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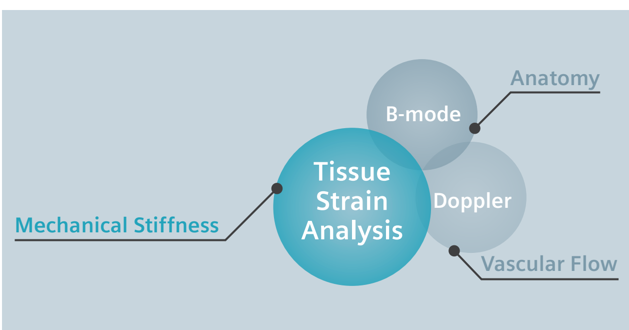
Acoustic Radiation Force Impulse and Shear Wave Detection Imaging in the Liver

Answers for life.

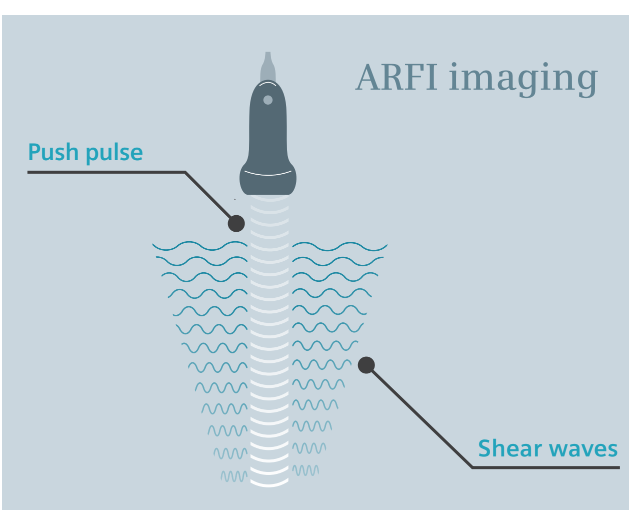
The Palpation Factor

New technologies in ultrasound elastography imaging, including Acoustic Radiation Force Impulse (ARFI) and shear wave detection imaging, are providing a new dimension of diagnostic information for physicians. At the Interdisciplinary Ultrasound Center of Germany's Munich University Hospital, Professor Dirk-André Clevert, MD, explores the possibilities of these new technologies and what they mean for the detection, diagnosis, and treatment of liver disease.

By Andrea McMurray



Tissue strain analysis provides a new dimension of diagnostic information from ultrasound technologies.



ARFI works almost like physical compression, but can penetrate deeper tissue. A push pulse generates lateral shear waves. The speed of shear waves is closely correlated to stiffness and can be accurately measured with new technologies. The ability to exactly measure the shear waves improves the consistency of exams.

"An entirely new dimension of information from ultrasound is provided through elastography, or tissue strain imaging," says Professor Dirk Clevert. "In addition to "seeing" and "hearing" with ultrasound using B-mode and Doppler ultrasound imaging, ultrasound elastography adds the "tactile" part, allowing us to obtain information about the mechanical stiffness of tissue. In the past, we were only able get this information via physical palpation – the age-old proven medical technique that has been used by physicians for over a thousand years."

Palpation requires a lot of experience, even when used in superficial organs and structures, as for example the breast or the thyroid. It is very difficult, if not impossible to be applied with confidence in deeper regions of the body. The advent of new ultrasound elastography technologies is about to change that: Siemens' new suite of Virtual Touch™ tissue strain analysis applications provides both qualitative and quantitative information about the stiffness of tissue, including deep abdominal tissue such as the liver.

This marks an important step in the development of elastography that has the potential to redefine how we use ultrasound in the diagnosis, treatment, and therapy of liver disease today.

How it Works

Unlike traditional, manual-compression ultrasound elastography, which has been around for several years now, Siemens' new Virtual Touch™ tissue strain analysis technologies use sound waves to compress tissue, a method known as Acoustic Radiation Force Impulse (ARFI) imaging. ARFI applies an ultrasound push pulse to a defined region of interest that causes displacement of the respective tissue. The extent of displacement and/or compression varies with the specific stiffness properties of different tissues: Stiff tissue will not be displaced/compressed as much as soft tissue.

“In addition to visual and audio information, I can now ‘virtually touch’ the tissue, allowing me to determine its texture.”

Professor 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.

The compression of tissue using ARFI push pulses generates shear waves that propagate perpendicularly to the push wave. An advanced, proprietary algorithm measures the velocity of these shear waves which correlates with the stiffness of tissue at a defined region of interest.

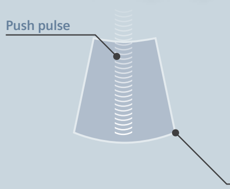
Virtual Touch tissue strain analysis offers both ARFI and shear wave imaging capabilities that allow the assessment of tissue stiffness.

