Pulmonary Blood Flow Measurement using Velocity-Selective Arterial Spin Labeling at 3.0T

Jia Guo[1] and Eric C. Wong[1]
[1]*University of California San Diego, La Jolla, California, United States*

Target Audience: The researchers who are interested in pulmonary blood flow measurement.

Purpose: Water MR imaging of the lung is challenging, mainly due to the relatively low water content and the air-tissue interface [1]. The problem worsens at higher field, e.g., the T2* of lung parenchyma is 0.74ms at 3.0 T, comparing to 2.11ms at 1.5 T [2]. To measure the pulmonary blood flow (PBF) using non-contrast MRI is also challenging at high field. We hypothesize that due to the inhomogeneous transit delays for the blood to reach the pulmonary parenchyma, the pulsed ASL signal is heterogeneously distributed across both tissue and large vessels. VSASL [3] creates a uniform transit delay (nominally zero) and may be a better way of quantifying PBF. In this study we demonstrate that it is feasible to measure PBF with VSASL at 3.0 T and the initial results are shown here.

Methods: Two young healthy subjects were scanned under a local IRB approved protocol. The scans were performed on a GE MR750 3.0 T scanner and a commercial 8-channel cardiac phase array coil was used. The imaging parameters were: Sagittal scan on the right lung, FOV=360*240mm with matrix size 128*64, slice thickness=30mm, bSSFP with TE/TR=1.24/2.79ms, ramp sampling, flip angle=60°, 4 TRs before reaching steady state. Both VSASL and FAIR were used to tag the blood. The general ASL tagging parameters were: TR=6s, with TI=900ms, 20 pairs of tag and control images acquired after two dummy scans. To reduce the respiratory motion, the subjects were instructed to breathe out and hold at this Functional Residual Capacity (FRC) position during both tagging and imaging period (~1s), and to breathe normally during the rest of the TR (~5s). To reduce the cardiac motion/pulsation, the tagging pulses were triggered by a finger pulse oximeter. As a comparison, a VSASL scan without cardiac gating was also carried out on subject 1.

For the VSASL, a BIR-8 VS tagging pulses were used to minimize the eddy currents. The v_{cut} was set to 2cm/s [3], through plane (L/R), in both VS tagging and the QUIPSS-like VS (QVS) pulses. The QVS pulse was right before the image acquisition to destroy the intravascular signals above the v_{cut} [3]. To explore the effeciency of the intravascular crushing, VSASL with v_{cut}=4 and 6 cm/s were also collected on subject 2. There was no delay between the trigger signal and the tagging pulse. For FAIR, the gap between the imaging and tagging plane was 15mm [5], and the delay between the trigger and the inversion pulse was 550ms, about 250ms [4] shorter than that suggested in [1].

A reference image of the vena cava was collected without tagging pulses to estimate the fully relaxed venous blood signal for quantification. To minimize the partial volume effect, the slice thickness was halved and then the signal intensity was scaled accordingly in the data processing.

The ASL images were calculated by pair-wise subtraction and averaged across repetitions. An ROI of lung tissue was outlined from the averaged control image. The temporal fluctuation was estimated by calculating the temporal STD. For quantification, the T2 decay of the venous blood during the VS tagging was compensated, including the effective TE of the BIR-8 pulse (~10ms), the gradient duration (~6ms in total). It was applied for both VS and QVS pulses. The T2* decay of lung ASL signal due to the shift of the echo and the center of the readout window was also compensated. For FAIR, a transit delay of 300ms was used in the quantification based on a previous similar study [5].

Results: As shown in **Fig. 1**, the VSASL signal was less stable (higher temporal fluctuation) and might have cancellation across repetitions without cardiac gating, mainly due to the pulsatile nature of the pulmonary blood flow. The VSASL and FAIR signals and the PBF maps of subject 1 are shown in **Fig. 2**. Comparing **Fig. 1** and **Fig. 2**, the VSASL images were consistent, though they were collected on different days. As shown in **Fig. 3**, for VSASL, as the v_{cut} increased from 2 to 4 and 6 cm/s, there were more intravascular signals detected in the big vessels. In comparison, on top of stronger ASL signal due to the inversion, FAIR showed quite stronger intravascular signals, biased the PBF values away from true tissue blood flow.

