ROBUST MEASUREMENT OF PULSE WAVE VELOCITY IN ANEURYSMATIC MICE: A PROOF OF CONCEPT STUDY

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Introduction

Abdominal aortic aneurysm (AAA) is a focal dilatation of the abdominal aorta, characterized by a slow degradation of the aortic wall that can lead to sudden death upon rupture. Currently the only criterion to decide whether to perform surgical intervention on AAAs is its size. Pulse wave velocity (PWV) is a non-invasive technique that provides a surrogate measure for aortic stiffness, and might prove an added value to characterize AAAs. However, accurate determination of PWV is not straightforward, especially in mice due to the high resolution needed in both time and space. We propose a robust technique to determine aortic PWV in mice noninvasively. We applied the technique in a proof-of-concept study to assess the potential of PWV to differentiate between aneurysmatic and non-aneurysmatic aortas in a AAA mouse model.

Methods

10 male ApoE -/- mice were implanted an osmotic pump infusing Ang II, to provoke aneurysm formation [Daugherty 2000]. Measurements were performed at baseline and after 28 days. We combined (i) in vivo, contrast-enhanced micro-CT scans that were reconstructed and segmented to obtain the 3D aortic geometry, and (ii) in vivo, high-frequency Pulsed Doppler ultrasound to measure blood flow velocities at different locations throughout the arterial tree. For all velocity waveforms the local minimum was detected as the foot of the wave and the transit time to the R-top of the ECG-signal was measured. The corresponding location of each velocity waveform measurement was determined on both ultrasound BMode images and the 3D model using the centerline distance to landmarks such as side branches. For each location the corresponding distance along the centerline was measured on the 3D model. PWV was subsequently estimated from a linear regression on the transit time of the wavefoot versus the longitudinal position along the aorta.
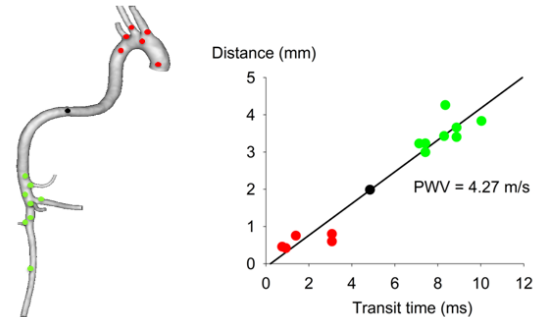

Figure 1: Linear regression to determine aortic PWV at baseline (no aneurysm present).

Results

At baseline, PWV measurements were comparable between all animals: PWV=3.83 ± 1.0 m/s (n=10). Four animals died at an early stage, in one animal no micro-CT scan was obtained at end stage. Three of the remaining 5 animals developed an AAA, 2 did not. Pulse wave velocities were slightly higher in aneurysmatic animals (PWV=5.13 ± 1.4 m/s , n=2) than in non-aneurysmatic animals (PWV=4.69 ± 0.6 m/s , n=3).

Discussion

We used non-invasive micro-CT images to calculate aortic PWVs with the actual distance between velocity waveforms along the aortic centreline. This technique is much less dependent on a single measurement error and thus more robust than using a tape-measured distance [Hartley, 2011]. As this was a proof-of-concept study, we did not include sufficient animals to allow for an in-depth statistical analysis comparing groups. We are currently trying to expand this study in order to compare ultrasound-based PWV to several other stiffness indicators, based on (amongst other) invasive pressure measurements, MMode ultrasound and post-mortem pressure inflation experiments on aortic tissue.

References

Daugherty *et al*, J Clin Invest, 105(11):1605-12, 2000.

Hartley *et al*, AJP-Heart and Circulatory Physiology, 301(2):269-78, 2011.