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Ultrasound Elastography for the Staging of Fibrosis in Chronic Liver Disease

- An important goal in managing chronic liver disease is to identify fibrosis before it progresses to cirrhosis.
- Ultrasound elastography offers a robust, noninvasive alternative to biopsy in diagnosing and staging liver fibrosis.
- Approaches to ultrasound elastography can be distinguished by the ways in which tissue displacement is induced.
- Shear-wave elastography is a recently introduced approach that diagnoses fibrosis through quantitative measures of tissue stiffness.

Liver disease and associated mortality are on the rise in the US. According to the Centers for Disease Control and Prevention, death rates for chronic liver disease and cirrhosis increased by 31% between 2000 and 2015—from 20.1 per 100,000 to 26.4—among those 45 to 64 years of age.

Chronic liver disease (CLD) has many causes, including the hepatitis C virus, the hepatitis B virus, nonalcoholic fatty liver disease and alcoholic liver disease. Ultimately, CLD can lead to severe and irreversible liver fibrosis—cirrhosis—a disease state with a high risk of complications and mortality. A central goal of CLD care is preventing progression to cirrhosis through early detection and effective management of the underlying disease. For many causes of CLD, knowing the stage of liver fibrosis is very useful for understanding the rate of disease progression and the risk of adverse outcomes. Liver biopsy is currently the gold standard for staging liver fibrosis but it has major limitations: It is invasive, expensive and subject to sampling error and interpreter variability.

For these reasons, noninvasive options for the diagnosis and staging of liver fibrosis have become increasingly important areas of research and clinical practice in recent years. These approaches include serum markers; mechanical measurements such as the vibration-controlled transient elastography (FibroScan); and imaging approaches including magnetic resonance elastography (MRE) and ultrasound elastography (USE), a rapidly developing technology that combines imaging and mechanical assessment.

Different Approaches to Ultrasound Elastography Rely on Different Types of Tissue Displacement

Ultrasound elastography evaluates the mechanical properties of tissue by applying mechanical force and measuring the resultant tissue displacement. Approaches to ultrasound elastography can be distinguished by the ways in which tissue displacement is induced. Strain-based elastography methods rely on the application of external pressure, whether through manual compression—with probe pressure, for example—or by taking advantage of endogenous forces such as cardiac or respiratory motion. Strain-based methods are typically described as "semi-quantitative elastography" because the deformation force is not known and therefore the methods cannot provide an absolute measure of tissue stiffness.

With more recently introduced shear-wave elastography techniques, tissue displacement is induced by the ultrasound system itself. The system uses acoustic force to induce tissue micromotion, which results in a shear wave propagating through tissue perpendicular to the ultrasound beam. The tissue motion created by the shear wave is measured and used to compute the tissue stiffness. Shear-wave techniques are quantitative and reproducible.

