Combination of Intravoxel incoherent motion (IVIM) and pulsed Arterial Spin Labeling (pASL) MRI on studying characteristic features of early stage Alzheimer's disease

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Introduction: Alzheimer's disease (AD) is characterized by changes in perfusion and microstructure within specific brain regions [1]. Early detection of characteristic features is vital for the treatment. Intravoxel incoherent motion (IVIM) MR imaging is able to separate 'pure' molecular diffusion and perfusion effects noninvasively [2]. Yet, the perfusion information derived from IVIM might be contributed by both arterial and venous blood. Meanwhile, Arterial Spin Labeling (ASL) is applied widely to quantify arterial cerebral blood flow (CBF) [3]. Both methods eliminate the need of contrast agent which promotes this combination promising for future clinical application. The purpose of this study is to evaluate the changes of perfusion in the cerebral hemispheres in early stage of AD patients with IVIM and ASL.

Methods: 11 early stage AD patients participated in this study with a signed consent. All MR scans were performed at 3.0T Philips Achieva system with body coil transmission and 8-channel head coil reception. The protocol consisted of IVIM, pulsed Arterial Spin Labeling (pASL) and TOF MRA. IVIM was carried out with a Spin-echo single-shot EPI sequence (three b-values 0, 200, 500s/mm^2, TE/TR=shortest/8000ms, FOV 240*240mm^2, 25 slices)[4]. pASL perfusion imaging was performed using 3D background suppressed technology with a Gradient-echo single-shot EPI sequence (TE/TR=16/4000ms, flip angle=90°, FOV 240*240mm^2, 25 slices, SENSE=2.5, No of dynamics=40, Post-labeling=1750ms) [5].The labeling plane was 200mm thick, with 10mm gap. The labeling plane was parallel to the ac-pc (anterior commissure-posterior commissure) line. To improve labeling efficiency and position the labeling plane accurately, a TOF MRA (TE/TR=3.5/23ms, flip angle=18°, FOV 220*220mm^2) was acquired to assist labeling plane positioning. Data was processed in Omni Kinetics from GE for motion correction. Further quantification was processed in Matlab and ImageJ. ADC_slow, f and CBF were calculated and analyzed [4]. CBF was calculated as following: $\mathrm{CBF} = \frac{6000 \cdot \lambda (SI_{control} - SI_{label}) \cdot e^{\frac{TI}{T_{1,blood}}}}{2 \cdot \alpha \cdot TI_1 \cdot SI_{PD}}$, with partition coefficient λ =0.9, $T_{1,blood}$ =1650ms, TI =2000ms, TI_1 =800ms, α =0.98[6].

Results: Figure 1a shows a representative f mapping. Obvious asymmetry can be noticed in bilateral cerebral hemispheres. Similar pattern can be observed in CBF mapping as shown in Figure 1b, which may indicate varied perfusion. Regional variation of f and CBF were analyzed in precuneus, anterior-cingulated cortex, superior temporal gyrus and transverse temporal gyrus, where showing obvious varied CBF. As shown in Table 1, differences in f and CBF can be observed in these ROIs. Only a significant difference was obtained in superior temporal gyrus between left and right.

	Precuneus		Anterior-Cingulated cortex		Superior Temporal Gyrus		Transverse Temporal Gyrus	
	Left	Right	Left	Right	Left	Rigth	Left	Right
CBF (mean) (ml/100g/min)	10.275	8.083	12.9508	10.7378	15.722	18.309	14.654	17.567
CBF(STD)	1.9308	1.6349	3.8386	4.0149	5.5425	6.3419	5.4322	5.4371
f(mean)	0.0246	0.0216	0.0207	0.0162	0.0307*	0.0228*	0.0248	0.017
f(STD)	0.0123	0.0138	0.0107	0.0100	0.0079	0.0032	0.0074	0.0051

Table 1: The averaged f and CBF values from the regions of precuneus, anterior-cingulated cortex, superior temporal gyrus and transverse temporal gyrus are presented as mean and STD. * indicates p<0.05.

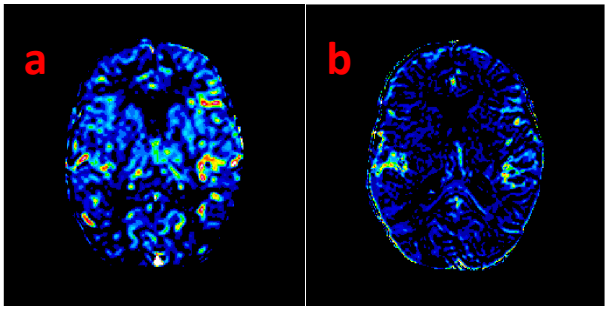

Figure 1: (a) The perfusion fraction(f)distribution of the cerebral with IVIM; (b)The CBF distribution of the cerebral with pASL within the same slice.

Discussion: With the combination of IVIM and pASL, our study revealed regional varied perfusion in the bilateral cerebral hemispheres. To the best of our knowledge, this study is the first study to explore the perfusion contribution with IVIM. The significant difference in f within superior temporal gyrus might indicate asynchronism in disease progress. Yet, the increase in f values might be induced by the compensation of reduced blood supply.

Conclusion: In this preliminary study, more detailed characteristic features of early stage AD could be evaluated by the combination of IVIM and ASL.

References:

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