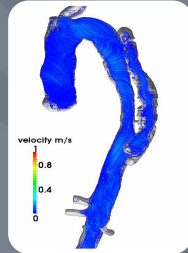


Diagnostic elements for the future

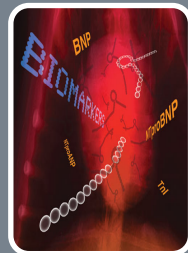
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Functional
imaging



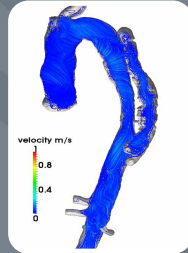
Genomics



Biomarkers

Diagnostic elements for the future

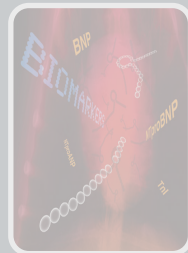
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Functional
imaging



Genomics



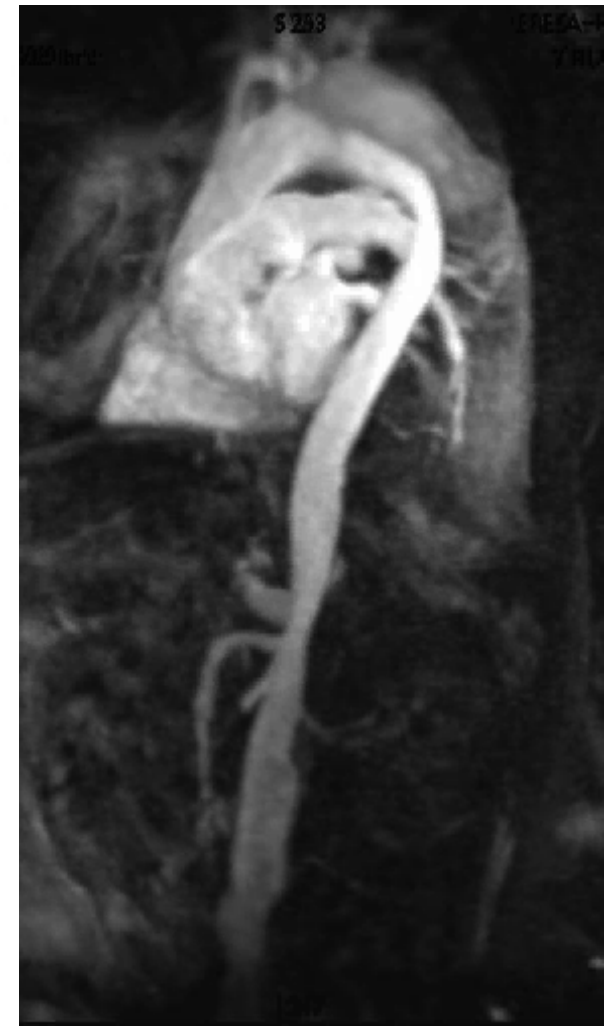
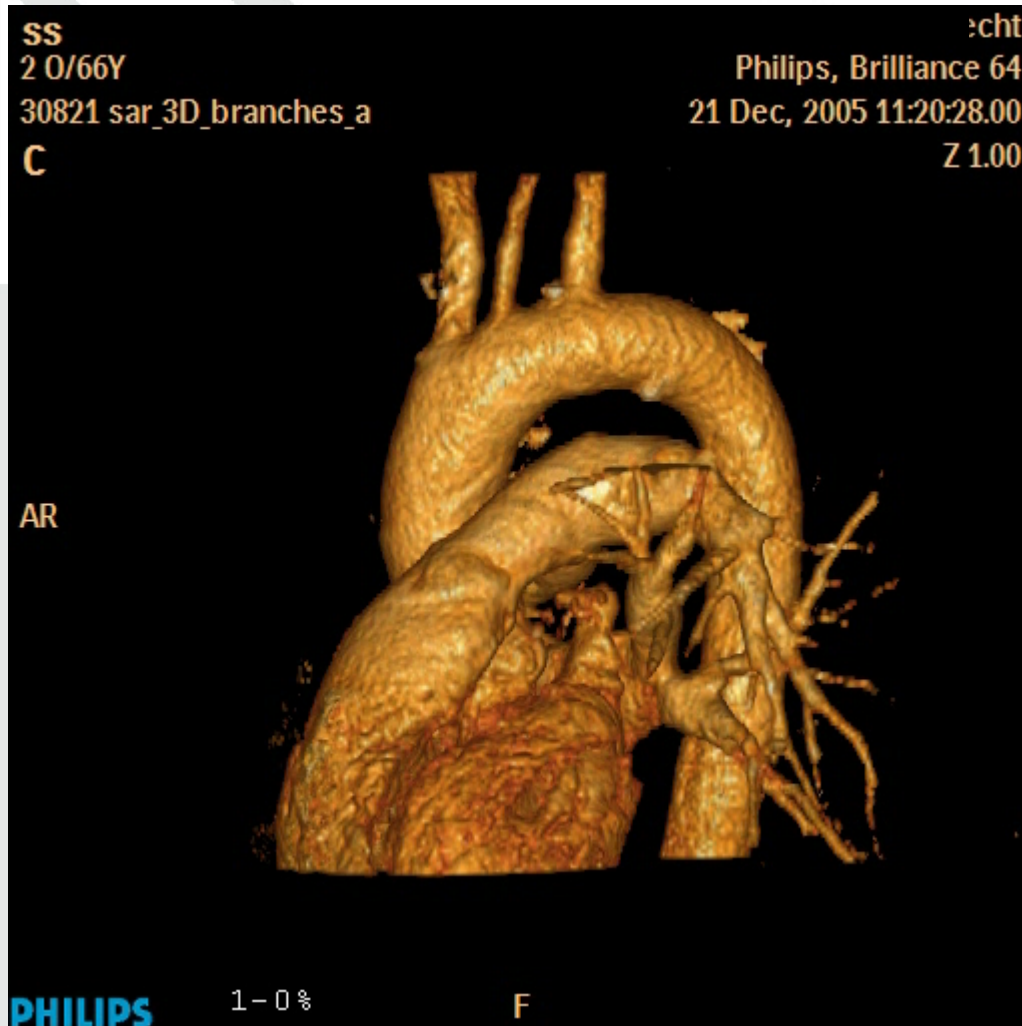
Biomarkers



