Secrets from High-Tech Poking

Duke University

Physicians use hi-tech scanners all the time to produce crisp and detailed images to help them diagnose illness. But they may not be getting the whole picture.

CT or MRI scanners are unable to provide potentially important clues about a tissues health namely, how it feels. Duke University biomedical engineers believe information about the stiffness of particular tissue such as organs or arteries can add an important dimension to the diagnostic process.

The trick is how to make measurements of stiffness without actually opening the patient up surgically.

One approach, in the early stages of development in labs at Dukes Pratt School of Engineering, uses sound waves. Among other areas of research, Gregg Trahey, professor of biomedical engineering, and his students are applying Duke-developed modifications to existing ultrasound technology to more completely understand the health of the heart and its arteries.

Underlying this approach is the assumption that healthy tissue should be soft and elastic, while damaged tissue will be stiff. In the case of the heart, stiffness means the muscle is dead or damaged hindering its ability to contract. In arteries, stiffness may indicate the presence of an atherosclerotic plaque that could dislodge from the vessel wall, potentially causing a heart attack or stroke.

Traheys method pushes the tissue with sound waves and measures how quickly it returns to its previous state, much like the rebound of the Pillsbury dough boy after his belly is poked. Trahey uses a sound wave-based technology, called Acoustic Radiation Force Impulse (ARFI) imaging, to capture how the tissue responds these sound-wave pokes.

Using ARFI, we have shown that we can make measurements of tissues stiffness, Trahey. Our next task is to compare our results with those of other approaches to see if our data is really reflective of the situation, and once we can do that, well need to determine if our measurements are actually predictive of the degree of disease in a patient.

The National Institutes of Health believes that this line of research holds promise and has backed it with a five-year MERIT (Method to Extend Research in Time) award to Trahey.

The prestigious MERIT awards provide long-term, stable support to investigators whose research and productivity are likely to continue in the future. The awards are intended to foster continued creativity and lessen the administrative burdens associated with the preparation and submission of research grant applications.

Traheys award came from the NIHs National Heart, Lung Blood Institute,

Conventional ultrasound focuses high frequency sound waves into the body either to create images of internal tissues or to heat them. ARFI is a special kind of ultrasound that employs two different sound pulses -- one pulse is a high-energy beam that pushes on tissues like sonic fingers and the other is a tracking beam that measures the resulting tissue motion.

To accomplish this, Trahey and his students use the latest ultrasound scanners available and modify them to perform ARFI studies. These modifications range from physically altering the transducers, which collects the rebounding waves, to writing new computer language to collect and synthesize the data.

One use of the technology currently being conducted is the study of atherosclerosis. Normal arteries are pliable, since they help move blood throughout the circulatory system. However, when the arteries get clogged, they lose these elastic capabilities.

"We hypothesize that we can tell the difference between hard and soft plaques with ARFI, since it essentially a stiffness-imaging modality," said Trahey. "We also hypothesize that in healthy people we will detect soft vessels, and that in patients with known vascular disease we will see stiff vessels.

Clinical trials are already underway assessing ARFIs ability to characterize vascular plaques as stable or vulnerable and to measure the stiffness of blood vessels. Ongoing trials are also being conducted to assess the ability of ARFI imaging to guide cardiac ablation surgeries and to characterize the stiffness of the myocardium throughout the cardiac cycle.

With NIH support, Trahey is also using ARFI to detect and characterize liver cancers and to guide minimally invasive surgeries of liver and kidney cancer.

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