

## In vivo measurement of regional and local pulse-wave velocity in mice with MRI at 17.6 T

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### Introduction:

Mouse models are increasingly used to investigate functional and cardiovascular parameters. Pulse wave velocity (PWV) is an important parameter for the evaluation of the arterial and cardiovascular risk. Several diseases such as hypertension and arteriosclerosis are associated with vascular abnormalities and arterial stiffening. In this work we present two different methods to noninvasively examine the PWV at different sites in the murine aorta: a regional multipoint transit-time (TT) method and a local flow-area (QA) approach. Both methods were validated with a deformable vessel wall phantom.

### Methods:

**QA-method:** Assuming a reflectionless and unidirectional waveform for the early systolic flow pulse, the pulse-wave-velocity can be described as:  $PWV = dQ/dA$  where  $Q(t)$  denotes the volume flow through the aorta and  $A(t)$  is the cross-sectional area of the vessel [1,2]. 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.

**Multipoint transit-time-method:** In order to examine the PWV continuously along the flow path an improvement of the two-point transit time method was used. Therefore 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 blood flow velocity as a function of time was segmented in 12 regions of interest (ROIs) as shown schematically in figure 3. 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.

Both methods were validated in a deformable vessel wall phantom made of polyvinyl alcohol (PVA) cryogel as shown in figure 1 [3]. Flow and pressure pulse waves in the phantom were generated by using a pulsed electrical pump. As a reference the PWV in the vessel phantom was measured with a movable pressure sensor using a TT approach. For the in vivo experiments five mice between 30 and 35g 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. Both methods were performed on a Bruker Avance 750 spectrometer. Imaging parameters were: TE 2.1 ms, FOV 25×25 mm<sup>2</sup>, slice-thickness 1.0 mm, resolution 98×98μm<sup>2</sup>, total measurement time: approx. 10 min.

### Results:

Figure 2 and figure 3 show representative results of the PWV measurements using the QA-method and the TT-method respectively. To compare the QA- and the TT-approach with an examination of the pressure wave propagation, MR experiments were performed at six different sites in the deformable phantom. Both MR methods were found to correlate well with the pressure measurements (QA-method versus pressure measurements:  $R^2=0.88$ ; TT-method versus pressure measurements:  $R^2=0.82$ ). Mean pulse wave velocity in the descending aorta of six C57BL/6J mice (age: 2 months) were found to be  $(2.8 \pm 0.2)$  m/s with the QA-approach and  $(3.1 \pm 0.1)$  m/s with the TT-method ( $R^2=0.83$ ). Examinations in the ascending aorta with the QA method in the same mice resulted in a mean PWV value of  $(2.8 \pm 0.3)$  m/s.

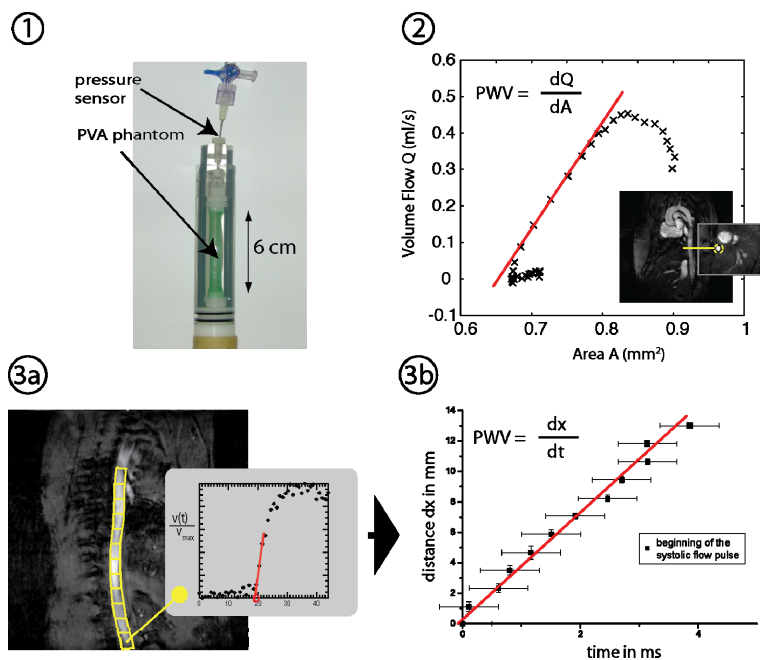


Fig.1 :Deformable PVA Phantom with a pressure sensor.

Fig.2 :QA method: PWV-calculation as the slope of the flow-area relation during early systole.

Fig.3 :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.

### Conclusion:

In this study, we have demonstrated the feasibility of high field MR microscopy to quantify local pulse wave velocity with two different image guided approaches. The in vivo PWV values measured with the MR-technique agree with values stated in literature (measured using Doppler ultrasound) [4]. While the multipoint TT-approach allows to assess local and regional PWV changes in the descending aorta, the local QA-approach is useful to detect early vascular abnormalities at locations where the TT-method is less beneficial such as the ascending aorta.

### References:

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