Free-breathing MRI improves diagnosis and monitoring of NAFLD

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Non-alcoholic fatty liver disease (NAFLD) is the most prevalent chronic liver disease in Western societies, having paralleled the increase in obesity and type II diabetes. NAFLD is associated with increased risk of cardiometabolic disease. With pediatric obesity on the rise, NAFLD is also the most common chronic liver disease in children. A portion of NAFLD patients go on to develop non-alcoholic steatohepatitis (NASH), a very aggressive form of the disease that causes liver tissue inflammation and fibrosis. NASH patients are at risk for cirrhosis, liver cancer and liver failure.

Magnetic resonance imaging (MRI) has become the preferred method of diagnosing and monitoring liver fat and iron, with magnetic resonance elastography (MRE) adding the ability to characterize liver tissue stiffness, which is related to fibrosis. But MR use is constrained by the need for patients to suspend breathing during the scan to minimize motion artifacts in the images. A team of scientists, engineers and physicians at UCLA has developed a new technology that can acquire data from liver MR scans as patients breathe normally (free-breathing MRI and MRE). "We can measure motion during the free-breathing scan and compensate for motion to create high-quality maps of liver fat, iron and stiffness," says Holden Wu, Ph.D., associate professor of radiology, bioengineering and physics and biology in medicine at UCLA.

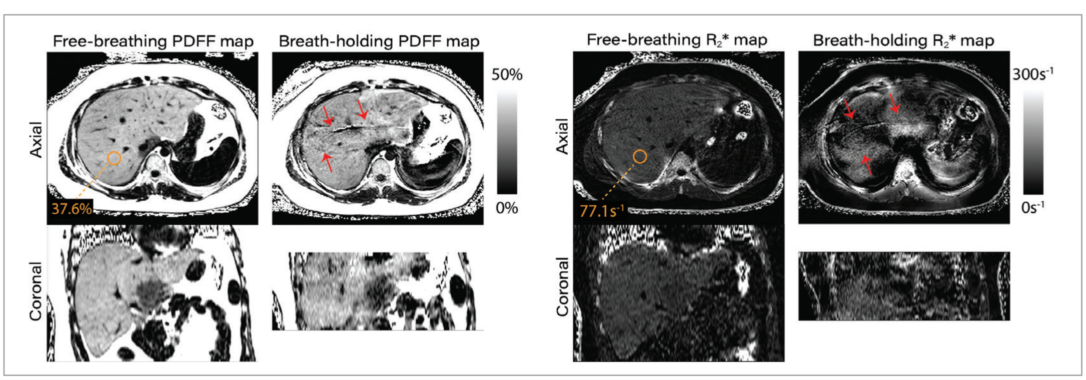
Whereas conventional liver MR scans rely on Cartesian sampling, which is sensitive to motion and requires patients to breath-hold, Dr. Wu and his colleagues have developed a new free-breathing MR method using non-Cartesian radial sampling that "is more robust and gives us more information we can use to measure and compensate for motion," explains Dr. Wu, while also "encoding all the information we need to reconstruct the quantitative maps for measuring liver tissue properties."

The team's free-breathing liver MR package — which is still in pre-clinical development, though it is transitioning to the clinical investigation phase — can be applied to clinical MR scanners currently in widespread use. Prototypes are already available for two field strengths — 1.5T and 3.0T — and the team is continuing to work with an industry partner to develop the package for different scanner software versions.

Dr. Wu and the team have published data comparing free-breathing liver MRI quantitative maps with standard breath-holding maps. "We selected only those subjects who can breath-hold so we can make a comparison," says Dr. Wu. "Even then, we noticed that a lot of subjects can't breath-hold very well and we had to make our comparisons in regions that didn't have artifacts from insufficient breath-holding." In these comparisons, maps produced using the free-breathing radial sampling technique matched up well with those produced using the standard breath-holding Cartesian sampling technique. In terms of image quality, "in challenging populations such as children and infants, our free-breathing technology achieved significantly better image quality by overcoming the challenges of breath-holding," says Dr. Wu.

The ability to acquire high quality-images and accurate quantitative maps of fat, iron and tissue stiffness in the livers of pediatric patients is an area of increasing interest as researchers — including Dr. Kara Calkins (Pediatrics), Dr. Shahnaz Ghahremani (Pediatric Radiology) and colleagues at UCLA — continue to find evidence that risk factors for liver disease often manifest well before adulthood. "If we can identify the early signs of the disease and intervene sooner, that could help avoid the future development of NAFLD and more severe forms of the disease," explains Dr. Wu.

In addition, the team is developing new methods of handling data undersampling in order to produce high-quality images and maps even when some data is missing from the free-breathing MRI scan due to motion compensation or scan acceleration. "Most recently, this has led us to develop deep-learning methods where we use substantial amounts of curated data to train deep neural network models for MRI reconstruction and mapping," says Dr. Wu. Their aim in developing this artificial intelligence system is to create high-quality liver images and maps very rapidly, which will further enhance the advantages of using free-breathing MRI to diagnose and study NAFLD.



A 17 year-old female with non-alcoholic fatty liver disease had a 3T MRI research scan to measure proton-density fat fraction (PDFF) maps for assessing liver fat and R_2* maps for assessing liver iron. **Standard breath-holding Cartesian MRI (18 sec) had prominent motion artifacts** (red arrows) due to breath-holding challenges. **The new free-breathing radial MRI method (4 min 6 sec) provided high-quality PDFF and R_2* maps without motion artifacts**, and also achieved larger volumetric coverage as the scan time was not limited by breath-holding capability.