THE HARTWELL FOUNDATION

2020 Individual Biomedical Research Award

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Development of a Geometrically Tunable Blood Shunt for Heart Reconstruction Surgery

More than 40,000 children are born with complex heart defects each year in the United States and one in four will require life-saving invasive surgery within the first year. In the most dangerous and complex form of these heart defects, children are born with only half of their heart properly developed. In contrast to a normal heart with two pumping chambers, these children have only one functional chamber to circulate blood to both the body and lungs. The defect requires immediate intervention by surgical reconfiguration of the blood flow from the heart to allow for proper blood oxygenation by the lungs and blood delivery to the rest of the body. The reconfiguration of the heart circulatory system is accomplished by a course of three staged reconstructive surgeries beginning within days of birth. The two subsequent planned surgeries typically occur around 6 months and three years of age, respectively, to further modify vascular structures around the heart. In the first stage, to establish a new and viable blood flow path through the heart the blood flow from the functioning heart chamber is directed primarily to the body, while a portion is diverted to the lungs for oxygenation by a surgically implanted fixed-diameter tube, called a blood shunt. The shunt makes it possible for blood to be supplied to both the body and lungs from the single pumping chamber of the heart. Balancing blood flow between the body and lungs is extremely challenging however and depends upon the shunt inner diameter: a selected shunt that is too narrow may limit flow to the lungs and damage blood cells, whereas a shunt that is too wide may draw too much blood and limit oxygen delivery to the rest of the body. Problematically, shunts of fixed diameter cannot accommodate for improper initial surgical sizing nor a child's rapid growth, leaving affected children to contend with shunt replacement surgeries and the risk of severe post-surgical complications and mortality. To address this unmet need in heart reconstructive surgery, Chris proposes a novel, geometrically tunable blood shunt that can increase blood flow *on demand*. In his proposed design, the outer surface of the shunt provides mechanical strength needed for suturing to the vasculature and resisting blood pressure, with a thick biocompatible polymer coating affixed to the interior surface of the shunt that can be made to contract when exposed to light, increasing the inner diameter of the tube and therefore, blood flow. Modification of the shunt internal diameter will be achieved by minimally invasive insertion of a light-emitting catheter. A working prototype of a variable-diameter blood shunt will be validated through in vitro experiments and pre-clinical evaluation in animal models. If Chris is successful, a tunable shunt will uniquely enable clinicians to revise blood flow in proportion to the child's growth, mitigating the risks of currently employed fixed-diameter shunts and eliminating the need for repeated revision surgeries in vulnerable young children.