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NUMERICAL MODELING OF BICUSPID AORTIC VALVE DISEASE

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A common congenital heart disease is the bicuspid aortic valve (BAV), when the valve presents only two leaflets instead of three. It has been found that BAV is related to an increased prevalence of ascending aortic dilatation and aneurysm when compared to tricuspid aortic valve (TAV). The altered fluid dynamics of BAV seem to be correlated to these complications. In particular, three peculiar aspects have been recognized so far from radiological images: high wall shear stresses (WSS) in the region of dilatation[1], asymmetry of the systolic jet entering in aorta[2], helical systolic flow in the ascending aorta[3].

In this work, we report on a study of the the fluid-dynamics of blood in ascending aorta aimed to understand the differences between a normally functioning BAV and a TAV configuration. We considered the assumption of rigid walls and we solved the incompressible Navier-Stokes equations in real geometries of patients with BAV considering physiological inlet conditions. To compare different scenario, we created on the same geometry a TAV configuration and different BAV configurations. The numerical results were obtained with the finite element library LIFEV (www.lifev.org).

In the first set of simulations, we do not model the leaflets but consider just the different shape of the orifice induced by the different configurations. We found that the three phenomena described above characterizing BAV configurations are recovered by our simulations [4, 5]. This suggested that the particular shape of the orifice of BAV configurations is the main responsible for the abnormal fluid-dynamics in the ascending aorta. To understand also the contribution of the presence of the leaflets, we included them in our second set of simulations. We found that in this case the presence of high WSS, the asymmetry

of the jet and the formation of systolic vortexes are further emphasized, suggesting that both the shape of the orifice and the leaflets contribute in the formation of abnormal fluid-dynamic patterns in BAV[6]. We will present in this talk several parametric studies, by varying the area of the orifice, its orientation to account for the two principal BAV orientations (antero-posterior and latero-lateral), the inlet flow rate, the dimension of the aorta.

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