Weekly Seminar: Fall 2009

Date: December 11

Time: 11:00 AM

Location: Latrobe Hall 107

Speaker: Tiffany Camp (Clemson University), special seminar

Title:*"Evaluation of Fluid Diodes as Pulmonary Heart Valve Replacements"*

Abstract

Children born with congenital heart disease often times suffer from severe chronic pulmonary insufficiency. Palliative treatments for this condition may come early on in the life of the patient; however, if it becomes severe enough, a pulmonary valve replacement may be required. There currently is not a permanent option for a replacements valve. Therefore, a need exists to develop a permanent solution. Knowing that the right heart circulation is more tolerant of moderate levels of regurgitation (0 – 35%) and pressure gradient (0 – 30 mmHg), this study investigates the hypothesis that a fluid diode, a motionless valve that offers low resistance to forward flow and high resistance to reverse flow, could serve as a permanent solution.

The diode valve concept was tested in vitro in a mock pulmonary circulatory system (MPCS). Transvalvular pressure gradient (TVG) and regurgitant fraction (RF%) were used to assess valve performance. The valve was tested *in vitro* over a range of pulmonary vascular resistances (PVR). *In vivo* testing was completed using a swine model. A parametric study was also done to find the effect of changing geometries on the flow regulating capabilities of the valves. Finally, flow field studies were performed using particle image velocimetry (PIV). The flow patterns, viscous shear and Reynolds shear stresses were analyzed, and the potential for platelet activation and thrombus formation was determined.

In the *in vitro* studies, the fluid diode maintained the RF% between 2% and 17% and TVG less than 17 mmHg for PVR values between 1 and 5 mmHg/Lpm. The diode performed acceptably in the animal model as well for PVR between 2.3 and 3mmHg/Lpm and pulmonary vascular compliance (PVC) between 2 to 3 mL/mmHg. The parametric study identified two dimensions that affect the valve performance. The total shear stress level and exposure times were found using the PIV data. A diode valve design was shown to have a cumulative shear stress of 38 dynes-s/cm2 at PVR = 6.3 mmHg/Lpm. This exceeded the threshold reported to trigger platelet activation.

As a whole, the study had showed that the diode valve concept shows promise as a replacement pulmonary valve. The fluid diode is capable of regulating flow to acceptable levels for some ranges of PVR and PVC.