REGIONAL TRANSIT TIME MEASUREMENT OF PULSE WAVE VELOCITY IN THE MURINE AORTA

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INTRODUCTION

Aortic stiffness increases in early stages of arteriosclerosis and is assessable by pulse wave velocity (PWV) MR-measurements [1,2]. So far literature reported only MR-studies in larger animals and humans. The apolipoprotein E-deficient transgenic mouse (ApoE-/-) is a convenient model to study arteriosclerosis [3]. A non-invasive MR-imaging technique to examine vessel function in the murine aorta by measuring the transit time of the pulse wave is presented here. As pulse wave and flow velocities are similar in humans and mice, but dimensions are about 20-times larger in humans, the challenges in this project were especially the temporal (1 ms) and spatial resolutions needed.

METHOD

The MR-technique was a transit time method that acquired the time course of blood flow velocities at two different positions of the aorta simultaneously (Fig.1) in an interleaved fashion (Fig.2) [8]. The PWV was calculated by: $PWV = d/\Delta t_{pw}$, with d being the distance between descending and abdominal aorta (Fig.1), and Δt_{pw} the delay between the onsets of the pulse waves in the flow velocity curves at the two locations (Fig.4). The MR-technique was based on a high-resolution CINE-sequence [4] with incorporated flow velocity encoding (TR: 5.0 ms, TE: 1.6 ms, resolution: 147x147 μm^2, slice thickness: 1 mm). To obtain a time resolution of 1 ms, the CINE-sequence was segmented (Fig.2). The total acquisition time was shorter than 30 minutes. All measurements were performed on a Bruker AVANCE 750 spectrometer (17.6 T, 750 MHz) equipped with an actively shielded gradient system (1 T/m) and a homebuilt TEM-resonator with an accessible diameter of 25 mm. The MR-method was validated on a homebuilt vessel phantom (made from poly(vinyl alcohol) cryogel) by pressure catheter measurements of the propagation of the pressure wave induced by a homebuilt pulse generator (Fig.3). For in vivo measurements the heart and breath trigger were acquired using a pressure balloon affixed to the mouse's chest and a homebuilt heart-triggering/breath-gating unit. Nine PWV measurements were performed on five ApoE-/- mice (age: eight months; western type diet for six months; body mass < 34 g) and six measurements were taken on four C57Bl/6 mice (wild type; eight months old).

RESULTS

MR- and pressure measurements on the vessel phantom yielded identical PWV values of 1.4 ± 0.1 m/s. In vivo measurements resulted in PWVs of 3.0 ± 0.5 m/s (mean ± sd) for the ApoE-/- mice and 2.6 ± 0.3 m/s for the C57Bl/6 mice. The mean PWV of the ApoE-/- mice is significantly higher than that of the C57Bl/6 mice with 96% confidence.

CONCLUSION

The validation measurements indicated the accuracy of the MR-technique. The in vivo PWV values measured with the MR-technique agree with values stated in literature (measured using Doppler ultrasound and pressure catheters) [3,5,6,7]. Our results demonstrate that the in vivo MR-measurement of PWV is feasible at a magnetic field strength of 17.6 Tesla in mice in a reasonable acquisition time. With the proposed MR-technique studies of vascular function in mice are accomplishable now.

PERSPECTIVE

Studies on progression and regression of arteriosclerosis in ApoE-/- mice upon treatment are performed currently.

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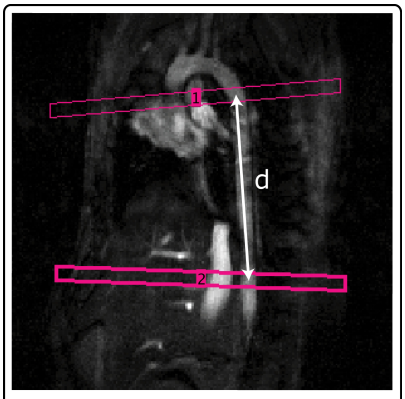

Fig.1: positioning of imaging slices

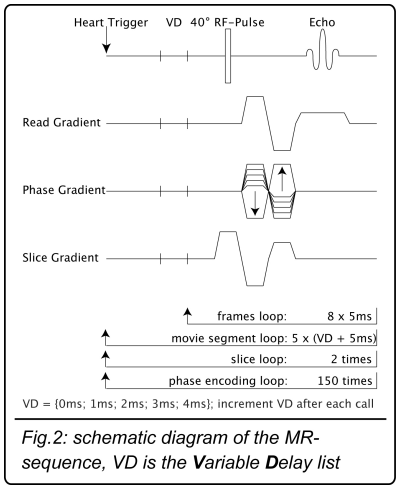

*Fig.2: schematic diagram of the MR-sequence, VD is the **V**ariable **D**elay list*

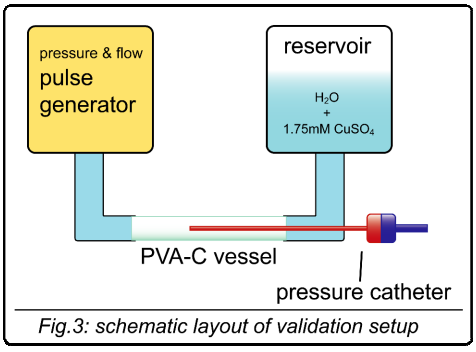

Fig.3: schematic layout of validation setup

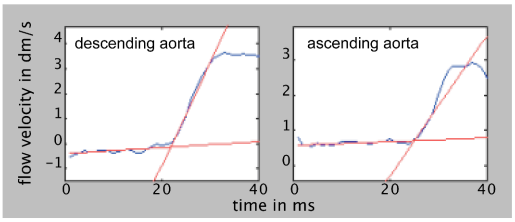

Fig.4: murine flow-velocity-time diagrams; transit time Δt_{PW} is given by difference in intersection times of the fit lines