

PHILIPS

Ultrasound

ElastQ Imaging

Introducing next-generation **shear wave elastography**

Philips ElastQ Imaging

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Tissue stiffness has long provided important information about disease or lack of it. Physicians have used palpation for centuries, noting that abnormal tissue is often more stiff than healthy tissue. Elastography is a way to visualize, record and report tissue stiffness parameters.

Philips ElastPQ, which features ultrasound shear wave point quantification, brought significant advances to elastography. Now, the introduction of shear wave Philips ElastQ Imaging provides real-time feedback, greater confidence in quantification, and speed to advance the use of elastography in clinical practice. It is the only solution to offer both PureWave technology and real-time shear wave imaging across abdominal applications. Compared with ElastPQ, ElastQ Imaging is twice as fast to perform and also increases confidence in the reliability of results.

The importance of liver assessment

Accurately staging the degree of liver fibrosis is essential in determining if antiviral therapy is appropriate, and to predict treatment outcome and potential for malignancy. With current drug therapy, early-stage fibrosis may be reversible.¹

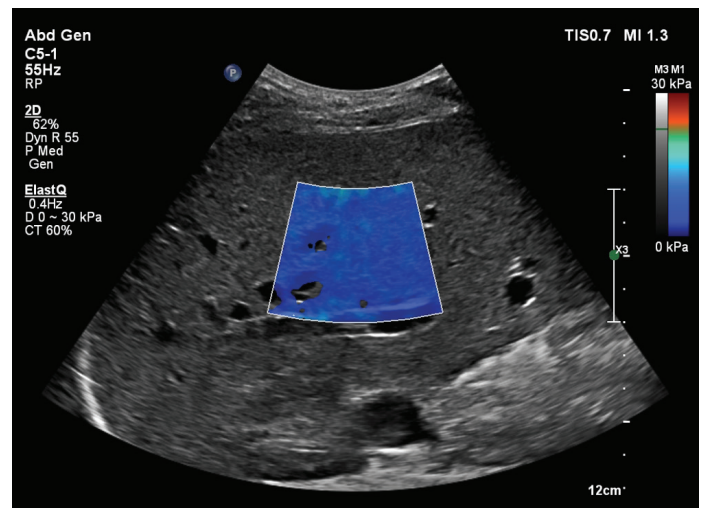
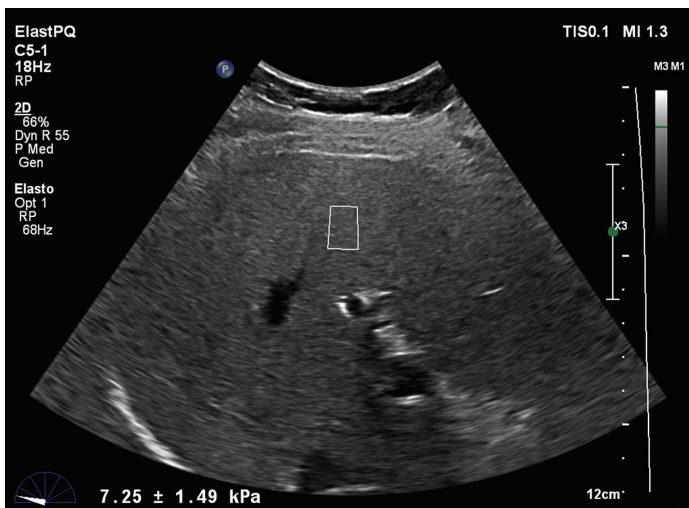
Elastography in liver assessment

ElastPQ has proven valuable in staging liver disease, reducing the need for costly and potentially painful biopsies in some patients. ElastQ Imaging advances shear wave elastography, providing a technique that is not only noninvasive and easy to use, but also offers clinicians additional confidence in the reliability of measurements, even for the technically difficult patient (TDP), such as a patient with a high BMI.

Quantitative vs qualitative assessment

Shear wave elastography with ultrasound differs from transient elastography initiated by mechanical stimulus, and also by the user compression or physiological motion of strain imaging. While strain imaging can offer a qualitative assessment of tissue stiffness, techniques using acoustic radiation force impulse (ARFI) such as shear wave point

quantification (ElastPQ) and shear wave imaging (ElastQ Imaging) provide a quantitative assessment of tissue stiffness. Shear wave elastography uses ARFI to “push” tissue, causing it to move by a few micrometers. This movement generates a transverse (shear) wave that moves more slowly in soft tissue and more rapidly in tissue that is stiffer.



