Resting cerebral hemodynamics, vasomotor reactivity and neurovascular coupling in mild cognitive impairment and early dementia

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Background and purposes

Differentiating normal brain aging from the earliest stages of neurodegeneration is critical for timely diagnosis and intervention in cognitive disorders. This study aimed to: (1) assess cerebral hemodynamic parameters in patients with documented mild cognitive impairment (MCI) and early dementia, in comparison to healthy controls; (2) identify potential hemodynamic biomarkers of early cognitive decline; and (3) explore predictive indicators of progression from MCI to dementia.

Materials and methods

We conducted a prospective study at the Neurosonology Laboratory of the University of Padua, enrolling 120 Caucasian subjects aged 70–80 years (mean 73, balanced by sex and education): 60 healthy controls, 20 MCI patients, and 40 with mild dementia. All underwent standardized duplex sonography of the extracranial and intracranial cerebral arteries. Subjects with significant stenosis of the extracranial circulation or inadequate temporal windows for transcranial sonography were excluded. Hemodynamic assessment included: (1) baseline measurement of mean flow velocity (MFV) and pulsatility index (PI) in the middle cerebral artery (MCA) and posterior cerebral artery (PCA); (2) vasomotor reactivity (VMR) via breath-holding test and calculation of the breath holding index (BHI); and (3) neurovascular coupling (NVC) evaluated during photic stimulation.

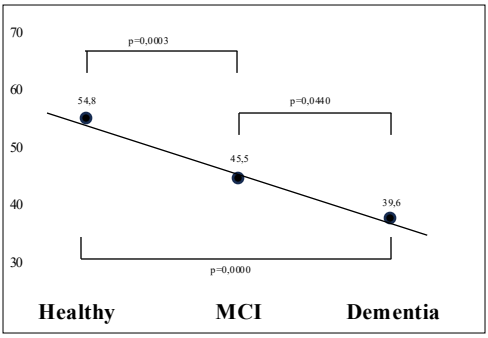
Results

A total of 120 Caucasian subjects (60 controls, 20 with MCI, 40 with dementia; mean age 73; 1:1 male-to-female ratio) were included. There were no differences between the three groups regarding the prevalence of cardiovascular risk factors. As for hemodynamic parameters, key findings included: (1) **progressive MFV reduction** in both MCA and PCA with increasing cognitive decline (MCA MFV: controls 54.8 cm/s, MCI 45.5, dementia 39.6; PCA MFV: controls 42.2, MCI 34.6, dementia 27.4) (*Figure 1, 2*); (2) **progressive PI elevation** (controls 0.76; MCI 0.84, p=0,0769; dementia 1.28 p=0,0000); (3) increased prevalence of **impaired VMR** (controls 0%; MCI 35%; dementia 82.5%; p<0,00001); (4) increased prevalence of **significant NVC dysfunction** (controls 0%; MCI 70%; dementia 90 %; p<0,00001).

Discussion and conclusions

Resting cerebral hemodynamics, VMR, and NVC parameters show progressive alterations across the cognitive spectrum and may represent early, non-invasive biomarkers of neurodegeneration. To our knowledge this is the first study demonstrating NVC dysfunction in patients with MCI and dementia. Our findings support the integration of transcranial sonography in the diagnostic workup of patients with suspected MCI and dementia and provide a basis for future longitudinal studies on progression risk.

Figures



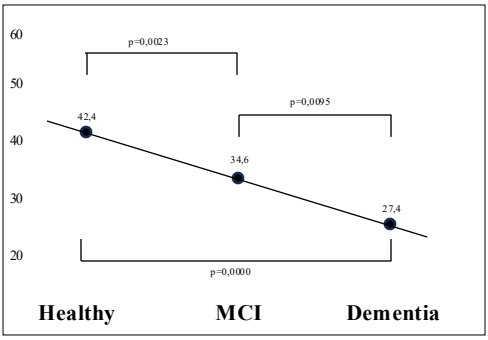


Figure 1. Resting mean flow velocity in the middle cerebral artery. **Figure 2.** Resting mean flow velocity in the posterior cerebral artery.