Project 1: Computational investigation of pressure loss from flow energy dissipation: relevance to Fontan-type modifications

The Fontan circulation or one of its many modifications is a common surgical procedure implemented in children with congenital heart defects (such as a uni-ventricular heart) to improve pulmonary circulation. Unfortunately, pressure loss from flow energy dissipation may impair cardiac performance when a heart with a single ventricle must support the circulation. The goal of this study is to develop a simplified model of the Fontan circulation, and use computational fluid dynamics software (ADINA) to model and investigate flows and energetics in this model. Ideally, this study will be relevant to the determination of operative strategies aimed at avoiding pressure losses, thus aiding univentricular heart function by conserving flow energy.

The successful candidate must take BMEN 633 Biofluid Mechanics during the Spring semester. This candidate should be willing to learn the physiological aspects of the Fontan modification, and develop a simplified model for investigation. Next, the student must use ADINA to evaluate this flow system. This project may be suitable as a 5th year MS project.

This is a collaborative project between Professor Gaver (BME) and Professor Robert Ascuitto (TUHSC Pediatric Cardiology). To apply for this position, please submit a statement of interest and resume to Dr. Gaver in the Department of Biomedical Engineering. For information, please contact Professor Gaver (dpg@tulane.edu).

Project 2: Experimental investigation of a viscous stick-slip response during bubble motion in a flexible-walled tube

The motion of a semi-infinite bubble in a flexible tube has long been used to model airway reopening phenomena in the lungs. Clinically, this is a very important problem, because is relates to the opening of collapsed airways that are occluded by the lung's lining fluid. Diseases such as infant respiratory distress syndrome (IRDS) and acute respiratory distress syndrome (ARDS) result in airway closure, and the reopening of these airways can induce significant damage to the epithelial cells that line the airway walls. Both diseases contribute to a significant number of deaths annually.

To date, experiments have investigated the steady-state responses in a flexible-tube model of reopening. Many of these experiments have explored the pressure-driven flow in the systems, and a 'yield pressure' is evident from the results. In contrast, during pulmonary ventilation, a given quantity of air is delivered to the lung (flow-forced) and observations indicate the existence of 'avalanching' behavior wherein multiple segments of airways reopen spontaneously after an initial yield pressure is reached. Recent mathematical models indicate the existence of a 'stick-slip' response that may exist at low flow rates – this prediction may explain the inconsistency between physiological and benchtop experiments. The goal of this project is to examine flow-based reopening phenomena to determine whether the stick-slip instability exists. Please note that though the mathematical description of this phenomenon is complex, the experiments should be relatively simple to complete.

The successful candidate must take BMEN 633 Biofluid Mechanics during the Spring semester. This project will entail the learning of LabView for acquiring the pressure during constant flow reopening experiments, and video analysis techniques for evaluating the unsteady velocity of the traveling meniscus.

To apply for this position, please submit a statement of interest and resume to Dr. Gaver in the Department of Biomedical Engineering. For information, please contact Professor Gaver (dpg@tulane.edu).

Project 3: Analysis of the stress field on a cell layer during pulsatile flow.

Cells that line the vascular system are repeatedly exposed to pulsatile flow, which generates mechanical stresses on the cell surface. These stresses are known to result in mechano-transduction of the cell. Currently, most experimental investigations of these systems assume a stress field that is relevant to steady flow, and ignores the Stokes boundary layers that exist during flow oscillation. This project will explore the unsteady stress fields that exist as a result of oscillating flow using the computational fluid dynamics package ADINA.

The successful candidate must take BMEN 633 Biofluid Mechanics during the Spring semester. The student must learn to use ADINA to evaluate the flow system. Dimensional analysis will be necessary to complete our understanding of the importance of Stokes layers in this flow. This project is a continuation of a very successful senior project completed during the 2002/3 senior project season. This project may be suitable as a 5^{th} year MS project.

To apply for this position, please submit a statement of interest and resume to Dr. Gaver in the Department of Biomedical Engineering. For information, please contact Professor Gaver (dpg@tulane.edu).