Effect of Normal Aging in the Flows of the Cerebral Blood and the Cerebro-Spinal Fluid.

O. baledent[1], S. stoquart el sankari[1], C. gondry-jouet[1], M. makki[2], M-E. meyer[1]
[1]hospital, amiens, picardie, France, [2]Children's Hospital of Michigan, detroit, michigan, United States

Introduction: Cine phase-contrast magnetic resonance imaging (PC-MRI) sequence is the unique noninvasive technique to study cerebro-spinal fluid (CSF) oscillations with the capability to quantify cerebral blood flow (CBF). It has the potential to become a clinically based sequence to study patients with hydrodynamic disorders (i.e. hydrocephalus), but reference values of normal control are required to diagnose neurologic pathologies. To the best of our knowledge there is no published reference of the global CSF oscillations values and CBF correlated to age. The purpose of this investigation was to study the brain aging effect on the CBF and CSF flow to establish reference values and correlate them with brain aging, to provide guidelines for clinical input.

Materials and Methods: CSF flow and CB flow were measured in a cohort of 31 healthy adult volunteers. This population was split in two groups: young (19 subjects, mean age = 27±4 years) and elderly (12 subjects, mean age 71±9 years). MR images were performed in 1.5T scanner and the protocol includes scout morphological sequence for a better determination of functional planes followed by retrospectively cardiac gated PC-MRI triggered with peripheral gating. Optimal imaging parameters for this sequence are: TR/TE= 30/12-17 ms, FOV= 160 x 120 mm^2, Matrix=256 x 128, Slice thickness= 5 mm, flip angle = 30°, Venc= 80 [cm/s] for blood flow and 10 or 5 [cm/s] for CSF flow. CSF oscillations were acquired at the cerebral aqueduct, and C2-C3 subarachnoid spaces (SAS). In addition a vascular sequence was performed to quantify blood flows in the internal carotid and vertebral arteries and the jugular vein. Dynamic flow images were analyzed on dedicated software, developed on site, based on a fully automated ROI segmentation algorithm [1]. These fast and friendly user post-processing tools calculate flow rate curves on a cardiac cycle basis and extract all main characteristic parameters of a flow curve: oscillatory volume, mean flow, peak flow, as well as temporal information characterizing propagation of the arterial pulse pressure in the various CSF compartments. Cerebral blood flow was determined by adding mean vertebral flow and internal carotid blood flow. The correlation between age and CBF was analysed using linear regression and statistical comparison between CSF flow and blood flow of the two groups were analysed with Mann-Whitney's test. Experienced neuro-radiologist reviewed and processed these images.

Results: Average CBF within the elderly group was significantly lower (509±103 ml/min) compared to that of young group (687±127 ml/min; p<0.01). The stroke volume of the CSF at the level of the aqueduct was also significantly lower in the elderly group (34±16 µl) compared to that of the young group (51±25 µl; p<0.01). The CSF stroke volume at the level of SAS at the level of C2-C3 was significantly lower in the elderly group (457±147 µl) compared to that of the young group (575±123 µl; p<0,05). The CSF at two different levels, arterial and venous blood flow, of both groups were compared during cardiac cycle as show in Figure 1. We found no correlation between age and CBF within the young group (Figure 2A) whereas linear correlation was observed (Figure 2B) in elderly group (R^2 =0.7;p=0,05).

Conclusion: These preliminary data demonstrate that CSF pulsations and the cervical level as well as aqueductal level decrease with age. We also demonstrate that blood flow decreases significantly with age. These findings are useful to study degenerative cerebral pathologies such as hydrocephalus [2-3], Parkinson and Alzheimer diseases and predict abnormal degenerative brain. Cerebral hemo-hydrodynamic studies are of great values for cerebral pathologies and we strongly believe that PC-MRI with these indices could play a key role in neuro-radiology.

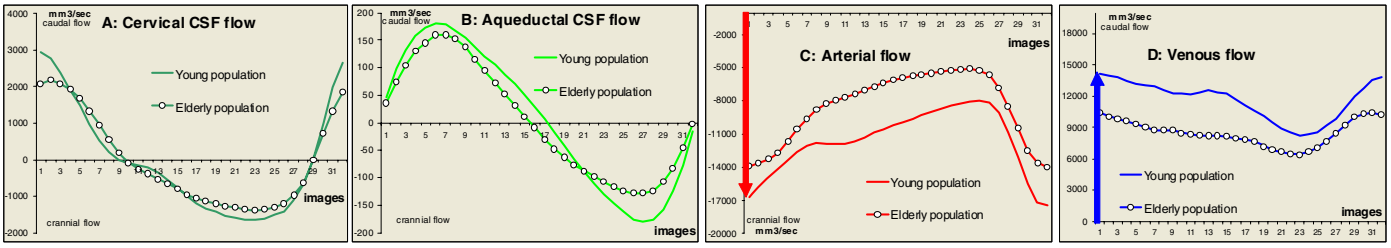

Figure 1: Plots of CSF flow at (A) the aqueductal level, and (B) at the cervical level comparing the two groups during the 32 phases of the cardiac cycle. Cerebral blood flow (CBF) of the two groups at the arterial level (C) and the venous level (D) throughout the 32 phases of the cardiac cycle.

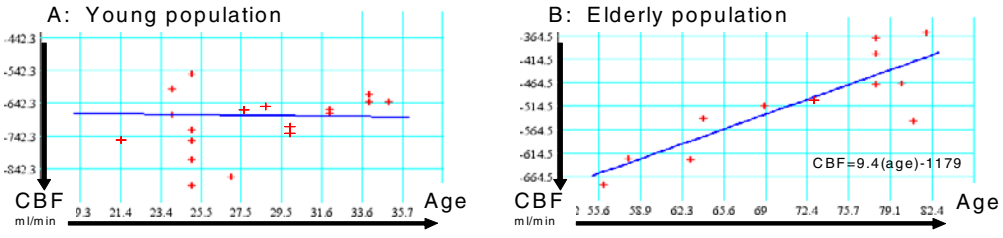

Figure 2: Correlation between age and cerebral blood flow (CBF) of (A) young group and (B) elderly group where linear regression was measured with R^2 = 0.7; p=0,05.

References: (1) Balédent O, Henry-Feugeas MC, and Idy-Peretti I. *Invest Radiol.* 2001;36(7):368-377. (2) Balédent O, Gondry-Jouet C, Meyer ME, et al.. *Invest Radiol.* 2004;39(1):45-55. (3). Luetmer P, Huston J, Friedman J et al.. *Neurosurgery.* 2002;50(3):534-543.