Aortic stiffness, cardiac energetic, systolic and diastolic function in healthy ageing.

Jehill D Parikh[1], Kieren G Hollingsworth[1], Andrew M Blamire[1], and Guy MacGowan[2]
[1]Newcastle Magnetic Resonance Centre, Newcastle University, Newcastle upon Tyne, Tyne and Wear, United Kingdom, [2]Cardiology, Freeman Hospital, Newcastle Upon Tyne, Tyne and Wear, United Kingdom

Target audience: Cardiac MR Scientist, Cardiologist.

Purpose: Aortic stiffness, measured by pulse wave velocity (PWV), is increasingly recognized as an independent marker of cardiovascular impairment[1]. It is well known that diastolic function reduces with age while aortic stiffness and cardiac torsion increase with age[1,2]. Cardiac energetics play an important role in ischaemic heart disease and heart failure[3,4] and PCr/ATP is reported to decline with age[2]. However it is not clear whether aortic stiffness is related to cardiac energetics or measures of diastolic function or cardiac torsion. Such a relationship (if any) may provide novel insights to the pathophysiology of age-related left ventricular dysfunction such as diastolic heart failure and potentially aid development of early intervention approaches. In this study we employed cardiac MR techniques to examine associations between PWV, diastolic function, cardiac torsion and cardiac energetics in healthy ageing.

Methods: 96 healthy males and females (divided into 6 groups; 20-29,30-39,40-49,50-59,69-69 years old with 16 subjects/group) were scanned using a Philips Achieva 3T scanner and a 6 channel cardiac coil. **PWV:** A high temporal resolution sequence (TR/TE/FA/NEX/slice thickness = 5ms/2.9ms/10^0/1/8mm, SENSE factor 2, FOV 300mm×225mm, reconstructed voxel size 1.17mm^2, VENC=150m/s, 44 phases, breath hold duration ~19s) was employed to acquire 2D phase contrast data from ascending (AAo) and descending (DAo) aorta (Figure 1). The Q-flow analysis package (Philips, Viewform) was employed to obtain the distance (ΔX) and flow curves, in order to determine time delay (ΔT) and compute **PWV= ΔX/ΔT** as shown in Figure 1. **P31 MRS:** A 10 cm diameter phosphorus surface coil (Pulseteq, UK) was employed to acquire spectra using a cardiac gated, slice selective 1D CSI sequence (16 phase encodes, TR-heart rate, duration 20 min) as the subject lay in a prone position. The myocardial spectrum (without skeletal muscle contamination) was processed using AMARES (jMRUI) to compute PCr/ATP after correcting for saturation , actual excitation flip angle and blood pool contamination[2]. **Cardiac Torsion**: A turbo-field echo sequence (TR/TE/FA/NEX/slice thickness = 4.9/3.1/10^0/1/10, TFE factor 9, SENSE factor 2, FOV 350x350mm, voxel size 1.37mm^2, tag spacing of 7mm) was employed to acquire tagging data from 2 mid-ventricular short axis slices in order to estimate torsion to shortening ratio (TSR) (using Cardiac Imaging Modelling package) [2]. **Cine:** High resolution balanced SSFP cines scans were acquired to obtain E/A, blood pool volumes and diastolic function including early filling percentage (EFP) as pervious described[2]. Group wise differences were assessed by t-test and correlations between indices by regression analysis.

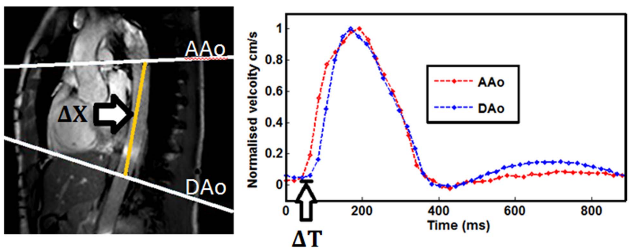

Figure 1: Planning of 2D phase contrast slices and typical flow curves to compute PWV

Results: Key subject characteristics and parameters are reported in Table 1 while Pearson's correlation coefficients are reported in Table 2. Both PWV and TSR increased with age, while EFP decreased with age (Figure 2). On average PCr/ATP ratio decreased significantly (p: 0.0022) from 2.0±0.3 for younger subjects (< 30 years) to 1.8±0.29 for middle aged subjects (30-60 years), but not for elderly subjects (>60 years), average PCr/ATP 1.9±0.4 (p>0.05).

Age(y)	SBP (mmHg)	DBP (mmHg)	E/A
27±2.3	120±10.5	65±6.9	3.3±1.2
34±2.8	127±10.2	71±8.0	2.6±0.8
45±3.2	124±9.3	68±7.1	2.7±1.4
55±3.0	124±7.4	69±9.2	1.9±0.9
63±2.6	127±14.8	68±7.6	1.6±0.6
74±2.2	137±10.8	72±7.8	1.03±0.4

Table 1: Key Subject characteristic and results

R	PWV	TSR	EFP	E/A	PCr/ATP
Age	0.54*	0.42*	-0.67*	-0.64*	-0.13 n.s.
PWV	-	0.33*	-0.38*	-0.34*	-0.17 n.s.

Table 2 Pearson's correlation coefficient
***p<0.0001, n.s. non-significant (p>0.05)**

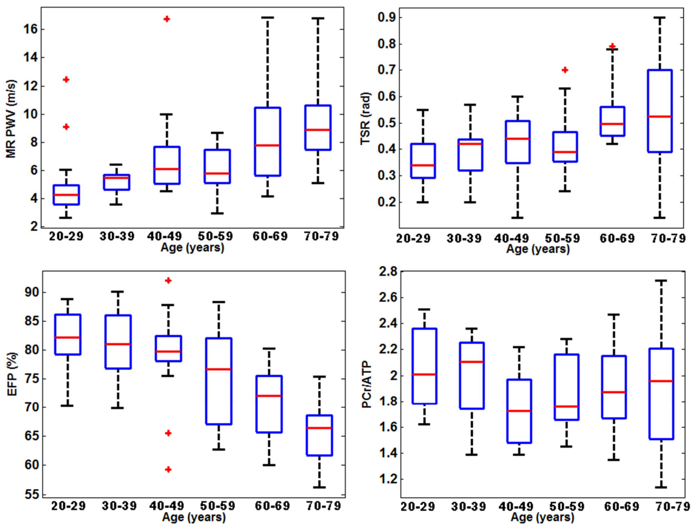

Figure 2: Group wise results for PWV, TSR, EFP and PCr/ATP

Discussion and conclusion: This study demonstrates age related increase in PWV, TSR and declining EFP and suggests a strong relationship between aortic stiffness, cardiac torsion and diastolic function in healthy ageing. Contrary to previous report[2] which suggest a decline in PCr/ATP ratio in old age (>60 years), PCr/ATP showed no significant change with age or measures of aortic stiffness. Future studies are warranted to determine whether interventions targeting aortic stiffness in middle age can prevent diastolic dysfunction in older adults. **Acknowledgements: Tim Hodgson, Louise Ward, Jennifer Ennis, Bianca Tobin, and British Heart Foundation (FS/11/89/29162).** **References: 1) Veersamy M, et al, Cardiology in Rev. 2014;22:223. 2) Hollingsworth KG, et al, AJP-Heart Cric. Physiol. 2012; 302: H885. 3) Weiss RG, et al, PNAS 2005;102: 808. 4) Neubauer S, N Engl J Med 2007; 356:1140.**