

# An overview of sonoelastography

The field of sonoelastography is developing rapidly, with many innovative ideas that promise to translate into clinical advances. David Cosgrove takes a look at some of these developments

**P**alpation, among the oldest of clinical skills, was used in ancient Egypt and is described in the Ebers Papyrus of 1552 BC. In it, practitioners were advised to feel for hard lumps in the breast as an indicator of malignancy.<sup>1</sup>

This is the basis of elastography, where a region of tissue is compressed and the degree to which it distorts (known as strain) is assessed. To achieve this, ultrasound has advantages over other imaging methods, with good resolution in both space and time, and its safety allows repeated examinations, so it has emerged as the dominant technique used for elastography.

The commonest way to apply the stress is simply by pressing on the skin with a conventional transducer – the tissue only needs to be distorted

by a few millimetres. The strain can be measured by tracking the movement of the tissue and comparing single ultrasound lines (A-mode tracking) or by comparing the two-dimensional information using the rich RF or raw data that has not been heavily processed, before and after compression or continuously during repeated compression movements. In the most popular implementation, Hitachi's real-time elastography, this is done in two dimensions, which is computationally demanding but has the advantage that side slip can be monitored (as long as it remains within the scanned plane) (see Figure 1). Another measurement approach, implemented on Toshiba's Aplio, leverages two-dimensional tissue Doppler techniques to look for tissue motion (see Figure 2).

**David Cosgrove**  
MA MSc FRCP FRCR

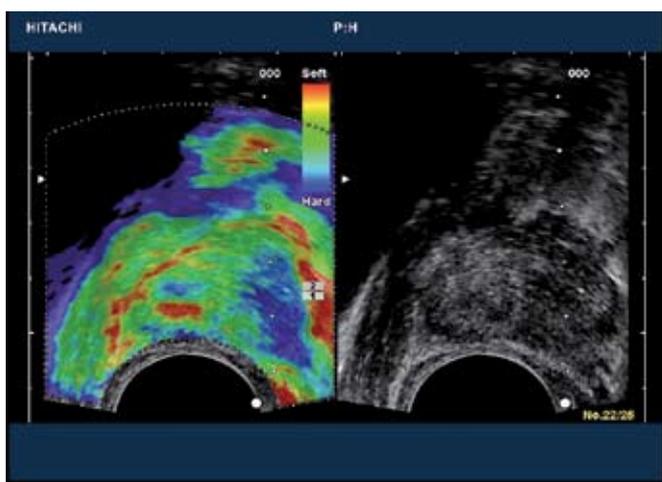
Professor

Imaging Sciences Department  
Imperial College  
Hammersmith Hospital  
London

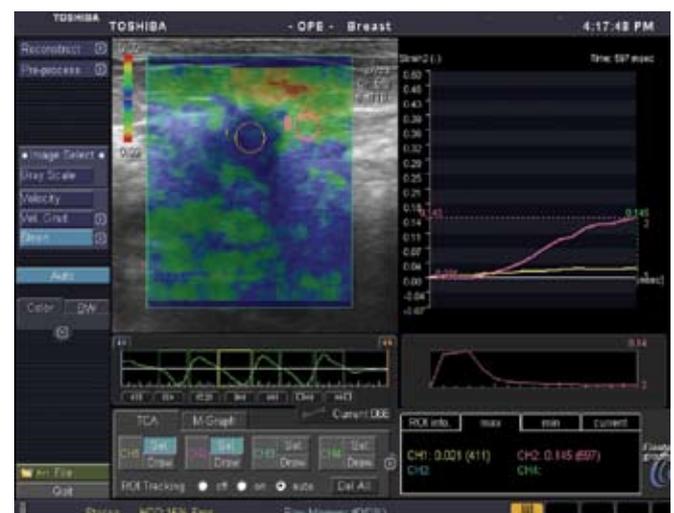


Have **your** say ...

Email us at:  
[hire-feedback@campden.com](mailto:hire-feedback@campden.com)



**Figure 1.** Prostate cancer. The right panel shows the B-mode frame of a prostate ultrasound scan with the corresponding elastography frame on the left. The colour codes blue for hard and red for soft. This hard lesion, which is not apparent on the B-mode, was a carcinoma on biopsy. This still is from a real-time sequence on the Hitachi system. (Image courtesy of Ellison Bibby, Hitachi Medical Systems)

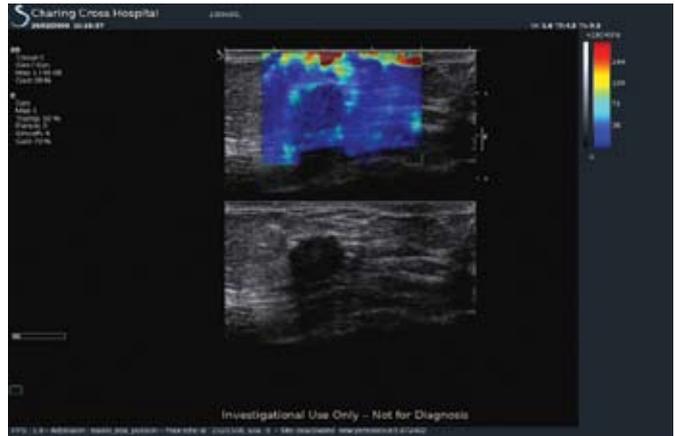


**Figure 2.** Breast mass. This carcinoma shows high stiffness, seen as red tints on the elastogram overlay at the top left. The Toshiba Aplio display includes quantification of the relative stiffness of the lesion and a chart showing the position of the frame in the compression–relaxation cycle. (Image courtesy of Dr Adrian Lim, Charing Cross Hospital, London)