4D imaging

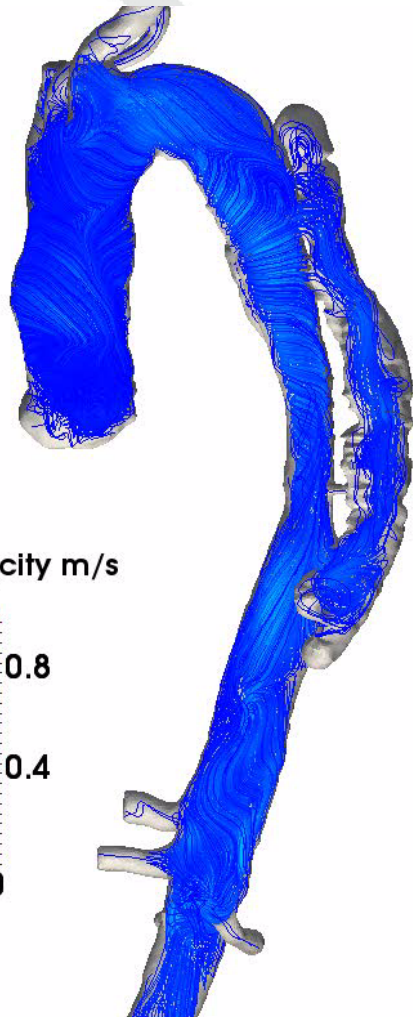
Dynamic CT

Dynamic MRI



Frans Moll, SITE 2007

Functional imaging



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CORRESPONDENCE

Research Correspondence

Imaging Biomarkers of Aortic Disease

Increased Growth Rates With Eccentric Systolic Flow

To the Editor: Is the aortic dilation that is commonly seen with bicuspid aortic valve (BAV) related to intrinsic aortic wall fragility or altered systolic hemodynamics? Recent publications on the topic favor the intrinsic fragility hypothesis. But recent advancements in imaging show very abnormal systolic flow in the ascending aortas of patients with BAV (1). We have been following a cohort of such patients who have eccentric, helical flow as demonstrated by a cardiac magnetic resonance (CMR) technique for dynamic blood flow imaging termed 4D Flow. One consequence of this eccentric flow is focally elevated wall shear stress at the convexity of the ascending aorta (2). We hypothesize that the degree of eccentric flow and resultant skewed shear stress directly contribute to the development of aortic pathology. Others have examined eccentric flow and enlarged aortic dimensions at a single time point (3), but causality and temporal evaluation have not been addressed. Here we investigate the relationship between flow and ascending aortic growth rates in patients with BAV.

