

Arterial, venous and CSF flow analyses using PC-MRI at intra/extra-cranial levels: a WIP study comparing MS patients vs matched controls

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Background: Multiple sclerosis (MS) is an autoimmune disease of which triggering co-factors are still hardly debated. Authors have recently hypothesized the role of a venous dysfunction from Doppler sonographic data in the pathophysiology of this disease (1). 2D Phase-Contrast MRI (PC-MRI) is a noninvasive technique enabling reliable quantification of CSF and blood flows in daily practice. Our purpose was to collect PC-MRI data on CSF, arterial and venous flows in MS patients and to compare them to those from a normative cohort of controls. **Material and methods:** Twelve MS patients underwent cerebral MRI using a 3T system (Achieva 3T, Philips Healthcare). Fast cine PC-MRI sequences with peripheral gating were performed (32 images per cardiac cycle; Repetition time: 24 ms; Echo time: 6 ms; Flip angle: 15°; matrix : 256x128; FOV:15 cm; slice thickness: 5 mm) in three slice locations (Fig 1): i: axial oblique transverse plane perpendicular to the great axis of the AS (numbered '1' in green) with flow encoding speed for CSF at 10 cm/s; ii: axial transverse plane perpendicular to the great axis of the spinal canal (numbered '3' in red) with flow encoding speed at 10 cm/s for CSF and 80 cm/s for internal carotid arteries (ICA), Vertebral arteries (VA), and internal jugular veins (IJV); and iii: coronal plane (numbered '2' in blue) with flow velocity at 80 cm/s for superior longitudinal sinus (SLS), straight sinus (SS) and both transverse sinuses (TS). PC MRI images were analyzed using a home-made software (<http://www.tidam.fr/>) to extract CSF oscillations, animate the flows and calculate arterial and venous flows curves during the cardiac cycle (CC). Stroke volumes of CSF, mean arterial and venous individual flows, and global intracranial (SLS + SS) and cervical jugular (right + left) venous flows were calculated. Results were compared to normal values in healthy controls (HC) (n=12), matched for age, using multivariate analysis. According to Monro-Kellie doctrine (2), brain pressure equilibrium is maintained through a regulated balance between input (arterial and CSF filling), and output (venous and CSF flushing) volume variations during each CC. Thus, we also matched MS patients to HC regarding total arterial cerebral blood flows. **Results:** (table 1) All arterial and venous flow values were comparable in MS patients and in HC in both intracranial and spinal locations. As previously observed in adults (3), venous flows at cervical level demonstrated high heterogeneity and right-sided dominance. In turn, CSF analysis showed increased dynamic oscillations in MS patients, but only at the cervical level. **Discussion/Conclusion:** These preliminary data failed to reveal significant differences in the venous cerebral and cervical outflows in MS patients when compared to a matched HC group, thereby contradicting the recent venous insufficiency theory, but need confirmation in larger cohorts. In this study, we highlighted the importance of a global approach of dynamic flows in the different cranial compartments (arterial, venous and CSF), investigating the venous flows as regards to arterial input. Note worthily, increased dynamic oscillatory CSF stroke volume was demonstrated at cervical level in MS patients, which contrasted with normal aqueductal flow, thereby suggesting imbalance between secretion and reabsorption of CSF in subarachnoid spaces.

	MS patients	Controls	P value
Age (years)	36 ± 10	31 ± 6	NS
SLS (ml/min)	254 ± 85	289 ± 57	0,32
SS (ml/min)	111 ± 45	114 ± 28	0,97
R TS (ml/min)	404 ± 281	398 ± 215	0,92
L TS (ml/min)	233 ± 143	208 ± 182	0,38
Total intracranial flow (SLS + SS)	365 ± 125	384 ± 73	0,69
R IJV (ml/min)	270 ± 237	352 ± 190	0,45
L IJV (ml/min)	153 ± 133	110 ± 170	0,37
Total jugular flow	428 ± 241	463 ± 177	0,61
R ICA (ml/min)	243 ± 111	252 ± 44	0,73
L ICA (ml/min)	235 ± 79	241 ± 50	0,75
R VA (ml/min)	70 ± 41	82 ± 32	0,34
L VA (ml/min)	84 ± 45	91 ± 36	0,66
Cervical arterial flow	631 ± 202	666 ± 115	0,23
Aqueductal CSF (μl)	50 ± 27	36 ± 18	0,22
Cervical CSF (μl)	548 ± 133	426 ± 80	0,01

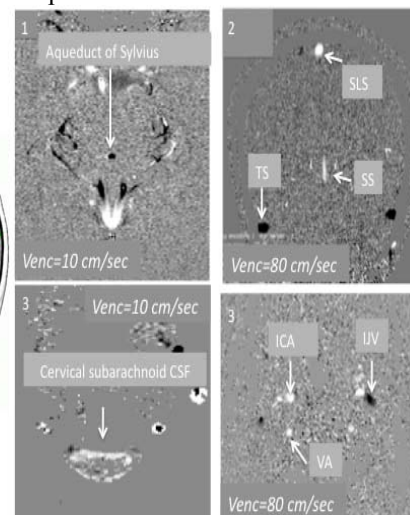
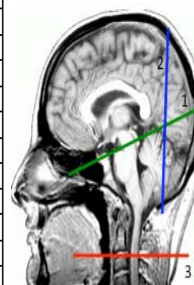


Table 1

Figure 1

Figure 2

Table 1: Measured flow values in MS and HC group. Mean flows in the vascular vessels are expressed in ml/min, while stroke volumes are in μl/CC. Comparison was achieved multivariate analysis.

Figure 1: Display of acquisition planes on mid-sagittal scout-view for AS (1) intracranial venous sinuses (2), and CSF/blood vessels at C2-C3 junction (3)

Figure 2: Display of cine-PC phase image for corresponding level with CSF encoding on bottom left panel and blood encoding on bottom right

References : 1-Zamboni et al. Chronic cerebrospinal venous insufficiency in patients with multiple sclerosis.J Neurol Neurosurg Psychiatry, 2009. 2- Kellie, G., *An account, with some reflections on the pathology of the brain*. Vol. 1. 1824:Edinburgh Med. Chir. Soc. Trans. 3- Stoquart-Elsankari et al. A phase-contrast MRI study of physiologic venous flows.J Cereb Blood Flow Metab, 2009.