category 4a (low suspicion of malignancy). Most of these masses will be imaged again after a short time interval or referred for further investigation (fine-needle aspiration or core biopsy).

This all suggests that we need new tools to increase the specificity of B-mode ultrasound findings. Elastography is emerging as a promising candidate for this role. The technique has been reported in the literature since the 1980s, but it has not become routine. Now elastography is more user-friendly, and real-time images can be generated.

**ESSENTIAL TECHNIQUE**

Elastography is currently offered by two vendors: Hitachi (EUB-8500 ultrasound scanner with integrated elastography software and a 6.5- to 13-MHz probe) and Siemens (Sonoline Elegra, 7.5L40 transducer at 7.2 MHz or VFX13-5 transducer at 10 MHz). The principle of the technique is essentially the same for both systems.

Tissue compression produces displacement that is mainly in the longitudinal direction, the direction of the ultrasound beam. This can be used to calculate the strain in the tissue being compressed. Strain tends to be smaller in harder tissue than softer tissue. So working backwards, once the strain has been calculated, the tissue hardness can be evaluated as well. The influence of probe movement on the skin's surface in the lateral direction is minimized during measurement.

Ultrasound elastography is performed at the same time as the standard imaging examination using the same probe. The lesion is first assessed using B-mode ultrasound. An adapter is then applied to the top of the probe to collect strain data, allowing perpendicular contact between the array and the skin. The operator identifies a region of interest around the lesion, ensuring that the target tissue occupies no more than one-third of the total ROI area. The lesion should be shown clearly on a double-screen display. The transducer is then used to apply weak repetitive pressure to the skin over the lesion (freehand compression technique).

It is important that pressure applied during freehand compression is only light. The Hitachi system has a pressure indicator on the ultrasound screen, which should read between 2 and 3 during elastography (Figure 1). Higher readings indicate that the pressure being applied is too great. Excess pressure may induce nonlinear properties of tissue elastography and lead to misdiagnosis: the greater the compression over the tissues, the higher the elastographic values, which opens the possibility of potential false-positive results.² No published data are available to confirm this point, but in practice elastographic mappings are modified and are more heterogeneous.

Real-time color mapping inside the ROI and over the conventional B-mode ultrasound shows elasticity measurements that are relative to the average strain (qualitative measurement).
lesions are coded in blue, soft ones in red. The Siemens system for ultrasound elastography requires operators to start with the transducer barely in contact with the skin's surface. Pressure is then increased in a cyclical manner over an approximately 10% strain range. The resulting data are displayed with a color map. Stiffer areas are depicted as dark or red and softer areas as light or blue (Figure 2). The Hitachi system classifies lesions on a five-point color scale (Ueno classification) on the basis of elastographic behavior (Figure 3). Lesions scoring 1 or 2 are considered to be benign. Those with a score of 3 are rated as indeterminate, while scores of 4 and 5 indicate malignancy. Cystic lesions typically display a "threelayer" presentation, with red (top), green, and blue (bottom) bands superimposed on the lesion (Figure 4). This elastographic finding is not exhibited by all cystic lesions, however.

Using either system typically requires practice on approximately 30 lesions before operators can obtain reliable data with this technique. Malignant lesions investigated with the Siemens system typically appear dark. The contrast between these lesions and background breast tissue is high. Benign lesions appear lighter and exhibit lower contrast. Malignant lesions also tend to be larger on ultrasound strain images than on corresponding B-mode ultrasound images (Figure 5). This pattern corresponds to the Ueno score 5 on the Hitachi software and seems to be related to the desmoplastic reaction commonly associated with malignancy.

