Ultrashort echo time magnetic resonance imaging of the lung using a high-relaxivity T1 blood-pool contrast agent

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TARGET AUDIENCE: contrast agent developer, lung imager, oncologist, radiologist

PURPOSE: Lung MR imaging is particularly challenging due to weak lung signal as a result of low tissue density and multiple air-tissue interfaces. To overcome low signal in the parenchyma, gadolinium (Gd) contrast-enhanced MR imaging is commonly used and remains the most established method for a lung MRI examination. Nonetheless, considerably greater enhancement remains an important goal. In this proof-of-concept study, we propose that the use of a high-relaxivity T1 blood-pool MR contrast agent [1] together with ultrashort echo time (UTE) MRI can substantially boost signal-to-noise ratio (SNR) and extend the window for imaging.

METHODS: Ten healthy female Long-Evans rats (Charles River, Wilmington, MA) were induced and maintained on 2.5% isoflurane for MRI. Rats were positioned prone, resting on a 36°C water blanket inside a 32-channel receive-only head coil. A 24-gauge angiocath was inserted into the lateral tail vein for contrast injection. Imaging was performed on a 3T scanner (Achieva, Philips). High-resolution T1-FFE and UTE sequences were acquired prior to contrast injection and at 5, 20, and 60 minutes post-injection. Parameters for T1-FFE: TR=4.8 ms, TE=1.9 ms, FA=25, NSA=8, FOV = 120 mm, 2 mm slices, 0.6×0.6 mm in-plane, 20 slices. Parameters for UTE: TR=15 ms, TE1=210 us, TE2=2.5 ms, FA=10°, 30°, 70°, NSA=1, FOV = 120 mm, 2 mm slices, 0.6×0.6 mm in-plane, 30 slices. Contrast was injected intravenously as a bolus (0.05 mmol/kg) followed by a 1.5 mL saline chaser. Four different contrast agents were compared: MnP2 (blood-pool), MnTPPS, MnTCP, and Gd-DTPA (Magnevist). The properties of the first three agents have been described previously [1].

RESULTS: Fig 1 shows that UTE provides substantial enhancement of lung parenchyma compared to conventional T1-FFE. A subtraction image (subUTE) can be used to highlight lung parenchyma while suppressing background tissue. Fig 2 shows relative lung parenchymal enhancement across the different contrast agents. It was also seen that the lung signal did not decrease significantly over at least an hour post-injection.

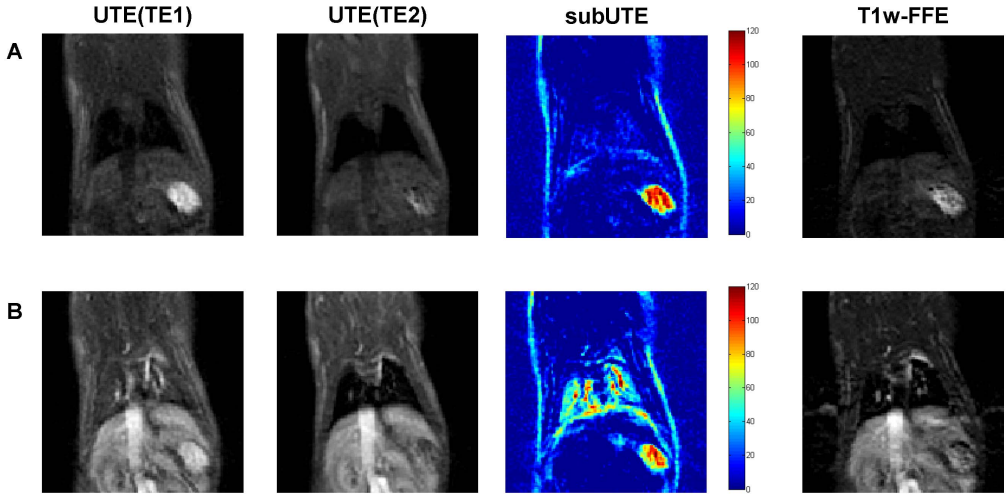

Fig 1. UTE lung MRI using a high-relaxivity blood-pool agent MnP2. MRI acquired in healthy rats (A) prior to and (B) 5 minutes after intravenous injection of MnP2.

DISCUSSION: Our new MRI approach for lung imaging achieves substantial gains in SNR in the lung parenchyma. The new blood-pool agent MnP2 increased relative enhancement by over 10-fold compared to Gd-DTPA, and the use of UTE imaging boosted SNR by a factor of 4 over conventional T1-FFE acquisitions. The new agent MnP2 also maintained steady enhancement over at least 60 minutes, thus providing a long time window for obtaining high-resolution, high quality images.

CONCLUSION: The current study presented a novel approach for highly sensitive lung MRI based on contrast-enhanced UTE imaging using a high-relaxivity blood-pool contrast agent.

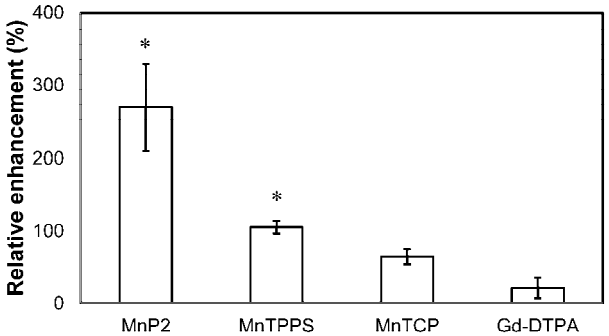

Fig 2. Relative enhancement of lung parenchyma with different contrast agents. Enhancement of lung tissue relative to pre-injection signal for MnP2 and agents with decreasing relaxivity (MnTPPS, MnTCP, Gd-DTPA). Significant differences from Gd-DTPA is denoted (* $p < 0.05$).

REFERENCES: 1. Cheng HL et al. J Magn Reson Imaging 2013 (Epub Nov 8)