In vivo measurement of local pulse-wave velocity in the right common carotid artery in mice with PC-Cine-MRI at 17.6 T

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Introduction:

Mouse models are increasingly used to investigate functional cardiovascular parameters. Pulse-wave velocity (PWV) is an important parameter for the evaluation of the arterial stiffness and cardiovascular risk. Several diseases such as hypertension and arteriosclerosis are associated with vascular remodeling and arterial stiffening. MRI methods have been used to quantify PWV in the murine aorta [1,2]. In this work we demonstrate the ability of high field MRI to quantify PWV in the right common carotid artery.

Methods:

Assuming a reflectionless and unidirectional waveform for the early systolic flow pulse, pulse-wave velocity can be described as the differential quotient PWV=dQ/dA where Q(t) denotes the volume flow through the right common carotid artery and A(t) is the time course of the cross-sectional area (QA-method) [2]. To measure the time dependant parameters Q(t) and A(t), a PC-Cine-FLASH-sequence with velocity compensation in all gradient directions was performed perpendicular to the vessel wall. Through-plane-motion encoding was achieved by acquiring two additional datasets using bipolar gradients for the slice-encoding direction. Cross-sectional areas were extracted by manually segmenting the magnitude images obtained from the flow encoded datasets. To reduce eddy current artefacts, the bipolar flow encoding gradients were combined with the spatial encoding gradients such that the total gradient amplitudes were minimized for the slice encoding direction. The temporal resolution of 1 ms at a repetition time of 5 ms was achieved by acquiring five cine datasets with a time delay of 1 ms between two subsequent datasets. Imaging parameters were: TE=2.1ms, FOV=25×25mm^2, slice-thickness=1.0mm, resolution=98×98 μm^2. The total scan time was 10 minutes. Pulse wave velocity values were extracted by applying a linear fit to the function Q(A) for the data corresponding to the early systole. All measurements were performed on a Bruker Avance 750 spectrometer with a maximum gradient strength of 1.0T/m and a 25mm homebuilt resonator in birdcage design. Mice (NMRI, n=4) with body weights between 25g and 30g were anesthetized using 1.5 vol.% isoflurane inhalation. ECG triggering and respiratory gating was applied for all MR measurements. The gradient cooling unit was used to maintain the body temperature at 37°C.

Results:

Figure 1 shows a representative magnitude image of the right common carotid artery during the systolic phase. The time course of the cross-sectional areas is shown in Fig. 2a. The corresponding volume flow is depicted in Fig. 2b. When evaluating the PWV as the slope of the linear function Q(A), a smoothing filter was applied to the time-dependant data Q(t) and A(t). Fig. 2c shows results of the PWV calculation. Mean pulse-wave-velocities for the right common carotid artery were measured to be PWV= (2.3 ± 0.3)m/s.

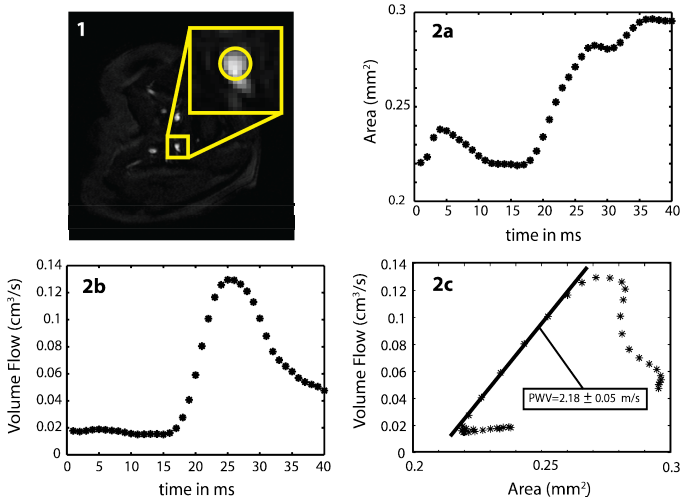

Fig.1 : MR image of the cross-sectional area of the right common carotid artery during systole.
Fig.2a : Cross-sectional changes of the right common carotid artery during systole.
Fig.2b : Volume Flow in the right common carotid artery during systole.
Fig.2c : PWV-calculation as the slope of the flow-area relation during early systole.

Conclusion:

In this study, we have demonstrated the feasibility of high field MR microscopy to quantify local pulse wave velocity in the right common carotid artery. The results are in a good agreement with PWV-values obtained by ultrasonic pulsed Doppler measurements [3]. A non-invasive method was provided to investigate local vessel stiffness, which will add to a better understanding of biomechanical aspects of intramural remodeling during atherosclerotic lesion development.

References:

[1] Zhao et. al. J Magn Reson Imag [2009]; 30:286-291
[2] Herold et al. Magn Reson Med [2009]; 61:1293–1299
[3] R. Williams et al. Ultrasound Med Biol [2007]; 33:1368–1375

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