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BIOE STUDENT
Ph.D. Proposal Presentation

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U.A. Whitaker 1103

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In Vitro Fluid Dynamics of Stereolithographic Single Ventricle Congenital Heart Defects from *In Vivo* Magnetic Resonance Imaging

Single ventricle congenital heart defects with cyanotic mixing between systemic and pulmonary circulations afflict 2 per 1000 live births. Following the atriopulmonary connection proposed by Fontan and Baudet in 1971, the present procedure is the total cavopulmonary connection (TCPC), where the superior and inferior vena cavae are sutured to the left and right pulmonary arteries. However, surgeon preference dictates the implementation of the extra-cardiac and intra-atrial varieties of the TCPC. Overall efficiency and hemodynamic advantage of the competing methodologies have not been determined. It is hypothesized that an understanding of the fluid dynamic differences between various Fontan surgical methodologies in the TCPC allows for power loss evaluation toward improved surgical planning and design. Toward such analysis, a previously developed data processing methodology is applied to create an anatomic database of single ventricle patients from *in vivo* magnetic resonance imaging (MRI) to examine the gamut of TCPC anatomies. From stereolithographic prototypes of representative cases, pressure and flow data are used to quantify control volume power loss to measure overall efficiency. 3-D particle image velocimetry (PIV) is employed to detail flow structures in the vasculature. Results are validated with dye injection flow visualization and 3-D phase contrast MRI (PC-MRI) velocimetry, highlighting flow phenomena that cannot be captured with *in vivo* MRI due to prohibitively long scanning times.

Preliminary results illustrate the variation of control volume power loss over several TCPC anatomies with varying flow conditions, the application of 2-D PIV, and validation approaches

with 3-D PC-MRI velocimetry. Data from control volume power loss evaluation demonstrate the groundwork for correlation with TCPC anatomy, providing added clinical knowledge of optimal TCPC design. Findings from PIV and 3-D PC-MRI velocimetry reveal a means for quantitatively comparing flow structure. Dye injection flow visualization offers qualitative insight into limitations of the selected velocimetry techniques.