Serial magnetic resonance or computed tomography angiography studies were retrospectively reviewed in 25 patients evaluated

with 4D Flow. All studies were performed for clinical indications. Thirteen patients had BAV (26.5 years of age, 5 female, 3.5 ± 0.7 cm baseline aortic size), and 12 with tricuspid aortic valve (TAV) served as controls (30.7 years of age, 3 female, 3.4 ± 0.5 cm baseline aortic size). The patients with BAV were relatively free of significant aortic valve disease; only 3 had greater than mild stenosis and 1 greater than mild insufficiency. None of the patients with TAV had valve disease. Ascending aortic diameters were measured at standard levels by 2 blinded reviewers, and the growth rate of the maximally enlarged segment was determined. Using a previously described qualitative approach, ascending aortic blood flow was graded as normal or mildly or markedly eccentric (2). All TAV controls had normal flow, whereas 10 of the 13 patients with BAV had abnormal flow (7 markedly eccentric). Normalized flow displacement from the vessel center, a recently developed parameter to quantify flow eccentricity, was calculated as well (4). Growth rates for controls and patients with BAV, and within the BAV group based on the degree of eccentric flow, were compared with unpaired Student *t* tests.

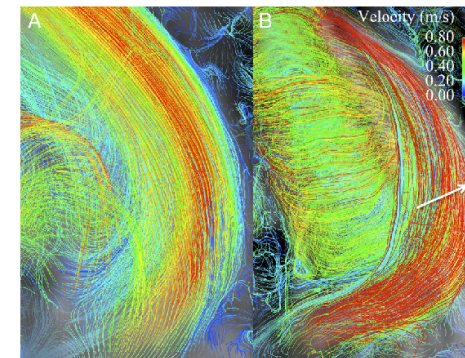
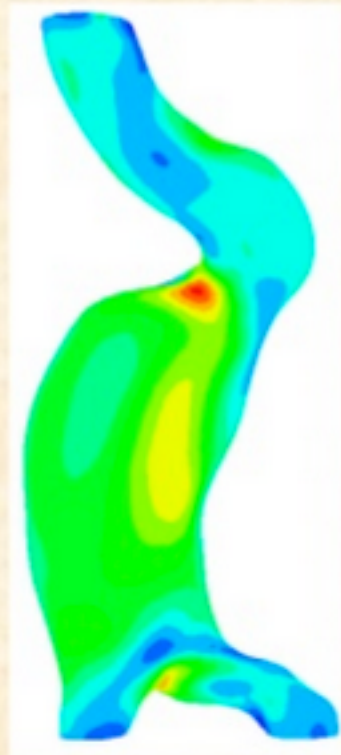
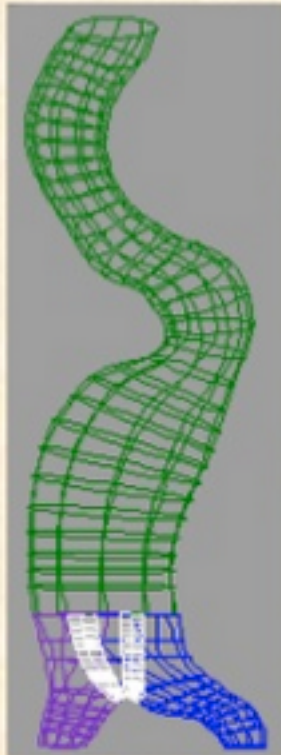


