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# Detection of time delay using cross-correlation for aortic pulse wave velocity evaluation

Yi Wang*[1], Edwin Estrada[1] and Nathaniel Reichek[1,2]

Address: [1]St. Francis Hospital, Roslyn, NY, USA and [2]Stony Brook University, Stony Brook, NY, USA
* Corresponding author

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## Introduction

Aortic compliance (AC) can be evaluated noninvasively and its reduction with age in normals has been demonstrated with both MRI and Doppler echo methods. Aortic pulse wave velocity (PWV), a measurement of the flow pulse traveling along aorta as a surrogate of AC, can be assessed using a single breath-hold phase contrast (PC) imaging technique. Accurate determination of the time delay (Δt) between flows in ascending and descending aortic regions is critical in PWV assessment.

## Purpose

We studied aortic compliance using a cross correlation approach for time delay detection and evaluated the aortic compliance results correlated with age in normal volunteers.

## Methods

A total of 120 healthy volunteers with informed consent (age: 59.5 ± 13.9) were screened to exclude hypertension, obesity and cardiovascular disease. Using the 'candy cane' view of aorta, an axial plane through the ascending and descending aorta at the pulmonary artery level was prescribed and a through-plane velocity encoded PC cine imaging was acquired on a 1.5 T MRI scanner. The distance traveled by the aortic pulse wave, ΔD, was determined as the distance along the central line between ascending and descending aorta in the 'candy cane' image. For Δt assessment, cross correlation algorithm was used: The cross correlations between the first halves (all flow points before the peak) of ascending and descending aortic flow curves was calculated by varying the relative time between them. The Δt was the time shift at the maximal correlation.

We then calculated PWV = ΔD/Δt and aortic compliance as AC = 1/(p*PWV2), where blood density p = 1057 kg/m3. Linear regression was used to determine the relationships between AC and age.

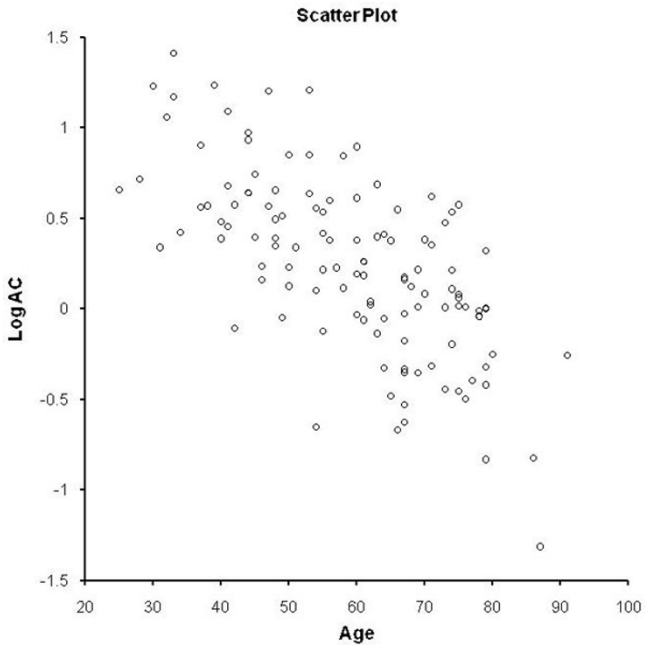


**Figure 1**

**Table 1: The Correlation between aortic compliance and age, in total and different genders**

| Prob > \|r\| under H0: Rho = 0 | Total (n = 120) | Male (n = 55) | Female (n = 65) |
|---|---|---|---|
| r | -0.56 | -0.43 | -0.66 |
| p | <.0001 | 0.0012 | <.0001 |

## Results

Aortic compliance evaluated with the cross correlation algorithm worked well on all cases without any user interaction. The mean+sd of aortic compliance in total population was (3.19 ± 4.19)*10-5/Pa (n = 120), (3.38 ± 4.91)*10-5/Pa in females (n = 65), (2.96 ± 2.99)*10-5/Pa in males (n = 55). The mean age in males was 57.47, 50.58 in females. Linear regression of the logarithm AC vs. age had an R of -0.56 in total population, with $p < .0001$, as illustrated in Figure. The age versus AC regression showed a stronger correlation in females than in males, as shown in Table.

## Conclusion

The aortic compliance results in normal volunteers using a cross correlation algorithm for delay detection showed a good correlation with age. This technique is an easy approach to evaluate aortic compliance in a single breath-hold and has the potential to be an efficient clinical tool for assessment of vascular stiffness.