Journal of Cardiovascular Magnetic Resonance

BioMed Central

Meeting abstract

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310 Cross correlation on 2D PCMR velocity data to determine aortic pulse wave velocity

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from 11th Annual SCMR Scientific Sessions
Los Angeles, CA, USA. 1–3 February 2008

Published: 22 October 2008

Journal of Cardiovascular Magnetic Resonance 2008, **10**(Suppl 1):A113 doi:10.1186/1532-429X-10-S1-A113

This abstract is available from: http://jcmr-online.com/content/10/S1/A113

Introduction

Aortic stiffness, as measured by pulse wave velocity (PWV), is an index of cardiovascular health and has predicted mortality in several patient groups. Aortic PWV may be estimated by dividing the distance between two transverse PCMR slice locations by the time differential of flow wave arrival times (transit time method). The arrival times of the flow wave are usually determined by estimating the temporal position of the foot of the flow waveform. Alternately, a PCMR slice can be acquired in the aortic plane and the flow wave measured at many locations in the descending aorta (multi-site method). A regression line may then be fit to the data to estimate central aortic PWV.

We have developed a multi-site method which contains two improvements over existing techniques. First, the arrival of the flow wave at multiple locations is estimated through a cross correlation with the most proximal waveform. Secondly, velocity data from the ascending, transverse, and descending aorta is used by acquiring two-directional PCMR data in the aortic plane and constructing velocity magnitude images for determining the flow waveforms (2D-XC).

Purpose

To compare the reproducibility of the 2D-XC method to: 1) a transit-time method (TT) using slices in the ascending and descending aorta, and 2) a foot-identified multi-site method (FOOT) using descending aorta velocity data.

Methods

Thirteen healthy volunteers (11 male, mean age 29.4 ± 7.4 years) with no evidence of cardiovascular disease were examined twice (separated by 2.9 ± 7.3 days) on a Philips 1.5 Tesla Intera MRI scanner.

TT methodology

PCMR images were obtained in two slices perpendicular to the aorta (ascending aorta and abdominal descending aorta). Average cross-section flow waves were then calculated and the wave propagation time and PWV determined.

FOOT methodology

An oblique sagittal PCMR slice covering the length of the aorta was acquired. Velocity waveforms were then computed at 30 evenly spaced points along the length of the descending aorta. The foot of each waveform is identified as in the TT methodology and the arrival time of the wave at each location is plotted against its distance from the first wave. PWV is the inverse of the slope of a line fitted to this plot.

2D-XC methodology

Data was acquired in an oblique sagittal PCMR slice. Velocity magnitudes were calculated from temporally-

