Importance of Stress Mapping of Aortic Wall in Aortic Valve Disease

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We read the paper by Guzzardi et al. (1) with great interest. These investigators demonstrate the effects of specific types of aortic valve anomaly on the pattern of aortic wall shear stress (WSS) measured by 4-dimensional cardiovascular magnetic resonance (CMR) and the relationships among WSS, ascending aorta shape and dilation, and wall degeneration. We have previously shown that increased WSS quantified by computational fluid dynamics (CFD) on the basis of pre-operative magnetic resonance imaging coincided with severe disruption of the media of the aorta, as documented by histological examination (Figure 1) (2). The findings of Guzzardi et al. (1) confirm and extend our previous findings.

It is widely accepted that endothelial shear stress or WSS plays a significant role in the pathophysiological remodeling of the vasculature (3). The measurement of WSS is difficult (4), and no methods exist that can be used to measure WSS in vivo. In both CMR and CFD, WSS is calculated from the gradient of the velocity adjacent to the wall and an assumed viscosity. Both CMR and CFD have advantages and disadvantages, but in the absence of direct measurements, it is intrinsically impossible to compare their ability to determine WSS. Instead of debating their relative merits, we suggest that it would be advantageous to integrate the methods to exploit their different advantages: the ability of CMR to measure velocity directly on the rather coarse length scales intrinsic to the method and the ability of CFD to refine its computational length scales in regions of interest by using knowledge of the basic equations of flow.

Integration of in situ measurement with computer modeling has a long history in weather forecasting (5), in which atmospheric fluid dynamics is computationally simulated using wind velocity, temperature, and humidity measured at a large number of weather stations across the globe. The same approach can be taken with 4-dimensional CMR and CFD in hemodynamic analysis—they are synergetic rather than confronting. We believe that routine use of the 2 methods of measuring WSS could have important clinical implications, particularly as advances in vascular biology enable us to link mechanical forces to cellular activity in the wall.

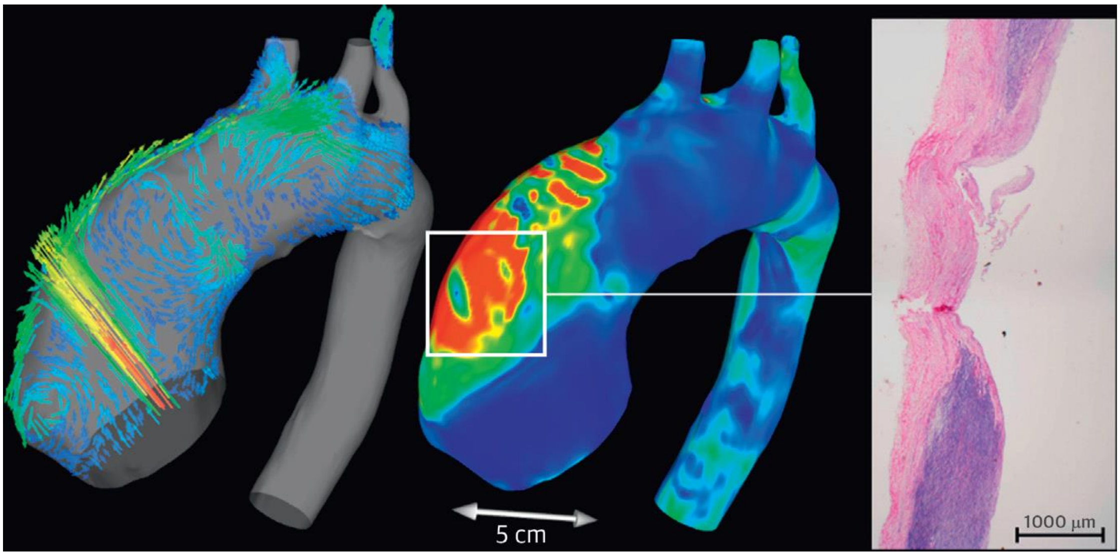

Figure 1 Blood Flow and Wall Shear Stress in Aortic Aneurysm and Bicuspid Aortic Valve. Blood flow pattern (**left**) and wall shear stress (**middle**) at the peak systole of a patient with a heavily calcified bicuspid aortic valve and an ascending aortic aneurysm, as well as histological examination of the tissue at flow impact (**right**).

References

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