Comparison of arterial transit times estimated using FEAST and LL-FAIR

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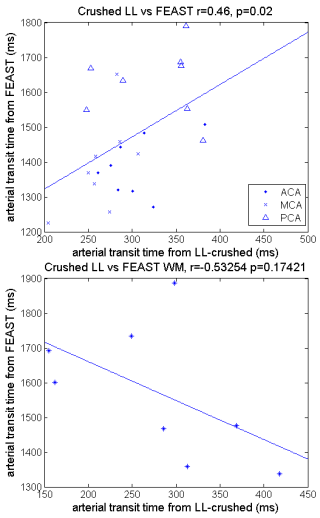
Introduction Arterial transit time is a critical parameter for calculating cerebral blood flow (CBF) using arterial spin labeling (ASL)[1]. Arterial transit time is also a novel physiological parameter that is uniquely measured by ASL and may have independent clinical significance for detecting CBF that is maintained through collateral flow sources. Most ASL experiments acquire data at a single delay time and assume that this delay is adequate for blood to arrive at the imaging region. Several ASL methods have been developed to measure arterial transit times. The first quantification of arterial transit time in humans used continuous ASL with varying postlabeling delays[2], though this approach is prohibitively time-consuming for routine use. In Look-Locker ASL[3], small flip angles are used to sample the ASL signal at various delays after pulsed labeling (LL-PASL). Finally, Flow Encoded Arterial Spin Tagging (FEAST)[4], compares crushed and uncrushed ASL data to estimate arterial transit time. In this study, we compared arterial transit times measured by Look-Locker FAIR and FEAST in healthy subjects.

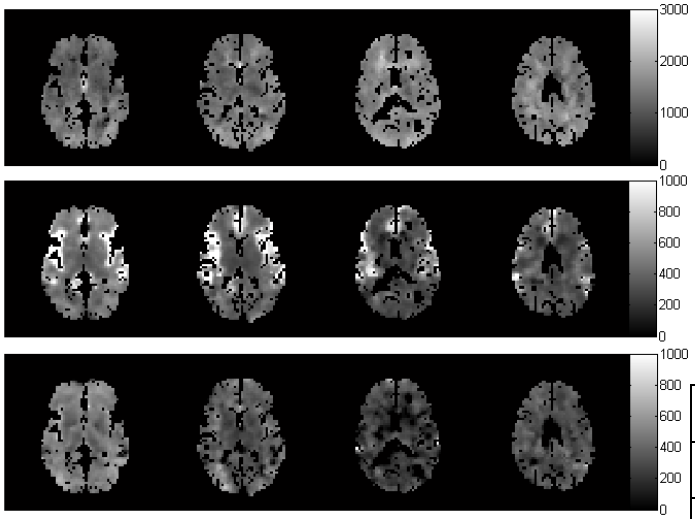
Methods Four healthy subjects were recruited and scanned on a 3T whole-body MR scanner (Siemens TIM Trio, Erlangen, Germany) with an eight channel receive-only head coil. FEAST based on pseudo-continuous ASL[5] was performed on all subjects with the following sequence parameters: labeling duration = 1.5s, post-labeling delay=1s, b=0 & 10 s/mm^2, TR/TE=3.2s/39ms. Look-Locker FAIR was implemented with the following parameters: flip angle = 25°, TI/ΔTI/final TI=100ms/300ms/2.8s, number of acquired time points = 10, b=0 & 1.7 s/mm^2. For both sequences, EPI was used to image 4 slices, 6mm thick, 1.5mm gap, 50 pairs of control/tag images. High resolution T1 images were also acquired using MPRAGE for coregistration and normalization.

Pair-wise subtractions between control/tag were generated for both datasets, and blood flow and transit time maps were fitted voxel-by-voxel using previously published models[3, 4]. Fitting was limited to gray and white matter voxels, determined from segmentation maps of the high resolution anatomical images in SPM5. Arterial transit time values were also extracted from regions of interest (ROIs) within each major cortical vascular distribution (anterior (ACA), middle (MCA) and posterior cerebral artery (PCA)) as well as from white matter (WM) in both hemispheres.



Results Sample arterial transit time maps with FEAST (top row), and from non-crushed LL (middle row) and crushed LL (bottom row) of a representative subject are shown below. Note the difference in scale between the FEAST and LL approaches. FEAST arterial transit time maps clearly show prolonged values in white matter. Artifacts around typical sites of large arteries are evident in the uncrushed dataset (middle row) resulting from suboptimal fit of the model to the high signal observed in these areas. The graphs on the right show the correlation between arterial transit time values obtained by FEAST and by crushed LL-PASL from ROIs within gray matter of major vascular distributions (top) and from WM (bottom). For vascular distributions, FEAST and LL-PASL arterial transit times are significantly correlated despite a difference of approximately 1 second between values (see table below for mean values).

Discussion Both FEAST and LL-PASL provide means of quantifying arterial transit times within clinically acceptable imaging times, and the measured values are significantly correlated within gray matter regions. LL-PASL measures the first arrival of labeled spins to the imaging slice, and is largely influenced by signal within arteries. Arterial transit times to white matter are much more difficult to obtain using LL-PASL. FEAST measures arterial transit time to the microvascular and tissue, which are about a second longer than the values obtained by LL-PASL. This difference demonstrates that most of the arterial transit time to tissue occurs in the microvasculature, and the labeling location relative to the imaging slice is a relatively minor factor for most geometries. The relatively long microvascular transit time may have physiological significance with regard to oxygen exchange, which is normally perfusion-limited. Comparisons of arterial transit times obtained with LL-PASL and FEAST may provide additional diagnostic specificity than either method alone in clinical applications, as LL-PASL should readily demonstrate altered transit times due to large artery disease whereas FEAST may be more sensitive to microvascular pathology. Future methodological development could combine the LL and FEAST approaches into a single acquisition providing both large artery and microvascular transit times.



References

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	FEAST	Uncrushed LL-FAIR	Crushed LL-FAIR
Subject	Tissue exchange time (ms)	Arterial transit time (ms)	Arterial transit time (ms)
1	1378.8 ± 465.3	414.3 ± 178.0	369.7 ± 93.9
2	1491.1 ± 233.1	373.7 ± 138.9	302.76 ± 154.6
3	1645.0 ± 438.7	350.5 ± 108.2	362.55 ± 100
4	1556.9 ± 338.7	385.5 ± 131.6	349.0 ± 71.5