Imaging the cerebral venous sinuses' puls curve by ultrafast dynamic BOLD MRI

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Introduction: Fast and dynamic imaging of the cerebral venous sinuses' puls curve could be a useful additional tool in clinical diagnostic imaging of diseases like cerebral sinus thrombosis. Here, we evaluated the consistency of rhythmic signal changes in the cerebral venous sinus in ultrafast blood oxygen level dependent (BOLD) acquisitions with the central venous pulse curve. For reference, two-dimensional (2D) phase contrast angiography (PCA) was performed and the central venous pulse was measured by duplex sonography.

Patients and methods: Eighteen healthy volunteers participated in the study (age: 20 – 40 years). All MRI exams were performed at 3 Tesla (Magnetom Trio, Siemens Medical Systems, Erlangen). The MRI protocol consisted of a three-dimensional T2-weighted scan of the whole brain (3D-FLAIR, isotropic voxel size, 1 x 1 x 1 mm) and a 2D PCA (single slices, slice-thickness 50 mm, oriented transversal, sagittal and coronal, respectively). Dynamic BOLD measurements (TR/TE = 100/36 ms; temporal resolution: 10 acquisitions per second; flip angle: 20°) were performed in a dynamic single-slice technique (200 acquisitions per slice, TA: 20 s, slice thicknesses: 5 and 10 mm, respectively) in seven different standardized orientations in order to cover a significant amount of all cerebral venous sinuses (see **Fig. 1**). During the whole protocol the volunteer's pulse frequency was monitored by pulsoxymetry and journalized. Directly after the MRI exam and the volunteer remaining in supine position the jugular venous pulse curve was measured by duplex sonography. For data analysis arterial pulsation, jugular pulsation and liquor pulsation as visualized by the BOLD acquisitions served as reference values. Regions of interest (ROIs) were defined in all dynamic BOLD slices and profile curves (time to signal intensity) were correlated to the reference parameters (see **Fig. 2**).

Results: The detection of pulsation in the superior sagittal sinus and the transverse and sigmoid sinuses was highly reliable. Sinus rectus was reliably detected in only 56 % (10 / 18) of the volunteers. Dynamic analysis of the data revealed a consistent correlation of the rhythmic signal changes in all venous sinuses to all reference parameters. Signal peaks in the venous sinuses occurred delayed when compared to the liquor pulsation, which is assumed to be an aftereffect of the arterial pulsation. In some volunteers the venous signal changes showed a doublet peak similar to the duplex sonographic appearance of the jugular venous pulse curve.

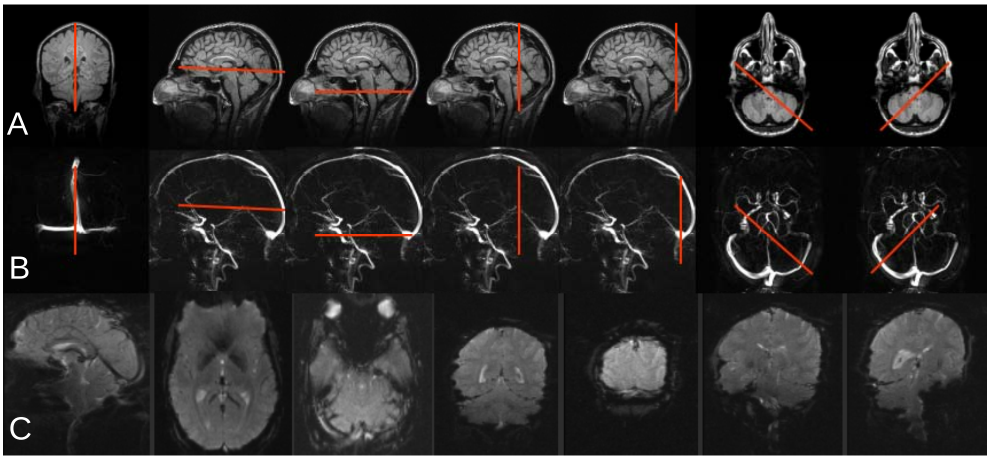

Figure 1: Seven standardized orientations of the single-slice BOLD acquisitions referenced to (**A**) 3D-FLAIR and (**B**) 2D phase-contrast angiography. (**C**) The corresponding BOLD images.

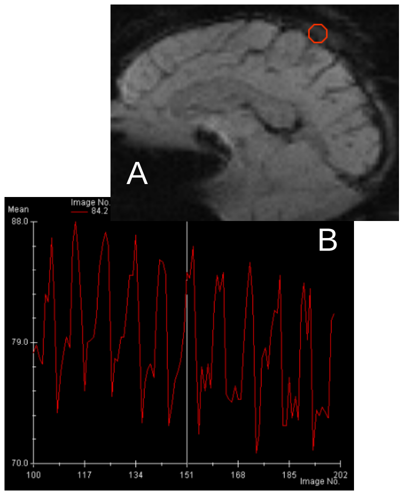

Figure 2: ROI-analysis. (**A**) Placement of a ROI in the superior sagittal sinus and. (**B**) the resulting time-to-signal curve.

Conclusion: Ultrafast single slice BOLD imaging is feasible to display the venous pulse curve in the large cerebral venous sinuses. The measurement is reliable and needs only few minutes of overall acquisition time, if all sinuses are in question. The most important potential field of application is the diagnostic imaging of cranial sinus thrombosis, where this new technique may serve as an additional dynamic tool. In addition, future applications could include diagnostic imaging of the hemodynamic impact of intracranial space occupying lesions such as a meningioma causing a sinus stenosis as well as the hemodynamic impact of flow-changing lesions like arterio-venous malformations.