

**Abstract Title:** Energy Losses following palliative strategies for hypoplastic left heart syndrome: Pilot study with computational fluid dynamics.

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**Abstract:**

Background

The difference in energy losses between the hybrid procedure and two types of Norwood procedures remain unknown. The physics of the fluid in the heart are governed by highly non-linear coupled equations that cannot be analytically solved by any current means. We utilized computational fluid dynamics (CFD) to solve for the pressure and velocity data across the heart. This is used to solve for and compare the energy loss of the three palliative strategies, along with the shear stress at the walls of the heart.

Methods

Three dimensional computer models of the modified Blalock-Taussig shunt, right ventricle-pulmonary Artery Shunt and Hybrid (pulmonary artery bands and patent ductus) were constructed using commercial CFD software FLUENT and GAMBIT. The computer models were controlled for size of conduit 3mm BT shunt and 4mm RV to PA. Velocity and pressure data were calculated at points of interest using the finite volume numerical method. This was a steady state and laminar flow model. These were used to compute the total pressure at the inlet of the tricuspid valve and the outlets of the pulmonary arteries and aorta. Also calculated were wall shear stress and total viscous force. Computer simulations were compared at fixed points utilizing published echocardiographic and catheter based vascular metric dimensions.

Results

When compared to classic Norwood procedures, overall energy loss was the highest for the hybrid procedure in systole. The shear stress for the hybrid procedure was lowest among all the palliative strategies for the HLHS. The maximum estimated velocity obtained was in the hybrid procedure. Qp/Qs values are all under one, but the closest to one is the hybrid case.

Conclusions

Given our preliminary findings, the Norwood procedure for HLHS have less energy loss compared to the hybrid procedure. However the shear stress of the hybrid was lowest.

Implications and Future Directions

Low shear stress in the hybrid implies less chance for stasis as well as least risk of clot or thrombus formation. However the hybrid procedure may be less favorable compared to the Norwood procedures if the cardiac function is diminished. Further study is needed to understand the implications of high shear stress on the vasculature and the biology of vessels supplying vital organs. More advanced circuits including pulsatility and non steady state computational fluid dynamics studies will advance our thinking.