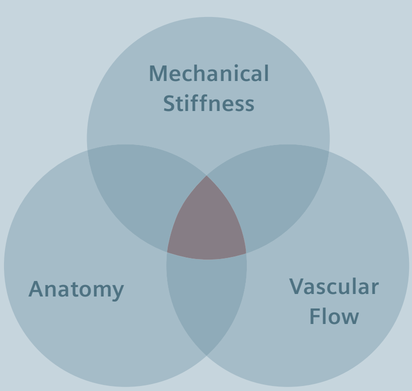
The Palpation Factor

An emerging technology, Acoustic Radiation Force Impulse imaging is expanding the use of ultrasound. At the Interdisciplinary Ultrasound Center of the University Hospital of Munich, Dirk-André Clevert, MD, explores the possibilities of tissue strain analytics and what it means for the detection, diagnosis, and treatment of liver disease.

By Andrea Röder

"An entirely new dimension of ultrasound information is provided with Acoustic Radiation Force Impulse [ARFI] imaging," says Clevert as we walk the halls of the university hospital until we get to his office near the ultrasound labs. "In addition to seeing and hearing with B-Mode and Doppler imaging, tissue strain analytics applications give us the information we only used to get from physical palpation – the age-old proven medical technique, which, however, is difficult to apply except to superficial organs and structures such as the breast or the thyroid."

Information Dimensions of Ultrasound



With tissue strain analytics, mechanical stiffness information can be combined with anatomical and vascular information to obtain a diagnosis from the intersection of these three information dimensions.

Two innovative applications that provide numerical and visual information on tissue stiffness are about to change that: Virtual Touch™ Tissue Quantification and Virtual Touch Tissue Imaging.[1] "This marks an important step in a development that will redefine how we use ultrasound in the diagnosis, treatment, and therapy of liver disease today."

Using sound waves, Virtual Touch Tissue Imaging and Virtual Touch Tissue Quantification are strain imaging applications that depict, evaluate, and measure the mechanical stiffness properties of tissue. An increase is often associated with pathology. An ultrasound push pulse is applied to a defined region of interest and the relative displacement of the tissue can be calculated. This displacement varies with the specific stiffness properties. "Stiff tissue will not be displaced as much as soft tissue, and what the system delivers is both visual and numerical information," says Clevert as we sit down in front of the ultrasound system, where he explains the technique. "This allows us to gather valuable additional parameters of diagnostic information that we didn't have before." The applications provide stiffness measurements at a depth of up to six centimeters and stiffness tissue maps at up to ten centimeters below the skin.

He shows me a screen with ten different measurements he has taken of a patient's liver. "I start by placing the region of interest about one to one-and-a-half inches below the liver capsule and then take ten separate measurements. The system calculates the average value out of those ten individual measurements," Clevert explains. "This value shows the stiffness – or softness – of the tissue, revealing information that may not yet be visible in the conventional B-Mode image."

