

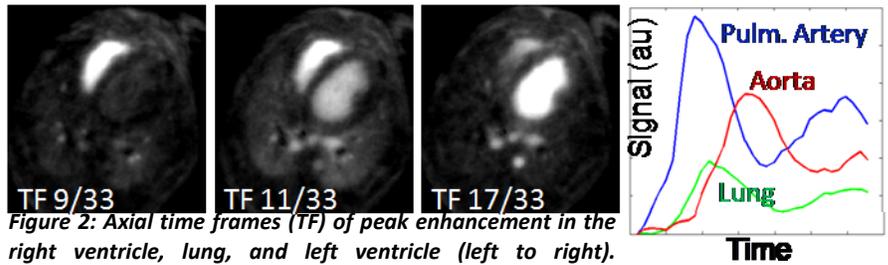
# SIMULTANEOUS SINGLE BREATH-HOLD MR IMAGING OF LUNG PERFUSION AND STRUCTURE USING 3D RADIAL UTE

Laura Bell<sup>1</sup>, Kevin Johnson<sup>1,2</sup>, Sean Fain<sup>1,2</sup>, Randi Drees<sup>3</sup>, and Scott Nagle<sup>1,2</sup>

<sup>1</sup>Medical Physics, University of Wisconsin - Madison, Madison, Wisconsin, United States, <sup>2</sup>Radiology, University of Wisconsin - Madison, Madison, Wisconsin, United States, <sup>3</sup>Veterinary Medicine, University of Wisconsin - Madison, Madison, Wisconsin, United States

**Introduction:** Accurate contrast-enhanced pulmonary perfusion MRI requires full chest coverage with high temporal resolution (~1s). To obtain such a temporal resolution with 3D Cartesian sequences requires a compromised spatial resolution of 3-4 mm during a reasonable breath-hold time<sup>1-4</sup>. While conventional resolutions are sufficient to identify lobular perfusion defects; they are inadequate to assess corresponding local lung or vascular pathology. Recently, 3D radial ultrashort TE (UTE) has shown promise in visualizing the short T2\* lung tissue by acquiring data before significant signal decay<sup>5-7</sup>. The purpose of this work was to develop and demonstrate a breath-held 3D radial UTE acquisition to simultaneously visualize lung perfusion and structure.

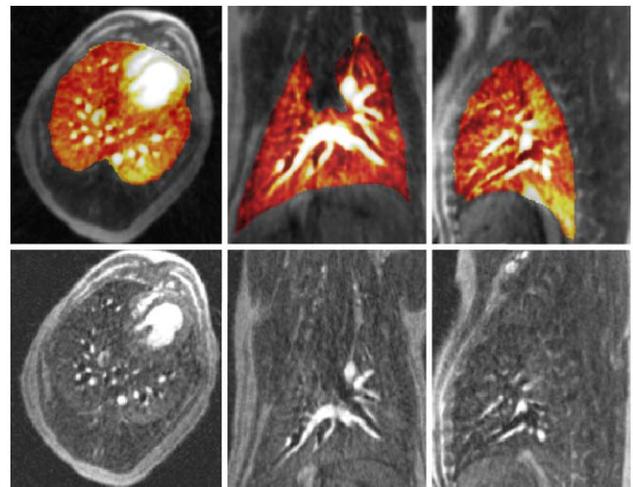
**Methods:** Six healthy dogs (~11 kg) were each scanned on two separate visits in this IACUC approved study using a 3T scanner (MR750, GE Healthcare, WI) with a 32-channel chest phased array coil. Two datasets were acquired with different scan parameters and were therefore excluded, resulting in a total of 10 datasets for analysis. Temporally interleaved 3D UTE images were acquired starting simultaneously with the injection of 2.3 ml (0.1 mmol/kg) of gadobenate dimeglumine followed by a 17 ml saline flush at 2 mL/sec. Relevant acquisition parameters include: TR/TE = 3.3/0.08 ms, 1 ms readout time, flip = 15°, 0.94 mm isotropic spatial resolution, and 1 sec time frames acquired over a 33 sec breath-hold. Dynamic 3D UTE images were reconstructed using view-sharing at 2.3 mm isotropic spatial resolution. Additionally, a single time-averaged UTE volume (8k projections) was reconstructed at 0.94 mm isotropic resolution.



**Figure 2:** Axial time frames (TF) of peak enhancement in the right ventricle, lung, and left ventricle (left to right). Temporal waveforms are seen on the far right.

A region-of-interest (ROI) was manually drawn within the right lung avoiding vessels to establish a lung tissue enhancement curve. Relative tissue enhancement was then calculated as (max signal - baseline signal) / baseline signal. Qualitative relative pulmonary blood flow (rPBF) maps were calculated using the indicator dilution method<sup>8</sup> on a pixel-by-pixel basis. Additionally, circular ROI's were manually centered in the pulmonary artery and aorta for temporal waveforms analysis.

**Results/Discussion:** Time-resolved lung perfusion using a breath-held 3D radial UTE acquisition showed relative lung enhancement of a factor of  $7.7 \pm 1.5$  compared to baseline. Fig. 1 illustrates the captured enhancement in right ventricle, lung tissue, and left ventricle over the breath-hold. The temporal waveforms are visualized in the pulmonary artery (blue), lung (green), and aorta (red). Fig. 2 demonstrates the ability to visualize both time-resolved perfusion (top row) and lung structure (bottom row) using the same dataset. Semi-qualitative rPBF maps represent lung perfusion in all orientations (Fig. 2 top row) with a clear gravitational gradient in the A/P direction, reflecting normal physiology in the supine position. The bottom row of Fig. 2 shows the matching structural image with high (0.94 mm) isotropic spatial resolution and good anatomic depiction of both vessels and lung tissue. All images show minimal cardiac motion despite the lack of cardiac gating due to the motion insensitivity of the 3D radial sampling pattern.



**Figure 1:** Qualitative rPBF maps (top row) are juxtaposed to their structural images (bottom row) simultaneously acquired during the 3D radial UTE acquisition in axial, coronal, and sagittal views. Structural images show good depiction of airway, vessels, and lung tissue due to the high isotropic resolution.

**Conclusions:** These preliminary results show the feasibility of using a time-resolved 3D radial UTE sequence for simultaneous qualitative pulmonary perfusion and co-registered structural analysis during a single breath-hold. As the data used to reconstruct each 3D volume in the perfusion time-course are under-sampled, image reconstruction may be further strengthened by the application of constrained reconstruction methods (e.g. compressed sensing or HYPR) to allow for the potential of semi-quantitative analysis.

**Acknowledgements:** Thanks to GE Healthcare, the Wisconsin Partnership Program, and the Hartwell Foundation for funding.

**References:** [1]Wang K et al, ISMRM 2012 #3958 [2]Fink C et al, Rofo (2004), 176: 170-174 [3]Nikolaou K et al, Invest Radiol (2004), 39:537-545 [4]Ohno Y et al, J Magn Reson Imaging (2004), 20: 353-365 [5]Johnson KM et al, ISMRM 2012 #0627 [6]Nagle SK et al, ISMRM 2012 #1343 [7]Togao O et al, MRM (2010), 64: 1491-1498 [8] Meier P et al, J Appl Physiol (1954), 6:731-744