High field in-vivo PC-MRI to quantify and compare regional and local pulse-wave velocity in the right common carotid artery in mice

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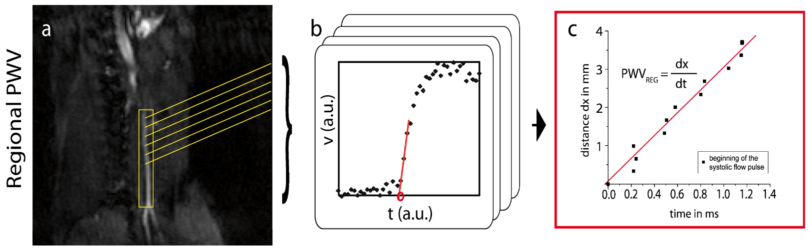
Introduction:

Mouse models are increasingly used to investigate functional and cardiovascular parameters. Quantification of the vessel wall function by estimating the pulse wave velocity (PWV) has emerged as a potential predictor of cardiovascular risk. Usually two different approaches are applied to quantify the PWV. A transit-time method (TT) to quantify an averaged regional PWV value (PWV_{REG}) and local (PWV_{LOC}) measurement techniques exploiting local volume flow (Q) -and cross-sectional area (A) changes. However no comparison of these two different measurement techniques have yet been performed with MR-based imaging. In this paper we present a multi-site TT measurement approach to quantify at the first time the regional PWV in the carotid artery and compare these results with local PWV values.

Methods:

Multipoint transit-time-method (TT): In order to examine the regional pulse wave velocity PWV_{REG} along the flow path, the axial flow velocity was measured using an in-plane PC-Cine-FLASH sequence with flow encoding gradients in the read- and phase-encoding direction. The axial flow velocity as a function of time was segmented in 12 regions of interest (ROIs) as shown schematically in Fig. 2c. By determining the start of the flow pulse in each segment, the transit time of the pulse wave was calculated allowing for the evaluation of the PWV. For the in vivo experiments mice were anesthetized with 1.5 vol.% isoflurane. ECG triggering and respiratory gating was applied for all MR measurements. By using an interleaved acquisition scheme a temporal resolution of 1ms could be achieved. All MR-experiments were performed on a Bruker Avance 750 spectrometer (17.6T). Imaging parameters were: TE 2.1 ms, FOV 25$\times$25 mm^2, slice-thickness 1.0 mm, resolution 98x98 μm^2, total measurement time: approx. 7 min.

QA-method: Assuming a reflectionless and unidirectional waveform for the early systolic flow pulse, the pulse-wave-velocity can be described as: $PWV_{LOC}=dQ/dA$ where Q(t) denotes the volume flow through the arterial vessel and A(t) is the cross-sectional area of the vessel [1]. To measure the time course of the parameters Q and A, a high resolution PC-Cine-FLASH sequence was performed perpendicular to the arterial vessel with through plane flow encoding.



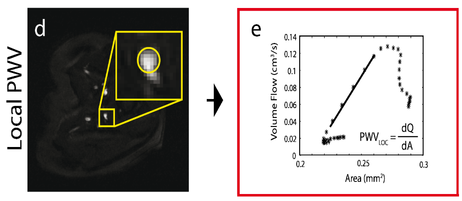


Fig.1a-c: **TT method**: Plotting the time points of the beginning systolic flow pulse over the distance to the first segment allows the calculation of the PWV; **d-e: QA-method**: PWV-calculation as the slope of the flow-area relation during early systole.

Results:

8 animals (ApoE (n=4); age:35-40 weeks; C57Bl6 (n=4) ; age: 8 weeks) were examined to quantify the correlation between the local and the regional pulse-wave-velocity. **Fig. 1a-c** and **Fig. 1d-e** show representative results of the PWV calculation using the TT-method and the QA-approach respectively. For the ApoE-mice mean local PWV_{LOC} was measured to be (3.5±0.6) m/s (mean ± standard error) in comparison to the mean of the regional PWV_{REG} of (3.5±0.7) m/s. For the C57Bl6 animals the two different measurement techniques revealed: PWV_{LOC} =(2.2 ±0.1) m/s and PWV_{REG} (2.5±0.2) m/s. The overall correlation as depicted in Fig. 2 shows a good compliance between the different measurement techniques.

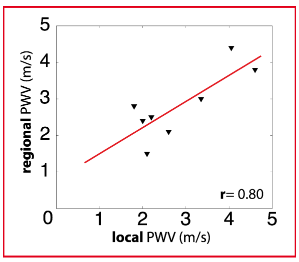


Fig.2: Correlation plot of the local and regional PWV values.

Conclusion:

In this study, we have demonstrated the feasibility of high field MR microscopy to quantify pulse wave velocity in the right common carotid artery. Since atherosclerotic lesion progression is expected to show a non-homogenous distribution along the propagation flow path, PWV_{REG} should differ from PWV_{LOC} in case of the diseased ApoE animals. However, the good correlation of the PWV_{LOC} and PWV_{REG} – data might be caused by the comparatively short vessel section that was examined, which concentrates the effect of regional averaging and gives PWV_{REG} a more local character. Moreover our results also might reflect a homogenous vessel wall remodeling instead of local dominated processes of atherosclerosis.

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References:

[1] Palliémoz et al. Magn Reson Med [2002];47:649-654.