There are three different Virtual Touch technologies:

- Virtual Touch™ imaging produces a qualitative elastogram that is more detailed and reproducible than a conventional, manual-compression elastogram.
- Virtual Touch™ quantification offers quantitative results by measuring the velocity of shear waves that are produced through push pulse compression.

Virtual Touch
imaging

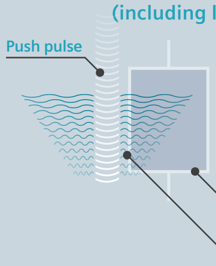
Virtual Touch™ imaging is indicated for assessment of tissue stiffness in abdominal and small parts (breast, thyroid, testes, etc.).



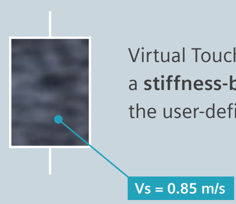
Virtual Touch™ imaging uses a push pulse and **creates a more detailed and reproducible qualitative elastogram** than is possible with manual compression elastography.

Virtual Touch
quantification

Virtual Touch™ quantification is indicated for assessment of tissue stiffness in abdominal (including liver) and small parts.



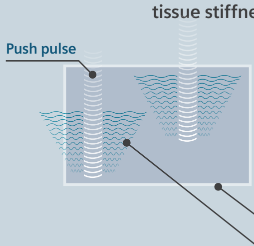
A push pulse generates lateral shear waves through the region of interest, and **the technology measures the speed of the shear waves.**



Virtual Touch quantification provides a **stiffness-based measurement** for the user-defined area of interest.

Virtual Touch
IQ

Virtual Touch™ IQ is indicated for assessment of tissue stiffness in small parts (breasts, thyroid, etc.).



A series of push pulses generates measurable shear waves across a region of interest so the **technology can combine imaging and quantification on a single screen.**

Virtual Touch IQ features unique, high-sample pulse sequences so you can **assess lesions as small as 3 millimeters.**

- Virtual Touch™ IQ combines compression imaging and shear wave measurements on a single screen, allowing both the qualitative and quantitative assessment of tissue.

"These new technologies allow us to gather valuable additional parameters of diagnostic information that we didn't have before," says Clevert.

The applications provide stiffness measurements at a depth of up to 8 centimeters and stiffness tissue maps at up to ten centimeters below the skin.

Integrating the Workflow

Clevert outlines the typical examination workflow when using tissue strain analysis. 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 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 imaging I can immediately determine whether it is stiff or soft."

Unlike conventional elastography, which provides the information on the basis of manual compression, Virtual Touch technologies use intelligent algorithms that automatically calculate the values. 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 these applications into the clinical routine."

The Third Dimension of Information

According to Clevert, tissue strain analysis 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 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

A

Virtual Touch™ imaging
Stiff Lesion in Patient With History of Colorectal Carcinoma

Courtesy of Dr. Dirk-André Clevert – Munich, Germany

A: Virtual Touch imaging delivers a qualitative assessment of tissue.

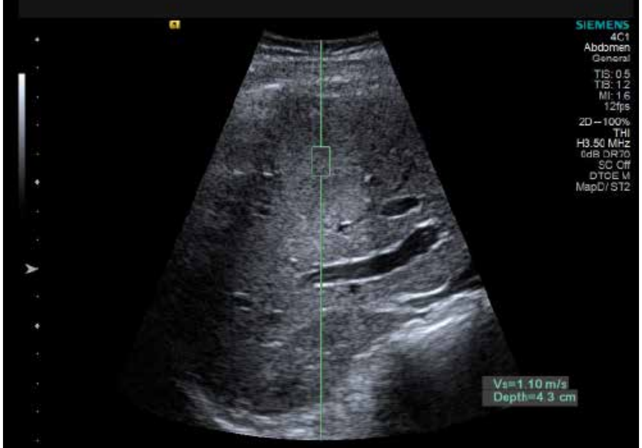
B: Virtual Touch quantification shows a shear wave velocity of 0.70 m/s in the tissue surrounding the hemangioma.

C: Inside the hemangioma, the shear wave velocity is clearly increased at 1.10 m/s.

B

Virtual Touch™ quantification
Normal Liver Tissue

C



Virtual Touch™ quantification
Liver Hemangioma

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. It is the increased stiffness as compared to the stiffness of a normal liver that adds the information to help with the diagnosis of abnormality," says Clevert. "With Virtual Touch applications, we have a very reliable and fast tool to assess tissue stiffness with 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 technologies 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 analysis helps us detect anomalies in the liver at a very early stage, when we haven't seen anything on standard ultrasound yet. 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 strain analysis lets us monitor the success of the treatment and change gear if necessary."

Clevert thinks that tissue strain analysis 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?" As the areas of use for ARFI and shear wave detection imaging expand, they will be integrated into a broader range of transducers. "These are great applications, and expanding their use will benefit all, patients and physicians alike."

Andrea McMurray is responsible for the customer testimonial program at Siemens Healthcare's Ultrasound Business Unit headquarters in Mountain View, California, USA.

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