Efficiency and Reliability of Vessel Encoding PCASL

Rui Wang[1], Zhentao Zuo[1], Rong Xue[1], Yan Zhuo[1], and Danny JJ Wang[2]

[1]State Key Lab of Brain and Congitive Science, Beijing MRI Center for Brain Research, Institute of Biophysics,Chinese Academy of Sciences, Beijing, China, People's Republic of, [2]Neurology,UCLA, Los Angeles, CA, United States

Introduction: Vessel encoding arterial spin labeling(VE-ASL) is a novel signal-to-noise ratio (SNR) efficient method for the mapping of vascular territories based on pseudo-continuous ASL (PCASL)(1). The tagging is implemented with additional gradient pulses applied across the tagging plane to encode the data with information about the location of the feeding arteries and the labeling efficiency may be vessel and subject dependent. The goal of this study was to estimate the labeling efficiency and longitudinal reliability of VE-PCASL for the 3 main feeding arteries, utilizing phase-contrast (PC) MRI as the reference standard.

Methods: 11 healthy subjects (6F/5M, 21-29 years of age) were scanned on a 3T Siemens Trio Tim System using body coil transmitter and 12-channel head coil as receiver. A VE-PCASL sequence with balanced gradients was used following Ref (1). Imaging parameters were as follows: labeling duration=1476ms, TR/TE/FA=3000ms/10ms/90^o, post labeling delay=1s, FOV=220x220mm^2,12 slices with 6mm thickness and 1.5mm gap, matrix size=64x64, 7/8 partial k-space, 120 measurements for 6 cycles, 2D EPI readout, and the total scan time was 6.2min. A time-of-flight (TOF) MRA was performed to visualize the right internal carotid (R), left internal carotid (L) and basilar (B) arteries, based on which positions of PC MRI and the tagging planes were determined (Fig.1). Single slice PC MRI, was performed perpendicular to the carotid and basilar arteries. Parameters were: voxel size=0.78x0.78x6mm^3, FOV=200x200mm^2, TR/TE/FA=19.65ms/5.1ms/10^o, maximum velocity encoding =100cm/s, and scan duration=32 sec. In addition, high resolution sagittal T1 MPRAGE image was acquired to obtain the gray and white matter masks of each subject. Each subject did the same experiment twice (time1 & time2,with 5-13 days of interval). For each experiment we chose two tagging locations (Fig.1) for VE-PCASL and PC MRI, at which the three vessels (R, L, B)were well separated. The labeling offset from the center of imaging slab was 84±4.5mm and 99±5.2mm for loc1 and loc2 respectively. The imaging coverage (whole cerebrum and partial cerebellum) were the same for two locations and PC MRI was conducted at the two locations. The data were analyzed using SPM8, MATLAB and SPSS. CBF was calculated based on Ref (2). The labeling efficiency of each vessel was estimated by the ratio between VE-PCASL measurement of blood flow (mL/min) and PC (average of two locations) measurement of total blood flow (mL/min) of the vessel of interest, assuming brain density of ρ=1.06 g/mL(3) and T1 of blood=1650ms.

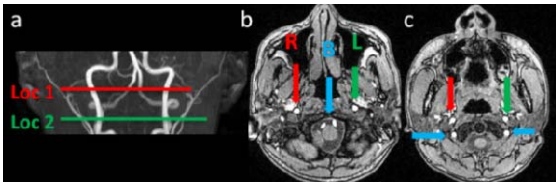

Fig.1 Labeling planes of location1 and location2 on the sagittal (a) and transversal (b, c) MRA images .

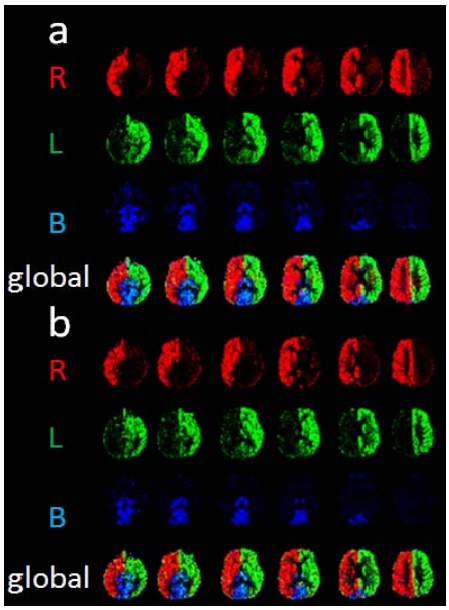

Fig.2 VE-PCASL CBF maps with labeling planes at location1(a) and 2(b) .

Results: The results of global labeling efficiency and those of the three main arteries of VE-PCASL are shown in Table 1. Repeated Measures ANOVA in SPSS indicate that there are no significant main effects of time, location or their interactions. The average intraclass correlation coefficient (ICC) is 0.623. The labeling efficiency is stable both across time and locations. However, it is lower for the basilar artery compared to left or right carotid arteries. Fig.2a&2b show CBF maps of R, L, B and their compositions for the labeling plane at location1&2 of the same subject, respectively. There is little difference between Fig.2a and Fig.2b.

Table 1 Labeling efficiency of global, R, L and B (mean±SD, n=11)

		global	R	L	B
Location1	Time1	0.804±0.076	0.930±0.143	0.906±0.161	0.483±0.118
	Time2	0.811±0.073	0.914±0.129	0.905±0.120	0.539±0.128
Location2	Time1	0.791±0.119	0.882±0.174	0.865±0.206	0.571±0.427
	Time2	0.829±0.084	0.925±0.114	0.913±0.148	0.589±0.166

Discussion: Our results are consistent with the relative labeling efficiency of VE-PCASL estimated using a histogram approach (1). However, the histogram approach is SNR limited and the estimated efficiency is relative to global PCASL. Using PC-MRI as the reference, our study calculated the global and R, L, B labeling efficiency of VE-PCASL, which is reproducible and is not sensitive to labeling locations. However, there might be underestimation of the tagging efficiency of the basilar artery since the imaging slab may not cover the whole cerebellum. In future clinical studies using VE-PCASL, in vivo estimation of labeling efficiency should be carried out given the variable anatomy of feeding arteries in patients with cerebrovascular diseases.

References: (1) Wong, EC, MRM, 58: 1086-1091, 2007. (2) Wang J et al., MRM, 48, 242-254, 2002. (3) Aslan et al.MRM 63,765–771 2010.

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