Making Waves to Detect Illness

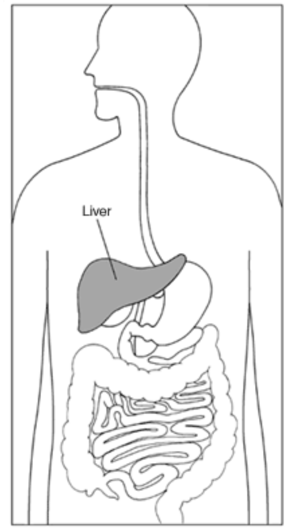

Figure 1. The Human Liver. *Source:* Wikimedia Commons.

Elastography is a relatively new field in medical imaging based on how elastic objects, like rubber, jello, or soft tissues in the body, change their shape when they are pressed or vibrated. With elastography, doctors can see what conventional imaging methods like ultrasound and MRI don't show. A specific type of elastography, shear wave elastography (SWE), is currently being investigated as a way to monitor diseases in organs such as the liver, breast, brain, and prostate.

SWE uses the speed of **shear waves**, a transverse wave that can travel through any deformable object, to assess the health of a particular tissue or organ. By comparing the shear wave speeds moving through healthy and diseased tissues, doctors are able to determine whether a particular patient needs to be treated, monitored further, or can be sent home with a clean bill of health.

SWE involves three basic steps:

1. Shake the tissue in some way to create a shear wave.
2. Do fast-imaging of shear wave propagation inside the tissue (usually hundreds of frames per second) using either MRI or ultrasound.
3. Analyze the images to measure the wave speed, wavelength, or both.

A potential application of shear wave elastography is in diagnosing a liver disease called liver fibrosis in which the liver becomes scarred and hardened. The current method of diagnosing liver disease is via biopsy, an invasive and stressful procedure where a needle is inserted between the ribs of a patient to get a small piece of the liver for study under a microscope. Needless to say, this technique is painful and can cause internal bleeding and other complications. SWE, which is both non-invasive and painless, is a potential alternative.

Several research labs, including a team of researchers at Massachusetts General Hospital, have been working to develop SWE techniques to monitor and diagnose liver disease. Recently, they reported promising results from a large clinical study that could lead to better management of liver fibrosis. Earlier studies had shown a correlation between high shear wave speed in liver tissue and liver fibrosis: the higher the speed, the worse the fibrosis. This led to a proposed classification system where a shear wave speed value of 2.7 m/s was chosen as the cut-off value for distinguishing severely fibrotic livers from healthy livers.

The purpose of their current study was to determine the validity of this SWE cut-off value of 2.7 m/s in a large number of patients. They studied a group of 338 liver patients using both liver biopsy, the traditional and reliable way to make a diagnosis, and SWE. They found that a shear wave speed of 2.7 m/s had a 95% sensitivity in detecting severe liver fibrosis. This means that when a patient's liver had a shear wave speed of 2.7 m/s or more, there was a 95% chance that the liver biopsy confirmed that the liver was severely fibrotic. This study shows that SWE can be an important tool in the hands of the physician and in the future may allow patients to avoid the potential complications of liver biopsy.

References

Dhyani, Manish, Joseph Grajo, Atul K. Bhan, and Anthony E. Samir. 2017. "Validation of Shear Wave Elastography Cutoff Values on the Supersonic Aixplorer for Practical Clinical Use in Liver Fibrosis Staging." *Ultrasound in Medicine and Biology* 43(6): 1125–1133.

Parker, Kevin J., Marvin M. Doyley, and Deborah J. Rubens. 2010. "Imaging the elastic properties of tissue: The 20 year perspective." *Physics in Medicine and Biology* 56(1): R1.

BiteScientist Profiles

Sanjay Yengul is a graduate student at Boston University and Brigham and Women's Hospital. Sanjay's research interests broadly relate to the application of physics principles in engineering and biomedical applications. He is particularly interested in the physics of acoustic and elastic waves. He is currently working on developing elastography techniques to diagnose, monitor, and even treat diseases such as liver fibrosis, breast cancer, and atherosclerosis. He lives in Brookline with his tennis racquet and his bicycle.

Kate Wooley-Brown is a physics teacher at Brookline High School. As a graduate student at Harvard University, Kate worked as an outreach specialist and led a mentoring program for fifth grade students focused on engineering design. At Brookline High School, she helps students as a Dreamfar High School Marathon Leader. In addition to running, Kate enjoys rock climbing, kitesurfing, water and snow skiing, playing with her dog, and interior design.

_v2: formatting and title changes June 22, 2018