Flow field post repair in critical aortic valve stenosis: Implication to recurring disease states. by Denise Medina

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Aortic stenosis in newborns is expressed as a severe obstruction to the left ventricular outflow tract due to congenital malformation of structures at the site of the aortic valve leading to abnormal hemodynamics. The purpose of this study was to identify the flow field under normal and post-balloon aortic valvuloplasty (BAV) environments and subsequent biological responses of valve endothelial cells (VECs). To extract the shear stress from the waveforms, CFD (ANSYS Canonsburg, PA) was conducted within the computationally reconstructed aortic structure from a pediatric patient who underwent the procedure and a normal pediatric patient. The velocity profile was prescribed to the inlet and the pressure profile was specified as the outlet boundary condition (Figure 1, 2 and 3). A transient simulation was conducted with a time step of 0.001 s and specifying a convergence criteria of 1x10-6 for momentum and continuity equations. Critical aortic valve stenosis is a major source of mortality and morbidity in newborns with congenital heart disease. BAV treatment widens the stenosed valve region using a balloon catheter to increase the effective orifice area and improve the blood flow circulation. Nonetheless, the peak velocity past the heart valve that underwent BAV treatment was 1.11 m/s, while the peak velocity observed in the healthy heart valve was 0.66m/s. Moreover, we observed that the fluid-induced shear stress profile on the ventricularis was considerably different compared to the fibrosa. A difference in shear stress between the normal and BAV cases was found, which resulted in altered gene expression in the latter case compared to the control group. We conclude that changes in the local velocity and trans-valvular pressure gradient leads to changes in responses at the cellular and molecular scales. These changes may contribute towards rapid re-stenosis post-BAV repair.