PHILIPS

Precision Diagnosis

Expert Perspectives

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Quantifying liver fat with ultrasound

Linked strongly with obesity, non-alcoholic fatty liver disease (NAFLD) is a significant health problem worldwide, affecting as many as one billion individuals.[1] Current reference standards for diagnosing and measuring NAFLD – liver biopsy and MRI – are impractical for various reasons. The emerging technique of ultrasound attenuation imaging could be helpful in screening for NAFLD. The method is non-invasive and can be done in less than three minutes with good technique.[2]

In Western countries, non-alcoholic fatty liver disease (NAFLD) has become the most common liver disorder, with a worldwide prevalence of about 25 percent.[3] The incidence of NAFLD tracks with obesity, which has increased dramatically in the United States to a point at which nearly half the states have obesity rates greater than 35 percent.[4] Globally, obesity has nearly tripled since 1975[5] and according to the World Health Organization (WHO), more than 1.9 billion adults 18 years of age and older were overweight, with over 650 million classified as obese.

Obesity and Type 2 diabetes increase the risk of NALFD, which can progress in a positive feedback loop via inflammatory processes to non-alcoholic steatohepatitis (NASH), leading to fibrosis and eventually cirrhosis, hepatocellular carcinoma and liver failure.[6] NAFLD has also been associated with heart attacks, stroke, complications from diabetes and negative outcomes in pregnancy and some surgeries.[7]

Ultrasound emerging as liver fat quantification (LFQ) tool

Continued developments in ultrasound technology are allowing clinicians to detect and stage liver disease earlier in its progression.[8] Ultrasound techniques such as elastography[9] have proven useful in quantifying fibrosis and cirrhosis, and a relatively new ultrasound technique called attenuation imaging has been developed to detect and quantify liver fat in NAFLD.

What is attenuation imaging?

Attenuation is the rate at which sound is absorbed when propagating in tissue. Sound will propagate more deeply when subjected to a lower attenuation coefficient. For example, murky water (left) has higher attenuation than clean water (right), thereby blocking light transmission. Fatty inclusions in the liver increase attenuation. Fatty livers normally appear bright and are highly absorbing.

Attenuation imaging is based on the principle of ultrasound attenuation, the measure of how much sound is absorbed as it propagates through the liver parenchyma. It essentially calculates the attenuation coefficient (i.e., the rate of amplitude loss) as the pulse travels through tissue. The presence of fat in the hepatic tissue raises the attenuation and therefore reduces the received signal amplitude more than comparable hepatic tissue without fat infiltration. Mathematically, the attenuation coefficient (AC) is the loss of amplitude in decibels per distance traveled in centimeters for a given frequency in megahertz (dB/cm/MHz).

Attenuation imaging at Southwoods Imaging

For more than a year, Dr. Richard G. Barr, a leading ultrasound expert, has been performing attenuation imaging on a research basis for about five patients a day, those whose doctor has requested diagnostic liver tests. For some of these patients, referring physicians will also request elastography to obtain a measure of liver stiffness. Both attenuation imaging and elastography can be done during the same ultrasound examination, with the patient in the same position and using the same transducer.

Patients are typically referred to Southwoods Imaging by hepatologists and less frequently by family practice or internal medicine physicians requesting ultrasound studies to determine the cause of right upper quadrant pain and abnormal liver function tests. In the past, Dr. Barr observes that he was only able to give a qualitative assessment of liver fat.

“Now that there is a quantitative way of measuring liver fat, it will make it a lot easier for us to let the referring physician know where the patient is quantitatively on the NAFLD spectrum,” he says. “Traditional gray scale imaging could provide only a rough estimate. We could tell if the liver had a high degree of fatty infiltration or if it was normal, but it was very hard to assess whether fatty liver disease was mild, moderate or severe. Attenuation imaging gives us a numerical value that will enable us to follow the patient over time.”

“We need to intervene with these individuals before NAFLD turns into NASH*, because once that stage is reached they could develop cirrhosis, hepatocellular carcinoma and or liver failure,” he says. “One of our patients who was told she had NASH lost 70 pounds in seven months. She returned, and her liver was completely normal. Her hepatologist didn’t believe that she had a normal liver, so a liver biopsy was performed and the test came back totally normal with no steatosis – suggesting that dietary changes can rapidly change the degree of fat in the liver.”

