THE HARTWELL FOUNDATION

2007 Individual Biomedical Research Award

Charles A. Cain, Ph.D.

Professor
Department of Biomedical Engineering

University of Michigan

Non-invasive Ultrasonic Tissue Erosion for Congenital Heart Disease Therapy

Incredibly, Dr. Cain intends to pursue “knifeless” surgery of the developing fetal heart while the fetus is still in the uterus, using the controlled application of high intensity ultrasound guided by real-time imaging. He seeks a surgical intervention of ventricular hypoplasia, a severe congenital heart disease characterized by an underdeveloped and dysfunctional ventricle, affecting approximately 1 in 10,000 live births. The disease is due to abnormal heart development during pregnancy, which obstructs blood flow to the fetal left or right ventricle of the heart. Creating a flow channel between the tissue separating the two ventricles can correct the fluid dynamics and today, is only resolved following 3-stage reconstructive heart surgery *after* birth. Unfortunately, because distractive forces caused by blood flow and blood pressure produces the primary stimulus for normal development and growth of the fetal heart while still in the uterus, the prognosis for vibrant long-term health of the child following successful surgery after birth, is poor. Surgically repairing the defect while the fetus is still in the uterus would be preferable, but cutting through the mother’s abdomen and uterus in order to penetrate the fetal skin and heart wall is simply too dangerous. In Cain's innovation (histotripsy), the ultrasound works by forming a cluster of microbubbles only at the treatment focus. The bubbles act as “acoustic mini-scalpels” to fragment cells, erode tissue, and where desirable, create the necessary perforation to enable restoration of blood flow between the heart chambers without bleeding, stitches, or risk of infection. Cain has recently demonstrated some proof of principle in pigs, but extensive work will be required to optimize ultrasound parameters and develop a motion tracking algorithm and strategy to allow the therapy focus to track the movement in the beating fetal heart. If the research is successful, using histotripsy to create channels for blood flow in the fetal heart will effectively redirect heart tissue development, so that ventricular hypoplasia never fully develops and kids otherwise born with this disease will have a chance for a normal life.