**Determination of Age-Related Regional Pulse Wave Velocity with 4D Flow MRI**

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**TARGET AUDIENCE:** People with an interest in vascular stiffness and/or the capabilities of 4D flow MRI.

**PURPOSE:** Current MR methods for pulse wave velocity (PWV) estimation primarily target global PWV values. However, vascular stiffness and thus PWV is known to vary regionally. This may be of particular interest with respect to focal diseases such as thoracic or abdominal aortic aneurysms. The purpose of the present study was to measure age-related differences in regional PWV using 4D flow MRI.

**METHODS:** 8 young (age: 23 ± 2 years) and 8 older (age: 58 ± 2 years) normotensive male volunteers were enrolled. Aortic 4D flow MRI velocity data were acquired on a 1.5T scanner (Philips Achieva) with a spatial resolution of 2.3-2.8 mm isotropic and a temporal resolution of 39-43 ms.

For each subject, a 3D segmentation of the aorta was generated for subsequent automated extraction of an aortic centerline and flow vs. time waveforms in a large number of planes perpendicular to the aorta. Travel-time was calculated between each plane and a reference location using the time-to-foot method, which tracks the point at which a line fitted to the upslope of the flow waveform crosses the base of the flow waveform. Travel distance was obtained from the aortic centerline. Global PWV in the suprarenal descending aorta (DAO) and regional PWV in three equally sized segments between the top of the aortic arch and the location of the renal arteries (proximal segment: PWVprox, mid: PWVmid, and distal: PWVdist) were calculated by piecewise linear fitting of travel-time vs. travel-distance.

The interaction between age and location was assessed with two-way ANOVA. Paired two-tailed t-tests were used to assess the difference in global and site-specific PWV between the two age-groups. Additionally, the age-related differences in regional PWV were compared against previously published data 1-3. Numerical results are reported as mean ± one standard deviation unless otherwise noted.

**RESULTS:** The global PWV in the descending aorta was lower in the young compared to older volunteers: 

\[ \text{PWV}_{\text{global, young}} = 3.6 \pm 0.3 \text{ m/s} \text{ vs. } \text{PWV}_{\text{global, old}} = 6.4 \pm 1.7 \text{ (p < 0.05)} \]

Two-way ANOVA revealed a significant interaction between age and location. A profile plot of PWV versus location is shown in Figure 2. The age-related differences in PWV were significant for the proximal DAO (PWVprox_young = 3.7 ± 0.4 vs. PWVprox_old = 8.8 ± 3.5) and the mid DAO (PWVmid_young = 3.3 ± 0.5 vs. PWVmid_old = 7.0 ± 2.1), but did not reach significance for the distal DAO (PWVdist_young = 4.5 ± 0.8 vs. PWVdist_old = 5.2 ± 1.5). A comparison between the present study and previously reported regional PWV in the DAO is shown in Figure 3.

**DISCUSSION:** Previous studies have demonstrated the capability of 4D flow MRI for the assessment of PWV 1-3. The present study extends those previous findings by showing that 4D flow MRI permits determination of regional PWV. Our results are well in line with those reported previously 1-3. The age-related differences in PWV observed here suggest that the PWV in the proximal and mid segments of the DAO increase more rapidly with age than the PWV in the distal DAO. The fact that the elastin-to-collagen ratio decreases towards the distal aorta, in combination with the life-long fragmentation of elastin, may offer a structural explanation for the observation that the PWV in the distal aorta changes less with age when compared to proximal and mid segments 6-7.

**CONCLUSION:** 4D flow MRI permits determination of regional age-related PWV. The present findings support previous observations that the proximal descending aorta stiffens faster with age than the distal descending aorta.

**REFERENCES:**