Estimation of Compliance in Aortic Aneurysms using Pulse Wave Velocity Measurements

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Introduction

Vessel wall compliance of arteries can be determined using its direct relation to pulse wave velocity, which can be measured accurately using MR measurements. Complicance of vessels is influenced by vascular diseases like atherosclerosis. In this study, we investigated the relation between compliance and different disease states such as atherosclerotic aneurysm and aortic dissection. The aim of this study is to investigate if pulse wave velocity measurements might be helpful to predict the risk of rupture in aortic aneurysms [1].

Methods

16 Patients with aortic aneurysm and 5 patients with aortic dissection were examined. Pulse wave velocity was measured using phase-contrast flow measurements. By using a method presented earlier [2] which involves retrospective cardiac gating, a temporal resolution of 3 ms could be achieved. Pulse wave velocity c was calculated from the vessel segment length Δx and the time delay between two flow curves Δt as $c = \Delta x / \Delta t$. The time delay was calculated by fitting a line to the ascent of the flow wave, which avoids artifact from reflected waves occurring later withing the cardiac cycle [3]. When possible, three slices were measured so that both a normal segment and a dilated segment of the aorta could be evaluated (Fig. 1). Total measurement time for three slices is about 10 minutes. For aneurysm evaluation, a multiphase three-dimensional gadolinium angiography (TR = 3.2 ms, TE = 1.1 ms) was acquired. This data was used for localization and for accurate determination of the vessel segment length Δx even in tortuous vessels and complicated aneurysm shapes. T2-weighted imaging was performed for separation of vessel lumen from thrombotic parts of the aneurysm.

Results

1. Comparison of the normal part of the aorta versus the dilated segment yields an average decrease in pulse wave velocity in the dilated segment, which corresponds to an increase in compliance. Substantial differences between large infrarenal aortic aneurysms and dissections were found. In the first case an increase or only slight decrease of pulse wave velocity is found, whereas in dissections a strong decrease of pulse wave velocity could be observed (see Fig. 1).
2. No relationship between aneurysm size and pulse wave velocity is found.
3. There is a negative correlation between thrombus size and pulse wave velocity in aneurysms (see Fig. 2). With increasing thrombotic fraction (defined as the maximum thrombus thickness divided by aneurym diameter), pulse wave velocity decreases.

Conclusion

Changes in pulse wave velocity connected to vascular diseases can be measured using MR phase contrast flow measurements. These correspond to changes in the wall property of the aorta which probably are characteristic for different disease processes. Detection of local changes in wall compliance might be helpful for delineation of the individual risk of aneurysms rupture. This is being investigated in an ongoing patient study.

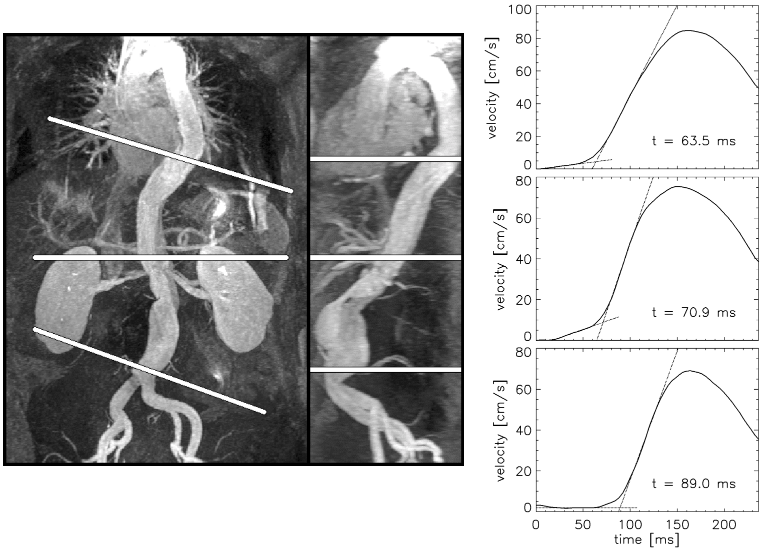

Fig. 1: Left: coronal and sagittal MIP of a 3D-Gd-angiography dataset from a patient with aortic aneurysm and dissection indicating the three slice positions where velocity measurements were taken. Right: velocity time curves acquired at the slice positions indicated. Vessel segment lengths were calculated from different views of the 3D data set to Δx_1=122 mm and Δx_2=129 mm. This results in pulse wave velocities of c_1=16.5 m/s and c_2=7.1 m/s for the upper and lower segment, respectively.

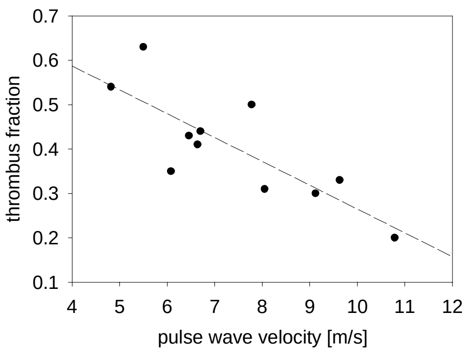

Fig. 2: Pulse wave velocity in aortic aneurysms of 11 patients versus thrombus fraction. A fit to a linear model is indicated by the dashed line (r^2 = 0.65).

References

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