High-Resolution Time-Resolved 3D Quantitative Flow MRI of Intracranial Vessels

M. Piccirelli1, G. R. Crelier2, R. Luechinger1, S. Kozerke1, and P. Boesiger1

1Institute for Biomedical Engineering, University and ETH Zurich, Zurich, Switzerland, 2Gyrotools GmbH, Zurich, Switzerland

Introduction

Time-resolved three-dimensional PC-MRI allows in-vivo acquisition of four-dimensional hemodynamic data in large vessels. In the aortic arch the depiction of velocity vectors, flow-field stream lines, and particle path lines reconstructions has been proven beneficial for the understanding of flow patterns and structure over the cardiac cycle, especially in the presence of congenital or acquired abnormalities1. There is considerable interest in expanding the application of these techniques to the intracranial arteries, as several cerebrovascular diseases are interlinked with abnormal flow2. However, the relative small scale of the arterial structures of interest requires acquisition of velocity information with high spatial resolution. The objective of this work was to investigate the feasibility of high resolution 3D quantitative flow MRI of intracranial vessels.

Methods

High resolution time-resolved 3D PC MRI protocols were optimized on 3 healthy volunteers on a 3T system (Philips Healthcare, Best, Netherlands) with 8-channel head coil. The nominal spatial resolution was varied from 0.5 to 0.15mm voxel volume. The other imaging parameters were: TE/TR 3.6-5.9/6.9-9.7ms, FOV 22x18x2.2cm, Venc 90cm/s, 19 cardiac phases, scan duration 17-37min, retrospective VCG triggering, SENSE factor 1.5-3.0.

Visualization of flow velocities, region-of-interest (ROI) analysis, and particle path lines reconstructions were performed with a commercial software package (GyroTools, Zurich, Switzerland). To measure and compare velocity profiles, cross-sectional planes were placed perpendicular to flow through the basilar artery (BA), through the left and right posterior cerebral arteries (LPCA , RPCA), inside the cavernous segments of the left and right internal carotid arteries (LICA, RICA), and after the ICA bifurcation in the anterior cerebral arteries (LACA, RACA). ROIs encompassing the vessel lumen were drawn in these planes for all phases of the cardiac cycle and used for quantification.

Results

Flow velocities could be quantified in all volunteers and at all resolutions. Results with the 0.3mm voxel size protocol are summarized in Figures 1,2 and Table 1. At resolutions below 0.3mm erroneous path lines reconstructions in the smaller vessels were an indication of insufficient SNR. At 0.3mm voxel size, very small arteries such as the posterior communicating arteries were clearly visible. Peak flow velocities of up to 6.8cm/s could be measured in these arteries.

Discussion and Conclusion

Quantitative flow data of sufficient spatial resolution is required for resolving flow patterns in very small structures like the communicating arteries or small-sized aneurysms. Our results indicate that time-resolved 3D quantitative flow measurements of the intracranial arteries is feasible on a clinical system with a spatial resolution of down to 0.3mm voxel size. Wall shear stress determination feasibility need to be investigated.

References: