Physical bench top experiments are performed to validate and complement ongoing computational fluid dynamics (CFD) studies analyses of ventricular assist device (VAD) circulation. VADs are used in patients whose heart do not function to its maximum potential due advanced stages of heart disease and, consequently, is unable to adequately supply blood to the systemic circulation. VADs are commonly utilized as a bridge-to-transplantation, meaning they are implanted in patients while waiting for a heart transplant. In such cases of long term utilization of VADs, it has been reported in the literatures that thrombo-embolic cerebral events occur in 14-47% of patients over the period of 6 to 12 months. This is a result of thrombus forming despite the use of anticoagulants and advances in VAD design. Accepting current rates of thrombo-embolisms, the main objective of the project is to identify and propose an optimal surgical cannula implantation orientation aimed at reducing the rate of thrombi reaching the carotid and vertebral arteries and thus reduce the morbidity and mortality rate associated with the long term use of VADs to patients suffering from advanced heart failure. 

The main focus of the experiment is on the physical aspect using a synthetic anatomically correct model constructed by rapid prototyping of the human aortic arch and surrounding vessels. Three VAD cannula implantation configurations are studied with and without bypass to the left carotid artery or to the Innominate artery with ligation of the branch vessel at its root. A mixture of water and glycerin serves to match blood viscosity measured with a rotating cone-plate viscometer. The Reynolds number in the ascending aorta is matched in the flow model. A closed loop mock circulatory system is then realized. In order to match the Reynolds number in the ascending aorta and LVAD cannula with that of the CFD model, a volumetric flow rate of 2.7 liters per minute is supplied through the synthetic VAD cannula and 0.9 liter per minute is supplied to the ascending aorta. Flow rates are measured using rotary flow meters and a pressure sensor is used to ensure a mean operating pressure of 100 mmHg is maintained. Synthetic acrylic blood clots are injected at the inlet of the VAD cannula and they are captured and counted at the vertebral and carotid arteries. The sizes of the thrombi simulated are 2, 3.5 and 5 mm which are typical of the range of diameters encountered in practice. Nearly 300 particles are release over 5 separate runs for each diameter, and overall embolization rates as well as individual embolization rates are evaluated along with associated confidence levels. The experimental results show consistency between CFD and experiment. This study provides confidence in the predictive capabilities of the bench-top model as a methodology that can be utilized in upcoming studies utilizing patient-specific aortic bed model.