In vitro patient-specific study of the Norwood procedure

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**Introduction**

The Norwood procedure is the first of a sequence of three cardiovascular operations for the surgical treatment of infants born with single ventricle heart defects to covert to the Fontan circulation, a circulation in which the single ventricle supplies blood to both the body and to the lungs. The Norwood is performed within days after birth.

**Goal of the surgery:** Simulate the surgery, Evaluate its effectiveness, Develop therapies.

**Objective:**
- Simulate surgery
- Evaluate effectiveness
- Develop therapies

**Facts:**
- Complicated surgery
- Multiple complications
- Mortality rate of 39% higher mortality rate

**Anatomy:**
- The anatomy of aorta is reconstructed in 3D from the magnetic resonance (MR) data (Fig. 2) and then manufactured by 3D printing using a layer-by-layer technique.
- Each patient has a unique anatomy and test section.

**Methods**

Build lumped parameter network model

A mock circulatory system is built around a lumped parameter model to the circulation and the 3D aortic test section with shunt. Figure 3 shows the lumped parameter (LPN) model of the Norwood circulation. This model is reduced to a more practical lab model (Fig. 5) by using Thermovent elements. System shown in Fig. 6 is the physical realization of reduced LPN model.

**Set-up, Measurements, and Data Analysis**

The system elements are set to patient-specific values. A pediatric ventricular assist device operates as an artificial left ventricle, which pumps blood from the ascending aorta. Pressures and flow rates are measured and recorded in real-time and compared with the predictions of the full LPN model and to clinical measurements for that particular patient.

**Conclusion**

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