Unlike ElastPQ, ElastQ Imaging features a large, resizable, color-coded Region of Interest that provides quantitative stiffness analysis.

ElastQ Imaging

Available on the Philips EPIQ ultrasound system, ElastQ Imaging features an adjustable large Region of Interest (ROI) for quantitative assessment of tissue stiffness. With EPIQ **n**SIGHT Imaging,² the custom precision beamforming and massive parallel processing architecture is leveraged to create detailed images of stiffness in real time. With ElastQ Imaging, a color-coded stiffness/velocity map allows the assessment of liver tissue stiffness using real-time feedback and through quantitative measurements with sample points for accurate and reproducible stiffness results. While the shear wave point quantification of ElastPQ features multiple pulses at a single location, ElastQ Imaging pushes multiple pulses at many locations.

ElastQ Imaging has eight configurable options for individual stiffness sampling. Measurements are in kPa (pressure) and m/s (velocity). A unique confidence map uses intelligent analysis to highlight areas of optimal shear wave propagation for improved measurement placement and increased clinical confidence. Post-acquisition tools include the ability to make retrospective measurements on stored loops and single-frame images.

ElastQ Imaging measurement flexibility

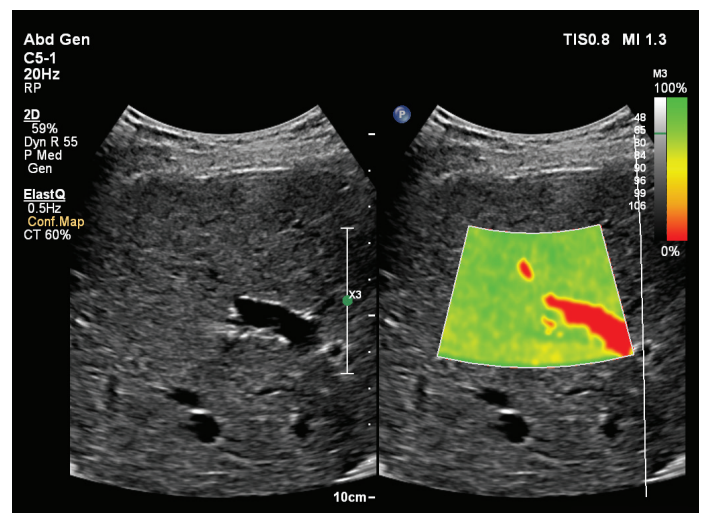
Every color pixel displayed within the ElastQ Imaging ROI has a discrete value. These values can be assessed pixel by pixel, but most likely a small circular area will be selected to produce a small sample average within the ROI. Users also have the option to define an irregular area to average as well. For every patient, multiple samples are typically acquired for a robust evaluation of liver stiffness. Also available is the selection of the “measure average region stiffness” (MARS) capability that allows a simple one-click measurement of stiffness in the entire color ROI for a quick liver fibrosis exam.

Sampling strategy

When using ElastPQ, multiple samples are taken in the same location, replicating biopsy sampling. With ElastQ Imaging, acquiring up to ten samples on five different but consistent frames across multiple cine-loops of the right lobe of the liver is recommended for optimal interrogation of overall tissue stiffness. B-mode frame rate of 20 to 30 fps allows for survey in real time to identify the ideal plane for stiffness measurement.

ElastQ Imaging confidence map

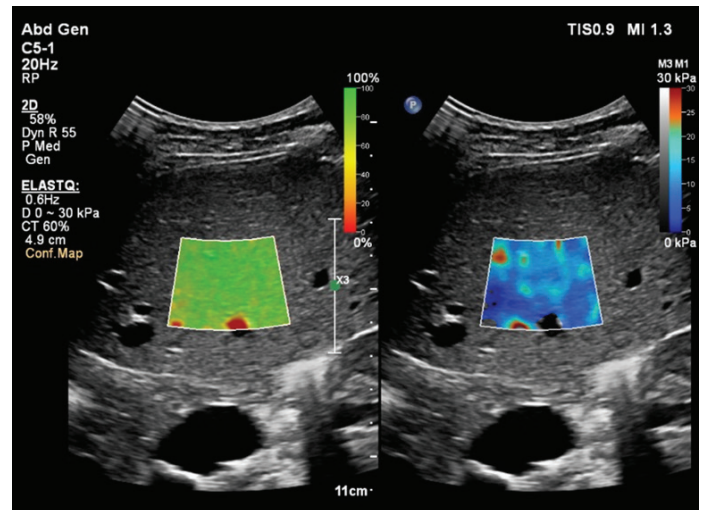
Because ElastQ Imaging provides a large color-coded map in real time, the ROI represents a greater area to assess changes in tissues stiffness. Discrete readings can be acquired anywhere within the ROI, enhancing confidence in the reliability of measurements. When performing ElastQ Imaging, a confidence map is also generated within the ROI using smart analysis of echo and shear wave signals. The color-coded confidence map reflects a value for each pixel, providing an indication of quality across the stiffness value map. This assists the user in obtaining measurements from the areas with the highest shear wave quality.



