Regional Aortic Pulse Wave Velocity with Two-Directional Velocity-Encoded MRI in Ischemic Heart Disease

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Introduction

Aortic Pulse Wave Velocity (PWV) is a powerful independent predictor of cardiovascular mortality in various patient groups. The PWV determined from through-plane one-directional velocity-encoded MRI (i.e., PWV_{tp}) with acquisition planes at two locations perpendicular to the aorta has been reported to give a global indication of the vascular status (1). However, regional differences along the entire aorta cannot be depicted.

Purpose

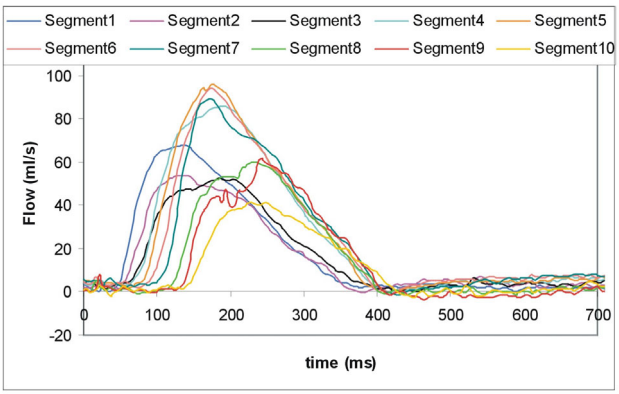
In this study, a new method of measuring PWV is described using two-directional in-plane velocity-encoded MRI with the acquisition planes parallel to the aorta, enabling regional depiction of the aortic vascular status in patients with ischemic heart disease. This new technique to determine the PWV is compared to the conventional PWV_{tp}.

Material and Methods

PWV_{tp} and PWV with in-plane velocity-encoded MRI (PWV_{ip}) were measured twice in eight healthy volunteers (mean age 30.4 ± 6.6 years) to evaluate reproducibility of the new method. Also, seven patients with ischemic heart disease were examined (mean age 67.9 ± 5.4 years). MRI was performed on a 1.5 T Philips Gyroscan Intera.

One-Directional PWV_{tp}: Two one-directional through-plane velocity-encoded MR acquisitions were performed consecutively (1), with acquisition planes positioned perpendicular to the aorta. Flow was determined at three locations: ascending aorta; end of aortic arch (DA prox) and near the bifurcation of descending aorta (DA dist) (Figure 1). The PWV_{tp} was determined from the distance between two acquisition locations measured along the coarse of the aorta and the time-difference between the points-of-arrival of the systolic wave. Point-of-arrival of the systolic wave was determined in the flow graph from the intersection of the offset in flow during diastole and the upslope of the systolic wave.

Two-Directional PWV_{ip}: In a stack of three consecutive acquisition planes, two-directional velocity-encoded MRI was performed. The stack was double-oblique planned covering the complete aorta. Scan parameters: TE/TR/α = 2.7/4.6/10°, slice thickness 15 mm, FOV 450 mm, scan matrix 128×128. Retrospective cardiac synchronization; 150 to 220 phases reconstructed per cardiac cycle. Velocity-encoding in two directions: FH and AP, with the velocity sensitivity set at 200 cm/s. The aorta was divided into ten segments of 4.2 cm (Figure 1). Per segment, the mean maximal velocity parallel to the axis of the aorta was determined, resulting in ten systolic flow-waves (Figure 2). The PWV_{ip} was determined from the distance between three consecutive segments and the time-difference of the points-of-arrival, while skipping the middle segment for each measurement, resulting in a mean PWV-value for over-contiguous segments of 8.4 cm. The PWV_{ip} of the aortic arch and descending aorta were determined by averaging the regional PWV-values of the first three and subsequent seven segments respectively, enabling comparison between PWV_{tp} and PWV_{ip}. Regional PWV_{ip} for the patients was defined as being increased when exceeding the mean PWV_{ip} plus twice the mean SD (derived from PWV_{ip} of the volunteers).



Results

PWV_{tp} and PWV_{ip} showed good correlation for volunteers for the descending aorta (Pearson correlation coefficient r_P = 0.88, p<0.01), but non-significant correlation for the aortic arch (r_P = 0.61, p = 0.15). Repeated measurements among volunteers showed small, non-systematic and non-significant (p>0.05) differences less than 0.4 m/s. Mann-Whitney U-test showed a significant increased PWV among patients compared to volunteers, both for PWV_{tp} and PWV_{ip} (Table 1). Four out of seven patients showed regionally increased PWV_{ip}, one patient in two segments, and three patients in one segment.

Conclusion

The assessment of PWV_{ip} is feasible and can detect global and regional abnormalities of aortic PWV, especially for the descending aorta.

Reference

1. Groenink M, et al. *Am J Cardiol* 1998: 15;82:203-208.

Table 1:

	patients mean (SD)	*p*-value Mann-Whitney U-test	volunteers mean (SD)
PWV_{tp} aortic arch	8.3 (2.2)	< 0.01	4.6 (0.7)
PWV_{tp} descending aorta	8.6 (3.7)	0.03	4.9 (1.5)
PWV_{ip} aortic arch	4.7 (0.7)	< 0.01	4.6 (0.4)
PWV_{ip} descending aorta	5.0 (1.5)	< 0.01	4.5 (0.8)