Babies born with a single functioning heart ventricle instead of the usual two require a series of surgeries during the first few years of life to redirect their blood flow. The resulting circulation, in which systemic venous blood flows directly into the pulmonary arteries, bypassing the heart, is referred to as the Fontan circulation. Patients with Fontan circulations have excellent early survival; however, over time, their circulations begin to fail, ultimately resulting in their death. Currently, the only treatment for failing Fontan circulation is a heart transplant and due to the relative high risk associated with transplantation in Fontan patients, coupled with the long wait times, many Fontan patients do not survive long enough to receive a donor heart. One of the reasons for this is a lack of understanding of the cascade of Fontan failure. Often patients are only identified as failing when they do not have enough time left to receive a heart transplant. The overall goal of our study is to use mathematical models of Fontan hemodynamics to improve our understanding of Fontan failure and its diagnosis at an earlier time point than current clinical approaches. This would allow for better management of patients on the heart transplant waitlist as well as the potential for the development of early interventions that could halt or reverse the progression of Fontan failure.

Starting at a recent Industrial Problem-Solving Workshop in Toronto Canada, we developed an ordinary differential equation model and a partial differential equation model of the Fontan circulation (Keener et al., SIAP, submitted). These models are so-called lumped parameter models, which uses analogies between fluid mechanics and electric circuits to model the
hemodynamics of the circulatory system. We would like to extend these models to look at changes in the Fontan circulation over time and combine the models with longitudinal clinical data to identify key model parameters in Fontan failure. There is also potential to look at the importance of various organs, such as the lungs, liver, kidneys, or heart, within the model on the overall behavior of the circulation. Participants will be given access to the original models, as well as clinical data from our hospital and sources in literature.