A New Method for the Determination of Aortic Pulse Wave Velocity

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Introduction

Aortic pulse wave velocity (PWV) has been reported to progressively increase with age as elastic properties of the arterial system decline[1]. Phase contrast MRA offers a powerful technique that, with optimization, can provide an accurate and non-invasive means of assessing PWV at multiple aortic locations, providing new clinical markers of cardiovascular risk attributable to regional aortic stiffness[2]. Herein, provisional results are given of an ongoing clinical trial assessing age-related aortic PWV within two volunteer groups, consisting of healthy individuals aged below 30 and a second group aged over 60. As a further aspect of the study, different methods of data-set analysis were compared for each group, in order to address variations in the literature regarding the characteristic of the propagating pulse wave that is used to correlate time delay between slices. A methodology typical of several literature reports using percentage of peak velocity[3-4] is compared to a new proposed technique that uses a percentage of sum flow for cross-correlation and 'triggering' of time delay between slices.

Methods

Imaging was performed with volunteers positioned supine within a 1.5 T MR (Excite HD, GEHT, Milwaukee) system, with VCG gating and an 8-channel abdo-torso coil. Interactive black blood SSFSE localisers with a 40cm FOV were used to establish a para-sagittal view of the aorta from ascending aorta to bifurcation. Such localisers also served to measure mid-lumen distances between selected slices. Thereafter, three cine phase contrast acquisitions were obtained at the slices prescriptions indicated on Figure 1. i.e. through the ascending and descending aorta at the level of the right pulmonary artery, through the thoracic aorta at the level of the diaphragm and through the abdominal aorta 1 cm above the bifurcation. The CPC studies used a fast segmented k-space acquisition with 1 view per segment with min TE (~3.3 ms) and TR (~6.9 ms), flip 30°, 256x128, 2 signal averages, FOV 28x28, 5 mm slice thickness, VENC = 150 cm/s. 50 temporal phases were retrospectively calculated. Total acquisition time was approx. 8 min.

The two groups consisted of normal volunteers under 30 (age 25±3, n=4) and over 65 (age 70±3, n=3). PWV values were determined using the localiser distances and the waveform time delay between slices. Two methods of analysis were used to define the time point for the PWV calculation. The first method used ROI velocity profiles normalized to maximum value and took the mean corresponding time delay at 20, 30 and 40% of velocity upstroke[1,3]. A second method was also applied that used flow rather than velocity data to establish a time point for PWV analysis[4,5]. Waveform time delay values were calculated from the time at which 10% of total sum flow crossed the ROI. This flow method takes into consideration temporal variation in lumen size and appears to provide MRI-derived flow data that is more equally spaced at low thresholds (Figure 2).

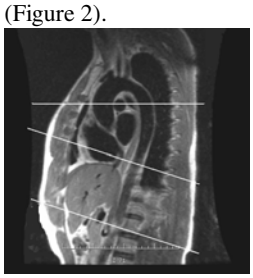

Fig 1. Slice locations for phase contrast measurements

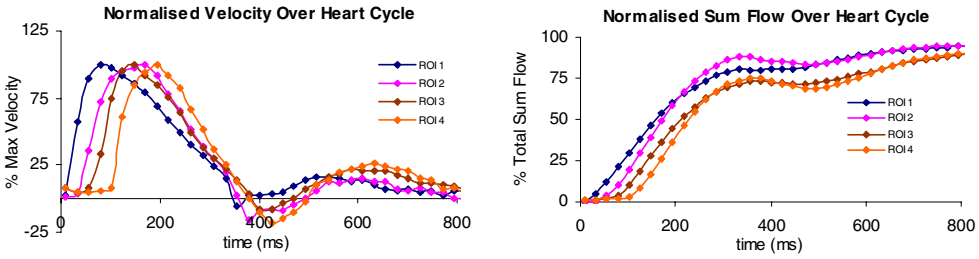

Fig 2. Typical normalised velocity and sum flow profiles from each ROI in the under 30 group

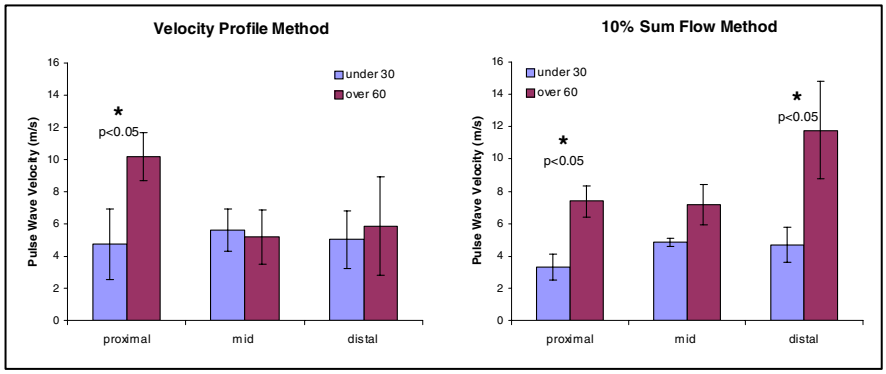

Fig 3. PWV values for each aortic region using both analyses. * $p < 0.05$ Students' t-test.

Results and Conclusion

PWV values of the magnitude 3-12 m/s were found within the two groups, typical of previous reported velocities determined using invasive methods[5]. Using the first velocity analysis method, values of PWV were significantly greater in the over 65 age group for the proximal region of the aorta, but not for the mid or distal regions where values were similar between groups. This confirms the previous MRI measurements of Rogers et al. with a significant increase in PWV with age ($p<0.05$) in the proximal region and small, non-significant, changes in the mid and distal region[1]. The 10% sum flow method, however, shows elevated PWV values with age in all three aortic regions, reaching statistical significance in both the proximal and distal regions. Smaller standard errors were also seen in 10% sum flow data. As further volunteer data is collected, more information about aortic regional PWV values and analysis techniques shall become available.

References 1) Rogers WJ et al. JACC 2001;38:1123-1129. 2) Oliver JJ, Webb DJ. ATVB 2003;23:554-556. 3) Wiesmann F et al. JACC 2004;44:2056-2064. 4) Vulliémoz S, et al. MRM 2002;47:649-654. 5) Shao X et al. MRM 2004;52:1351-1357.