

By Dr. K. Schilling

ShearWave Elastography and Breast Imaging

At a busy breast imaging facility in Florida the advanced ultrasound technique, ShearWave Elastography (SWE) has altered the way women are cared for both for benign and suspicious findings. SWE has reduced the number of benign lesions mistakenly flagged for biopsy, significantly decreasing the false positive rate of ultrasound. The technique has also helped reduce the initial level of false negative diagnoses in patients who ultimately are found to have breast cancer. This article describes the role ShearWave technology plays in the breast imaging center and gives examples of cases in which it assists in refining the ultrasound diagnosis.

Florida is not one of the 22 current “breast density” states in the United States which have a legal requirement that women must be informed of their personal breast density. Nevertheless, for the last five years, the Christine E. Lynn Women’s Health & Wellness Institute, in the Boca Raton Regional Hospital in Florida has been proactively educating patients at the time of their exam and informing them of their personal breast density and their US National Cancer Institute (NCI) Lifetime Risk of developing breast cancer. At the same time, women with high breast density are informed of the supplemental screening tools available. These include ultrasound, both 2D imaging and with ShearWave Elastography, molecular breast imaging and MRI. A formal risk assessment program is also available such that an appropriate personalized screening plan can be developed for interested women.

The author

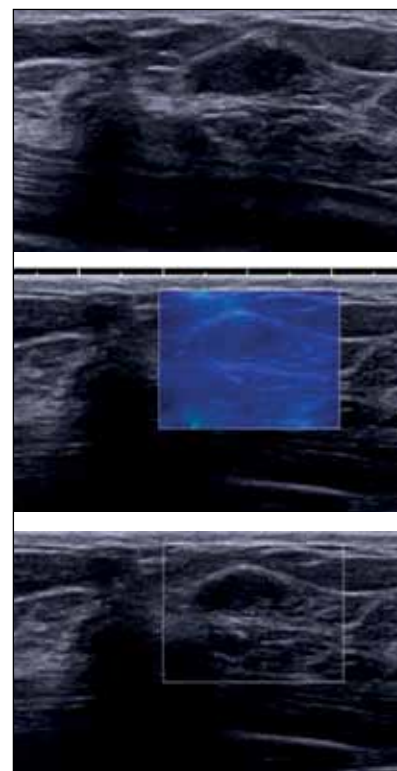
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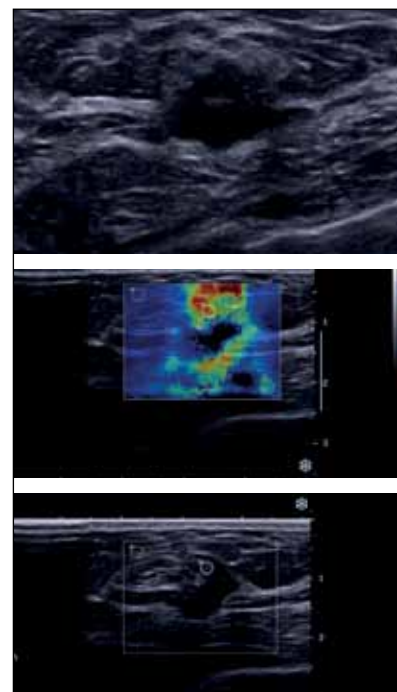
As most women with high breast density are not at extreme risk requiring MRI, bilateral whole breast ultrasound is offered to the majority of patients. Several studies have been reported over the last decade showing the improved sensitivity in breast cancer detection when ultrasound is added to mammographic screening of patients with dense breasts. However, a high false positive rate and low PPV₃ of the generated biopsies have also been reported. (PPV₃ is otherwise known as biopsy yield of malignancy or positive biopsy rate, PBR).

The ultrasound BI-RADS lexicon relies on lesion morphology to include evaluation of the margins of a mass, its internal characteristics, and posterior and local features to standardize the interpretive criteria. In the 1980s, Doppler analysis of lesions assisted the physician by providing additional information regarding lesion vascularity, with a resulting improvement in the specificity of the interpretation. Nevertheless, many women were still undergoing unnecessary biopsies for benign disease.