The amount of green in this ElastQ Imaging confidence map demonstrates that the stiffness value is highly reliable.

Every pixel in the ROI is assigned a confidence value from 0 to 100 and a corresponding color between red and green. Low values (red) indicate that the stiffness value for a given pixel is less reliable. High values (green) indicated that the stiffness value for a given pixel is more reliable.

Several factors can lower the confidence value: tissue areas with blood flow (vessels), low echogenicity (such as the gallbladder), low shear wave strength (as when scanning deep in the TDP), or with large tissue motion (as with no breath pause). The confidence map reflects shear waves strengths but may not detect ultrasound artifacts such as reverberation and rib shadowing artifacts.

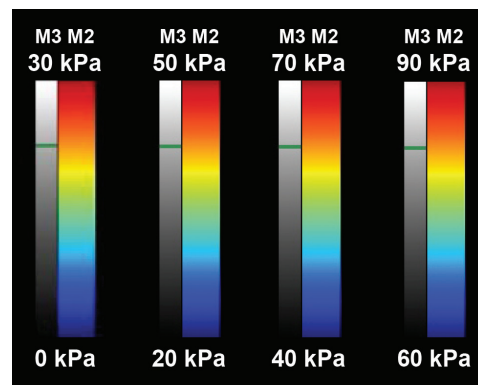


Intelligent analysis highlights areas of optimal shear wave propagation for improved measurement placement and increased clinical confidence.

Selecting ElastQ Imaging stiffness value ranges

ElastQ Imaging allows a maximum stiffness value to be selected and displayed using various ranges on the color map. Tracking pulses are then optimized for that stiffness value. Selecting a color map with the stiffness value near the map's maximum value will optimize tracking pulses to provide measurements with greater accuracy. For example, shear waves travel more slowly in softer tissue and so the stiffness might be set to 8 kPa. Shear waves travel faster in stiffer tissue, and so the maximum value might be set to 32 kPa.

To optimize tracking pulses and provide more accurate values, a color map with the stiffness value near the maximum value of the color map is selected. For example, if performing a liver stiffness measurement with the default map of 30 kPa yields a value of 40 kPa, the 20 kPa to 50 kPa map is then selected and measurements repeated.



ElastQ Imaging offers four scale choices for tissue stiffness.

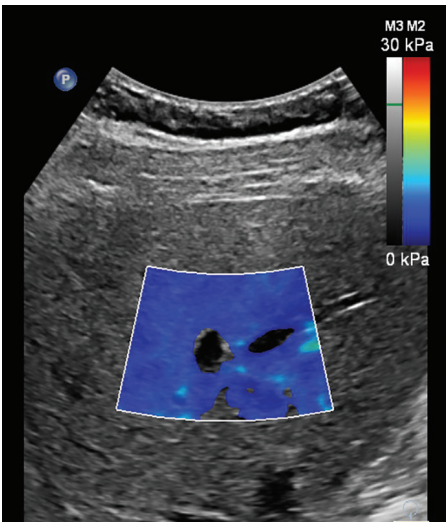
IQR and IQR/median

Interquartile range (IQR) is the spread of 50% of the measurements around the median and is the best measure of how much variability there is in the technique. IQR/Med is an effective way to access the quality of multiple sampling calipers (at least five) that have been collected in kPa. If the IQR/Med is <30%, the measurements in kPa are consistent.

