Journal of Cardiovascular Magnetic Resonance

BioMed Central

Poster presentation

Open Access

Comparison of different MRI techniques for measuring aortic compliance

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from 13th Annual SCMR Scientific Sessions
Phoenix, AZ, USA. 21-24 January 2010

Published: 21 January 2010

Journal of Cardiovascular Magnetic Resonance 2010, **12**(Suppl 1):P137 doi:10.1186/1532-429X-12-S1-P137

This abstract is available from: http://jcmr-online.com/content/12/S1/P137

Introduction

Maintenance of aortic visco-elastic properties is essential for proper physiology(1). Reduced aortic compliance has shown to correlate with different pathologies (e.g. dissection). Invasive techniques using pressure catheters are historically the gold standard for measuring aortic stiffness. Transit-time (TT) (2) and cross-correlation (XC) (3) are recently introduced as MRI techniques for measuring pulse wave velocity (PWV), which reflects the vessel compliance. However, the reproducibility and behavior of these techniques have not yet been studied, which is the purpose of this work.

Methods

Thirty consecutive cardiac patients (22 males/8 females; age = 51 ± 15 years), along with five healthy volunteers, were scanned on a 3 T MRI system (Siemens TIM TRIO, Erlangen, Germany). Three velocity-encoded (venc) cine images of the descending aorta were acquired: one ("candy cane") series along the aortic path and two cross-section series separated by about 12 cm. The imaging parameters were: flash sequence; TR/TE = 40/2 ms; flip-angle = 15°; slice-thickness = 8 mm; venc = 150 cm/s; #phases = 128; scan-time = 26 s/slice of shallow breathing.

In-house software was created with Matlab for analyzing the images. Figs. 1 and 2 show images of the same person, where PWV was calculated with TT and XC methods, respectively. Five of the conducted MRI scans were repeated twice with different position markers and scouting to compute the scan-rescan variability. Two experts analyzed the images to determine inter-observer variability. One of the experts analyzed the images twice to compute intra-observer variability. Paired *t*-tests and Bland-Altman analysis were conducted to measure the difference significance between the results. $P < 0.05$ was considered statistically significant.

Results

The measured PWV values ranged from 2-16 m/s. The inter-observer/intra-observer variabilities were low as indicated by the interclass correlation-coefficient r = 0.94/0.98 and 0.83/0.87 for the TT and XC methods, respectively. The scan-rescan results did not show significant dif-

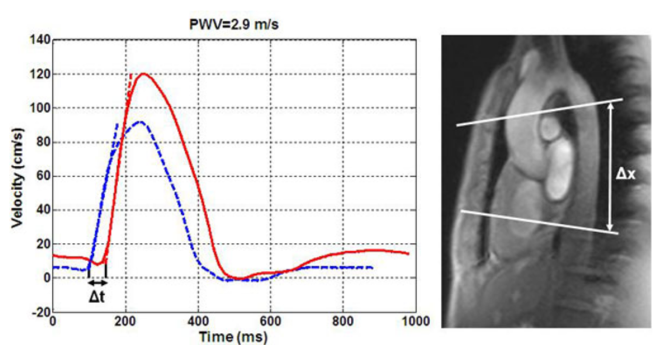

Figure 1

Transit-time method for calculating PWV. Velocity curves (left) are computed at two distant points along the descending aorta (right). PWV = Δx/Δt, where Δx is the distance between the two locations and Δt is the time difference between the two velocity curves.

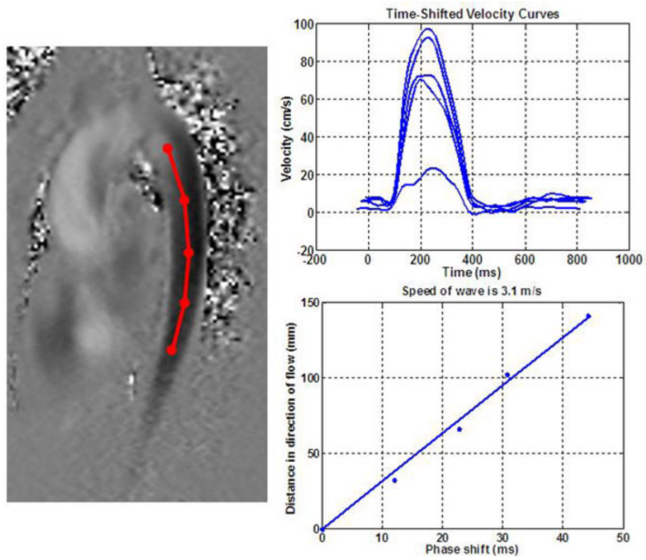

Figure 2
Cross-correlation method for calculating PWV. Flow patterns (up) are computed at several points along the aorta path (left). Cross correlation is used to estimate the time shift between consecutive points. Linear least-square fitting is used to calculate PWV (down).

ference (P > 0.2). The mean differences between the repeated measurements were 0.035 and 0.17 m/s for TT and XC methods, respectively. Bland-Altman analysis

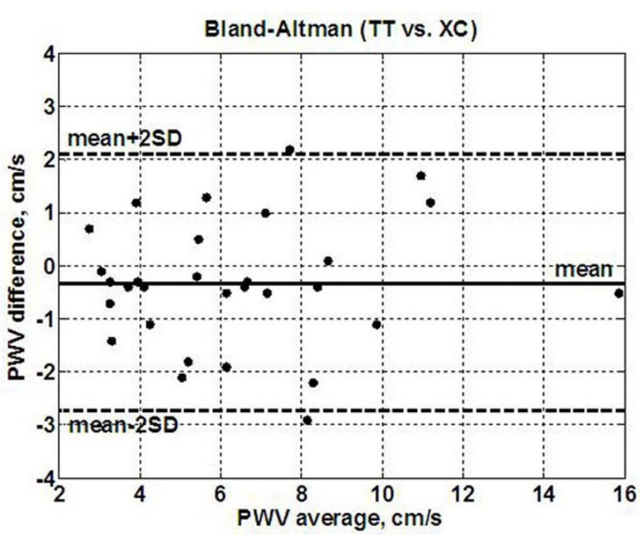

Figure 3
Bland-Altman plot for the correlation between TT and XC methods for calculating PWV. The plot shows no significant bias between the two methods. All points lie within the ± 2SD margin.

(Fig. 3) showed no significant difference between the two methods, with XC slightly overestimating PWV.

Discussion and conclusion

The TT and XC methods provide reproducible means of estimating PWV in the aorta. The TT method produced the most reproducible measurements with minimal user interface. The XC method has the shortest processing time and requires only one series of MRI images. Both techniques require high temporal resolution for accurate measurements. In conclusion, either technique can be used for estimating aortic PWV with insignificant difference between the results.

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