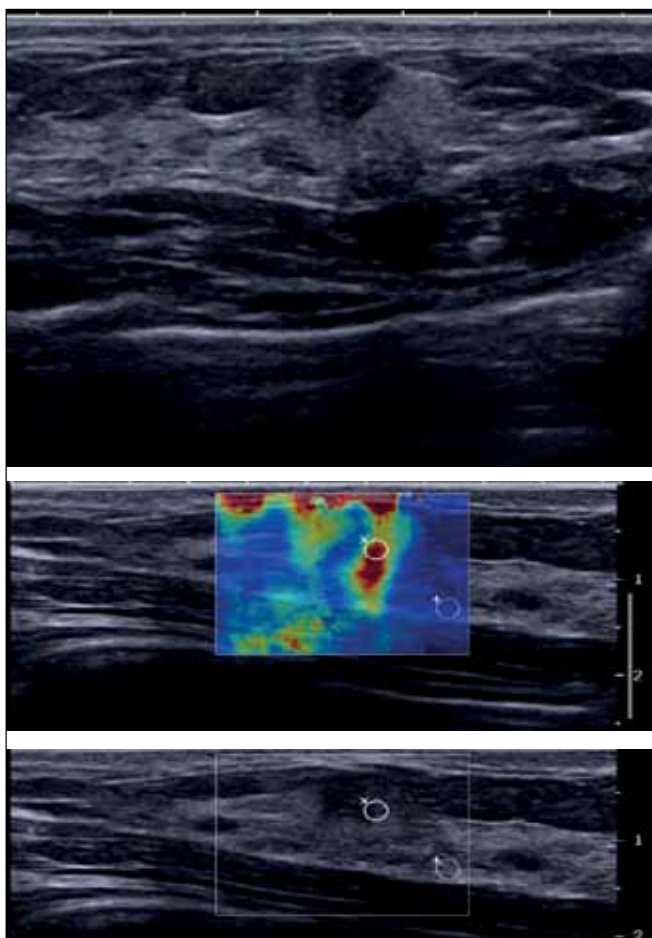
To minimize the number of such biopsies of benign lesions and to maximize the identification of those



Case 1. Oval circumscribed hypoechoic solid mass. Homogeneously blue on SWE consistent with soft lesion. Biopsy proven fibroadenoma. Could have been given BIRADS 2 or 3 rather than BIRADS 4A requiring biopsy.



Case 2. Oval parallel slightly lobulated hypoechoic solid mass. Significant stiffness within lesion and surrounding tissue with marked heterogeneity. Invasive ductal carcinoma grade 3. Will not be mistaken for a benign lesion with SWE findings. SWE decreases false negatives.



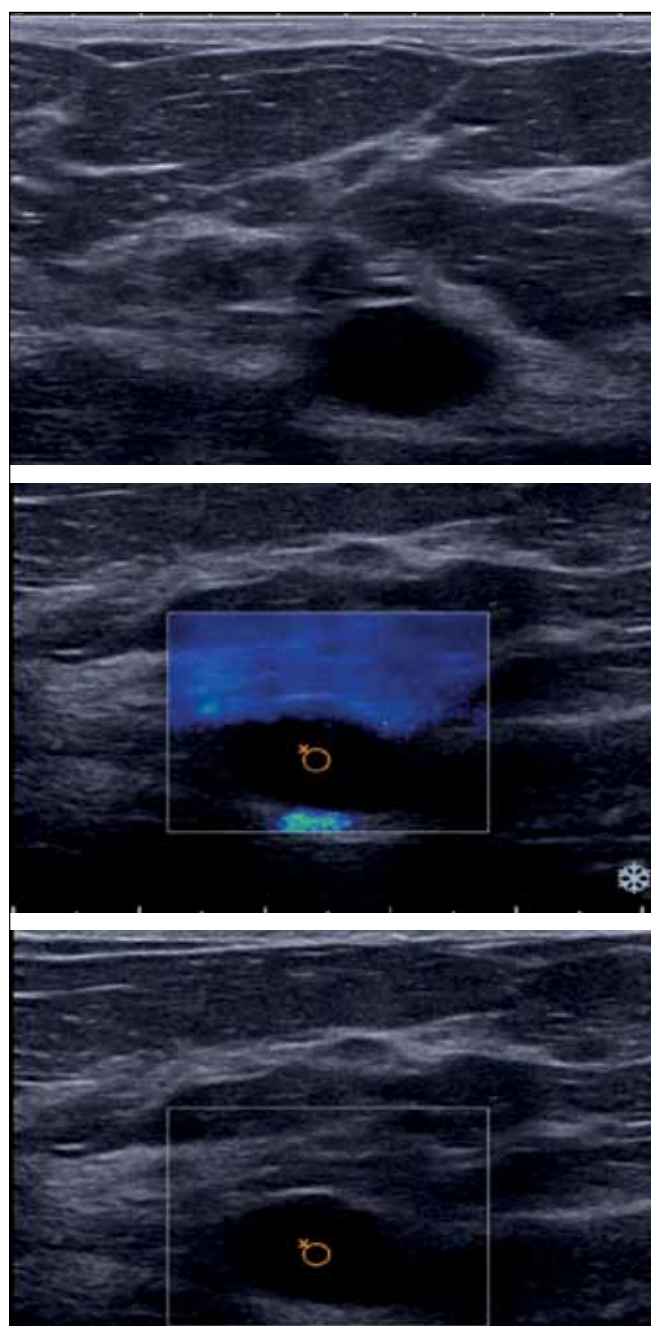
Case 3: Small superficial hypoechoic solid mass appearing slightly taller than wide. SWE shows heterogeneity with significant stiffness. Invasive ductal carcinoma grade 1. Lesion will not be mistaken for a benign finding. SWE decreases false negatives.

