Pulsed arterial spin labeling perfusion in healthy aging and early dementia

C. Preibisch[1], A. Förschler[1], A. Wohlschläger[1], C. Sorg[2], A. Kurz[2], T. Grimmer[2], H. Förstl[2], C. Zimmer[1], P. Alexopoulos[2]

[1] Abteilung für Neuroradiologie, [2] Klinik und Poliklinik für Psychiatrie, Klinikum rechts der Isar der TU München

Introduction

Cerebral blood flow (CBF) is correlated to neuronal activity and cerebral metabolic rate [1]. Pulsed arterial spin labeling (PASL) perfusion imaging is a magnetic resonance imaging (MRI) technique relying on the detection of magnetically labeled water, which permits safe and economical multiple repeated measurements, and has been proven to be a useful instrument for the investigation of brain pathologies [2,3]. Alzheimer's Disease (AD), being the most common cause of dementia, is a neurodegenerative disorder, leading to cerebral structural alterations, as well as to changes in neurotransmitter systems in the cortical association areas and the limbic system [4]. The transitional clinical stage between normal cognition and dementia in AD is usually referred to as mild cognitive impairment (MCI) [5]. The aim of the present study was to determine regional cerebral perfusion changes in patients with MCI and AD as compared to cognitively normal young and elderly controls using a PASL technique.

Subjects and Methods

Resting CBF maps were obtained from 20 young (YC: 30.7 ± 9.1 a) and 24 elderly (MC: 67.2 ± 6.1 a) cognitively normal controls, 24 patients with MCI (69.1 ± 7.9 a) and 19 patients diagnosed with mild dementia in AD (72.0 ± 9.4 a).

Instrumentation: 3 T whole body scanner: body coil for transmit; 8-channel head coil for receive

Pulses Arterial Spin Labeling:

• PULSAR sequence [3] using a STAR tagging scheme [5] for labeling and a WET presaturation of the imaging volume [6].

• Thin slice periodic saturation pulses (Q2TIPS) [7] control for the length of the tagged blood bolus.

• Imaging parameters: single-shot EPI readout; TR/TE/α = 2500ms/17ms/90°; TI1/TI1S/TI2 = 700ms/ 1200ms/1500ms; 11 slices (aligned to Hippocampus, comprising parietal lobe); matrix 64x63; voxel size 3.75x3.75x6 mm³; gap 0.6 mm; 80 pairs of labeled-control; scan time 7 min 18 sec.

• Whole brain single shot EPI (voxel size 3.75x3.75x3 mm³; 40 slices) and T1-weighted TFE volume (voxel size 1x1x1 mm³; 170 slices) for spatial coregistration and normalization.

Postprocessing:

• Spatial preprocessing, calculation of CBF-maps [8] (including correction for partial volume effects [9]) and analysis of variance across groups were performed with custom programs written in MATLAB and SPM8 (http://www.fil.ion.ucl.ac.uk/spm). Results were thresholded at p < 0.05, FWE corrected.

Results

Lower perfusion in the right superior parietal cortex was found in healthy elderly subjects (MC) when compared to young controls (YC). Compared to healthy elderly controls, in patients with MCI regional perfusion was reduced in the left superior parietal, middle occipital and right angular cortex. Somewhat more widespread hypoperfusion extending to bilateral precuneus was found in patients with AD. The difference between patients with MCI and AD in the middle Cingulum was only significant at p < 0.001 uncorrected.

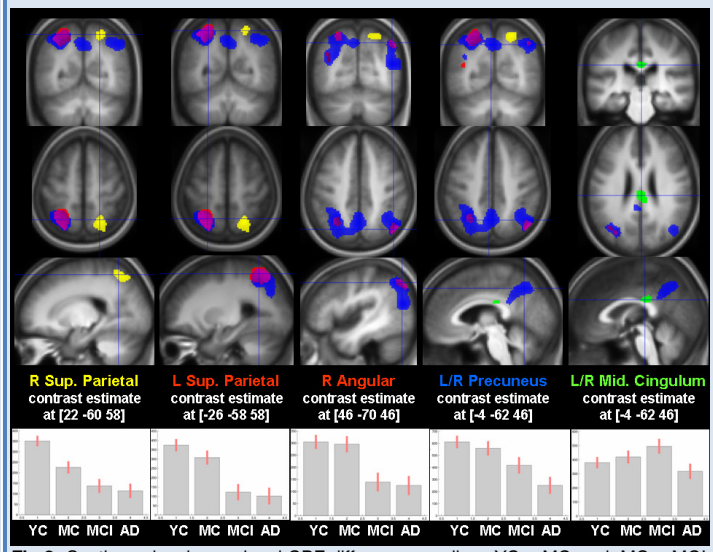

Fig 2: Sections showing regional CBF differences: yellow: YC > MC; red: MC > MCI; blue: MC > AD at p < 0.05 FWE corrected; green: MCI > AD at p < 0.001, uncorrected.

Results

Table 1: Peak MNI coordinates of CBF differences (p < 0.05 FWE corrected):

Anatomic location	cluster size T	peak	x	y	z
YC > MC					
R Sup. Parietal	338	5.3	22	-60	58
MC > MCI					
L Sup. Parietal	886	5.29	-26	-58	58
R Angular	127	5.04	46	-70	46
L Mid. Occipital	135	4.61	-40	-66	22
MC > AD					
L Sup. Parietal	3442	6.21	-30	-58	52
L/R Precuneus		5.48	-4	-62	46
L Mid. Occipital		5.32	-30	-74	32
R Angular	1516	5.86	48	-64	46
R Mid. Temporal		5.69	46	-72	18
MCI > AD					
R/L Mid. Cingulum	133	3.86*	2	-26	28

*p < 0.001, uncorrected

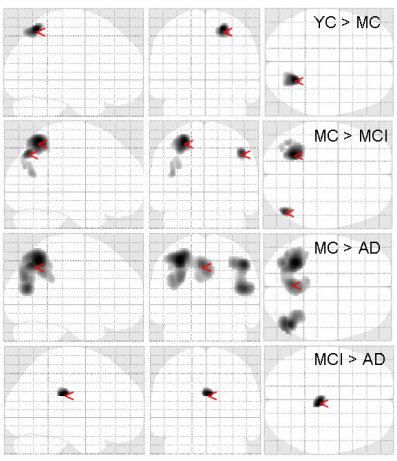

Fig 1: Glass brain representations of regional CBF differences. Arrows indicate plot coordinates of contrast estimates in Fig. 2.

Conclusion

These results confirm previous findings of hypo-perfusion in parietal areas of patients with MCI and AD as compared to age matched controls. In addition, we found small but significant perfusion decreases in elderly- in comparison to young controls in the right parietal lobe. This suggests that PASL is capable of identifying perfusion deficits associated with neurodegenerative disorders and may be a valuable tool for investigating the transition from normal ageing to dementia.

References: [1] Gonzalez et al. AJNR 16:1763-1770 (1995). [2] Golay & Petersen. Neuroimaging Clin N Am 16:259-268 (2006). [3] Wintermark et al. J Neuroradiol 32:294-314 (2005). [4] Blennow et al. Lancet 368(9533):387-403 (2006). [5] Winblad et al. J Intern Med 256:240-246 (2004). [6] Edelman & Chen. MRM 40:800-805 (1998). [7] Ogg et al. J Magn Reson B 104:1-10 (1994). [8] Luh et al. MRM 41:1246-1254 (1999). [9] Nöth et al. JMRI 24:1229-1235 (2006). [10] Johnson et al. Radiology 234:851-859 (2005).