Sensitivity and Detectability of Regional Differences in CASL Perfusion Between Subject Groups

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Introduction Several recent studies have investigated the sensitivity of arterial spin labelling (ASL) techniques in the detection of task-related changes in perfusion[1,2], but in spite of the growing number of investigations of cerebral perfusion in various subject groups using ASL, the sensitivity and detectability of differences in absolute perfusion between groups have not been systematically assessed. The purpose of this study was to examine the limits of detection of group perfusion differences at a cluster level using resting-state continuous ASL (CASL) data from two groups of age-matched, healthy, adult volunteers after implantation of artificial perfusion increases of 10-40 ml/min/100 ml in the perfusion images for one of the two groups.

Methods The subject group consisted of 30 healthy, right-handed adult volunteers (15 male, 15 female, mean age 28 years, range 20-42) with no history of psychoneurological illness. Perfusion images were acquired with a 1.5 T GE Signa Horizon Echospeed scanner (GE Medical Systems, Milwaukee, WI, USA) using a multislice continuous ASL technique.[3,4] The control EPI images from the ASL acquisition were registered to a high resolution EPI template image, [5] and the transformation matrix from this registration was applied to the perfusion maps. The subjects were then separated into two age- and gender-matched groups, and a voxel-based group analysis was performed to confirm the absence of any existing regional perfusion differences between the groups. Perfusion increases of 10, 20, 30, and 40 ml/min/100ml were embedded into 14 clusters in the co-registered perfusion images for group 2, using cluster sizes of 5.6x5.6 mm^2 and 7.5x7.5 mm^2. The voxel-based group analysis was then repeated for each cluster size and embedded perfusion change by fitting an analysis of covariance (ANCOVA) model at each intracerebral voxel, covarying for age. Regional differences in perfusion were tested at the level of voxel clusters, with the cluster-level significance threshold set to a corrected p-value of 0.05.[6]

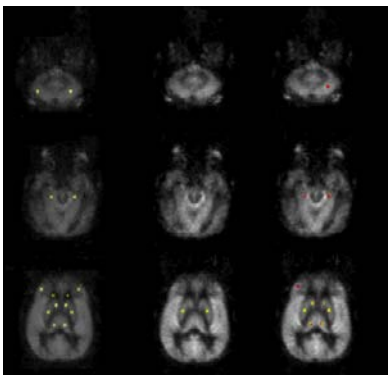
Results The detectability of the implanted perfusion changes is shown as a function of the magnitude of the perfusion increase and the size and location of the cluster in table 1. Figure 1 shows two examples of the regional perfusion changes detectable at a significance level of p=0.05 for perfusion increases of 10 and 30 ml/min/100ml with a cluster size of 5.6x5.6 mm^2, as well as an overlay of the locations of all the implanted perfusion changes. The sensitivity was highest for clusters in the putamen and lowest for clusters in frontal white matter.

Discussion The sensitivity of ASL perfusion images for detecting regional differences in perfusion between groups is likely to be dependent on the signal to noise ratio and resolution of the perfusion imaging technique as well as the heterogeneity of the subject groups, since each of these factors will contribute to the variability of the perfusion on a regional level. In addition, the sensitivity is likely to vary substantially across brain regions, as this study has demonstrated. These preliminary results have important implications for the design of studies aiming to investigate differences in regional perfusion between groups, and highlight the importance of including sufficient subject numbers to ensure adequate statistical power for a given effect size. We are currently investigating the effects on detectability of other factors such as the post-processing techniques used, including smoothing, image registration, and statistical inference methods (eg parametric vs. nonparametric), and the number of subjects in each group.

Table 1: Detectability of implanted clusters as a function of the cluster size and the magnitude of perfusion change in ml/min/100ml (L/R = left/right)

Cluster location	Cluster size =5.6x5.6 mm^2				Cluster size =7.5x7.5 mm^2			
	Δperf (ml/min/100ml)				Δperf (ml/min/100ml)			
	10	**20**	**30**	**40**	**10**	**20**	**30**	**40**
Putamen	L,R	L,R	L,R	L,R	L,R	L,R	L,R	L,R
Caudate		R	L,R	L,R		R	L,R	L,R
Thalamus		L	L,R	L,R		L,R	L,R	L,R
Hippocampus			L,R	L,R		L,R	L,R	L,R
Cerebellum			L	L		L	L	L,R
Frontal GM			R	L,R			L,R	L,R
Frontal WM				R		R	R	L,R

Figure 1. Left: Group perfusion images showing the positions of the implanted perfusion changes. Centre/Right: The detected clusters corresponding to perfusion increases of 10 and 30 ml/min/100ml, respectively. (Cluster size = 5.6x5.6 mm^2.)



References:

[1]Tjandra et al. *NeuroImage* 27:393-401 (2005)

[2]Kemeny et al. *Human Brain Mapping* 24:173-183 (2005)

[3]Alsop et al. *J Cereb Blood Flow Metab* 16:1236-1249 (1996)

[4]Alsop et al. *Radiology* 208:410-416 (1998)

[5]Studholme et al. *Pattern Recognition* 32:71-86 (1999)

[6]Bullmore et al. *IEEE Trans. Med. Imag.* 18:32-42 (1999).