White matter cerebrovascular reactivity measured with pseudo-continuous arterial spin labeling at 3T

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Introduction

White matter lesions form an important expression of ischemic small vessel disease and have been found to be associated with dementia, cognitive decline and silent infarcts (1;2). The neuropathological substrate underlying WMH is thought to be ischemia due to hypoperfusion. A reliable marker of hypoperfusion in the brain is the vasodilatory capacity of the cerebral vasculature. This autoregulative mechanism enables the cerebrovascular system to keep the cerebral blood flow (CBF) constant during fluctuations in the arterial blood perfusion pressures through vasodilatation of the cerebral vasculature. Studies have shown that the cerebrovascular reactivity (CVR) is impaired in patients with diffuse confluent white matter hyperintensities and reduction is associated with a higher incidence of stroke (3;4). Until now, no widely available method was available to assess the autoregulative status of white-matter. With the recent developments in arterial spin labeling (ASL), such as pseudo-continuous labeling and background suppression, the quality of perfusion images has improved considerably and assessment of the white matter perfusion has become feasible. The aim of this study was to study the ability of ASL to assess the cerebrovascular reactivity of white matter using a pseudo-continuous ASL technique after intravenous administration of acetazolamide.

Methods and materials

MRI measurements were performed on a 3 Tesla MRI scanner (Intera, Philips Medical Systems) equipped with a SENSE-8-channel head coil. Twenty-five healthy volunteers (11 men; 14 women; age, 61±8 years) were investigated with a pseudo-continuous ASL sequence (5) with background suppression and regional perfusion imaging (RPI) (6) before and 15 minutes after administration of an intravenous bolus of 14 mg/kg acetazolamide (maximum dosis 1200 mg). The pseudo-continuous ASL parameters were: FOV, 240x240 mm^2; 17 slices, SENSE, 2.5; label duration, 1650 ms, TR, 825ms; TE 14ms. RPI perfusion imaging was acquired for segmentation of the flow territories of the basilar and internal carotid arteries. For M_0 and segmentation purposes an inversion recovery sequence was acquired. A T_1 image was calculated from the inversion recovery sequence and segmented with SPM5 into gray and white matter probabilistic maps. Thresholding of the white matter maps was applied to avoid partial voluming of gray matter. All images were co registered to correct for motion. Differences between pre and post acetazolamide CBF were tested using paired *t* test (SPSS 15.01). Differences between gray and white matter CVR were evaluated with an independent *t* test. The study was approved by the institutional review board, and informed consent was obtained.

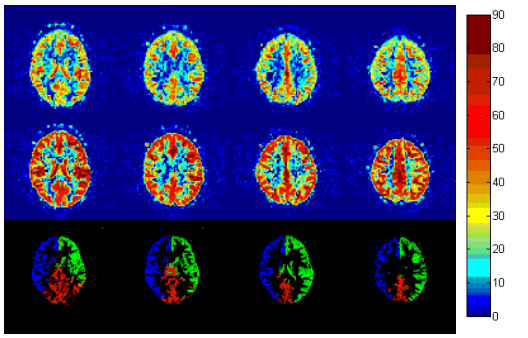

Figure 1: *Representative CBF (ml/min/100gr) maps pre and post acetazolamide, and RPI of the basilar an carotid arteries*

Results

Figure 1 shows representative CBF images pre and post acetazolamide. There was a significant increase in CBF in all flow territories of the basilar and carotid arteries in both the white and gray matter after acetazolamide injection (Table 1). In the white matter, there was a mean increase of 62%, from 14.0±4.5 to 22.7±7.5 ml/min ($p<0.01$). In the gray matter there was a significant increase in CBF of 59.5%, from 42.2±8.7 to 67.3±13.7 ml/min ($p<0.01$). There was no significant difference between the CVR measurements in the white and gray matter ($p=0.55$). Figure 2 shows the CVR reactivity measurements of the individual flow territories of the basilar and carotid arteries in the white and gray matter. The correlation between the white and gray matter CVR measurements was 0.65 (Pearson's r, $p<0.01$). For the individual flow territories of the basilar and carotid arteries, the correlations were, respectively 0.71, and 0.56 and 0.63 for the left and right carotid artery ($p<0.01$).

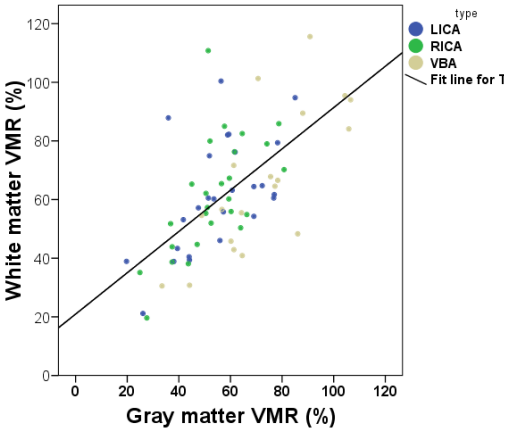

Figure 2: *CVR measurements in the white and gray matter*

Conclusion

The most important finding of this study is that with pseudo-continuous ASL with background suppression it was feasible to measure cerebrovascular reactivity in the white-matter. An increase in CBF in the white matter after injection of acetazolamide was found that corresponded with the increase in CBF in the gray matter. The possibility of overestimation of CVR in the white matter cannot be excluded, as the transit times of labeled blood may be shorter after injection of acetazolamide than before. Knowledge of the white matter autoregulative status may provide important understanding in the aetiology and pathogenesis of white matter disease.

	White matter		Gray matter	
	Pre	*Post*	*Pre*	*Post*
LICA	14.6 ± 2.9	23.4 ± 4.7 *	42.8 ± 6.8	66.0 ± 10.8 *
RICA	14.4 ± 3.3	23.0 ± 5.1 *	43.7 ± 7.6	66.9 ± 12.2 *
VBA	12.9 ± 7.5	21.7 ± 12.8 *	40.2 ± 11.0	69.0 ± 17.7 *

Table 1. CBF in ml/min/100gr pre and post acetazolamide in the basilar and carotid arteries. * indicates a significant increase ($p<0.01$)

References

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