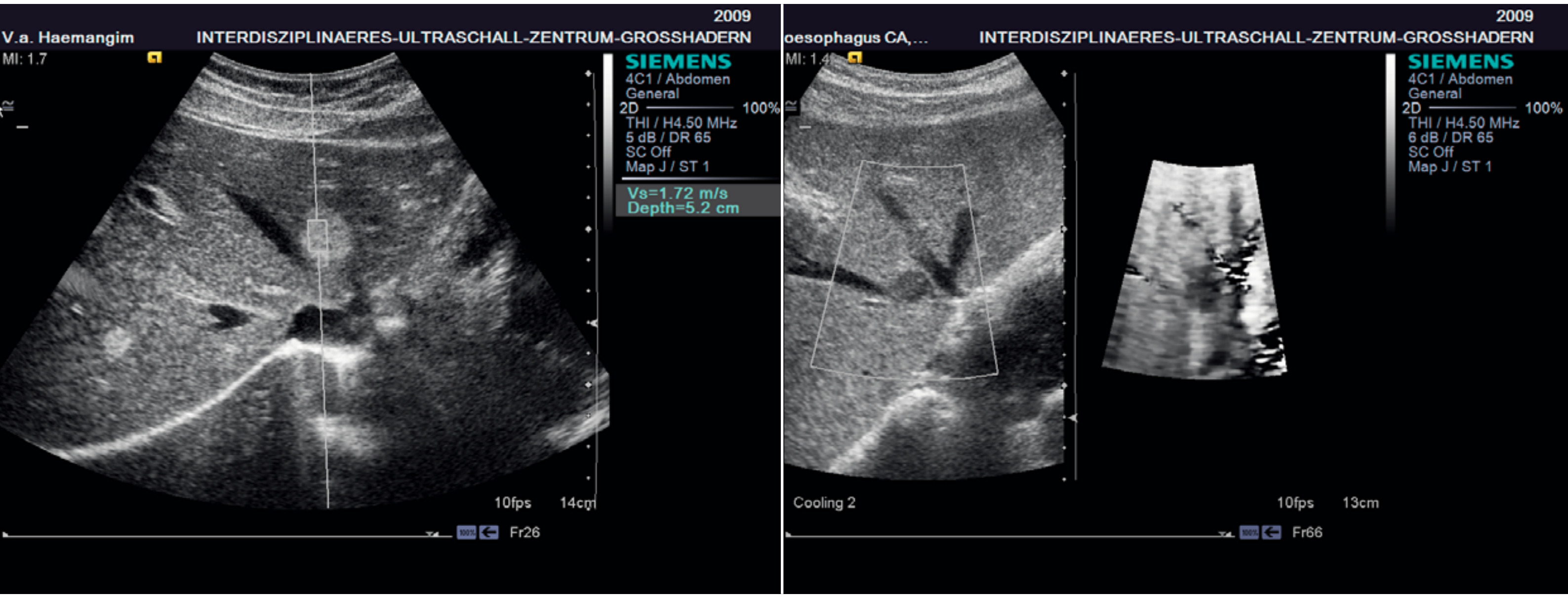
Integrating the Workflow

Clevert outlines the typical examination workflow when using tissue strain ana-

[1] Virtual Touch Tissue Quantification and Virtual Touch Tissue Imaging are not commercially available in the U.S.

Dirk-André Clevert, MD, Section Head of the Interdisciplinary Ultrasound Center at the University Hospital of Munich, Germany, considers tissue strain analytics the most important development in ultrasound technology since the advent of Doppler imaging.

lytics. A thorough exam of the liver using B-Mode and Doppler imaging provides an overall status of the liver tissue as well as blood flow in the hepatic and portal veins and other vessels. "This will tell me if there are anomalies that are signs of liver disease: fibrotic and cirrhotic changes, fluid, open vessels, general flow," he says. That accomplished, the application of Virtual Touch Tissue Quantification will reveal a numerical value that allows a classification of tissue stiffness. "And if I see a lesion in the standard B-Mode, for example, a hemangioma, with Virtual Touch Tissue Imaging I can immediately determine whether it is stiff or soft." Unlike elastography, which provides the information on the basis of manual compression, Virtual Touch Tissue applications use intelligent algorithms that automatically calculate the values.



Virtual Touch Tissue Quantification of a liver heamangioma (left) and Virtual Touch Tissue Imaging of a liver metastasis in a patient with oesophageal cancer (right)

> "In addition to visual and audio information, I can now 'virtually touch' the tissue, allowing me to determine its texture."
>
> Dirk-André Clevert, MD, Section Head, Interdisciplinary Ultrasound Center, University Hospital of Munich, Germany

At the same time, they address the challenges related to user-dependence and variability, as well as consistency and reproducibility. "That's a great advantage and an absolute prerequisite for integrating strain imaging applications into the clinical routine."

