Improved Aortic Stiffness Assessment in the Elderly Using Multi-Site Flow Displacement

K. Kraft[1], X. Shao[2], R. Arena[3], D-Y. Fei[2]

[1]Radiology, Virginia Commonwealth Univ., Richmond, VA, United States, [2]Biomedical Engineering, Virginia Commonwealth Univ., Richmond, VA, United States, [3]Physical Therapy, Virginia Commonwealth Univ., Richmond, VA, United States

Introduction

Aortic stiffness is an emerging predictor of cardiovascular risk, and wave velocity (pressure or flow) is a widely accepted parameter to assess such stiffness. A number of favorable attributes render MR an excellent modality for evaluating central arterial wave velocity, and several rapid acquisition MR methods have appeared in recent years. To date, however, no method has proven ideal among elderly subjects, who typically exhibit significant vessel tortuosity and low peak aortic blood velocity.

A one-dimensional (1-D) velocity method[1,2] previously proposed to measure aortic wave velocity (AWV) performs well in young and middle-aged subjects, whose aortic blood moves appreciably during the sequence echo time, and is therefore well resolved from the residual static background. However, when aortic blood velocity is low, as is often the case in subjects over age 60, depiction of the flow waveform and hence the wave velocity may be inaccurate. Likewise, a proposed AWV measurement sequence employing 2-D cylindrical RF excitation of the thoracic aorta,[3] requires that the vessel remain straight over an appreciable length, which is seldom the case in the aged population.

In order to address these shortcomings, we have proposed[4] a novel strategy for rapidly assessing AWV, based on aortic blood displacement (rather than velocity) during early systole. Herein, we test the hypothesis that, compared with the velocity method, this proposed method may yield improved precision of AWV data, especially among older subjects.

Methods

The displacement AWV sequence employs a single RF comb to excite aortic blood at multiple paraxial sites along the descending thoracic aorta in end diastole, followed by an oscillating frequency encoding gradient to track fluid motion during a single systolic ejection. The currently implemented sequence excites nine sites within a 20-cm length of vessel, and has a temporal resolution of 2 ms and a total acquisition time of 140 ms. Offline-reconstructed position-versus-time plots exhibit curvilinear flow displacement trajectories, corresponding to fluid motion at each of the excitation positions. By differentiating these flow displacement trajectories, velocity waveforms, and in particular, the flow "feet" (points of initiation of constant acceleration) are obtained. From the temporal latency of the flow feet, the AWV can be reliably determined. If the aorta is not straight within the measurement field, curvature correction can be applied.

Sixty-seven apparently healthy men and women (age 21 to 84 years) underwent AWV measurements using both the displacement and velocity methods. Typically, 7 trials were conducted using each of the two methods, and each AWV result was an average of at least 5 trials. The group was partitioned into three age categories. The coefficient of variation (CV), the standard deviation over the mean, was evaluated for each subject and method, and then averaged over each age tertile.

Results

Age group	Age range	N	Age	PFV (m/s)	AWV-displacement		AWV-velocity	
					AWV (m/s)	CV (%)	AWV (m/s)	CV (%)
Young	21-38	23	29 ± 5	1.09 ± 0.18	4.64 ± 1.05	9.9	4.54 ± 0.91	9.5
Middle	39-58	23	47 ± 6	0.84 ± 0.18	5.73 ± 0.85	12.6	5.70 ± 1.18	10.5
Aged	59-84	21	68 ± 8	0.57 ± 0.09	7.60 ± 1.75	10.7	6.33 ± 2.23	13.8

PFV = peak aortic flow velocity; CV = coefficient of variation

The AWV results were not significantly different in the young and middle-aged groups ($p > 0.05$ by paired t-test). However, for the aged group, the new method yields a lower CV and standard deviation than the velocity method as well as a significantly higher wave velocity result ($p < 0.05$). The results also confirm the expected increase in AWV and decrease in peak aortic flow velocity with age.

Conclusion

Consistent with our hypothesis, the proposed displacement AWV method exhibits reduced measurement variability among elderly subjects, and its implementation will likely improve the reliability of aortic stiffness assessments in such populations.

References

1 Kraft K et al. Magn Reson Med 2001 46:95-102. **2**. Itskovich V et al. Radiology 2001; 219(2):551-557. **3**. Macgowan CK et al. Magn Reson Med 2002;48:115-121. **4**. Shao X et al. Magn Reson Med 2004 in press.

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