Accurate Measurement the Transit Time and Tag Delivery Time of Pulsed Arterial Spin Labeling: Comparing 8-Channel Phased Array Coil and Quadrature Birdcage Coil

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Introduction PASL technique was first proposed by Kwong et al. [1] and further developed to flow-sensitive alternating inversion recovery (FAIR) by Kim [2]. It has the advantage of being fully non-invasive and the potentially high repeatability compared to DSC-MRI. However, because of relative low SNR, PASL methods are still not widely used. The recently developed 8-channel phase array coils give us an opportunity to improve the SNR of PASL. Besides this, with the availability of whole-body excitation coils on high-field MR systems, it has become possible to use wider tagging bands which can also contribute to increase SNR in PASL. In this study, we investigated the transit time and tag delivery time of PASL for both 8 channel phase array coil and quadrature coil. Representative inflow curves are presented, with the standard kinetic model applied [3].

Methods Three healthy subjects underwent the PASL experiments using the FAIR tagging scheme a GE 1.5T Signa TwinSpeed system (GE Healthcare, MKE), with the 8 channel phase array head coil and the quadrature (T/R) head coil respectively. Adiabatic inversion was done using a c-FOCI radiofrequency pulse. The gap between inversion and imaging regions was 10mm. Image acquisition was performed with a single shot, 2D gradient-echo EPI sequence (FOV 240mm; 64x64 matrix; TE 18ms; bandwidth 125k; slice thickness 5mm; interslice gap 1.5mm). 6 slices were positioned parallel to the ACPC line and acquired from inferior to superior in a sequential order. Each PASL scan had 32 acquisitions took 3 min. 19 steady-state scans with TIs of 0.3, 0.4, 0.5, 0.6, 0.65, 0.7, 0.75, 0.8, 0.85, 0.9, 1.0, 1.1, 1.2, 1.4, 1.6, 1.8, 2.0, 2.3 and 2.6s were carried out on each subject. Multiple-subtraction analysis was consistent for all experiments. Perfusion-weighted maps were generated by subtracting tag images from control images. Maps at a single TI were averaged together to produce a single map for each TI. Regions of interest (ROI) were drawn in both sides of bilateral temporal lobes. Signal intensities from voxels within an ROI were averaged and plotted versus TI. This inflow plot was fit with the equation described by the standard kinetic model (SKM) as following:

$$\Delta M = \begin{cases} 0 & 0 < t < \tau_a \\ 2fA(e^{-t/T_{1,app}} e^{-k\tau_a} - e^{-t/T_{1,blood}})/k & \tau_a < t < \tau_a + \tau \\ 2fA(e^{-t/T_{1,app}} e^{-k\tau_a}(1-e^{-k\tau}))/k & \tau_a + \tau < t \end{cases} \quad \text{and} \quad k = 1/T_{1,blood} - 1/T_{1,app}$$

First, the signal intensities of 6 TIs from 1.4 to 2.6s ($\tau_a+\tau<t$) were used to fit the $T_{1,app}$ and $2fAe^{-k\tau_a}(1-e^{-k\tau})$. Then the calculated $T_{1,app}$ value and signal intensities of 6 TIs from 0.65 to 0.9s ($\tau_a<t<\tau_a+\tau$) to fit the $e^{-k\tau_a}$ and *2fA*. Combining the two times fit results together, the transit time τ_a and tag delivery time τ could be obtained. The $T_{1,blood}$ value of 1.3s is used during the calculation [4].

Results Fig.1 showd the experiment and theory signal intensity of FAIR for the first image slice of subject 1 with the 8 channel phase array coil (Fig.1A) and quadrature coil (Fig.1B). We could see they were corresponding quite well. This proved the accurate of our fit method. The fitted results for the transit time τ_a and tag delivery time τ of the three subjects were showed in table 1. The average τ_a for the three subjects were 592±15ms for 8 channel coi and were 584±13ms for quadrature coil. So there is no difference for the τ_a between the two coils. This correspond to the SKM theory that the τ_a is mainly decided by the gap width between the inversion and imaging regions. But on the contrary, the average τ for 8 channel coil were 594±55ms, which is nearly 100ms longer than that of quadrature coil 496±54ms. This is caused by the relative longer tag width of whole body excitation mode used with 8 channel phase array coil.

		Subject 1	Subject 2	Subject 3
τ_a (ms)	8 ch	605	595	576
	Quadrature	583	572	598
τ (ms)	8 ch	656	574	552
	Quadrature	558	457	473

Table 1. The fitted transit time τ_a and tag delivery time τ for three subjects with 8 channal phase array coil and quadrature coil.

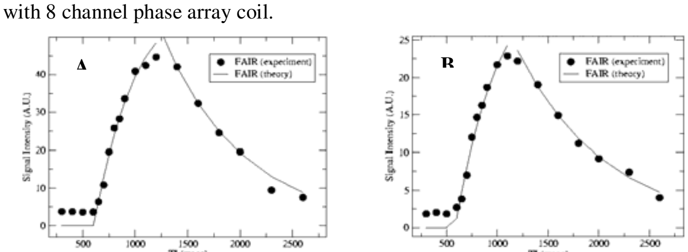

Fig.1 The experiment and theory signal intensity of FAIR for the first image slice of subject 1 with 8 channel phase array coil (A) and quadrature coil (B).

Conclusion The transit time τ_a and the tag delivery time τ of FAIR with 8 channel phase array coil and quadrature coil were measured in our study. The results showed the τ of 8 channel coil was nearly 100ms longer than that of quadrature coil on 1.5T. This will help to improve the SNR of PASL. Besides this, the transit time τ_a was also obtained for this pulse sequence. This will help us to calculate the accurate CBF map in the future study.

Reference 1. Kong KK et al. Proc Natl Acad Sci USA 89:5675-5679;1992. 2. Kim SG et al. MRM 34:293-301;1995. 3. Richard B. Buxton et al. MRM 40:383-396;1998. 4. Calamante F et al. NMR Biomed 9:79-83;1996.