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Ultrasound technique offers more precise, quantified assessments of lung health

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Researchers from North Carolina State University and the University of North Carolina have developed a technique that uses ultrasound to provide non-invasive assessments of pulmonary fibrosis and pulmonary

edema. The technique has been shown to both quantify lung scarring and detect lung fluid in rats. A study on pulmonary edema in humans is under way.

The new ultrasound technique is significant because it would allow healthcare providers to determine how effective medical interventions are at reducing lung scarring (pulmonary fibrosis) or fluid in the lungs (pulmonary edema).

"Assessing the extent of fibrosis in the lung currently requires computerized tomography (CT) scans, and sophisticated pulmonary function tests," says Marie Muller, co-senior author of the study and an associate professor of mechanical and aerospace engineering at NC State. "Both aspects of the assessment present challenges.

"CT scans use radiation, so you want to limit their use. They are also expensive, and require a trained radiologist. For all of these reasons, they are not suitable for frequent monitoring. Ultrasound is a good solution because it does not pose a cancer risk, it's portable, it's relatively inexpensive, and our technique effectively gives users a quantitative assessment of the fibrosis."

"One of the pulmonary function tests is called a DLCO test," says Dr. Tom Egan, co-senior author on the study and a professor of surgery at UNC. "The DLCO test measures the amount of gas exchange surface in the lung, and it requires specialized equipment that you won't find outside of hospitals and some large pulmonary clinics. The specialized technology means that this testing can be expensive—particularly now, due to heightened decontamination procedures associated with the COVID-19 pandemic. If this new ultrasound technology can reduce our reliance on DLCO tests, that would likely reduce costs for patients."

"Being able to monitor pulmonary edema in patients with heart failure

would also be very useful," Muller says. "This is often done by assessing fluctuations in a patient's body weight in order to estimate how much fluid has collected in the patient's lungs—which is not as specific as we'd like it to be.

"We've recently received a grant from NIH to investigate if our novel ultrasound technique can quantify pulmonary edema in heart failure patients."

"Pulmonary fibrosis is a major public health problem," Egan says. "The most common form of pulmonary fibrosis affects 200,000 Americans, with 50,000 new cases diagnosed each year.

"Pulmonary edema is another common condition. It can be caused by a number of health conditions, but affects more than 75% of patients with heart failure."

The new technique makes use of the multiple transducer elements on conventional ultrasound probes to direct multiple ultrasound waves at lung tissue. As the ultrasound waves bounce back to the transducer, the data is collected and fed into a computational model that determines the density of healthy alveoli in the lung. This can be used to provide a quantitative assessment of the amount of fibrosis in the lung tissue. Researchers are testing whether it can also quantify the amount of water in the lung.

The current paper demonstrates the efficacy of the technique in assessing pulmonary fibrosis and edema in rats, and distinguishing between the two lung abnormalities.

"The automated quantitative assessment would allow the technology to be used by personnel with minimal training, and would allow healthcare providers to compare data across time," Muller says. "For example,

caregivers would be able to tell if a patient's edema is getting better or worse."

"Because this is ultrasound, people have a hard time grasping this concept: there are no images; the output is a number," Egan says.

"The quantitative element of this work is particularly important, given that previous approaches to assessing lung health with ultrasound could really only provide qualitative assessments," Muller says. "They could say that lung health was bad or good, but couldn't give you measurable gradients between the two."

The researchers have received funding for a study focused on using the technique to assess pulmonary edema in human patients, and are applying for funding to pursue the work in patients with pulmonary fibrosis.

"We've seen new treatments come online in recent years for pulmonary fibrosis patients," Egan says. "It would be valuable to determine how effective they are, and what factors may contribute to their effectiveness."

More information: Kaustav Mohanty et al, In-Vivo Assessment of Pulmonary Fibrosis and Pulmonary Edema in Rodents Using Ultrasound Multiple Scattering, *IEEE Transactions on Ultrasonics, Ferroelectrics, and Frequency Control* (2020). DOI: 10.1109/TUFFC.2020.3023611

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