The Hybrid Norwood (HN) is a relatively new first stage procedure for neonates with Hypoplastic Left Heart Syndrome (HLHS), in which a sustainable univentricular circulation is established in a less invasive manner than with the standard procedure. A computational multiscale model of such HLHS circulation following the HN procedure was used to obtain detailed hemodynamics. Implementation of a reverse BT shunt (RBTS), a synthetic bypass from the main pulmonary to the innominate artery placed to counteract aortic arch stenosis, and its effects on local and global hemodynamics were studied.

A synthetic and a 3D reconstructed, patient specific anatomy after the HN procedure were utilized, with varying degrees of distal arch obstruction, or stenosis, (nominal and 90% reduction in lumen) and varying RBTS diameters (3.0, 3.5, 4.0 mm). A closed lumped parameter model (LPM) for the peripheral or distal circulation coupled to a 3D Computational Fluid Dynamics (CFD) model that allows detailed description of the local hemodynamics was created for each anatomy. The implementation of the RBTS in any of the chosen diameters under severe stenosis resulted in a restoration of arterial perfusion to near nominal levels. Shunt flow velocity, vorticity, and overall wall shear stress levels are inverse functions of shunt diameter, while shunt perfusion and systemic oxygen delivery correlates positively with diameter. No correlation of shunt diameter with helicity was recorded.

In the setting of the hybrid Norwood circulation, our results suggest: (1) the 4.0mm RBTS may be more thrombogenic when implemented in the absence of severe arch stenosis and (2) the 3.0mm and 3.5mm RBTS may be a more suitable alternative, with preference to the latter since it provides similar hemodynamics at lower levels of wall shear stress. CFD analyses of synthetic and patient derived geometries demonstrated consistent trends of vascular bed perfusion, vorticity, oscillatory shear index and wall shear stress levels. Helicity was found to be highly dependent on anatomy and level of stenosis.

Major: Mechanical Engineering

Educational Career:
Bachelor’s of Mechanical Engineering, BS, 2009, University of Central Florida
Master's of Mechanical Engineering, MS, 2011, University of Central Florida

Committee in Charge:
Dr. Alain Kassab, Chair, MAE
Weiwei Deng, UCF MAE
Yuanli Bai, UCF MAE
Eduardo Divo, Embry-Riddle Aeronautical University, Dept. of Mechanical Engineering
William DeCampli, University of Central Florida College of Medicine

Approved for distribution by Dr. Alain Kassab, Committee Chair, on April 9, 2015.

The public is welcome to attend.