

Oral presentation

Eccentric flow jets and elevated wall shear stress with bicuspid aortic valves

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Introduction

The role altered hemodynamics play in dilation of the ascending thoracic aorta (AsAo) in bicuspid aortic valve (BAV) patients is controversial. We previously reported that abnormal systolic helical flow is a common finding in the AsAo of BAV, but not tricuspid aortic valve (TAV), patients.

Purpose

We now seek to further characterize the altered fluid-mechanical environment in the AsAo of these patients with the goal of elucidating factors that may predispose to aneurysm.

Methods

Time-resolved, 3D phase contrast MRI (4D Flow) was used to assess AsAo blood flow in 55 individuals: 22 patients with BAV and 25 with TAV, and 8 healthy volunteers. Systolic flow patterns were characterized with 3D visualization software (EnSight, CEL, Inc. Apex NC). Abnormal helical flow was defined as greater than 180° curvature of high velocity peak systolic streamlines around slower, central helical flow in the AsAo. Vectorial wall shear stress (vWSS) was calculated at peak systole for 12 angular segments along the AsAo circumference just above the level of the sinotubular junction using proprietary software (flow tool, University of Freiberg).

Results

Abnormal helical flow was demonstrated at peak systole in the AsAo of 17 of 22 BAV patients, but in none of the TAV patients or healthy volunteers; this flow pattern was seen in BAV patients with both dilated ($n = 7$) and normal AsAo ($n = 10$), in the absence of aortic stenosis ($n = 7$), and was associated with eccentric systolic flow jets in all cases. Figure 1 demonstrates right-handed helical flow and a right-anterior flow jet in a patient with fusion of the right and left aortic leaflets. Figures 2 exhibits normal and eccentric systolic flow jets in the AsAo. Peak systolic vWSS was elevated in the right-anterior quadrant of the AsAo in 13 BAV patients with abnormal right-handed helical flow compared to TAV controls: 1.40 versus 0.52 N/m², $p < 0.001$. Patients with left-handed helical flow ($n = 4$) showed a trend toward increased vWSS in the left-posterior quadrant.

Conclusion

4D Flow demonstrates eccentric systolic flow jets in BAV patients that are associated with altered AsAo wall shear stress. Right-handed helical flow resulted in elevated vWSS in the right-anterior quadrant of the AsAo, which is where BAV patients are known to have asymmetric dilation. Our data support the hemodynamic theory in the ongoing debate regarding why BAV patients develop AsAo aneurysm.

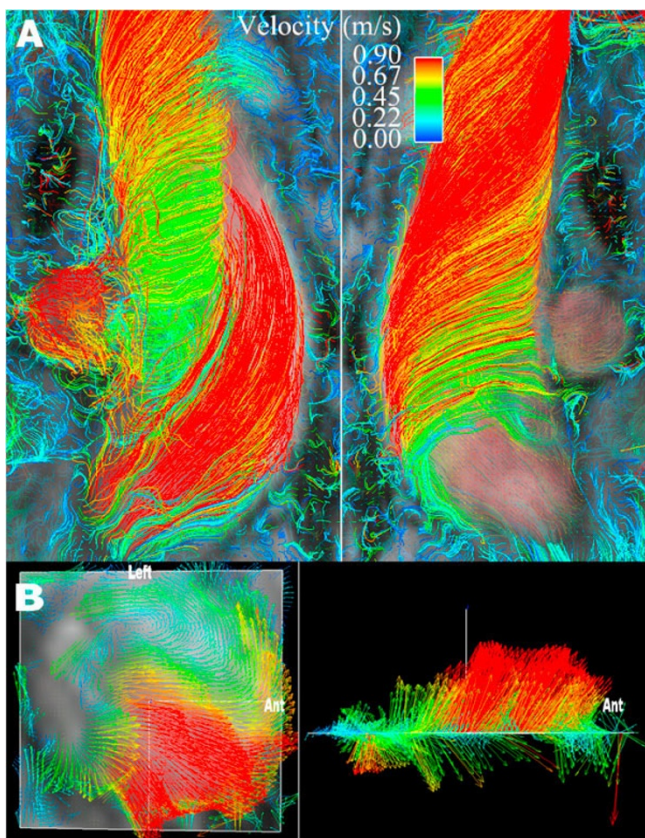


Figure 1

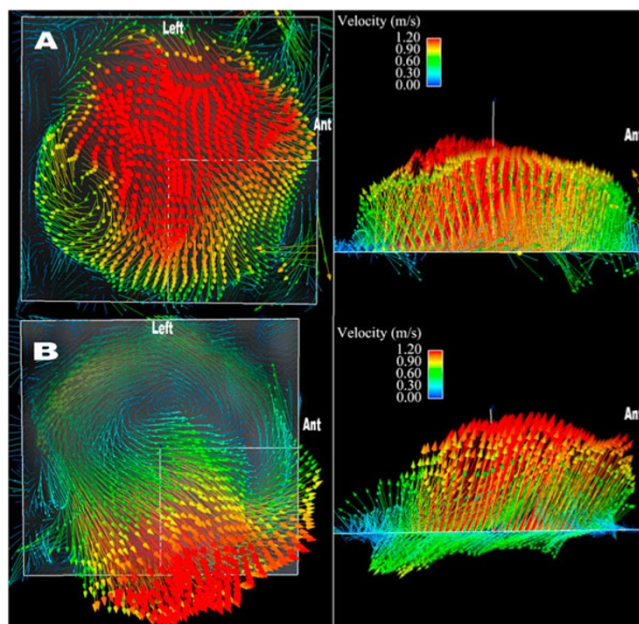


Figure 2