Performing attenuation imaging

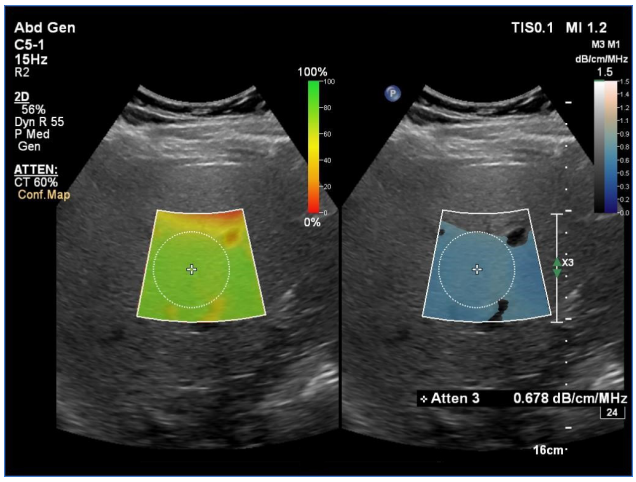
Dr. Richard G. Barr
Southwoods Imaging (Boardman, Ohio)

Dr. Barr follows Society of Radiologists in Ultrasound (SRU) guidelines for liver elastography to acquire attenuation measurements. The transducer (e.g., C5-1 PureWave curved abdominal) is positioned perpendicular to the liver targeting the right lobe with an intercostal approach. The examination should be performed in mid breath-hold if liver stiffness values are also being acquired. Liver stiffness measurements are taken, then in the same window, attenuation measurements are acquired. In less than a minute of scanning time, the clinician can obtain a significant amount of information about the patient.

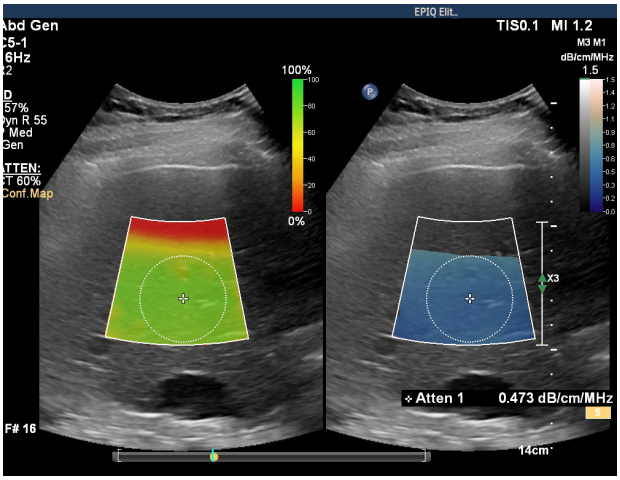
"We always look for reverberation and other artifacts, and often we may have to place the region of interest in a different location – a little deeper than we do for liver stiffness values," Dr. Barr notes. "After the five measurements, we calculate the interquartile range (IQR)/median, which some experts suggest should be maintained below 10 to 15 percent."

On a technical note, the size and placement of the measurement box is important in determining the placement of the ROI – as it is well known that reverberation artifact is present up to two centimeters below the liver capsule and should be avoided.[10-11] The Philips attenuation tool features a color-coded confidence map that enables the user to place the ROI in artifact-free areas. The attenuation overlay is shown only when the estimates exceed a confidence threshold of > 60 percent, allowing the exclusion of vessels, shadows and other artifacts.

"The confidence map is useful to help you avoid taking measurements in areas where there are artifacts," Dr. Barr says.



A patient with NAFLD demonstrating the use of the Confidence Map to indicate where to place the ROI for performing attenuation imaging.



Normal liver as depicted with attenuation imaging. The Confidence Map shows where to position the ROI.

Changes between repeat scans

Dr. Barr stresses that the goal in attenuation imaging is not necessarily to identify a cut-off value between mild and moderate steatosis, but rather to observe changes between successive scans.

"What we need is a value of what's considered a 'normal,' liver, so we basically want to pick out those patients who have greater than five percent liver fat, which would put them in the category of 'liver steatosis,'" he says. "These are the people we want to monitor to see if their condition is getting worse or better."

