Compliance and pulse wave velocity MR measurements in assessment of aortic properties on patients with familial hypercholesterolemia

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Introduction

Detection of early atherosclerosis is important, because preventive medical treatment can be started in childhood to avoid the severe outcomes such as stroke and myocardial infarction. Angiography can not detect changes in the arterial wall before the lumen begins to narrow. Ultrasonography is useful in evaluating the carotid walls and screening for the risk of cerebral stroke. MRI can examine any part of the body and will be useful in screening of atherosclerosis. Familial hypercholesterolemia (FH) is an autosomal dominantly inherited disease with a prevalence of ≈1/500. FH patients have higher level of low density lipoproteins in blood. The lipids accumulate into the arterial intima, which leads to stiffening of the vessel wall before the lumen starts to narrow. Pulse wave velocity and compliance are measures of elasticity of a vessel wall. The purpose of this study was to use compliance and pulse wave velocity (PWV) in detection of early signs of atherosclerosis in patients with FH-North-Karelia mutation.

Methods

We studied 38 FH patients from North Karelia, Finland aged 6 to 48 years and 24 control subjects of similar age. The patients had the same North Karelia mutation verified by DNA-test which decreases the phenotypic variance. The controls were healthy non-smokers.

MR studies were performed with 1.5 T Siemens Vision equipped with body array coil. An oblique sagittal turbo spin echo image (TR/ TE/ Flip Angle/ FOV/ Matrix/ Slice Thickness = 700ms/ 30 ms/ 180/ 400x300/ 130x256/ 7mm) was obtained to assess distance from ascending to descending aortic velocity measurement planes (Fig 1a). Then a velocity encoded flow measurement sequence was performed (TR/ TE/ Flip Angle/ FOV/ Matrix / Slice Thickness/ VENC = 26ms/ 5ms/ 30°/ 300x300 /256x256/ 6mm/ 150cm/s). Blood pressure and heart rate were measured immediately after MR imaging with an automatic "Omega 1400™"-meter. The flow images were analyzed with NIH Image software (http://rsb.info.nih.gov/nih-image) to obtain the mean velocity of the blood flow in ascending and descending aorta as a function of time. From the flow velocity -time curves it was possible to assess the time delay of the pulse wave arrival between the two measuring planes. The distance between the two planes was then divided by the delay time in order to get PWV. The anatomical images (fig 1b) were analyzed to obtain the luminal diameter of ascending and descending aorta at systole and diastole. The compliance (%/mmHg) of the wall was calculated using the equation [(Ds-Dd)/Dd]/(Ps-Pd), where Ds = luminal diameter in systole, Dd = luminal diameter in diastole, Ps = systolic blood pressure and Pd = diastolic blood pressure.

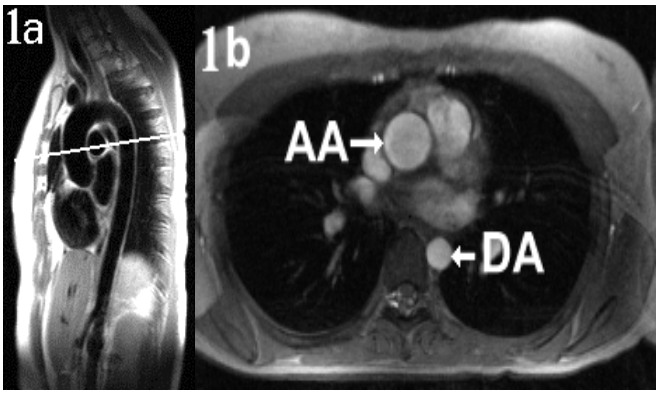

Figure 1a) Oblique sagittal TSE image. The line indicates the imaging plane of the image 1b. 1b) Anatomical axial image used for measuring the systolic and diastolic diameters of the ascending (AA) and descending (DA) aorta

Results

Age, gender and systolic blood pressure were significant single explanatory variables for pulse wave velocity (fig 2) and compliance of the descending and ascending aorta. Women had lower PWV and higher compliance than men. The FH-disease did not have association with the parameters measured. There was a negative linear correlation between the pulse wave velocity and the compliance as expected (fig 3).

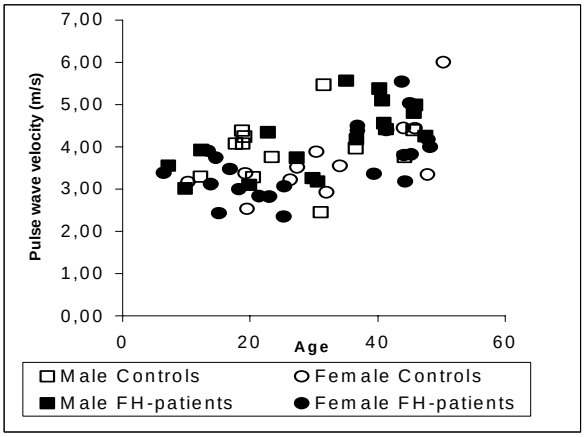

Figure 2. The correlation between pulse wave velocity and age. The pulse wave velocity increases with aging. R^2=0.279, p=0.000

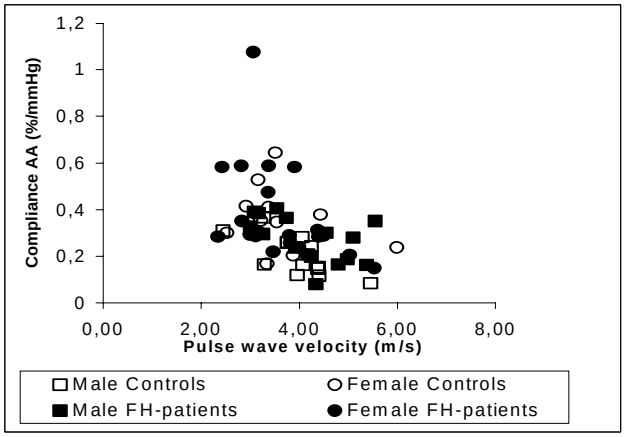

Figure 3. The correlation between pulse wave velocity and compliance of ascending aorta.When PWV increases CAA decreases and vice versa. r= -0.464.

Conclusions

MRI is a noninvasive means to measure compliance and pulse wave velocity of the aorta in young individuals. Pulse wave velocity increases and compliance decreases with aging both in healthy controls and in patients with FH.