The Third Dimension of Information

According to Clevert, tissue strain analytics is the most important development in ultrasound technology since the advent of Doppler imaging. "In addition to visual and audio information, I can now 'virtually touch' the tissue, allowing me to determine its texture. In addition, Virtual Touch Tissue Quantification lets me obtain a numerical value to confirm and exactly determine what I see." For Clevert, this is a decisive advantage over conventional elastography imaging, which provides visual information only. "It takes us beyond such statements as 'a little red, a little blue,' as provided by a conventional elastogram. It gives us a numerical value related to tissue stiffness, allowing us to assess the state and development of the disease."
Visual information provided by B-Mode and Doppler ultrasound imaging is an indispensible and valuable tool in liver diagnosis today; however, it has its limitations. Often, there are no visible anomalies, but the laboratory data continue to show that something is wrong. "Virtual Touch Tissue Quantification allows us to measure whether there are abnormalities in the liver parenchyma indicating an increased stiffness of the liver before it becomes visible in the B-Mode image," says Clevert. Currently, he is participating in a study comparing the results of Virtual Touch to other established methods of defining liver stiffness. "With Virtual Touch Tissue software applications, we have a very reliable and fast tool to assess tissue stiffness, which gives us the additional advantage of being able to see what we are doing. By combining numerical values with the visual ultrasound information of the tissue and flow, we can make sure that we have really assessed it all." In addition, Virtual Touch Tissue applications can be used for a wide variety of patients, including those with advanced ascites or distinct portal hypertension.

Therapy Control

Determining the stiffness of the liver will be increasingly requested by referring physicians. "Virtual Touch tissue analytics helps us detect anomalies in the liver at a very early stage, when we haven't seen anything on standard ultrasound yet.

Virtual Touch Tissue applications use intelligent algorithms that automatically calculate tissue stiffness values and reduce user-dependence and variability.

At a Glance

Tissue strain analytics comprises a suite of applications offering a new dimension of information: mechanical strain properties of tissue. These applications provide visual and numerical data not available using conventional sonographic imaging.

Three applications are currently available:

- eSie Touch™ elasticity imaging uses gentle compression to obtain a high-resolution elastogram.
- Virtual Touch™ Tissue Imaging allows clinicians to create a relative stiffness map (elastogram) for any region of interest.
- Virtual Touch Tissue Quantification is the first and only application to provide a numerical value of shear-wave speed related to tissue stiffness at a precise anatomical location.

It tells us whether the liver is fibrotic or cirrhotic." At Clevert's lab, the technology is also used to determine the success of Interferon therapy used to treat chronic and acute Hepatitis C. "The therapy with Interferon is expensive; however, not all patients respond and it can have adverse effects. Virtual Touch tissue analytics lets us monitor the success of the treatment and change gear if necessary."

Clevert thinks that tissue strain analytics will be implemented in the clinical routine in the near future. He says that an experienced user can make the measurements in less than three minutes. "Who wouldn't want to make use of the additional information if it can be obtained so fast and in such an uncomplicated manner?" He and a team of researchers have recently published the results of a study investigating the use of ARFI and contrast-enhanced ultrasound to classify unclear renal tumors. "Both techniques are complimentary. We were able to characterize and visualize unclear renal masses." As research for other applications continues, so does the integration of ARFI into higher and lower frequency range transducers. "This is a great application, and expanding its use will benefit all, patients and physicians alike."

Summary

Challenge:

- Clarify inconclusive laboratory findings
- Obtain information regarding the mechanical stiffness properties of tissue

Solution:

- Tissue strain analytics provides a new dimension of diagnostic information through qualitative or quantitative measurements of the mechanical stiffness of tissue

Result:

- Enables early detection of liver disease
- Greyscale image presents a map of regions and localized areas that shows relative stiffness in the tissue
- Virtual Touch applications together with conventional sonographic scans may enable physicians to avoid unnecessary biopsies
- Numeric value provides a good understanding of the general condition of the tissue
- Excellent means of therapy control

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Further Information

www.siemens.com/strain