In all, Dr. Barr's center has used attenuation imaging on over 200 patients, including more than 100 patients who were part of a retrospective study[12] of chronic liver disease by multiparametric ultrasound, which encompassed attenuation imaging and shear wave imaging. The study concluded that the widespread use of attenuation imaging among the general population could be very useful in screening for advanced chronic liver disease.

> "In our practice, almost 50 percent of the patients for whom we do a liver ultrasound have some degree of fatty infiltration of the liver. With the combination of quantitative fat liver assessment via attenuation imaging and liver stiffness through elastography, the probability of NASH can be better assessed."

Dr. Richard G. Barr

Going forward

As attenuation imaging is an emerging technique, it is not yet reimbursed in the United States; the American Medical Association has issued a Category III CPT code starting in January 2022.

"In the USA, Medicare tracks the use of the Category III code," Dr. Barr observes. "As increasing numbers of clinicians recognize the value of attenuation imaging and begin using it clinically across the country, the technique should ultimately receive a Category I CPT code, which is reimbursable. Once that happens, we will absolutely make it part of our routine abdomen exam – either a limited right upper quadrant study or a complete exam."

x2

Data from 1988 to 2008 show that NAFLD has doubled in the USA during that time period.[13]

Global prevalence among the general population may be as a high as

ONE BILLION[1]

Characterized by accumulation of fat in ≥5% of hepatocytes in the absence of significant alcohol consumption (<30 g/day for men and <20 g/day for women or secondary causes of hepatic steatosis[14]

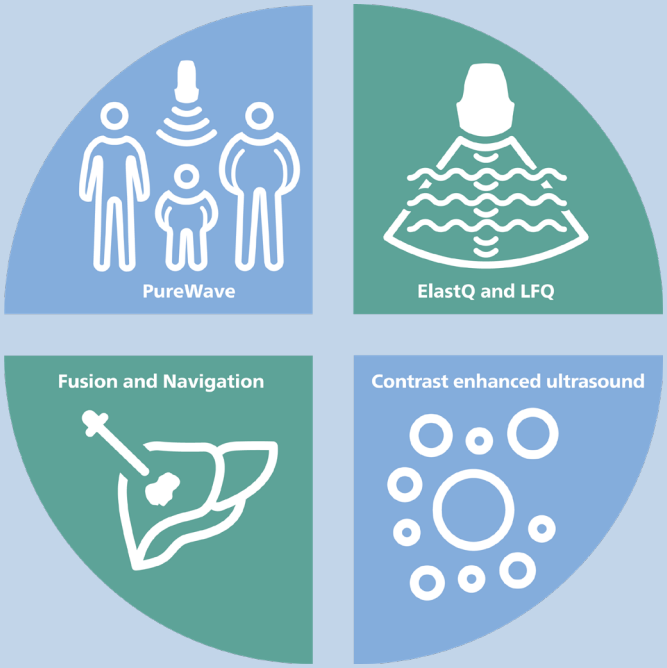
33.5%

Current USA projections indicate a 21 percent increase in NALFD from 2015 to 2030, leading to a 33.5% overall prevalence by 2030.[15]

The Ultimate Solution for Liver Assessment

Philips' attenuation imaging and hepato-renal index (HRI) imaging are new LFQ tools to complement its current liver solution, with innovations designed to quantify fatty liver disease in its early stages. These innovations join a number of existing solutions for liver assessment:

- ElastQ shear wave elastography: Provides a non-invasive, reproducible, and easily performed method of assessing tissue stiffness that is seen as a replacement for costly and painful liver biopsy.
- Contrast-enhanced ultrasound (CEUS): Ultrasound contrast agents for liver assessment allow the user to study the enhancement patterns of suspicious liver lesions in real time, for faster and more confident diagnoses. With Philips EPIQ Elite, CEUS is seamlessly integrated into the standard workflow, providing exceptional detail throughout arterial, portal, and late-phase scanning.
- Image fusion and navigation: Image fusion combines the advantages of multimodality imaging directly on the ultrasound system using electromagnetic tracking. By combining CT/MR/PET with the live ultrasound and real-time position of the patient, clinicians have access to a powerful diagnostic tool that limits radiation due to the need for less conformity scans while maximizing throughput in the department.
- PureWave Imaging: PureWave crystal technology is the biggest breakthrough in piezoelectric transducer material in 40 years. The pure, uniform crystals of PureWave are 85% more efficient than conventional piezoelectric material, resulting in exceptional performance.



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