MRI-based pseudo-Continuous Arterial Spin Labeling Suggested Reduced Perfusion in Patients with Multiple Sclerosis

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Introduction:

Multiple studies have implicated hypoperfusion as one of the pathological events in multiple sclerosis (MS) (1, 2, 3). However, relatively little is known about the regional perfusion deficits in MS brains compared to healthy controls. In addition, majority of published studies on hypoperfusion in MS involved administration of exogenous contrast agent. The objective of this study is to quantify cerebral blood flow (CBF) in multiple brain regions in MS and compare these values with healthy controls using pseudo-Continuous Arterial Spin Labeling (pCASL) technique (4).

Methods and Materials:

Ninety eight patients with relapsing remitting MS (RRMS) with median age of 44.1 yrs (range 20- 60yrs), and EDSS (extended disability status score) of 2.11±1.93 (range=0-6.5), and fourteen healthy control subjects (median age of 32 yrs, range 32-50 yrs) were recruited for this study. Informed consent was obtained from all participating subjects. In controls there was no evidence of neuropathic disorder or history of cerebrovascular disease, ors intracranial pathology on MRI.

MRI scans were performed on a 3 T scanner (Achieva, Philips Medical Systems, Best, Netherlands). An 8-channel phased array head coil was used for data acquisition. A balanced pCASL sequence was used in this study. Imaging parameters for all pCASL experiments were: single-shot GE-EPI, with FOV=240x240, matrix=80x80, voxel size = 3x3 mm, 29 slices acquired in ascending order, slice thickness of 5 mm, no inter-slice gap, labeling duration 1650ms, post labeling delay 1525 ms, pulse repetition time 4500 ms, echo time 16 ms, SENSE factor 2.0, number of dynamics 40, and total scan duration 5.5 min. In addition, high-resolution sagittal T1-weighted images using Magnetization Prepared Rapid Gradient Echo (MPRAGE) sequence were acquired for registration and gray and white matter segmentation with the following parameters:, TR/TE = 8.3 ms/3.8 ms, flip angle 6^0, number of slices160, voxel size 1 x 1 x 1 mm^3, field of view = 256 x 256 mm^2, and duration 5.2 min.

The CBF maps were calculated using the published method (5). Following skull stripping, the CBF images were resampled to 1x1x1mm^3 and were registered to the high resolution T1 images. The high-resolution T1 images and the CBF maps were transformed to the Montreal Neurological Institute (MNI) space using nonlinear registration (6). The CBF images were segmented into WM, gray matter (GM), and various anatomical structures to obtain the average regional CBF values.

The statistical analysis of CBF between controls and MS patients was performed using the student's t-test. $p<0.05$ was considered as significant.

Results:

As an example, the average CBF maps in controls and MS patients are shown in Fig.1. As expected, CBF is higher in GM compared to WM in both controls and patients. Also, at least two CBF values in WM, represented by green and blue, can be seen in this figure. We compared the results of regional CBF values in MS and control subjects. The results are summarized in Fig. 2. As can be seen from this figure, all the structures that were examined show reduced CBF in MS. For example, the average CBF values across all controls were 32.8±3.9 and 67.1±5.8 ml/100 ml/min (mean ±SD) for global WM, and GM, respectively, while the corresponding values for MS patients were 26.7 ± 5.5 and 54.6 ± 11.4 ml/100 ml/min.

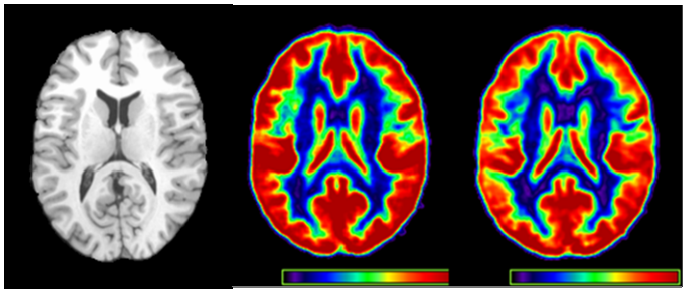

Fig.1. Averaged CBF map in controls (left) and MS patients (right). In the color coded CBF map, red indicate highest CBF values while blue and purple the lowest (see the color bar)

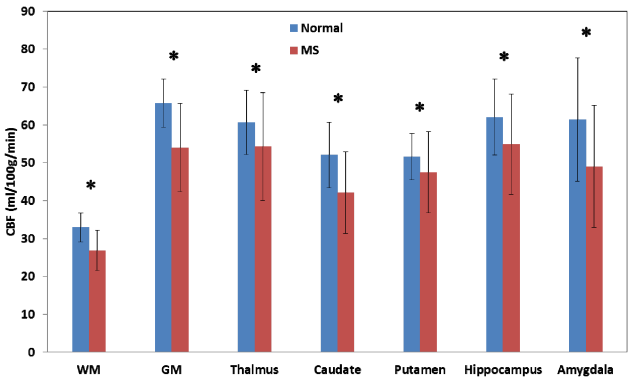

Fig. 2: Regional CBF differences between MS and normal controls. * indicates $p<0.05$.

Discussions and Conclusions:

MRI based pCASL is a promising technique for quantification of tissue perfusion. Our study suggested that there is a significant regional perfusion reduction in MS patients. The lowest CBF value in WM mainly corresponds to central WM, the area where chronic MS lesions appear with high probability. The persistence of chronic lesions in poorly perfused WM strongly implicates hypoperfusion as an important factor that interferes with lesion repair.

Reference

1. Varga AW, Johnson G, Babb JS, Herbert J, Grossman RI, Inglese M: Neurol Sci 2009, 282: 28-33.
2. Ge Y, Law M, Johnson G, Herbert J, Babb JS, Mannon LJ, Grossman RI. AJNR Am J Neuroradiol 2005; 26:1539–1547.
3. Adhya S, Johnson G, Herbert J, Jaggi H, Babb JS, Grossman RI, Inglese M. Neuroimage 2006, 33: 1029-1035.
4. Aslan S, Xu F Wang PL, Uh J, Yezhuvath US, van OM, Lu H. MRM 2010;63(3):765-771.
5. Alsop DC, Detre JA. J Cereb Blood Flow Metab 1996;16(6):1236-1249.
6. Tao G, He R, Datta S, Narayana PA. Comput Methods Programs Biomed. 2009;95:105-115