patients who truly need biopsy, ShearWave Elastography can, for every lesion found by ultrasound in the breast, provide the clinician with supplemental information on the local tissue stiffness.

Clinical breast diagnosis is in part based on the stiffness or hardness of a palpable mass to suggest its etiology. Physical exam findings of breast malignancy date as far back as 2100 BC; nowadays, the breast imager can use information on the stiffness of a lesion and its surrounding tissue to suggest an accurate diagnosis.

In practice, SWE is rapidly acquired in a real-time setting and provides reliable, reproducible information non-invasively. The Aixplorer instrument from SuperSonic Imagine, the company which pioneered the technology, was cleared by the FDA in 2013 for its real-time quantification of tissue elasticity as expressed in kilopascals (kPa) and m/s.

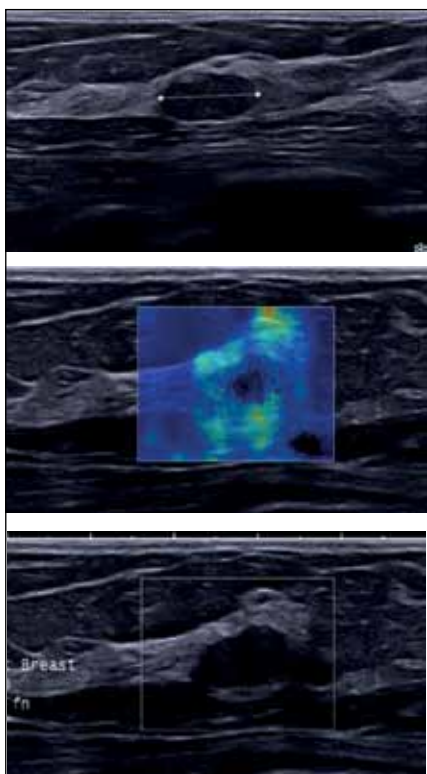
The speed of the shear wave generated by the UltraFast scanner is imaged, quantified and color-encoded by the system which operates at 5,000 frames per second. The technology enabling the interpretation of fast moving shear waves, is at the base of the system's UltraFast platform which acquires images 200 times faster than conventional ultrasound systems. The system generates a two-dimensional, color-encoded map of tissue elasticity superimposed on a B-mode image of the



Case 4: Deeply positioned hypoechoic mass with slightly indistinct margins. Lesion does not propagate shear waves consistent with fluid. Aspiration found a cyst. Aspiration could have been avoided with the use of SWE, changing BIRADS 4A to BIRADS 2. SWE decreases false positive findings on ultrasound.

same area for anatomical correlation. The information on the viscoelastic properties of breast lesions and their surrounding tissue can improve diagnostic accuracy.

