Comparison between CBF difference of ASL and parameters of DSC-MRI in the ischemia disease

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INSTRUCTION: The proper and timely diagnosis of the location and volume of decreased cerebral perfusion can provide valuable insight to the treatment of intracranial atherosclerotic disease. Dynamic susceptibility contrast (DSC) imaging is the MRI perfusion technique most often used in current clinical practice. The usage of gadolinium contrast agent gives DSC-MRI the capacity of presenting multiple parameters, such as relative cerebral blood flow (CBF) and mean transit time (MTT), while also makes it technically impractical to repeat and contraindicated in patients with poor renal function. Arterial spin labeling (ASL) is a noninvasive alternative method to acquire cerebral perfusion images. Though the 3D ASL is less sensitive to the transit time than the 2D approach, the cerebral blood flow (CBF) in 3D ASL could still be underestimated by the morbid long transit time, which is very common among patients with angiostenosis. The employment of longer post label delay time (PLD) can overcome this transit time effect at the cost of SNR. So in clinical practice, two PLDs are routinely used to evaluate both blood flow and transit time. Many studies has focused on the comparison between CBF from single PLD ASL and parameters from DSC in ischemic lesions [1-4], while none has evaluated the CBF difference between two PLDs. The aim of this study is to discover the information from CBF difference by comparing it with DSC-MRI.

Method: 5 intracranial atherosclerotic patients were involved, with age from 40 to 75 years old, mean age 55. 3 patients (2 male and 1 female) have middle cerebral artery stenosis and 2 (both female) have basilar artery stenosis. MR scanning was performed on a 3-T whole-body MRI system (Discovery 750, GE Healthcare, Milwaukee, WI, USA) with an 8-channel head phase array coil. 3D TOF was used to locate the lesion with parameters: 1.4 mm slice thickness in total 136 slices, TE 2.5ms, TR 21ms and flip angle 15 degree. 2D Axial T1Flair, T2w and DWI images were used for routine clinical diagnosis. The axial 3D PCASL sequence was scanned with following parameters: FOV 24x24 cm, 4mm slice thickness with 36 slices, Matrix 512x8. PLD was set to 1525ms and 2525ms separately. The 2D Axial DSC-MRI was scanned with parameters: 5mm slice thickness with 6.5mm slice spacing in total 20 slices, TE 19.2ms, TR 1500ms, flip angle 60, FOV 24x24 cm, 60 phases, scan time 90s. Both ASL and DSC were analyzed using commercial software Functool 9 in the AW4.5 workstation. Each patient's data (including CBF from ASL with 2 PLDs, rCBF. rCBV, MTT, time to peak (TTP), bolus arrive time (BAT), time to maxium (Tmax) from DSC-MRI) was normalized to a whole brain's epi template using SPM8 (The Wellcome Trust Centre of Neuroimaging, Institute of Neurology, University college London) in Matlab 7, to eliminate different distortion and slice coverage's effect. The CBF difference (ΔCBF) was got from normalized CBF with PLD 2525ms minus CBF with PLD 1525ms. The correlation coefficient between ΔCBF and DSC parameters was given by the cosine theorem in the vector space model:

$$CC(v_1, v_2) = \frac{v_1 * v_2}{|v_1||v_2|}$$

in which v1 and v2 represent the two matrixes to be compared. The two matrixes are more similar when the correlation coefficient is closer to 1. The Analysis of Variance was employed to analyze the differences between parameters.

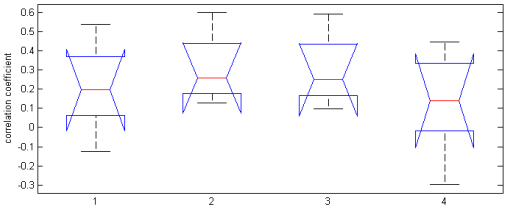

Fig.1: Correlation coefficient between (1) ΔCBF and MTT; (2) ΔCBF and TTP; (3) ΔCBF and BAT; (4) ΔCBF and Tmax.

Result: Correlation results are illustrated in Fig.1. ΔCBF and TTP have the highest mean correlation coefficient 0.3116 ± 0.1860. The mean correlation coefficient between ΔCBF and BAT is 0.3010 ± 0.1918. The mean correlation coefficient between ΔCBF and MTT is 0.2094 ± 0.2429. The mean correlation coefficient between ΔCBF and Tmax is 0.1324 ± 0.2793. There is no statistically significant difference between each parameters (P= 0.5753).

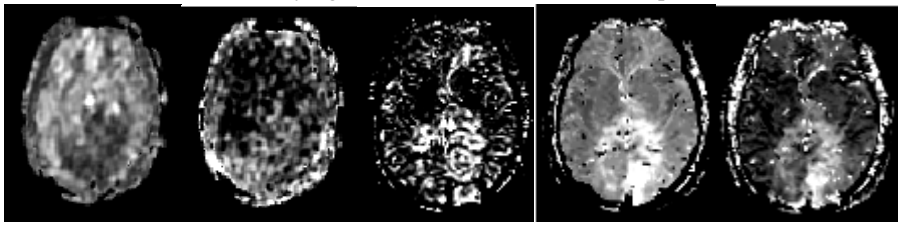

Fig.2: Image demonstration: (1) CBF with PLD 1525ms; (2) ΔCBF; (3) Tmax; (4) TTP; (5) BAT.

Discussion: 3D PCASL could provide perfusion information without contrast agent injection, with the limitation that transit-time sensitive CBF is the only derivation. Although there is multi-delay multi-parametric approach, it is still not available for the routine clinical exam [5]. The combination of ASL with 2 PLDs is a compromise but efficient way to identify the collateral circulation and pathological low perfusion. The CBF from short PLD ASL can be easily modulated by the long transit time while long PLD's is not sensitive [6]. So the CBF difference between long PLD and short PLD reflects the transit time information. In this work, the CBF difference has high correlation coefficient with TTP. TTP is proved to be sensitive to the hypoperfusion in ischemic stroke where ASL with single PLD has limited performance in [7-8]. No statistically significant difference was derived from the analysis of variance may due to the limited patient number. Further work is also needed to discover the performance of ΔCBF in lesion diagnosis.

Conclusion: The CBF difference derived from 3D ASL with 2 PLDs has high correlation with TTP in DSC-MRI.

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