White matter Cerebral Blood Flow detection using Arterial Spin Labelling

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Objective: Since the inception of Arterial Spin Labelling (ASL) as a means of endogenously measuring parenchymal perfusion[1], there has been a lack of consensus over whether the technique has the sensitivity to detect the effect within the white matter of the brain[2]. This study sought to influence this debate by measuring normal cerebral white matter perfusion both prior to and following a vasodilatory challenge, in order to establish whether there was a detectable difference between these conditions.

Methodology: A cohort of thirteen normal, healthy volunteers (six female, seven male) were scanned at 3T (Achieva, Philips Medical Systems, Best, Netherlands) using the QUASAR sequence[3]. Participants were scanned once at baseline, and were then administered 1000mg Acetazolamide (Diamox sodium perenteral; Wyeth Laboratories, Maidenhead, UK), infused intravenously over a period of ten minutes, followed by a saline flush, while remaining within the magnet bore. The QUASAR sequence was then repeated a further four times, with a reduction in the bolus length of the crusher gradients, to account for any increased blood velocity. The sequence length meant that acquisitions were timed approximately seven minutes apart. Data were subsequently analysed using user-designed software from the Test-Retest study[3], and the Statistical Package for the Social Sciences (SPSS 14).

Results: Following the vasodilatory challenge, the overall contrast-to-noise ratio was such that it was possible to detect differences in white matter perfusion [Figure 1]. The mean increase in white matter perfusion across all participants was extremely statistically significant, indicative of the validity of the technique (WM CBF-pre=19.8±3.0ml/100g/min; WM CBF-post=25.8±3.2ml/100g/min ($t=7.1665$, $p<0.0001$)). Example maps are shown [Figure 2] from one participant's data to show the perfusion capacity of the brain, first at baseline level pre-Diamox, followed by the mean map of the four post-Diamox timepoints, which echoes the cohort total quantified in Figure 1, and finally a map of the difference between the two conditions.

Figure 1: Mean white matter CBF increase post-Diamox, showing standard error

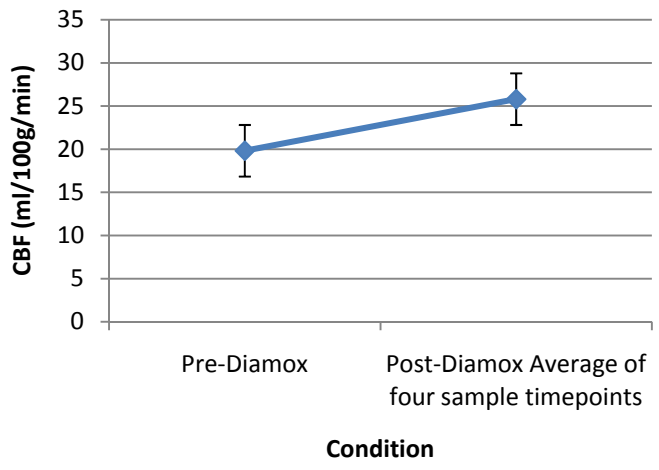
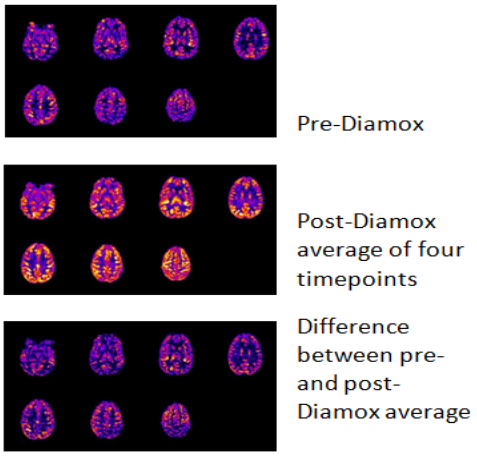


Figure 2: Example ASL CBF maps pre-Diamox, post-Diamox, and difference between conditions (EC112716)



Discussion: The present study demonstrates significant differences in white matter perfusion following administration of a potent vasodilator, using Arterial Spin Labelling. This suggests that it is indeed possible to detect Cerebral Blood Flow within this tissue type, a fact which has been widely debated. The difference between the conditions was approximately 1/4 of that detected using the same method in grey matter, but remains a robust effect, not only in terms of whole brain CBF values in millilitres of blood per 100g of tissue per minute, but also in terms of regional flow maps [Figure 2].

References:

1. Petersen, E.T. et al. Non-invasive measurement of perfusion: a critical review of arterial spin labelling techniques. British Journal of Radiology 2006; 79:688-701.

2. van Gelderen, P. et al. Pitfalls of MRI measurement of white matter perfusion based on arterial spin labelling. 2008; 59:788-795.

3. Petersen E.T. et al. The QUASAR reproducibility study, Part II: Results from a multi-center Arterial Spin Labeling test-retest study. NeuroImage 2009; 49:104-113.