BLOOD FLOW-PRESSURE DIAGNOSTICS OF PULMONARY VALVE INSUFFICIENCY IN REPAIRED TETRALOGY OF FALLOT USING PATIENT SPECIFIC GEOMETRY

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Background: Adult subjects who have undergone repair of Tetralogy of Fallot (rTOF) in infancy are typically left with severe pulmonary valve (PV) insufficiency, and subsequently develop age-related RV enlargement, which in turn can lead to right ventricular (RV) dysfunction and occasionally sudden death. While the physiological conditions associated with the dysfunctional RV and the deficient PV are well understood, quantitative diagnostic criteria to determine the most appropriate time for pulmonary valve replacement surgery are not known. The objective of this study was to apply computational fluid dynamics (CFD) and fluid-structure interaction (FSI) tools to understand the blood flow mechanics in both rTOF and normal subjects as a means to estimate diagnostic parameters to access the state of PV insufficiency.

Methods: Subject-specific 3D geometry for branch pulmonary artery (PA) anatomy was reconstructed from MRI scans of individual subjects (rTOF and normal). Pressure was measured using fluid filled catheter and the velocities were measured using cine-phase contrast MRI imaging. CFD analysis was performed by using pulsatile pressure and velocity boundary conditions at appropriate inlet and outlets of the branch PAs. Velocity from the CFD results were validated using the measured flow rate at identical locations . Further energy parameters were obtained from the combined CFD and clinical pressure-flow data, and compared between normal and rTOF subjects.

Results: The rTOF subject had a significant negative component in energy transfer rate over a cardiac cycle compared to a normal subject. This is manifestation of the back flow due to the non- functioning PV. Further, the peak energy transfer rate for forward flow in the branch PAs in a normal subject is almost twice as compared with an rTOF subject. Our analyses also showed flow regurgitation in the left PA, matching the observed flow pattern shown in the MRI scan of the rTOF subject.

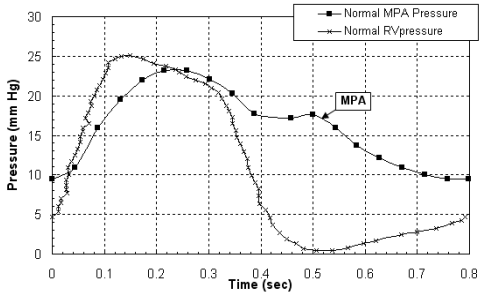

Fig1 : Pressure and flow in RV and MPA for a sample normal subject.

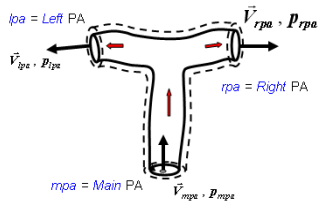

Fig2 : Schematic representation of branch PA geometry.

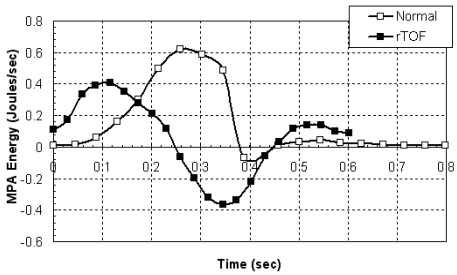

Fig3 : MPA total energy for a comparable normal and rTOF subject.