Examining the distribution of the local pulse wave velocity in mice using a k-t BLAST QA-method

Volker Herold[1], Alexander Gotschy[1], Patrick Winter[1], Eberhard Rommel[1], Wolfgang Rudolf Bauer[2], and Peter Michael Jakob[1]
[1]*University of Wuerzburg, Wuerzburg, Bavaria, Germany,* [2]*Medizinische Universitätsklinik, University of Wuerzburg, Bavaria, Germany*

Introduction: Local elastic properties of the murine aortic vessels such as the pulse-wave-velocity (PWV) can be calculated using PC-MRI and quantifying simultaneously the blood-flow (Q) and the cross-sectional area pulse (A) (QA-method) [1]. Since atherosclerotic plaque burden and changes of the local elastic parameters are distributed inhomogeneously along the arterial blood vessels it is of paramount interest to not only determine the local pulse wave velocity at one location, but to examine the distribution of the local PWV along the entire blood vessel. Using a k-t BLAST technique, we could significantly accelerate the data acquisition and thus realizing the quantification of the local PWV at 10 different sites along the murine aorta in one experiment.

Methods:

The time course of the blood volume flow Q and the cross sectional area A was measured using a high resolution PC-Cine-FLASH sequence performed perpendicular to the abdominal aorta with through plane flow encoding at 10 different sites along the ascending and descending aorta. The local pulse wave velocity PWV was estimated using the QA-method (i.e. PWV=dQ/dA for early systolic time points, see **Fig. 1b**). For k-t BLAST reconstruction we acquired a temporal undersampled (af=10; lattice sampling pattern as described in [2], see **Fig. 1a**) dataset supplemented by a training dataset with 8 centered k-space lines. The post processing for each undersampled slice-data-set was performed according to [2].The resolution of the training dataset (i.e. the number of center-k-space lines) regulates the high-temporal frequency suppression in the reconstructed images (by spatially averaging high frequency effects) acting like a low pass filter on the final QA-plots. The kt-BLAST undersampling and reconstruction technique allowed to reduce the total measurement time by a factor of almost 10 without compromising the accuracy of the PWV calculation. All in vivo measurements were performed on a Bruker Avance 750 spectrometer (17.6T) with a maximum gradient strength of 1.0T/m and a 27mm homebuilt TEM resonator. C57/Bl6 mice at the age of 8 months were anesthetized for MR-measurements using 1.5 vol.% isoflurane inhalation. ECG triggering and respiratory gating was applied for all MR measurements. Imaging parameters were: TE 2.1 ms, FOV 25×25 mm^2, slice-thickness 1.0 mm, resolution 98×98 μm^2, temporal resolution of fully sampled data-sets: 1ms [1].

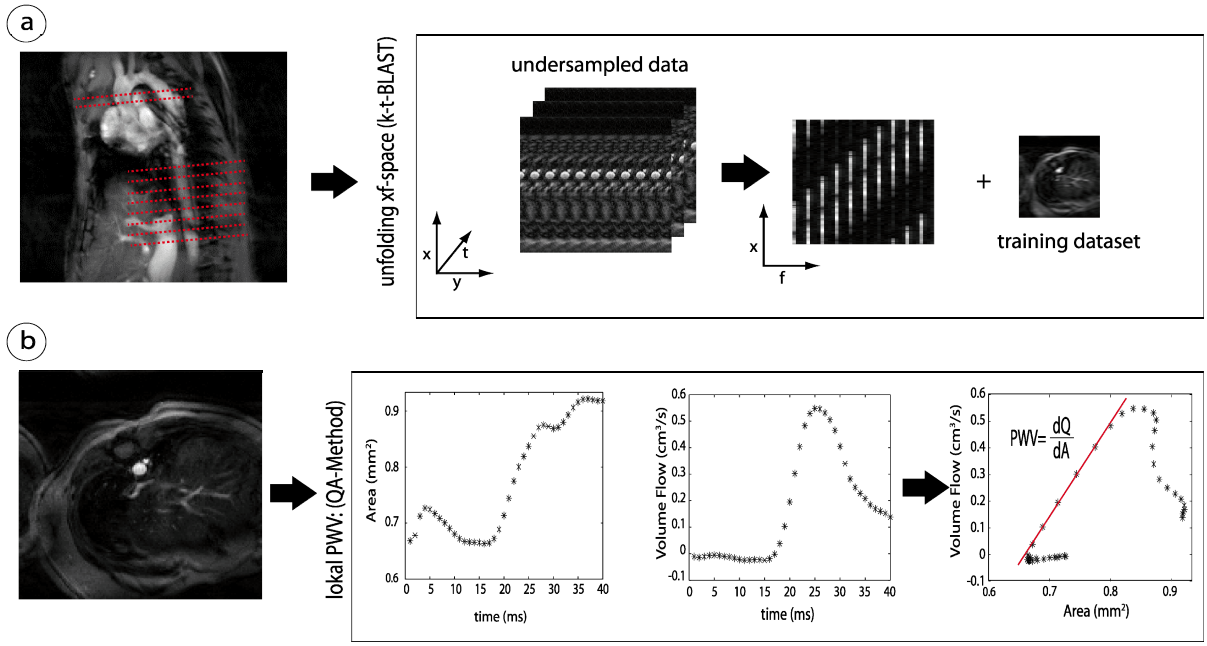

Fig.1: **a)** Temporally undersampled data-sets were acquired at 10 different slices perpendicular to the murine aorta and reconstructed based on the kt-BLAST-method. **b)** Subsequently the local pulse wave velocity was calculated based on the time courses of the local volume flow- and cross-sectional area changes.

Results: Local pulse wave velocities were measured in four C57/Bl6-mice (age: 8 month) at the ascending (2 slices) and the descending aorta (8 slices) as illustrated in **Fig.1a**. Mean PWV for the ascending aorta for all animals was measured to be (2.2 ± 0.2) m/s. A significant difference between the mean PWV for the ascending aorta and the descending aorta (2.5 ± 0.2) m/s could be detected ($P<0.05$). However no significant differences of the PWV values within the two different slice groups (ascending and descending aorta) could be found indicating a low level of changes in the vessel wall function due to atherosclerotic disease. Future experiments will focus on the evaluation of the local PWV distribution in ApoE$^{-/-}$-mice.

Conclusion:

The presented method allows the quantification of the local PWV at 10 different sites along the murine aorta in less than 15 min. in mice and thus enabling for the first time to examine the distribution of local elastic properties during one experiment. Knowing the distribution of the local PWV would be of great value in particular when examining early atherosclerotic changes. The presented method is also not limited to small animal studies. All human MR-studies examining mechanical vessel wall parameters based on low frequency changes (such as the vessel wall compliance, PWV, elasticity) would benefit from the stability and significant time reduction.

Acknowledgement:
This work was supported by:
Deutsche Forschungsgemeinschaft (SFB 688).

References:

[1] Herold et al., Magn Reson Med, [2009]; 61:1293–1299.
[2] Tsao et. al, Magn Reson Med., [2003]; 50:1031–1042.