

Cranio spinal Hydrodynamic view of neurodegenerative disease by 2D-PCMRI

O. Balédent¹, S. El Sankari², C. Gondry-Jouet³, A. Fichten⁴, O. Pottie¹, R. Bouzerar¹, J-M. Serot⁵, O. Godefroy², H. Deramond³, and M-E. Meyer¹

¹Image processing, University hospital Jules Verne, Amiens, Picardie, France, ²Neurology, University hospital Jules Verne, Amiens, Picardie, France, ³Radiology, University hospital Jules Verne, Amiens, Picardie, France, ⁴Neurosurgery, University hospital Jules Verne, Amiens, Picardie, France, ⁵Geriatry, University hospital Jules Verne, Amiens, Picardie, France

Background: 2D Phase-Contrast MRI (PC-MRI) is a non invasive reliable technique which enables rapid quantification of cerebrospinal fluid (CSF) and cerebral blood (CBF) flows, and is helpful for aetiological diagnosis of Chronic Adult Hydrocephalus (CAH). In some patients, differential diagnosis with neurodegenerative pathologies (such as Alzheimer Disease: AD) may be difficult. Our purpose was to evaluate PC-MRI to study the effects of AD or Mild Cognitive Impairment (MCI) on intracranial flows. **Material and methods:** Ten MCI and 9 mild AD patients were identified (neurological and neuropsychological assessment). They underwent cerebral MRI using 3T scanner. Fast cine PC-MRI pulse sequences with peripheral gating were performed in 3 minutes (32 images per cardiac cycle; matrix : 256x128; FOV:16 cm; thickness 5 mm; vps 4). CSF in the aqueduct (venc 10-20 cm/sec) and in the cervical spaces (venc= 5 cm/sec) were investigated. A third slice was added at the cervical level (venc=80 cm/sec) to investigate internal carotids, vertebral and jugular vessels. PC MRI images were analyzed with home-made processing software (open to share) to automatically extract CSF oscillation in complex anatomic region as cervical spaces (figure 1), merge csf and blood flows inside morphological images (figure 2), animate the flows and calculate global arterial and venous flows curves during cardiac cycle. Stroke volume of CSF, arterio-venous flows, arterial pulsatility index (API) were then calculated. Results were compared to normal values in age matched elderly healthy (HE) population (n=12), and to CAH patients (n=13), using multivariate analysis. **Results:** (table 1), Arterial CBF was significantly increased in MCI patients (638 ± 126 ml/min; $p=0.009$), as well as pulsatility index (API = 119 ± 69 , $p=0.02$). On the contrary, the vascular parameters were decreased in CAH patients (arterial CBF: 450 ± 129 ml/min). Cervical CSF analysis showed similar values in the 4 populations (HE: 457 ± 154 μ l; MCI: 584 ± 152 ; AD: 450 ± 221 ; CAH: 455 ± 133 ; $p=0.22$). Aqueductal CSF stroke volumes were comparable in HE and AD (HE: 34 ± 17 ; AD: 39 ± 18 μ l). Interestingly, aqueductal CSF was hyperdynamic in MCI patients (73 ± 33 μ l), but less than in CAH patients (167 ± 89 μ l). **Discussion:** These preliminary data suggest increased arterial cerebral flows in MCI. These results support the vascular theory of AD pathophysiology. Furthermore, these features may be helpful for the differential diagnosis between CAH (benefiting from ventriculoperitoneal shunting) and other frequent neurodegenerative causes of cognitive disorders, like MCI and AD. **Conclusion:** PC-MRI enables reliable, safe and rapid (3 minutes) measurements of CSF and blood flows. It provides new hydrodynamic view helpful for the aetiological diagnosis of dementia in some complex cases.

Table 1

Characteristic	HE	a MCI	AD	HCA	P-value
Nb of subjects	12	10	9	13	NS
Age (years)	71 ± 9	78 ± 7	79 ± 5	70 ± 6	NS
MMSE	29 ± 2	26 ± 3	21 ± 3	NE	<0.05
BPM	78 ± 10	65 ± 8	72 ± 8	73 ± 15	0.06
Arterial Flow (ml/min)	509 ± 108^s	$638 \pm 126^*$	560 ± 83	$450 \pm 129^*$	0.009
API	59 ± 12^s	119 ± 69^s	107 ± 50	93 ± 42	0.02
Arterial pulse volume (ml)	0.8 ± 0.3^s	$1.4 \pm 0.4^*$	1 ± 0.3	$0.8 \pm 0.4^*$	0.004
Venous Flow (ml/min)	367 ± 130^s	$522 \pm 157^*$	457 ± 71	$361 \pm 92^*$	0.01
AV Stroke Volume (ml/cc)	0.7 ± 0.3^s	$1.3 \pm 0.3^*$	1 ± 0.5	$0.9 \pm 0.4^*$	0.01
Cervical Stroke Volume (micro.L/CC)	457 ± 154	584 ± 152	450 ± 221	455 ± 133	0.22
Aqueductal Stroke Volume (micro.L/CC)	$34 \pm 17^*$	73 ± 33	39 ± 18^s	167 ± 89^s	<0.001

* and \$: symbols meaning significant difference between the two populations in pairwise comparison

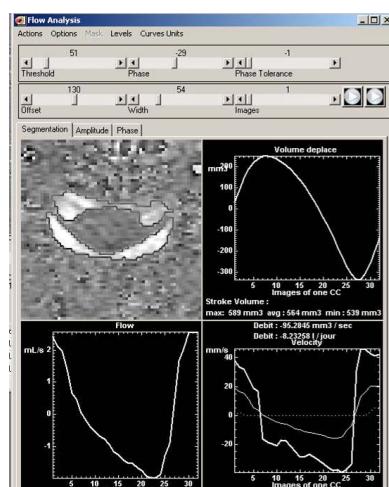


Figure 1 : cervical CSF segmentation algorithm based on the temporal evolution of the signal is used to quickly calculate CSF oscillations curves (velocity, flow and volume).

Figure 2 : 3D morphological reconstruction (fiesta) including CSF (green) flows and arteries (red) and veins (blue) blood flows during diastolic period.

