Dual vessel labeling scheme for non-contrast time-resolved MR angiography
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Target audience
MR physicists and engineers interested in MR angiography (MRA)

Introduction
Hemodynamic information is required for the accurate diagnosis, effective treatment, and follow-up examination of numerous diseases. Furthermore, an assessment of collateral blood flow is another important factor for maintaining the viability of brain tissue when the primary feeding artery is compromised. We have reported a vessel-selective volumetric non-contrast time-resolved magnetic resonance angiography (MRA) technique for the assessment of collateral blood flow [1]. In this technique, three ASL scans with labeling slabs positioned over the left internal carotid artery (LICA), the right internal carotid artery (RICA), and the posterior circulation (POST) are used to image respective territories of these arteries. However, one limitation of this approach is the difficulty in achieving selective labeling, particularly of the posterior circulation, because of tortuous vascular anatomy in the neck. Here we propose a vessel-selective time-resolved non-contrast MRA using dual vessel ASL scheme. Dual vessel ASL has been devised by Zimine et al [2]. We hypothesize that vessel-selective time-resolved MRA with the dual vessel-labeling scheme helps with aforementioned issue of selective labeling because the positioning of the inversion slabs with respect to vascular anatomy is different. In this study, the feasibility of this method for intracranial angiography was validated in healthy volunteers.

Materials and Methods

Theory and Pulse Sequence: The vessel-selective time-resolved MRA technique combines PULSER with three dimensional (3D) segmented T1-weighted turbo field echo sequence (T1-TFE). The PULSAR preparation scheme with the Look-Locker sampling was used for spin labeling in this study. The dual vessel labeling schemes are shown schematically in Fig. 1. With the dual vessel labeling approach, posterior circulation is always included in the inversion slab, and one only needs to ensure that one of the ICAs is excluded. Assuming that the posterior circulation is labeled identically in both ASL scans, the territories can be recalculated in the following manner, where LP/RP are perfusion maps of combined left/right ICA and posterior territories.

Volunteer and patient study: local-IRB approval was obtained and all study participants provided written informed consent. A total of 7 volunteers were included in the study. All examinations were performed on a Philips Achieva 3.0 Tesla scanner equipped with a 32-element head coil. Imaging of dual vessel labeling schemes was then performed on all volunteers using the following parameters: FOV of 220×200 mm², matrix of 224×162, 3D acquisition with 100×1 mm slices, resolution of 0.98×1.36×1.00 mm³, FA of 10°, TR of 4.5 ms, TE of 2.2 ms, sensitivity encoding (SENSE) factor of 3.0, temporal resolution / final TI of 220 ms/2115 ms, total scan time of 2 labeling scheme (ICAs and POST)x5 min=10 min. Three-vessel-labeling scheme was performed for labeling-efficiency comparison in all subjects. In this experiment, we investigated how the labeling efficiency depends on the arrival time of labeled blood. The labeling efficiency was determined by the contrast-to-noise ratio (CNR) of peak time and arrival time to peak signal. The image quality of this technique was compared to that of TOF-MRA in terms of the depiction of detailed anatomy by two board-certified radiologists independently and analysed using weighted kappa (K) statistics.

Results
Volunteer studies were successfully performed, with clear depiction of major intracranial vessels in all studies (Fig 2). As shown by the signal intensity curve derived from four different locations, each vessel territories from the dual vessel labeling schemes data are very similar to those measured with the three-vessel-labeling scheme. With the dual vessel labeling schemes the arrival time to peak signal (mean values ± stdev) were 575ms ± 20.5, 795ms ± 52.5 and 1015ms ± 52.5 for M1, M2, M3, respectively, and 575ms ± 50.5, 795ms ± 34.5, and 795ms ± 20.2 for the same territories obtained from dual vessel labeling schemes labeled data. A pair wise t test between signal intensity obtained using the three vessel-labeling and dual vessel labeling schemes showed no significant difference for all three-vessel territories (P ≥ 0.25). Compared with TOF-MRA, dual vessel labeling was similarly successful at visualizing the branches of the cranial arteries. The inter-modality agreement was excellent (K=0.95, 95% confidence interval [CI]; 0.61-1.0).

Discussion and conclusion
In the result of the comparison labeling efficiency, both the CINEMA-SELECT and the dual vessel-labeling scheme yielded almost similar arrival times and CNR. It is important to note that dual vessel labeling scheme data are the same as in the data acquired with the CINEMA-SELECT. Visualization of anatomic structures with dual vessel labeling schemes was comparable to that with TOF-MRA, according to the results of this study. The clinical utility of any MR technique increases if the same information can be obtained in a more efficient manner. The dual vessel-labeling scheme, proposed in this study, provided identical vessel-selective MRA information as the three vessel-labeling scheme even though it required two scans only.