# SONOELASTOGRAPHY



**Figure 3.** Fibroscan of liver. The transducer with its small piston is seen together with its screen, which displays an oblique line that corresponds to the traverse of the shear wave. Its slope relates to the shear wave velocity and is interpreted as a kPa value. (Image courtesy of Prof Simon Taylor-Robinson, St Mary's Hospital, London)



**Figure 4.** Elastogram of a breast mass. The upper pane shows the transient elastogram taken with the Supersonic Imagine Aixplorer system with stiff coded in red; a carcinoma is shown with its typical stiff halo that is larger than the B-mode image, shown in the lower pane. This still is from a real-time sequence. Quantitative kPa values are obtainable by rolling an ROI across the image. (Image courtesy of Dr William Svensson, Charing Cross Hospital, London)

A successful and ingenious way to measure tissue stiffness uses a mechanical push from a small piston to launch a compression wave into the tissue (see Figure 3). The transient distortion of the tissue generates a shear wave that travels laterally away from the line of the compression push in a three-dimensional pattern, and the minute up and down movements of the tissue are visualised by an interrogating ultrasound beam. This produces a line on the monitoring screen, the slope of which indicates the speed of movement of the shear wave, which is related to the Young's modulus of the tissue by a simple formula. Thus this device can be used to estimate the elasticity of tissue as a measure of its stiffness. It has been implemented for the liver in the Fibroscan (Echosens), where it has proved to be useful in assessing the degree of fibrosis in chronic liver diseases such as hepatitis B and C. However, it is not an imaging device and suffers from the limitation that non-uniform fibrosis causes wide variations in the measurements.

Crucial to its implementation is the fact that the push pulse generates shear waves that differ in important ways from the more familiar longitudinal compression waves that constitute ultrasound. Shear waves are analogous to the ripples on a pond's surface: the particles move up and down while the wave travels horizontally under the influence of elastic forces between adjacent particles. Acoustic shear waves travel much more slowly than longitudinal waves (1–10 m/s, compared with 1,540 m/s in tissue). They require an elastic medium to support them, so true fluids do not conduct shear waves, although very viscous fluids behave more like soft tissue.

A quite different and highly innovative approach is to use the acoustic radiation force of the ultrasound wave to push the tissue, rather like an acoustic puff of wind. This can be achieved at mechanical indices well within the FDA recommended upper limit of 1.9, and this has been implemented in the SuperSonic Imagine Aixplorer system (see Figure 4). The transient push is achieved by sending repeated focused pulses down the intended push line, each with a pulse length similar to those used for colour Doppler, and they are generated with a conventional transducer. The push pulses follow closely upon each other such that the speed of travel of the resulting push is faster than the speed of sound in tissue; this supersonic push generates a sonic shock that amplifies the effect of the push beam. The to-and-fro particle motion that is generated triggers a conical shear wave that travels sideways away from the push line. Although the conducting particles only move up and down by a few microns, this displacement can be detected by conventional ultrasound, although, as it only lasts for a few milliseconds in tissue, a special imaging mode is required to demonstrate them.

In the Aixplorer the speed of the shear wave is measured in a unique manner: it transmits a completely unfocused ultrasound field that floods the tissue so that a whole region of interest is interrogated in a single frame and the echoes are focused on receive using parallel processing. This generates the very high frame rate needed to track the shear wave (as high as 5,000 frames per second). The resulting images of the shear wave's velocity are displayed as an overlay in real time on the simultaneously acquired B-mode, much as is conventional with colour Doppler.

The measured speed of the shear wave is converted to kilopascals; measurement tools give a numerical readout that can be used to compare the kPa of areas of interest within the image.

An important benefit of generating the displacement acoustically is that it removes the need for the operator to distort the tissue manually, so it should be easier to learn and more reproducible. These advantages are indeed emerging from the initial clinical experiences and will be tested in the ongoing multinational clinical trial.

Since the system operates at such a high speed and does not require the operator to distort the tissue, it could be extended to 3D elastography, with potential advantages.

Thus the field of sonoelastography is developing rapidly with many innovative ideas that promise to translate into clinical advances. ■

## Reference

1. Sakorafas GH. Breast cancer surgery, historical evolution, current status and future perspectives. *Acta Oncologia* 2001;40:5-18.



For more elastography, visit ...  
[hospitalradiologyeurope.com](http://hospitalradiologyeurope.com)