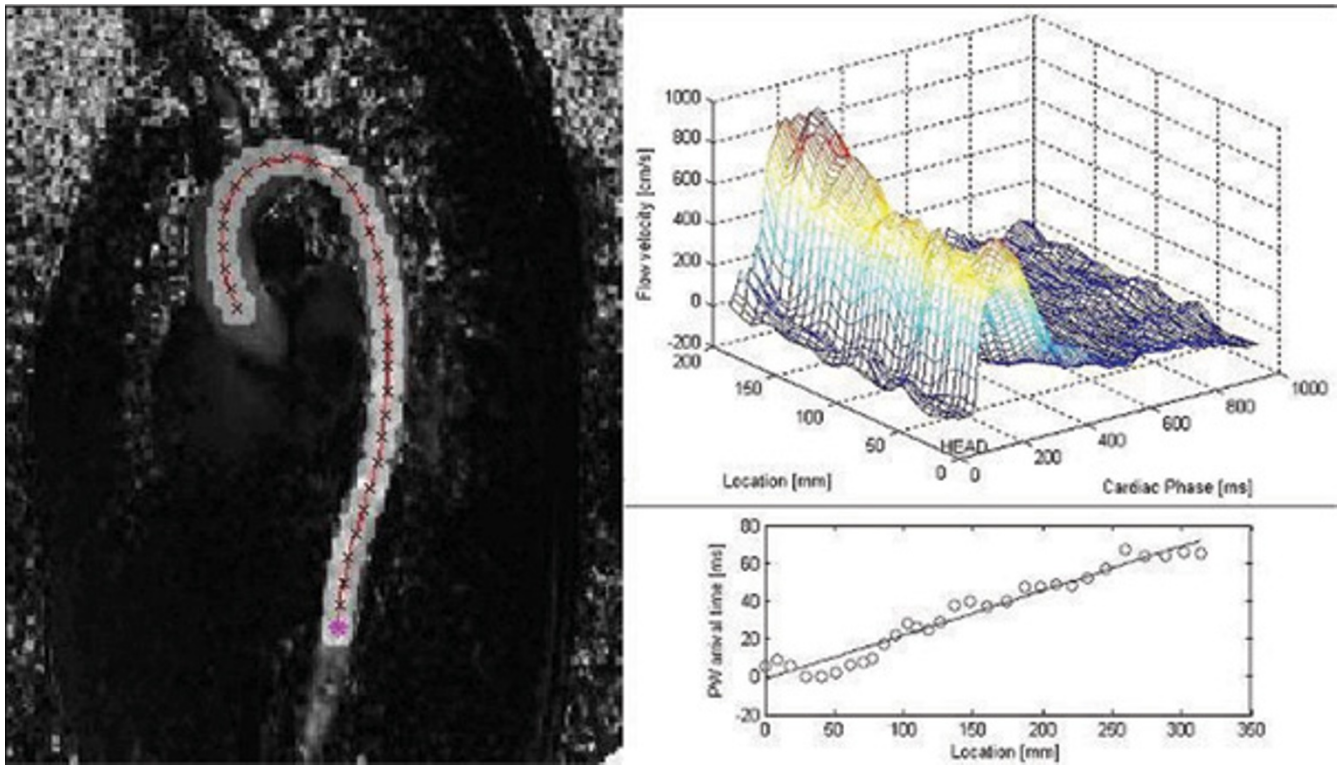

Figure 1
A new method to estimate aortic PWV using cross correlation of multiple velocity waveforms obtained from 2D PCMR data is presented. The reproducibility of this new method was found to be superior to other methods of measuring PWV. Measurement locations on the aorta are shown by x's (left), 3D flow waveform plotted (top right), arrival time vs. location plotted to calculate PWV (bottom right).

paired PCMR images with perpendicular velocity encoding directions. The waveform at 30 evenly spaced points along the aorta was then compared to the first waveform using a cross-correlation function to determine a delay for each location and therefore, the PWV, (Fig. 1).

Inter-test reproducibility was evaluated for each methodology by the absolute value of the experiments' difference between scans (as a %), and were compared using a repeated measures ANOVA with a Huynh-Feldt correction followed by a least significant difference post-hoc test. $p < 0.05$ was considered statistically significant.

Results

No statistically significant difference was observed between the three estimates of PWV (FOOT: 4.18 ± 0.59 m/s, 2D-XC: 4.45 ± 0.47 m/s, TT: 4.07 ± 0.57 m/s, p = 0.15). *The 2D-XC methodology had a superior inter-test reproducibility than either the FOOT or TT methods* (Fig. 2).

Conclusion

We have developed a new PWV estimation methodology that uses data from the ascending, transverse, and descending aorta and a cross-correlation to determine PWV. The 2D-XC method is a more reproducible method than either the established TT or multi-site methods. This suggests the 2D-XC method could detect more subtle changes in PWV in lower numbers of subjects.

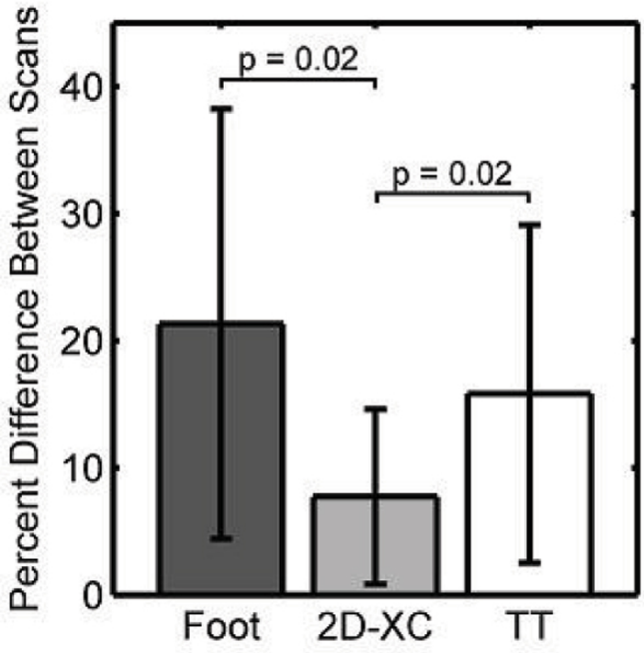

Figure 2
2D-XC method shows superior reproducibility.