CLINICAL UTILITY

Many prospective studies have been published with comparable results. Elastography has been shown to increase the specificity of B-mode ultrasound to 85% to 98.5% and to increase the positive predictive value while slightly lowering or not affecting the sensitivity (78% to 87%). Results from one group suggest that elastography works better in lesions that have a diameter no greater than 15 mm, and that the best results are obtained in lesions less than 5 mm across. Investigators from this same group have modified the Ueno classification so that a score of 1 indicated a three-layer pattern, score 2 a lesion with an even elastic pattern (diffuse green), and score 3 a mostly elastic lesion with some small stiff areas (blue). The negative predictive value for cancer using this modified elastography classification was 98% (874 lesions). Researchers using the Hitachi system have reported high reproducibility of elastography data (good intra- and interobserver agreement). Interobserver reproducibility using the Siemens technique and measuring lesion size was not very good. This was the case even if the average area under the receiver operator characteristics curve after ultrasound strain imaging was greater than that after B-mode ultrasound alone.

If a lesion exhibits characteristics that are typical of a malignant mass or a benign cyst on routine B-mode imaging, then elastography will not be useful for characterization. Elastography will, however, be extremely useful when characterizing complicated cystic lesions and benign solid masses because it can add another descriptor: soft lesion. This additional information may help operators decide which strategy to adopt when faced with lesions that are of low suspicion for malignancy (BI-RADS category 4a): intervention or repeat imaging after a short interval. Elastography can produce falsenegative and false-positive results. False-positive results have been reported for fibrous or calcified fibroadenomas and fibrous mastopathy. Meanwhile ductal carcinoma in situ and invasive cancers without desmoplastic reaction may appear soft on elastography (score 3, Ueno classification). This reinforces the message that an elastography score should be considered together with all other ultrasound findings and not used as a stand-alone diagnostic tool.

EMERGING TECHNIQUES

An alternative method is to take a quantitative approach to elastography. One ROI is placed over normal breast tissue (reference area, fat lobule), another over the target lesion, and the strains calculated for both. The strain produced in the fatty tissue is then divided by that of the lesion. This ratio will be low if the lesion is benign and high if it is malignant.

In a study of 155 lesions (108 benign, 47 malignant) that used a cutoff value of 4.3 to divide the two groups, the method yielded a sensitivity of 89.4%, specificity of 88.8%, and accuracy of 89%. This type of quantification should increase the reproducibility of qualitative assessments. Elastography could potentially be used for many other applications besides differentiating between...
benign and malignant lesions. Such roles have yet to be investigated and evaluated. Areas of interest include postradiotherapy imaging, local staging of breast cancer (searching for multifocality), staging of axillary lymph nodes, "secondlook" imaging following breast MRI, improving localization of lesions, and investigating tumor response to neoadjuvant therapies. New elastography technologies are being investigated clinically as well. One promising method is supersonic shear wave elastography, which combines two innovative concepts. The same conventional ultrasound probe is used to manipulate the tissue and to image it. An ultrasonic focused beam creates acoustic pressure, removing the need for external compression. The resulting motion is imaged using an ultrafast ultrasound acquisition. Quantitative elastography information (kPa) is available using this technique. Elastography ultrasound is emerging as a valuable adjunct to B-mode ultrasound for the evaluation of breast lesions. Reliable information can be obtained from experienced operators. The findings must, however, always be integrated with other ultrasound findings. Guidelines on the proper use of elastography, based on the Hitachi system, have been defined.  

- Elastography may increase the specificity of ultrasound in the evaluation of breast lesions. It is not indicated for surgical scars, diffuse lesions, or lesions larger than the transducer field of view.
- Elastography interpretation requires global experience in breast imaging. Operators should scan and interpret at least 30 cases under the supervision of an expert before performing the technique on their own in clinical practice.
- Elastography acquisition can be termed "correct" when the value on the monitor is at least 2 or 3. Color homogeneity throughout the scanning area around the lesion is another way of evaluating examination quality.
- At least two correct elastography acquisitions lasting five seconds should be obtained for each lesion. The area scanned should cover almost all of the field of view.
- Two elastography scores should be acquired through perpendicular scanning planes for lesions with a mixed texture on B-mode ultrasound.
- The pressure applied with the probe must be constant and perpendicular to both the front margin of the lesion and the thoracic plane. Lateral movements must be avoided.

Disclosures:

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