Conclusion: In this study, our initial results demonstrated that VSASL can be used to measure PBF at 3.0 T. Compared to FAIR and VSASL at higher v_{cut} (4, 6 cm/s), VSASL using v_{cut}=2cm/s gave less large vessel signal, and may thus provide a more accurate estimate of tissue PBF.

Reference: 1. Hopkins, et al. JMRI 32:1287 (2010); 2. Yu, et al. MRM 66:248 (2011). 3. Wong, et al. MRM 22(6):727 (2005); 4. Payne, et al. J App. Phy. 100(1):1136 (2006). 5. Bolar, et al. MRM 55(6): 1308 (2006). **Acknowledgement:** NIH R01 EB002096.

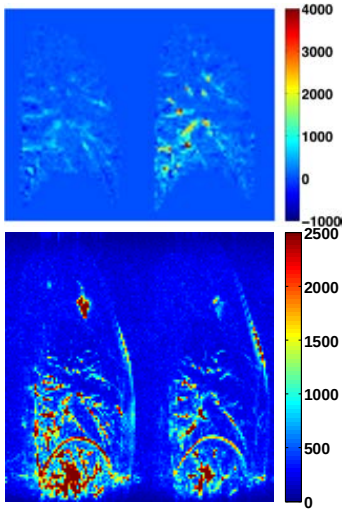

Fig. 1 Non-gated (top left) and gated (top right) VSASL images (masked, a.u.) of Sub. 1 and the temporal STD maps accordingly (unmasked, a.u.).

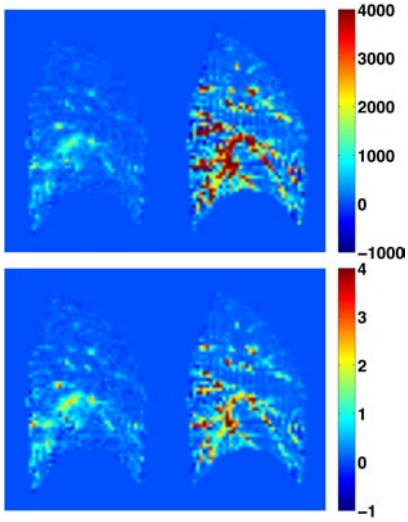

Fig. 2 Lung ASL images (a.u.) of VSASL (top left) and FAIR (top right) of Sub. 1; and corresponding PBF maps (bottom, ml/min/ml).

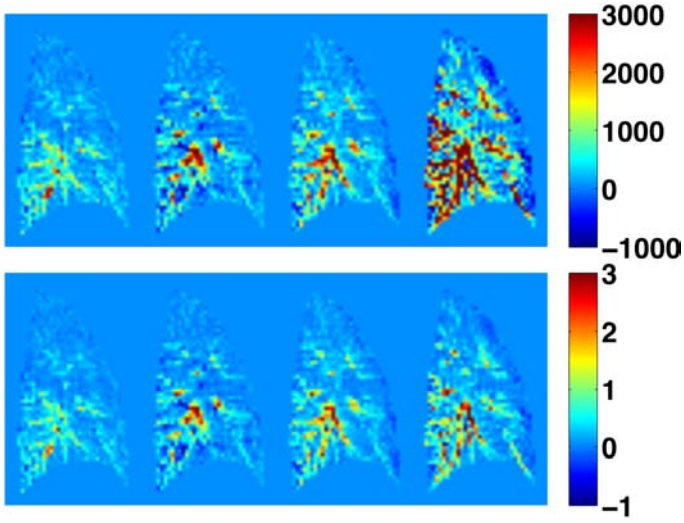

Fig. 3 Lung ASL images (top) of VSASL at v_{cut}=2, 4, 6 cm/s and FAIR of Sub. 2; and corresponding PBF maps (bottom, ml/min/ml).