Hemodynamic Effect of a Fontan Assist Device on a Numerical Fontan Circulatory Model under Various Medication Scenarios

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Patients with single-ventricle heart disease and failing Fontan circulation represent the largest and most rapidly growing subgroup of adults with congenital heart disease referred for transplant assessment. Few clinical therapies are available for improving Fontan hemodynamics. Mechanical circulatory support devices have been used successfully in the clinical setting to assist the single ventricle, but no device is currently available to support the subpulmonary circulation. A subpulmonary pump could be used to support patients with failing Fontan circulation by mitigating chronic venous hypertension and restoring normal physiology. Our group designed a Fontan assist device (FAD) to augment right-heart (subpulmonary) flow and decrease venous pressures. To ensure that our FAD could achieve target hemodynamic parameters, we developed a numerical Fontan circulatory model to evaluate the interaction between the cardiovascular system and the FAD. To ensure that the circulatory model can mimic real-world clinical conditions, we investigated the effects of various medications in the FAD loop. Results showed that the FAD can significantly increase cardiac output in Fontan patients and can create a pressure difference between the pulmonary arteries and venae cavae. Further, the systemic venous pressure can be significantly reduced by using the FAD plus diuretic treatment. The downstream pulmonary artery pressure can be increased by augmenting the FAD with vasodilator treatment, diuretic treatment, or both.