An automated tool for measuring aortic pulse wave velocity

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Introduction

Aortic pulse-wave velocity (PWV) is a marker of arterial stiffness. It has been associated with end organ damage independent of age, sex, and hypertension duration. With MRI, aortic PWV is calculated using the aortic arch distance (Fig 1.a), and the transit time (Δt) needed for the pulse-wave to cover this distance (Fig 1.b).

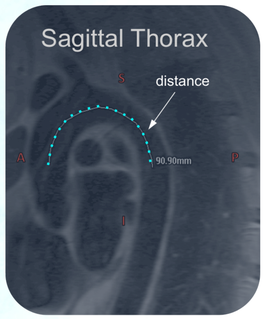


Fig 1.a: aortic arch distance.

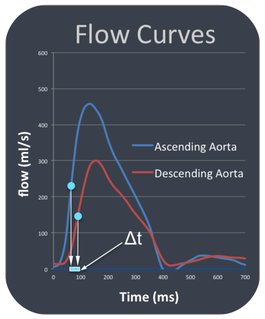


Fig 1.b: Δt measurement at half maximum velocity.

Objectives

Aortic arch distance can be easily measured using MRI Data, however Δt is cumbersome to calculate with conventional software. Typically both the ascending and descending aorta must be contoured. The resultant flow curves must then be transferred to another program. Our objective is to create an automated tool for computing Δt which will make aortic PWV easy to measure for population studies and individual clinical evaluation.

Materials & Methods

Our automated tool was designed in Java using a three-step approach. (1) Detect the ascending and descending aorta using the Hough Transform algorithm. (2) Compute flow curves. (3) Calculate transit time (Δt) between half maximum velocity (Fig 1.b).

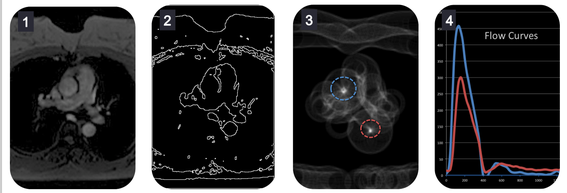


Fig 2.a: original image

Fig 2.b: processed to edges

Fig 2.c: Hough Transform output. Bright spots signify likely circles.

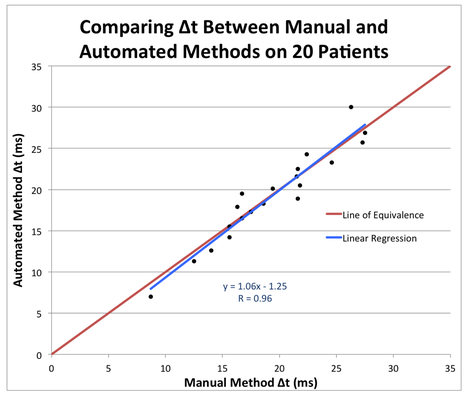
Fig 2.d: computed flow curves.

Fig 2: Algorithm progression.

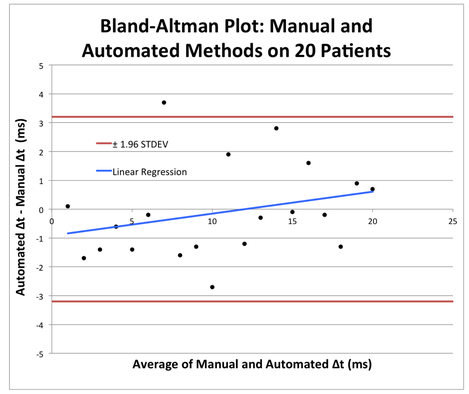
To evaluate the performance and accuracy of the automated method:

- 300 studies (phase contrast MRI) were randomly selected from the Dallas Heart Study 2.
- Automated tool computed Δt for all 300 studies.
- 20 studies were selected for comparison with manual method using QFlow (Medis v.4.1.6).
- Equivalence Analysis with Bland-Altman Difference Plots.

Results



In the validation set of 20 studies, linear regression shows an excellent correlation between the automated (A) and manual (M) methods (r=0.96, A = 1.06M-1.25). Bland-Altman difference analysis has strong agreement with minimal bias (mean difference (A-M) = 0.0575+/-0.817 ms).



Conclusions

Our automated method successefully computes Δt, and may be instrumental for efficiently measuring aortic PWV in future population studies and in the clinical setting.

References

- Victor, RG, et al; Dallas Heart Study Investigators. The Dallas Heart Study: a population-based study... in CV health. Am J Cardiol. 2004
- Kevin S King, et al; APWV Predicts White Matter Hyperintensity Volume. Radiology. 2012

Acknowledgements

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