MRI evaluation of vessel wall stretch in healthy and diseased aortas

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Target Audience

Researchers interested in properties of the aortic wall, and/or displacement encoding with stimulated echoes (DENSE) MRI.

Purpose

Mechanical properties of the aortic wall have been used to diagnose and characterize cardiovascular disease. Aortic stiffness correlates with aortic disease and disease progression. Mechanical regulation from strain and wall shear stress is hypothesized to influence remodeling in the cardiovascular system [1, 2]. Current non-invasive techniques for assessing aortic deformation are based on diameter changes, and are sensitive to through-plane motion of the aorta. We propose a new MRI approach that measures the regional stretch of the aortic wall itself using DENSE [3].

Methods

The ascending aorta of three young volunteers (29±4 years old), three patients with valve disease (54±18 years old), and five patients with dilated aortas (64±6 years old) were studied with DENSE MRI and CINE imaging. These were acquired in a slice in the tubular portion of the ascending aorta. Because of the SNR limitation, single-phase DENSE was used. The timing of the single-phase DENSE encoding was set to the maximum dilatation of the aorta according to the cine images, and acquisition in diastole. The aorta was segmented and circumferential stretch was computed to acquire mean stretch for the aorta, as well as mean stretch within four quadrants of the aorta: left-anterior, right-anterior, right-posterior, and left-posterior. Local flow fields were also acquired using phase contrast MRI (PC-MRI). The PC-MRI acquisition was a 3D time resolved acquisition covering the whole ascending aorta for full hemodynamic assessment [4].

Results

The three young volunteers had an mean circumferential aortic stretch of 7%. The three patients with valve disease had a mean stretch of 3%, and the five patients with dilated aortas had a mean stretch of 1%. Figure 2 shows the circumferential stretch for the four quadrants for all subjects. The data shows that all three groups have higher stretch in the right-posterior quadrant of the aorta. Figure 3 shows flow and DENSE data of a patient with eccentric flow towards the right-posterior quadrant due to the valve disease.

Discussion

This novel application of DENSE imaging allows for direct assessment of regional stretch in the ascending aorta. Clear differences are seen between volunteers, patients with valve disease, and patients with aortic dilation. Regional differences along the aortic lumen are evident, which cannot be imaged with other non-invasive techniques. Our pilot study suggests that DENSE may play a central role in better understanding how mechanical differences in the aortic wall interrelate with disease progression. A clear difference is seen between the young volunteers and the older patients, and then between the patients depending on whether the aorta is dilated or not. Regional differences in stretch could be seen in all three groups with increased stretch values towards the right-posterior quadrant of the aorta. In a few patients, correlation between flow difference and stretch is seen, as demonstrated in figure 3, which may allow identification of aortic disease at early stage as well as a better understanding of the role hemodynamics play in disease progression.

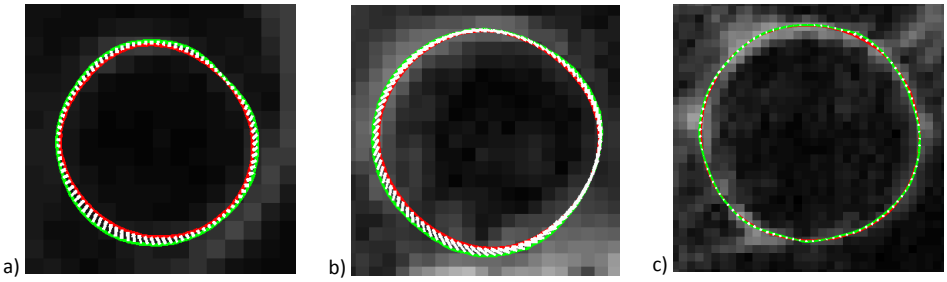

Figure 1
DENSE MRI of: a) a young volunteer; b) a patient with valve disease but without dilatation; c) a patient with an dilated aorta. The images illustrate the relative displacement from systole to diastole.

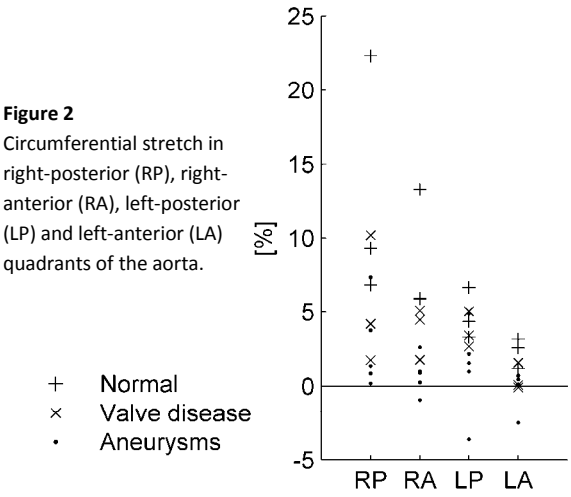

Figure 2
Circumferential stretch in right-posterior (RP), right-anterior (RA), left-posterior (LP) and left-anterior (LA) quadrants of the aorta.

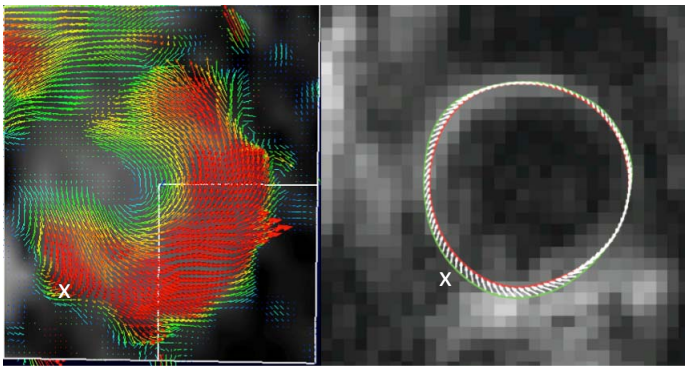

Figure 3
Flow and DENSE data in the same view for a patient with eccentric flow towards the right-posterior quadrant due to valve disease and larger stretch in the right side of the aortic wall (left in image). The white x marks the location of the right-posterior aortic wall.

References

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