Reproducibility of Pulse Wave Velocity Measurements with Phase Contrast Magnetic Resonance and Applanation Tonometry

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Objective - To compare the reproducibility of an MR-based cross-correlation method for quantifying aortic pulse wave velocity with applanation tonometry.

Background – It has been shown that aortic compliance decreases as a result of ageing, atherosclerosis, and hypertension [1]. Aortic pulse wave velocity (PWV) is often used as a surrogate marker of aortic compliance [2]. Clinically, PWV is usually measured with applanation tonometry. Our lab has developed a new PCMR-based technique using cross-correlation analysis [3]; however, the reproducibility of this method has not been compared to applanation tonometry in normal or patient populations.

Methods – The study population consisted of 13 normals volunteers and 9 asymptomatic patients with elevated calcium score by CT. Pulse wave velocity was assessed twice by each PCMR and applanation tonometry.

Applanation tonometry was performed using a Sphymacor device (AtCor Medical, Sydney, Australia) to take pressure measurements at the carotid and femoral arteries. The time delay was combined with an estimate of distance between the two measuring sites to determine the transit time of the wave, and compute the pulse wave velocity.

For the PCMR/Xcorr method, scans were performed on either a 1.5T Philips Intera (Philips Medical Systems, Best, The Netherlands) or a 1.5T Siemens Avanto scanner (Siemens Medical Solutions, Erlangen, Germany) using a 5 or 6-element phased array cardiac coil. Oblique sagittal slices along the length of the descending aorta oriented perpendicular to the long-axis ("candy cane" view) were acquired with in-plane velocity encoding (venc = 200 cm/s). Using a retrospective ECG-gated acquisition, 128 phases were obtained over the cardiac cycle. The temporal resolution for all acquisitions was 8.1 +/- 1.0 msec.

For the cross-correlation analysis to process the PCMR data, the centerline of the aorta was manually defined on a peak systolic frame, and velocity curves were created at 30 equally-spaced points along the length of the aorta. Using the flow wave form at the first location, cross-correlation analysis was used to determine the time lag between two adjacent velocity profiles. A line was fit to a plot of the lags versus distances along the aorta using a robust bi-square linear regression. The slope of this line is the pulse wave velocity.

Results – Mean PWV values from PCMR and applanation tonometry were not statistically different in both normals (PCMR: 5.6 +/- 1.2 m/s; TONO: 6.1 +/- 1.2 m/s, P = 0.26) and patients (PCMR: 9.7 +/- 2.8 m/s; TONO: 9.0 +/- 2.1 m/s, P = 0.57). Bland Altman analysis showed that there was a 0.4 m/s bias with tonometry being higher (CI = +/- 1.3 m/s) and in patients, there was a 0.6 m/s bias with PCMR being higher (CI = +/- 3.2 m/s).

In normals, the average coefficient of variation (CV) was *significantly lower* for PCMR than tonometry; 3.4 +/- 2.3% versus 6.3 +/- 4.0%, respectively (P = 0.03). However, the coefficient of variation was not statistically different in patients (Figure 1). In patients with a higher pulse wave velocity, the reproducibility of the cross-correlation tended to be lower.

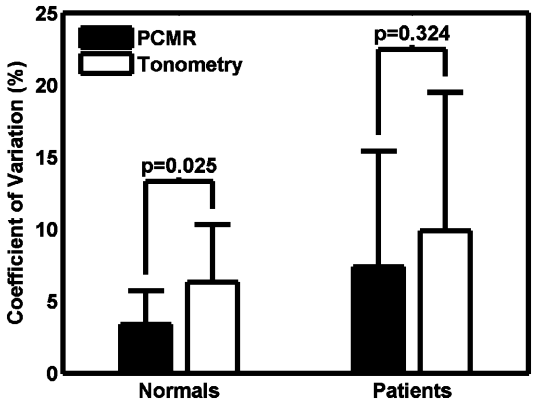

Figure 1 – Reproducibility as assessed by coefficient of variation between the Cross-correlation PCMR method and applanation tonometry in both normal and patient populations.

Conclusion – PCMR combined with cross-correlation analysis was shown to produce comparable estimates of aortic PWV when compared with applanation tonometry in both patients and normals. The MR-based method was more reproducible in normal volunteers; however, the reproducibility of this method in patients with a higher pulse wave velocity was not statistically different than that obtained with tonometry.

References - 1. Farrar, D.J., et al., *Circulation*, 1991. **83**(5): p. 1754-63. **2.** Willum-Hanse T, et al., *Circulation*, 2006. **113**(5): p. 664-670. **3.** Fielden, S.W., et al., *J. Magn Reson Imaging*, 2008. **27**(6): p. 1382-7.