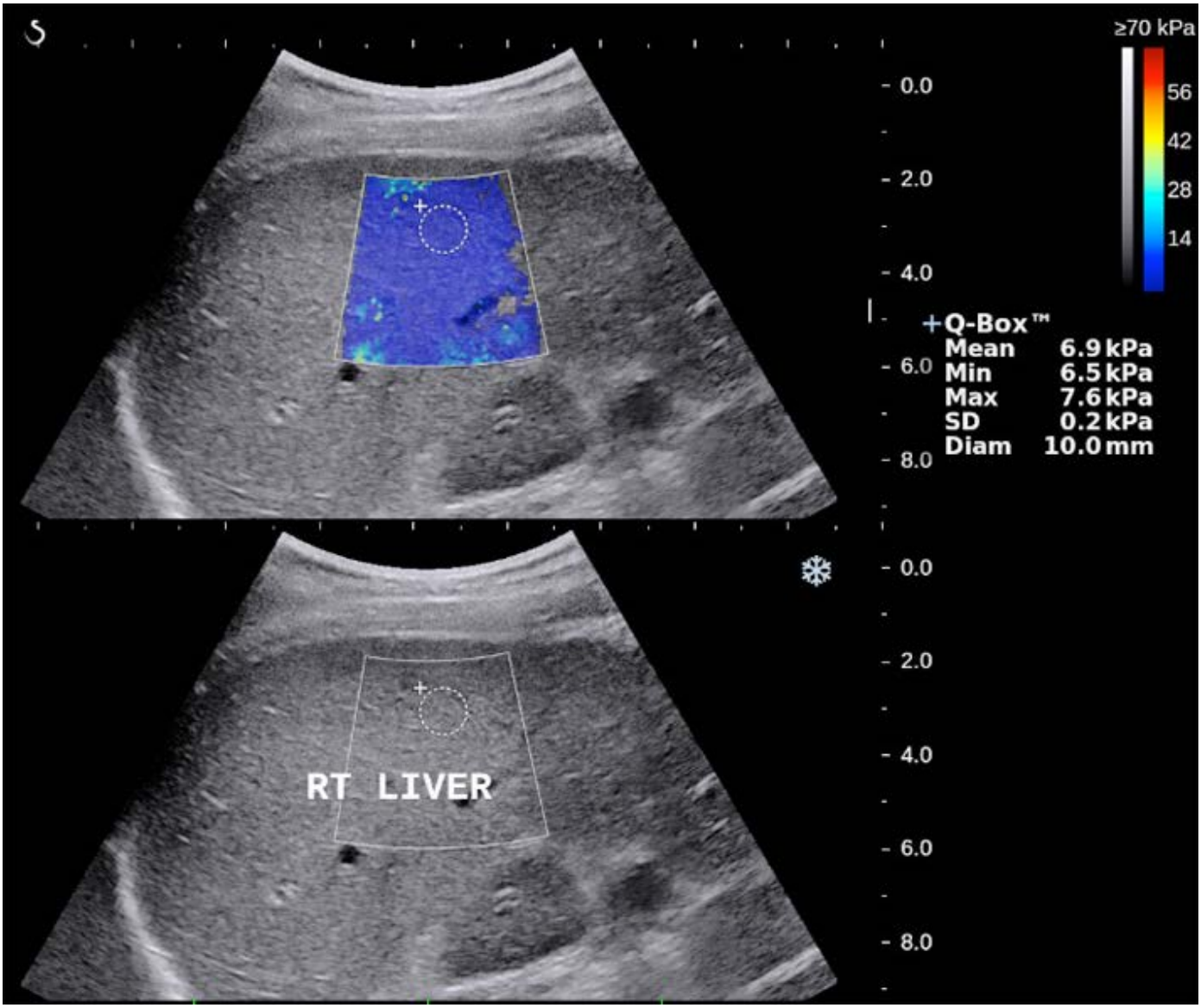

Figure 1. Shear-wave elastography acquisition in liver tissue is shown here. Each colored pixel represents a shear-wave speed estimate. Mean shear-wave speed is measured in a circular region of interest. Image courtesy of Arinc Ozturk, MD.

Studies Validate Shear-wave Elastography for Staging of Liver Fibrosis

Multidisciplinary Researchers have been working to advance shear wave-elastography for use in the clinic. In a 2015 study reported in the journal Radiology, a team of investigators at Massachusetts General Hospital sought to assess the efficacy of the technique for the staging of fibrosis in chronic liver disease, while also exploring the relative accuracy of measurements obtained from different sites on the liver. Between January 2010 and March 2013, 136 patients underwent shear-wave elastography prior to a scheduled liver biopsy. The researchers then compared the elastography measures with the biopsy results. They found that the estimates of liver stiffness corresponded particularly well with fibrosis severity in the upper right lobe of the liver, suggesting that shear-wave elastography could be used as a noninvasive means of staging fibrosis in patients with liver disease.

The Mass General team next sought to validate the previously described diagnostic performance of the technique across multiple sonographers in a study published in 2017 in Ultrasound in Medicine and Biology. Estimates of sensitivity and specificity were similar to those in the original study, leading to the conclusion that the results were likely generalizable. Other research both before and after the Mass General study has found similar diagnostic performance across a range of ultrasound elastography systems, and shear wave-elastography is presently in use for liver fibrosis staging at many centers in the U.S.

Technical improvements to shear-wave elastography continue to be made, further improving the accuracy of the technique. Currently, the Mass General team is applying advanced image processing techniques to improve and automate ultrasound elastography.

Scheduling

Ultrasound elastrogaphy is performed by the Division of Abdominal Imaging in the Department of Radiology at Massachusetts General Hospital in Boston and Chelsea. Orders can be placed in Epic (inside the Partners network) or Physician Gateway (outside the Partners network) or by calling 617-724-4254.

Further Information

For more information about ultrasound elastography, please contact Anthony E. Samir, MD, MPH, Center for Ultrasound Research & Translation, Department of Radiology, Massachusetts General Hospital. We would like to thank Dr. Samir and Arinc Ozturk, MD, Center for Ultrasound Research & Translation, Department of Radiology, for their advice and assistance in preparing this article.

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