Occasionally it can be seen that the stiff tissue of a malignancy will include not only a part or all of the tumor itself but also surrounding breast tissue. This may be due to a local increase in oncotic pressure surrounding a cancer due to leakage of fluid from tumor-induced neo-vascularity as a result of leaky basement membranes. Additionally, it has been suggested



Case 5: Circumscribed hypoechoic parallel solid mass. SWE shows moderate stiffness larger than the solid lesion. Low grade DCIS. SWE will assure BIRADS 4 diagnosis rather than BIRADS 2 or 3, decreasing false negative assessment.

that a local desmoplastic reaction may add to stiffness in the tissues surrounding a cancer or that there is increased collagen cross-linking with abnormal collagen fiber alignment. Such mechanical properties of the tissue cannot be seen on pathological examination.

MAJOR ADVANTAGES OF SWE

A major advantage of SWE is that the results are not dependent on the expertise of the operator, neither when the results are generated from individual scans nor from scans of the same patient by different operators or at different times.

In practice, the system's color mapping capability has become an important tool for the training of the technologists in our facility. Through the morphologic assessment of a specific lesion the likelihood of malignancy can be assessed. When a benign lesion is suspected morphologically, the amount of transducer pressure on the breast can be varied to result in the appearance of a benign lesion (blue).

CLINICAL ADVANTAGES OF SWE

ShearWave Elastography improves the management of the breast cancer patient; the examinations are accurate and reproducible. In a study of 1800 patients using the Aixplorer system the results clearly showed that SWE helps reduce negative biopsies. In fact the PPV₃ of lesions evaluated by SWE and BIRADS morphology characteristics together as compared to BI-RADS alone increased from 52.6% to 67.1% with a $p < 0.001$. In addition, by adding SWE parameters to BIRADS assessment of sonographic lesions, approximately 90% of BI-RADS 4a lesions could be downgraded to BIRADS 3, thereby avoiding an unnecessary invasive procedure.

Elastography also has prognostic potential as increased stiffness is found in tumors of higher grade, of larger size and with a greater likelihood of lymphovascular inva-

sion and nodal involvement. The stiffer tumors are also more likely to be HER2+ and triple negative.

The series of cases illustrated in this article show some of the clinical applications and resulting benefits of real-time, quantified and color-mapped SWE.

CONCLUSIONS

In our facility, ShearWave Elastography has significantly improved the quality of care and overall diagnostic performance of our physicians when breast ultrasound is performed. The technique gives us the ability to reliably downgrade a sonographic lesion from one of low suspicion requiring biopsy (BI-RADS 4a) to one of low suspicion not requiring biopsy (BI-RADS 2 or 3). This has resulted in our recommendation of whole breast ultrasound in patients with elevated risk or breast density in order to achieve supplemental cancer detection above that detected with mammography alone. Additionally, with the information provided by SWE, we are able to better triage patients requiring biopsy, prioritizing those most likely to harbor a malignancy thus enabling swift diagnosis and treatment.

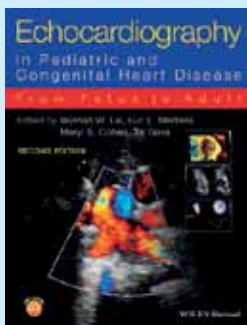
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Book review

Echocardiography in Pediatric and Congenital Heart Disease: From Fetus to Adult, 2nd Ed.

Edited by W. W. Lai, L. L. Mertens, M. S. Cohen, T. Geva ; Feb 2016, 928 pp Wiley, €263.30,



This comprehensive textbook on the echocardiographic assessment of pediatric and congenital heart disease has been updated for a second edition with an emphasis on new technologies. The highly-illustrated full-color reference contains 1200 figures, and 600 video clips on a companion website.

- Fully updated, with new chapters on the assessment of the post-Fontan procedure patient and on pregnancy and heart disease
- Each lesion chapter includes new section highlighting the key elements of the echocardiogram(s)
- Written by experts from the leading centers around the world, with numerous new authors
- Revision emphasizes new technologies and quality of images
- Comprehensive content contains overview of ultrasound physics, discussion of laboratory set-up, protocol for a standard pediatric echocardiogram and quantitative methods of echocardiographic evaluation, including assessment of diastolic function