Improved Aortic Pulse Wave Velocity Assessment with Inplane Velocity-Encoded MRI: Validation and Reproducibility

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Introduction
Aortic Pulse Wave Velocity (PWV), defined as the propagation speed of the systolic blood pressure or flow wave through the aorta, is associated with arterial wall compliance in cardiovascular diseases and connective tissue disorders such as hypertension, diabetes and Marfan syndrome. PWV can be acquired accurately intravascularly during catheterization but this invasive method is not suited for screening. Non-invasive 1-directional (dir) velocity-encoded MRI is widely used to determine PWV based on the transit-time method, but this method shows only moderate correlation and relatively high variation when compared to pressure measurements.

Purpose
2-dir VE MRI with high temporal resolution is introduced to determine PWV along the full course of the aorta. Accuracy is assessed in patients by comparing with invasive pressure measurements during catheterization and reproducibility is determined by repeated acquisition in healthy volunteers.

Results
Validation: In 15 patients (mean age 57±9 years) scheduled for catheterization, pressure measurements were acquired during pullback with a 6F saline filled catheter (Cordis Corp., Miami Lakes, FL). The catheter was advanced through the aorta until just distal to the aortic valve and then pulled backward. Pressure waves were recorded at ten locations 5.8 cm apart. The PWV averaged over the aorta was determined from the distance between measurement locations and the transit-time of the wave (Fig. 1B) (assessed fully automatically at the start of the upstroke of the propagating wavefront, by detecting the intersection of the constant diastolic flow and the increase in flow at systole, modeled by linear regression).

PWV-method 2: 2-dir VE MRI was performed in a double-oblique stack of three consecutive slices with slice thickness 10mm, FOV 450mm, acquisition voxel size 3.5x3.5x10.0 mm3, velocity sensitivity Venc 200 cm/s in AP and FH direction, maximal number of reconstructed phases (temporal resolution 5-10 ms). From the 2-dir VE data, the 2D velocity vector field of the blood flowing through the aorta is constructed. The aorta was segmented and the maximal velocity along the centerline of the aorta was determined over time at 100 equidistant measurement sites along the centerline (Fig. 1C). The PWV averaged over the aorta was determined from the distance between each measurement site and the transit-time of the wave (again assessed fully automatically at the start of the upstroke of the velocity wavefront).

Reproducibility: In 15 healthy volunteers (mean age 30±10 years), PWV was assessed with both MRI-methods twice, with repeated scanning after repositioning.

Conclusion
Pulse Wave Velocity assessed from 2-directional inplane velocity-encoded MRI over the full course of the aorta is very accurate when compared to the gold standard (invasive pressure measurements) and can be performed reproducibly. The widely used 1-directional through-plane velocity-encoded MRI is less accurate and shows more variation than 2-directional velocity-encoding.

Acknowledgement: Funding for this study by the Netherlands Heart Foundation (project 2006B138) is gratefully acknowledged.