Design and Development of a Magnetically-driven Ventricular Assist Device (MVAD): *in vitro* implementation in the Fontan circulation

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ABSTRACT

Around 8% of all newborns with a Congenital Heart Defect (CHD) have a single functioning ventricle. The Fontan operation has served as a palliation for this anomaly for decades, but the surgery entails multiple complications and survival rate is less than 50% by adulthood [1]. A rapidly testable novel alternative is proposed by creating a magnetically-driven ventricular assist device (MVAD) with no moving parts that can be used to provide assistance to the cardiovascular circulation while reducing the caval pressure. A benchtop Mock Flow Loop (MFL) of the cardiovascular circulation with a Fontan total cavo-pulmonary connection (TCPC) is configured to validate this hypothesis. The MFL is based on a Lumped-Parameter Model (LPM) comprised of upper and lower systemic circulation as well as left and right pulmonary circulation compartments. Needle valves are used to accurately replicate vascular resistance (R) while compliance chambers are used to mimic vascular compliance values (C) [2]. The MFL centerpiece is the truncated aortic arch vascular bed with an implanted MVAD. A ferro-fluid solution is mixed in water to simulate magnetically-charged blood. The pulsating flow is induced by drawing the ferro-fluid from a main reservoir with a Harvard Apparatus *Medical* pump while the MVAD provides assistive momentum to the TCPC. Baseline values are tuned and validated against patient-specific waveforms. Flow and pressure sensor data at specific points in the MFL are acquired via a National Instruments multichannel data acquisition board and processed using LabView. Two prototypes of the MVAD consisting of different wire diameters and wrapping angles are tested to validate the hypothesis and optimize the caval pressure reduction.

REFERENCES

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[2] Vukicevic M, Chiulli JA, Conover T, Pennati G, Hsia TY, Figliola RS. "Mock circulatory system of the Fontan circulation to study respiration effects on venous flow behavior." *ASAIO journal (American Society for Artificial Internal Organs: 1992)* 59.3 (2013): 253