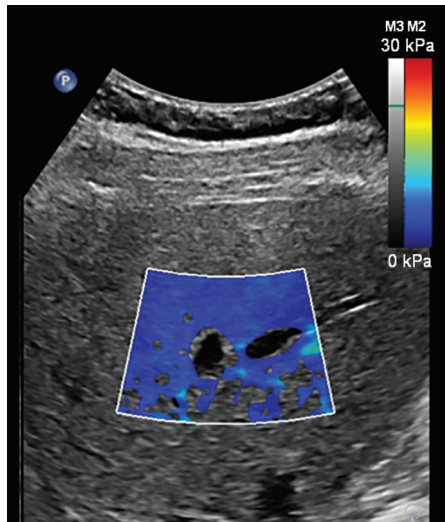
Using the confidence threshold

The confidence threshold sets those areas of a stiffness/velocity image with lower confidence as transparent. For example, setting the confidence threshold to 60% will set areas of a stiffness/velocity image with a confidence value of less than 60% as transparent. The transparent areas will not be measured. Changing the confidence threshold will not change the confidence map.

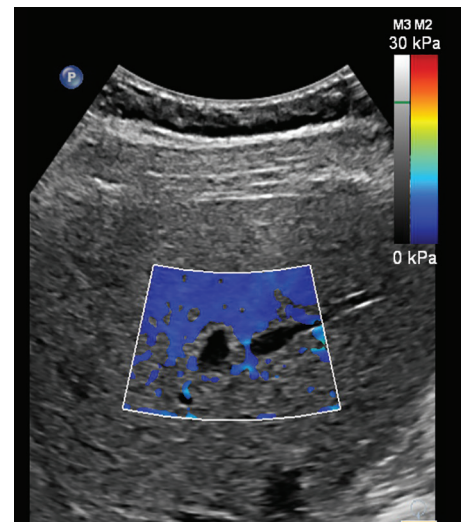
Adjusting the confidence threshold



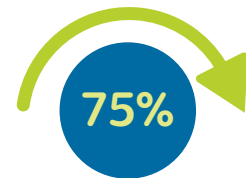
Confidence threshold



Confidence threshold

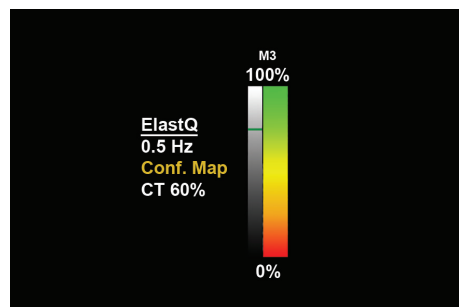


Confidence threshold

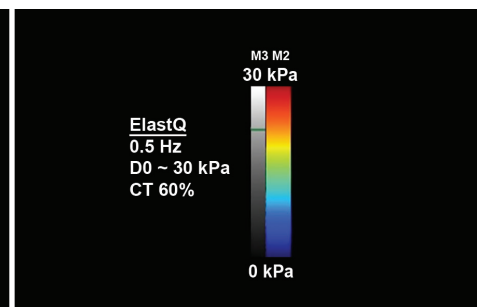


Use of the confidence map can enhance the exam if the scan technique is proficient, but it cannot overcome suboptimal scanning technique. Examples of suboptimal scanning technique are placing the ROI and taking measurements within 1.5 cm of Gleason's capsule (producing a reverberation artifact) or placing the ROI on the edge of a rib or lung shadow.

ElastQ Imaging makes it easy to display the stiffness and confidence maps side-by-side.



Confidence map



Stiffness map

Effectively using ElastQ Imaging³

Patient's preparation

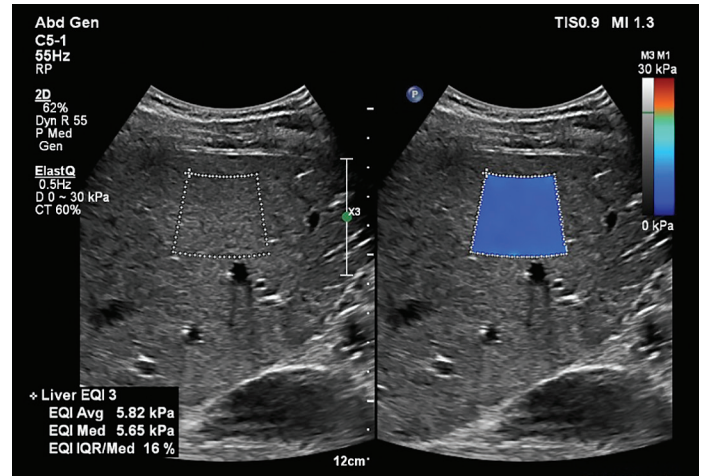
- Fast for at least six hours prior to the examination
- Supine or left lateral oblique decubitus position with the right arm in maximal extension

Acquiring the ElastQ Imaging data:

- Ensure good transducer contact with adequate gel
- Position the transducer in the right intercostal space and aligned with the ribs
- Image liver segment 7 or 8, keeping the liver capsule parallel to the transducer surface
- Position the ROI box in the center of the image and 1.5-2 cm below the liver capsule
- Do not place the ROI box on or near a rib shadow or the liver capsule
- Ask the patient to pause breathing in a relaxed manner, rather than taking and holding a deep breath
- Wait for a stable image
- Acquire a cine loop with a minimum of six-second length

Optimal sampling caliper placement:

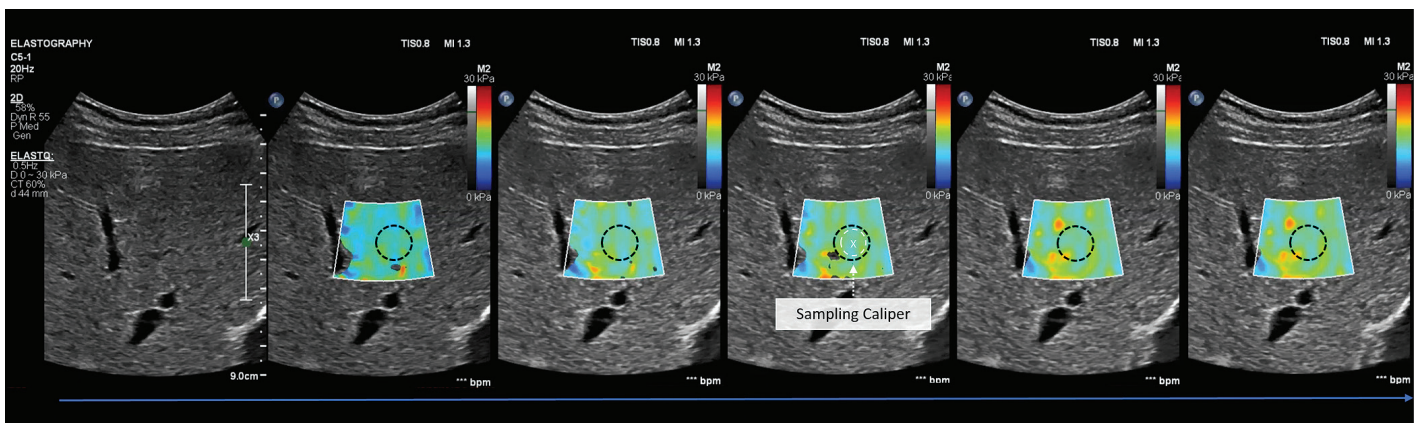
- Review cine loop to identify frames where the tissue is stable and the color-coded stiffness/velocity map is consistent
- Measure areas of most representative color(s) that change the least over time
- Avoid measuring over rib shadows or areas near blood vessels
- Verify that the calipers are placed in areas with high confidence (green on the confidence map)
- Take no more than two measurements on one frame per cine loop acquisition



Sampling a normal liver using an average of the entire Region of Interest.

Summary of liver stiffness results

- For a reliable evaluation of liver stiffness, measurements should be acquired from multiple cine loops of the right lobe
- For each cine loop, pick a single frame where no more than 2 calipers should be placed
- Once at least five calipers on five different frames have been acquired:
 - Refer to the median across the sampling calipers (it eliminates the outliers)
 - Refer to the IQR/median as a quality criterion for measurements in kPa.



A review of multiple frames from a single cine loop acquisition for an optimal sampling caliper placement.

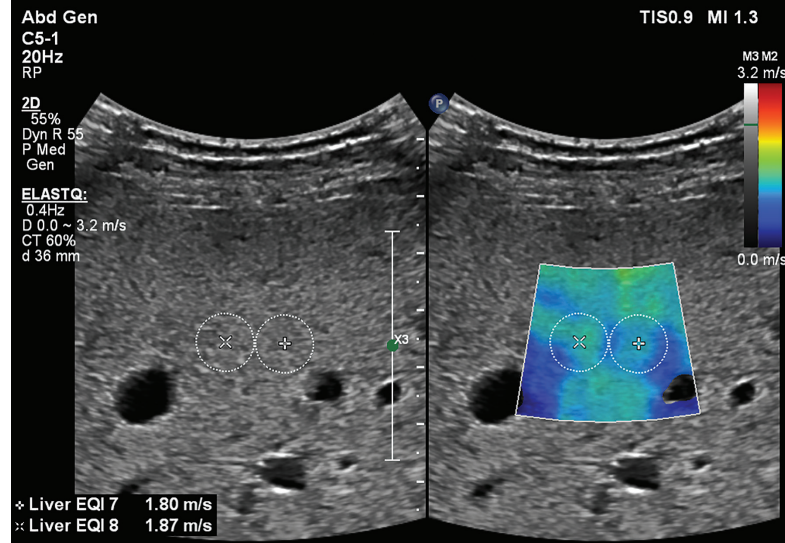
Generating a report

The post-acquisition tools and quantification of ElastQ Imaging allow adjustment of the overlay, blending and confidence thresholds in review.

