

Aortic Pulse Wave Velocity Evaluation in Normals and Heart Failure Patients

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Aortic compliance (AC) can be evaluated noninvasively and its reduction with aortic pathology and 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 for AC, can be assessed using a single breath-hold phase contrast (PC) imaging technique. Congestive heart failure (CHF) is often associated with a chronic cardiac remodeling process in which the heart muscle either cannot pump (eject) the blood out of the heart very well (systolic heart failure); or the heart muscle is stiff and ventricular chambers do not fill with blood easily (diastolic heart failure). We hypothesize that aortic stiffness is increased in the CHF population and its age dependency differs from that in normals.

METHODS As normal controls, 229 healthy volunteers gave informed consent (106 male, age: 58.4 ± 15.1) and were screened to exclude hypertension, hyperlipidemia and cardiovascular disease. CHF patients (n=58, 41 male, age: 55.3 ± 13.6) had been referred for clinical CMR study. Breath hold ECG gated SSFP cine images covered the heart in short axis views. Using the 'candy cane' view of the 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 acquired with VENC of 150 cm/s, TR/TE/FA = 98ms/2.9ms/15° and voxel spatial resolution $1.3 \times 2 \times 6$ mm³ on a 1.5T MRI scanner. The distance traveled by the aortic pulse wave, ΔD , was determined as the distance along the center line between the axial sections as measured in the 'candy cane' image. For flow pulse onset, the cross correlation between the first halves of the ascending and descending aortic flow curves was calculated by varying the relative time shift between them. The time shift at the maximal correlation was taken as Δt . We then calculated $PWV = \Delta D / \Delta t$. Linear regression was used to determine the relationships between PWV and age in both groups.

RESULTS: PWV in CHF and in normals correlated with age, as shown in **Figure 1** upper and lower scatter plots, respectively. The regression for normals was: $\text{Log}(PWV) = 0.147 + 0.0124 * \text{Age}$; while in CHF patients: $\text{Log}(PWV) = 0.4544 + 0.0072 * \text{Age}$. However, the relationship is stronger ($R^2 = 0.35$ in normals and 0.19 in CHF) and steeper (slope=0.0124 in normals and 0.0072 in CHF) in normals. The ventricular function indices of both groups are listed in **Table**. The elderly patients with CHF have lower PWV than normals, reflecting increased circulatory transit times (**Figure 2**).

CONCLUSIONS: The thoracic aortal stiffens with aging in CHF patients, but the slope of the age relationship are markedly reduced as compared to normals.

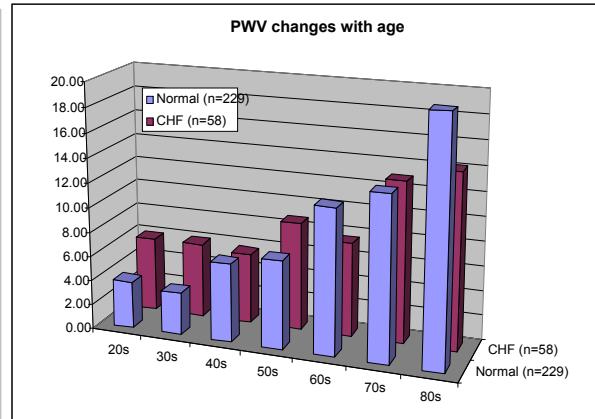
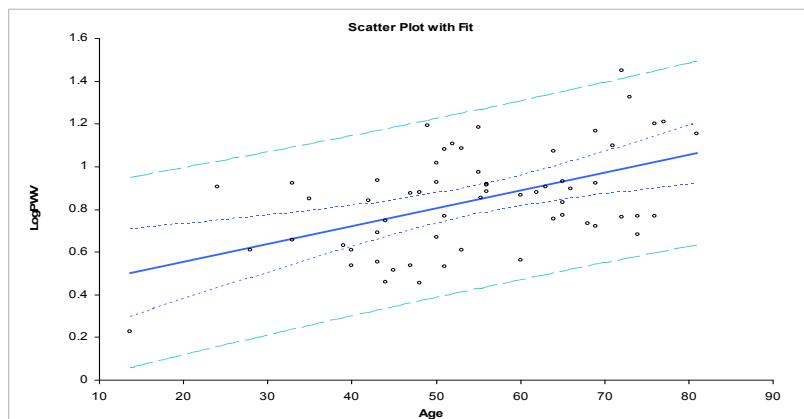


Figure 2. The PWV changes between normals and CHF patients in all age groups

Mean SD	PWV (m/s)	LVEF	LV Mass index	Pulse Pressure
Normals (N = 229)	58.4 15.1	57.9 5.5	50.9 9.2	52.4 14.6
CHF (N = 58)	55.3 13.6	50.9 12.4	63.3 18.4	50.5 15.4

Table. Ventricular function indices and other parameters between normals and CHF patients

Figure 1. The scatter plot of the fitting curve between pulse wave velocity and age on the upper panel: CHF patients with $R^2=0.19$, $p<0.01$, $n=58$; while on the lower panel: normals with $R^2=0.35$, $p<0.01$, $n=229$.