Aortic Root Stiffness and Mechanical Properties of Healthy Adults

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Background: Arterial stiffness, often expressed in terms of pulse wave velocity (PWV), is an important risk factor for cardiovascular disease. PWV can be determined locally and non-invasively, by means of ultrasound.

Aim: To assess PWV, local compliance (Cs), distensibility (Ds) and Young's modulus of the aortic root using non-invasive ultrasound measurements.

Methods: 10 healthy volunteers aged 21-39, 1 male, were scanned using ultrasound (GE, Vivid E95) with a phased array transducer 1.5-4.5MHz. DICOM images were recorded from the parasternal long axis: M-mode for diameter measurements, and apical 5-chamber view for blood Doppler velocity, sequentially. Each measurement was repeated 3 times for 20s. Velocity and diameter waveforms were extracted offline in Matlab based on grey-scale thresholding. PWV was determined using the ln(D)U-loop method [1]. Wall thickness was extracted from the B-mode images used to measure the diameter. Distensibility and compliance were calculated as $Ds=1/(\rho \cdot PWV^2)$, $Cs=dA/dP=Ds \cdot A$, where $\rho=1050kg/m^3$ blood density, A is the cross-sectional area, and Young's modulus was calculated as previously described [2] using the Bramwell-Hill and Moens-Kortweg equations.

Results: Across all patients mean PWV was 3±0.8m/s, mean distensibility was $1.3 \cdot 10^{-4} \pm 0.61 \cdot 10^{-4} Pa^{-1}$, and mean compliance was $0.6 \pm 0.31 m^2 Pa^{-1}$. The average wall thickness was 0.4±0.06cm while Young's modulus was 63.6±40.4kPa. These results are comparable to corresponding values reported in the literature using other techniques.

Conclusions: Aortic root PWV, distensibility, compliance and Young's modulus can be determined using ultrasound measurements of diameter and velocity. Further studies are required to investigate the potential clinical utility of aortic root parameters.

References:

1. J Feng and AW Khir. Determination of wave speed and wave separation in the arteries using diameter and velocity'. Journal of Biomechanics, 43(3)455-462,2010.
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