EQI Liver Stiffness Calculations	
Liver EQI Avg	4.15 kPa
Liver EQI Med	3.39 kPa
Liver EQI IQR/Med	27 %
Liver EQI IQR	0.91 kPa
Liver EQI Std	2.62 kPa
Liver EQI Avg Vel	1.13 m/s
Liver EQI Med Vel	1.05 m/s
Liver EQI IQR/Med Vel	13 %
Liver EQI IQR Vel	0.14 m/s
Liver EQI Std Vel	0.31 m/s

EQI Liver Stiffness Measurements							
	EQI Avg	EQI Std	EQI Med	EQI IQR	EQI IQR/Med	EQI Max	Conf. Threshold
Liver EQI 1	5.53 kPa	2.07 kPa	5.12 kPa	2.12 kPa	41 %	11.1 kPa	60 %
Liver EQI 2	11.6 kPa	0.441 kPa	11.6 kPa	0.706 kPa	6 %	12.5 kPa	0 %
Liver EQI 3	3.36 kPa	1.19 kPa	3.00 kPa	1.41 kPa	47 %	7.94 kPa	60 %
Liver EQI 4	2.69 kPa	0.567 kPa	2.65 kPa	1.06 kPa	40 %	4.24 kPa	60 %
Liver EQI 5	3.58 kPa	1.23 kPa	3.35 kPa	1.50 kPa	45 %	7.41 kPa	60 %
Liver EQI 6	3.60 kPa	1.48 kPa	3.00 kPa	1.85 kPa	62 %	9.35 kPa	60 %
Liver EQI 7	3.42 kPa	0.766 kPa	3.35 kPa	1.06 kPa	32 %	5.29 kPa	60 %
Liver EQI 8	2.68 kPa	0.418 kPa	2.65 kPa	0.706 kPa	27 %	3.88 kPa	60 %

Samples obtained using ElastQ Imaging can be stored and displayed as a report. Up to ten samples can be stored and displayed as individual results. A running average is displayed as separate result.



ElastQ Imaging at a glance

- ROI of 6 cm x 5 cm allows for a robust estimate of liver stiffness, as well as confident visualization and comparison of stiffness between large tumors and normal tissue
- B-mode frame rate of 20 to 30 fps provides a real-time survey to identify the ideal plane for stiffness measurement
- Real-time shear wave confidence map offers smart analysis of shear wave fidelity at every pixel
- Every stiffness image has a corresponding confidence image
- The measure average region stiffness (MARS) capability offers one-click measurement of stiffness in the entire color box, and allows for a quick liver stiffness assessment
- Post-acquisition tools and quantification capability allow for calculation of new stiffness measurements on stored cine-loops after the patient visit or on images retrieved from a PACS

An evolution that's more of a revolution

The Philips EPIQ ultrasound system offers an ultimate ultrasound solution for liver assessment, treatment planning and monitoring.

- ElastQ Imaging harnesses the power of *n*SIGHT Imaging to bring real-time shear wave elastography to ultrasound for definitive tissue stiffness data

- PureWave transducer technology offers exceptional liver imaging, even on challenging patients
- Contrast-enhanced ultrasound provides superb liver tissue flow analysis
- Image fusion and navigation to allow for fast clinical decisions and advanced treatment planning

1. Sohrabpour AA, Mohamadnejad M, Malekzadeh R. The Reversibility of Cirrhosis. *Aliment Pharmacol Ther.* 2012;36(9):824-832.
 2. Thiele K, Jago J, Entekin R, and Peterson R. Exploring *n*SIGHT Imaging – a totally new architecture for premium ultrasound. Philips White Paper, 452296295791, SEP 2013. (www.usa.philips.com/healthcare/resources/feature-detail/nsight)
 3. EFSUMB, SRU and WFUMB guidelines, 2017.

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