Does the heart beat the brain? Analyze MRI data to estimate the absorption of pulsatile energy of blood flow in the brain.

Aim:

In this project, you will develop analysis methods to estimate how much kinetic energy from the pulsatile blood flow is absorbed in the brain, when the blood passes through the tissue.

Background:

Excessive deposition of heartbeat-induced pulsatile energy in the brain is one of the potential mechanisms that lead to vascular brain damage in ageing people. Blood flow to the brain is very high: The brain receives approximately 20% of the cardiac output, while it makes up for only 1% of the body weight. Normal, healthy vessels are very elastic, and function as a so-called windkessel that absorbs the pulsatile energy from the heart at the input of the vascular tree (the aorta), and provides a steady virtually non-pulsatile flow at the capillary bed. With aging, the vessel walls become more and more stiff, and the damping of the pulsatile energy towards the capillary bed is reduced. This leads to increased pulsatility in the microvessels of the brain, which is thought to induce damage, like vascular remodeling, leakage and tissue damage.

With MRI, quantitative measurements of blood flow can be obtained, using phase contrast velocity encoding. In this project, you will develop image analysis methods to quantify the amount of kinetic energy (1/2 ρ v^2) present in the main feeding arteries of the brain, and in the main draining veins. We have data available from 7 tesla 4D phase contrast velocity imaging in both patients and matched controls.

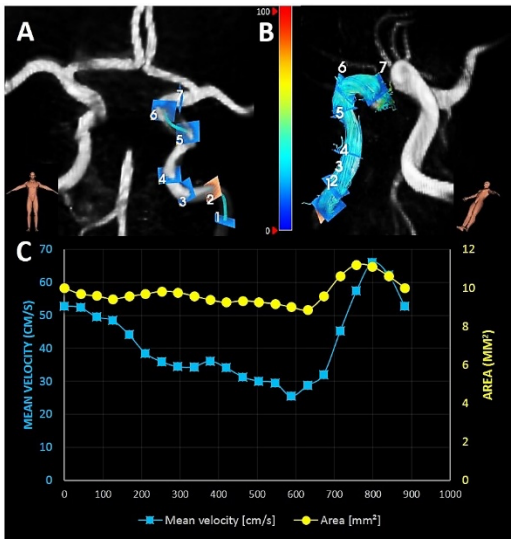

***Figure**. Illustration of the 4D phase contrast velocity MRI data of a patient. A. Cross sections through the different internal carotid artery (ICA) segments indicated by numbers from 1 to 7. The left and right ICA are the main feeding arteries of the brain, together with the smaller basilar artery. B. Visualized streamlines through the selected planes. C. Mean velocity curve (cm/s) in blue and lumen area curve (mm2) in yellow for a randomly chosen segment (#6) over the cardiac cycle (x-axis: time over the cardiac cycle in milliseconds, relative to the trigger originating from a pulse oximeter at the finger tip).*

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