DISTAL CEREBRAL ARTERIAL PULSATILITY USING 4D FLOW MRI

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Target audience: Researchers and clinicians interested in cerebral arterial pulsatility measurements.

Purpose: Age related high pulsatility of distal brain arteries is thought to damage exposed brain tissue, leading to brain atrophy and cognitive decline among elderly[1]. This mechanism is sometimes referred to as pulse wave encephalopathy. Previous studies have focused on assessing central pulsatility or pulsatility in cervical arteries feeding the brain[2]. Here we investigate the potential use of high-resolution 4D Flow MRI to assess pulsatility of distal branches of the cerebral arterial circulation.

Methods: Ten healthy volunteers (3 female) were recruited (age range 29–53 years). All scans were performed on a 3T scanner (Discovery MR 750, GE Healthcare, WI, USA) with a 32-channel head coil. 4D Flow MRI data was acquired by PC-VIPR[3] prescribed to cover the entire intracranial volume. Scan parameters: 16,000 radial projections; acquisition resolution, 300 x 300 x 300; imaging volume, 22 x 22 x 22 cm; Velocity encoding, 110 cm/s; TR/ TE, 6.5/2.7 ms; flip angle, 8°. Time resolved images were reconstructed by retrospective gating using a recorded peripheral pulse signal. A time-composite complex difference image was reconstructed to provide anatomical detail of the vascular system. During post-processing step, the entire vascular tree was subject to a centerline extraction process, storing coordinates for every branch as well as labels for points along the branch. A centerline guided flow tracking algorithm was used to visualize the distal arteries prior to selecting arteries for further analyses. After the user defined vessels of interest, a flow rate waveform was calculated for every selected branch by averaging flow data obtained in local cross-sectional cut-planes automatically placed in every centerline point perpendicular to the axial direction of the vessel. Pulsatility index, calculated as (Qmax-Qmin)/Qmean was measured in **(1)** the internal carotid artery (ICA); (**2**) basilar artery (BA); **(3)** distal middle cerebral artery at the level of the sylvian sulcus (dMCA); **(4)** distal anterior cerebral artery at a level above callosum (dACA). The dACA was not labeled according to side, instead just one dACA branch was used in every subject; and **(5)** distal posterior cerebral artery (dPCA).

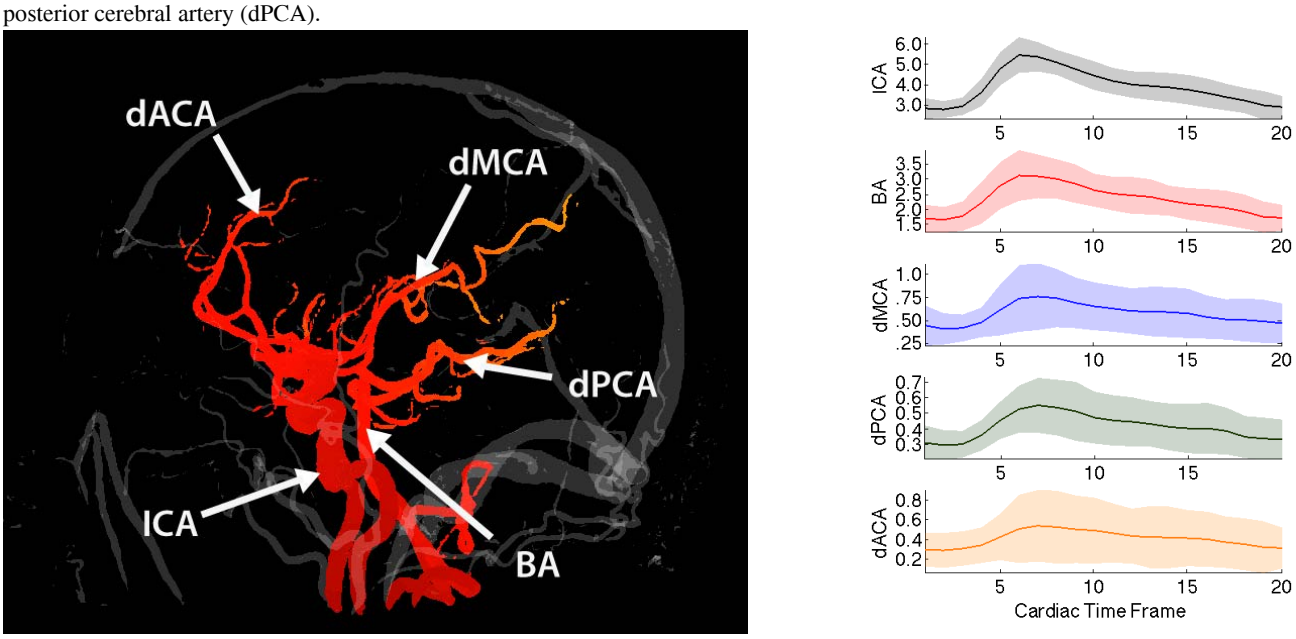

Figure 1. *(L) Centerline-guided flow tracking was used to simplify the process of locating the distal arterial branches of interest. The arrows indicate vessels where pulsatility was analyzed (R) Average waveforms and standard deviation for all investigated arteries, given in mL/s. Left and right arteries were averaged except for the BA and the dACA.*

Vessel	Pulsatility Index
ICA	0.80 ± 0.15
BA	0.74 ± 0.14
MCA	0.71 ± 0.08
PCA	0.72 ± 0.13
ACA	0.74 ± 0.16

Results & Discussion: Distal cerebral arterial pulsatility was successfully assessed in all ten subjects. Visual inspection verified that expected waveform morphology was present in all measurements. Figure 1 displays the average waveform for every distal branch, as well as for the ICA and BA. Notably, on average distal branches had highly similar pulsatility indexes. Also, distal arteries had a slightly lower pulsatility index compared to their feeding proximal artery, indicating some attenuation in pulsatility due to vascular compliance. The results shown are comparable to those reported by a previous ultrasound study[4], however we note a tendency of 4D Flow MRI derived values to be slightly lower. This was presumably an effect of lower temporal resolution. Regression analysis revealed that 48% of the variance in distal MCA pulsatility index could not be explained by the variance in ICA pulsatility index, indicating that distal pulsatility measurements provide unique information that cannot be inferred from more proximal pulsatility estimates.

Conclusion: High-resolution 4D Flow MRI measurements may be used to quantify distal cerebral arterial pulsatility. This information provides additional detail in pulsatility analyses that may be useful in studying pulse wave encephalopathy.

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References:1. Mitchell et al, Brain 2011, 2. Wåhlin et al Neurobiol Aging 2013, 3. Gu et al AJNR 2005, 4. Tegeler et al, J Neuroimaging 2013