Accelerated Phase-Contrast MR Imaging: Comparison of SENSE, k-t BLAST and Doppler Ultrasound for Velocity and Flow Measurements of the Aorta

A. Stadlbauer[1], W. van der Riet[2], S. Globits[3], G. Crelier[4], and E. Salomonowitz[1]

[1]MR Physiks Group, Department of Radiology, Landesklinikum St.Poelten, St. Poelten, Austria, [2]European MRI Consultancy (EMRIC), Strasbourg, France, [3]Third Department of Internal Medicine, Landesklinikum St. Poelten, St. Poelten, Austria, [4]GyroTools, Zurich, Switzerland

Purpose: We sought to evaluate differences in velocity and flow measurements of the aorta between accelerated phase-contrast MR imaging using SENSE and k-t BLAST, and correlated peak velocities to Doppler ultrasound. To investigate the feasibility of SENSE and 6-fold k-t BLAST for time-resolved 3D velocity mapping of aortic blood flow.

Materials and Methods: 2D PC-MR imaging perpendicular to the ascending and descending aorta was performed at 1.5 Tesla (Philips Achieva) in 11 volunteers using SENSE (R=2) and k-t BLAST (2-, 4-, 6-, and 8-fold). Peak velocity, mean velocity, and stroke volume of the accelerated PC experiments were compared using Spearman's ρ, Bland-Altman analysis, and Wilcoxon rank-sum tests. Peak velocities were additionally correlated to velocity measurements from continuous wave (CW) Doppler ultrasound. Further, differences in time-resolved 3D blood flow patterns investigated with 3D PC-MR sequences accelerated with either SENSE (R=2) or k-t BLAST (6-fold) were investigated in volunteers and in 2 patients suffering from aortic diseases using the GTFlow software tool (GyroTools).

Results: Strong correlations (R=0.991–0.836) between SENSE and k-t BLAST were found for all three parameters. In peak velocity significant differences were found between SENSE and all k-t BLAST experiments (marked with '*' in Figure 2), but not for 2-fold in ascending and 2- and 4-fold k-t BLAST in descending aorta. For mean velocity no significant differences were found. Stroke volume revealed significant differences for all k-t BLAST experiments in the ascending and for 6- and 8-fold k-t BLAST in descending aorta (marked with '*' in Figure 2). Comparisons of peak velocities from CW Doppler ultrasound showed significant correlations for all acceleration techniques (R=0.929–0.808), but a significant underestimation for k-t BLAST 6 and 8 (marked with '#' in Figure 2). Bland-Altman analysis for peak velocities between CW Doppler and acceleration techniques revealed an increase in mean difference form SENSE (14.3m/s) to k-t BLAST 8 (29.5m/s). Reconstruction of 3D flow patterns revealed attenuations in blood flow dynamics for k-t BLAST 6 compared to SENSE 2.

Conclusion: SENSE with R=2 and k-t BLAST with low acceleration factor (2- and 4-fold) are significant correlated in phase-contrast flow measurements. The effects of higher acceleration factors have to be considered for the use in phase-contrast flow measurements.

Figure1: A) Magnitude and B) phase image of the ascending (Asc AO) and descending (Des AO) aorta. Time course of flux in the C) ascending and D) descending aorta.

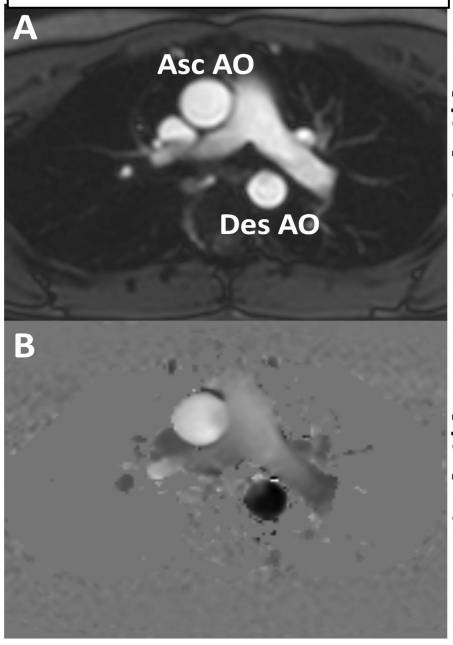

Figure2: Box plots of peak vel., mean vel., and stroke vol. for the ascending and descending AO. (Note: * signif. diff. to SENSE 2; # signif. diff. to CW Doppler)