Impact of Local Arterial Compliance and Shear Stress on Baroreceptor Function in Children with Repaired Coarctation of the Aorta

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Background and Aims

Reduced aortic compliance and baroreceptor dysfunction have been implicated in the ontogeny of post-coarctectomy hypertension. MRI may be used to evaluate local arterial compliance and shear stress that may influence arterial remodeling. Assessment of local compliance at any particular level of the aorta is possible once the change in area for the given change in aortic pressure is known. Thus assessment of local aortic compliance at the level of the aortic baroreceptors is possible using MRI to determine if there is a link between reduced aortic compliance and diminished baroreceptor sensitivity. MRI also offers detailed data on flow volumes and velocities and has been used to evaluate wall shear stress in the aorta using a number of different methods. Increased low velocity shear stress has been shown to affect aortic remodelling in animal models of coarctation and it is possible that surgical approach may affect low velocity flow profiles, hence influencing arterial compliance. This study was designed to measure these variables along the aortic arch and determine potential effects on the aortic baroreceptor and blood pressure control.

Patients and methods

Twenty-six children (mean age of 9.2±0.2 years) with early repair of coarctation of the aorta (CoA) and 18 age-matched controls underwent detailed cardiac MRI with evaluation of aortic compliance using simultaneous non-invasive measurement of central blood pressure. Shear stress was calculated using the average flow method. This calculates shear stress using volume and flow from the segmented MR images based on the formula:

$WSS = 4mQ\sqrt{(\pi/A^3)}$

Where m = dynamic viscosity, Q = volume flow, A = vessel area. 0.0035 Pa S^{-1} was used for dynamic viscosity.
Spontaneous baroreceptor reflex sensitivty (sBRS) was determined using sequence analysis.
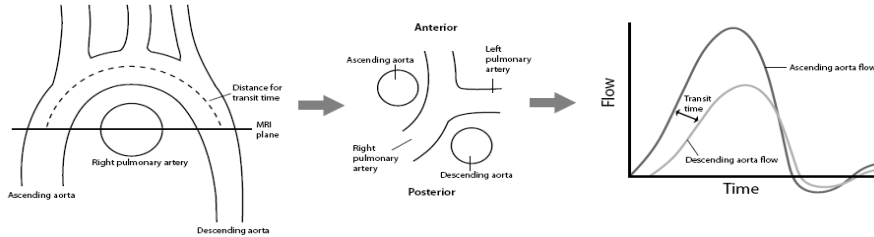

Figure 3 The oblique sagittal image of the aortic arch demonstrated on the left of the diagram was used for the measurement of distance in calculating PWV. This image was then used to generate an axial short axis image of the ascending and descending aorta through the right pulmonary artery and phase contrast sequences recorded to generate flow curves and a transit time as seen on the right of the diagram.

Results

Table 1

	Control	CoA	P Value
Number	18	26	-
Age	9.5±0.2	9.2±0.2	0.28
BSA	1.16±0.03	1.06±0.03	0.10
Amb SBP	114.2±2.2	117.6±2.0	0.10
CSP	92.5±1.8	96.7±1.0	0.04
H:W	0.67±0.02	0.67±0.02	0.27
Comp AAO	4.2±0.3	3.9±0.3	0.50
Comp DAO	1.4±0.1	1.3±0.1	0.58
Comp Arch	2.5±0.1	1.8±0.2	0.004
AAO Shear	1.2±0.1	1.0±0.1	0.4
DAO Shear	2.0±0.2	1.8±0.1	0.41
PWV MRI	3.9±0.2	3.7±0.1	0.47
LVMI	48.3±1.5	49.6±1.5	0.53
Stroke Index	47.1±1.6	47.3±1.5	0.91
sBRS	12.9±1.1	12.0±1.1	0.61

Data are expressed as mean±standard error. Statistical significance is taken as P value <0.05.
BSA, body surface area; Amb, ambulatory; CSP, central systolic pressure; H:W, height width ratio; Comp AAO, ascending aorta compliance; DAO, descending aorta; LVMI, left ventricular mass index; sBRS, spontaneous baroreceptor reflex sensitivity

	Control	SFR	EEA	P Value
Number	18	14	12	-
Comp Arch	2.5±0.1	1.7±0.2	1.9±0.2	0.004
sBRS	12.9±1.1	14.2±1.6	9.7±1.3	0.61

Although there were no significant differences in ambulatory blood pressure measured between the three groups, there was a significant difference in aortic arch compliance. This difference was seen between the SFR subgroup and controls (p=0.02). There was also a trend towards lower sBRS in the SFR group (0.07). Apart from this there were no further differences in MRI measured variables between the three groups including H:W, PWV, shear stress or left ventricular mass index (table 1).

Conclusions

Normotensive children with early effective repair for CoA have reduced aortic compliance at the level of the aortic arch. This is associated with higher central blood pressure although no difference in aortic shear stress. Patients with SFR have reduced aortic compliance compared to patients with EEA and a relative increase in sBRS which may indicate a compensatory increase in baroreceptor sensitivity to maintain blood pressure control in patients at longer term risk for hypertension.

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