Assessment of hypertension on cerebral blood flow and dementia using CASL MRI

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Introduction: Hypertension is considered a risk factor for incident amnestic MCI [1]. Recent studies indicate that mid-life hypertension is associated with decreased cerebral blood flow [2] (CBF) and dementia in a population study [3]. A four-year study of elderly subjects is being conducted at University of Pittsburgh to identify the risk of hypertension to Alzheimer's disease (AD) dementia. Preliminary results are being generated from the first two years (2002-2003) of the dementia studies.

Methods: Regional CBF (rCBF) was measured in 20 age-matched healthy controls, 19 MCIs, and 22 early ADs (Table 1) after informed consent. Blood flow velocities, perfusion rates, and T_1 relaxation times were measured in each elderly volunteer using phase contrast (PC) Cine, multi-slice continuous arterial spin labeling (CASL), and saturation recovery MRI, respectively on a 1.5 T GE Signa scanner. Multi-slice CASL used Alternating Single and Double adiabatic inversions (ASD) [4] (3.7s pulse train at 92% duty cycle) and ramp-sampled echo-planar imaging (EPI) to acquire 19 continuous axial slices (64×64 matrix, 20cm FOV, 5mm thick, 0 spacing, 21ms TE, 76kHz effective receiver bandwidth, 1 s TR_{acq}, 700ms postlabeling delay, 90^0 flip angle, 50 pairs), with a sequential superior to inferior slice acquisition order to minimize residual magnetization transfer (MT) effects. Coronal T_1-weighted spoiled gradient-recalled echo (SPGR) images covering the whole brain were acquired for gray and white matter segmentation.

Absolute CBF maps of gray matter were calculated using the kinetic model of CASL [5] and the assumption that gray matter CBF was a global constant. A deformable atrophy-corrected registration method was used to warp the CBF maps to the standard colin27 brain space. The warped CBF maps were smoothed with a 6 mm Gaussian kernel. Image-based voxel-by-voxel t-tests were performed between subgroup-with-hypertension and subgroup-without-hypertension within each group (healthy controls, MCIs+ADs, MCIs and ADs) using Statistical Parametric Mapping (SPM2, Wellcome Department of Cognitive Neurology) and customized to correct for differences in the functional volume scanned in the difference subjects.

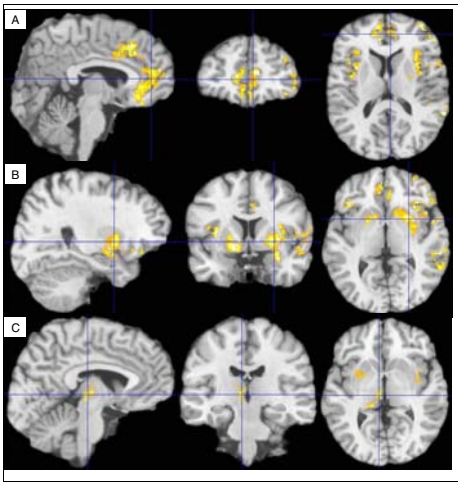

Figure 1: CBF two-tailed t-test results using SPM2 ($p < 0.02$).

A & B) Normal controls: $CBF_{HTN} < CBF_{noHTN}$

C) MCI + AD subjects: $CBF_{HTN} < CBF_{noHTN}$

Table 1: Demographics

Class	Total	Female	Hyper tension	Ages
Normal	20	13	9	81.9 ± 3.2
MCI	19	10	7	83.6 ± 3.9
Early AD	22	16	8	83.3 ± 2.9

Table 2: Regions of Hypoperfusion in Hypertensives

Comparisons	Findings ($p < 0.02$)
Normal	Anterior cingulate gyrus Superior temporal & right posterior cingulate gyrus
MCI +AD	Superior temporal & right thalamus
MCI	Right thalamus
AD	Right superior temporal

Results & Discussion: The t-test results between subgroups were overlaid on the surface section of our standard brain (Fig. 1). The regional findings are summarized in Table 2. We only observed hypoperfusion for the subgroup with hypertension compared to the subgroup without hypertension. We previously reported compensatory hyperemia (e.g., anterior cingulated gyrus) in MCI and AD subjects along with decreased rCBF in specific brain regions in this cohort. The presence of hypertension appears to moderate the increase in blood flow, suggesting at least one mechanism for vascular risk in dementia. Hypoperfusion was most evident in normal subjects, suggesting that vascular damage occurs well before the onset of dementia symptoms.

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