Figure 1. Normal and Eccentric Flow

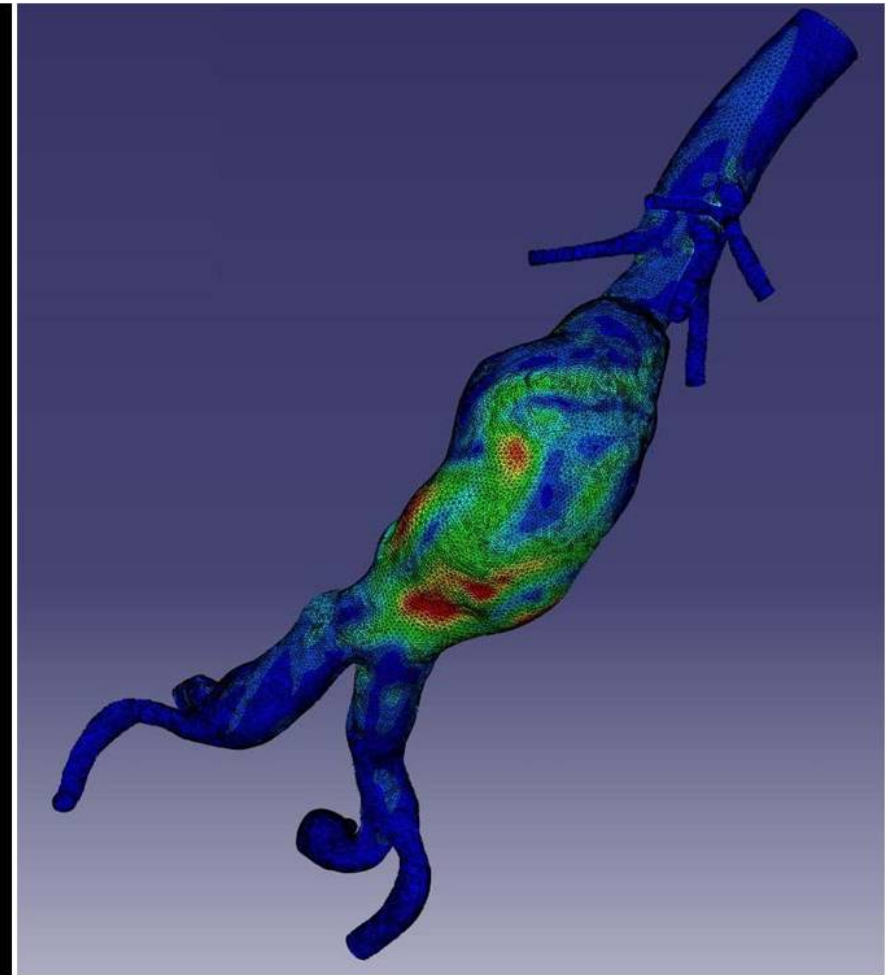
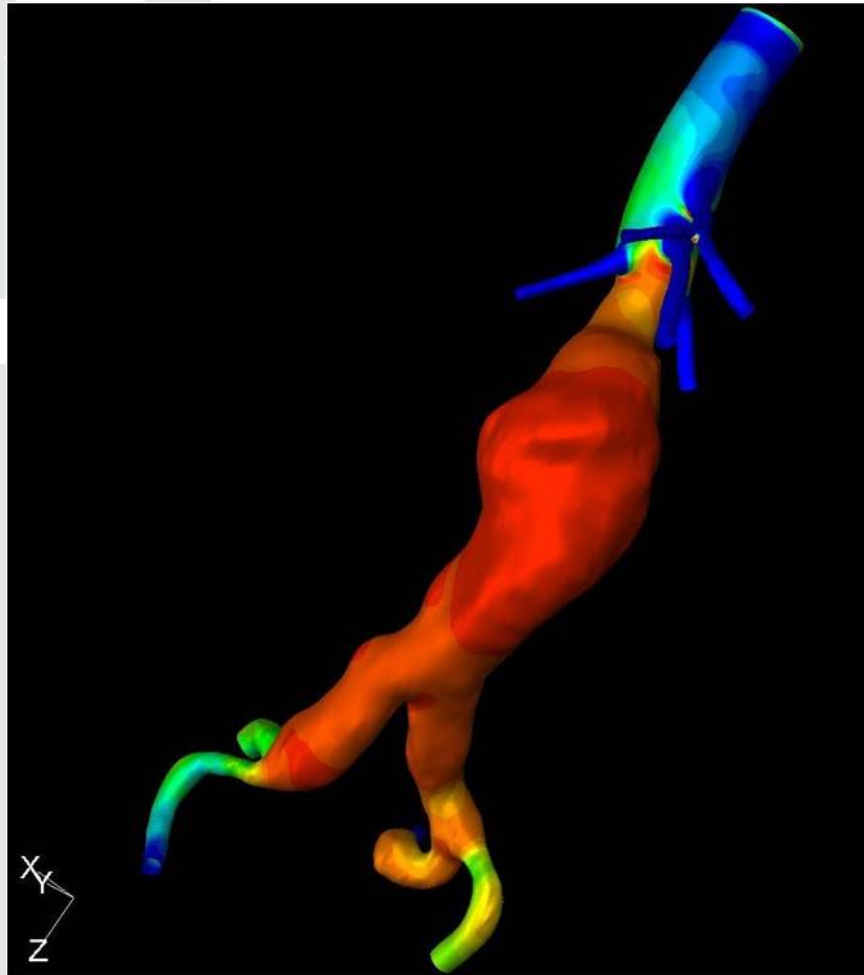
Streamlines representing peak systolic flow in the ascending aorta of 2 representative patients with bicuspid aortic valves. Normal-appearing streamlines that smoothly course through the ascending aorta (A) are seen in an 18-year-old woman who had stable aortic dimensions. Eccentric streamlines resulting in helical ascending aortic flow (B) are shown for a 32-year-old man with interval aortic growth of 1.3 mm/year. Growth occurred at the level highlighted by the arrow where eccentric systolic flow and wall shear stress were maximum.

Computational analysis and mathematical modeling



Need student with experience in Finite Element Analysis software (Abaqus, Ansys), Computer Aided Design software (Patran, Abaqus, Rhino3D), mechanical stress, non-linear elastic material properties.

Fluid pressure and mechanical stress



Fluid pressure and mechanical stress distributions on the wall of an aortic aneurysm model. Dilana Hazer, PhD project, Universität Karlsruhe