Weekly Seminar: Fall 2010

Date: Friday October 1

Time: 11:00 AM

Location: Maryland Hall 110

Speaker: Pavlos Vlachos (Virginia Tech.)

Title: *"Hydrodynamics of left-ventricular filling and diastolic dysfunction"*

Abstract

Cardiovascular disease (CVD) is the number one killer in the US and worldwide and over 70 million Americans suffer from various forms of CVD with an overall cost of health care exceeding 430 billion USD. The increasing age of our population, the obesity and diabetes epidemics and the increased survival of patients undergoing therapies that lead to heart disease further magnify this serious health problem. Thus, there is a critical need to understand the fundamentals of cardiovascular flows in order to better diagnose, monitor, and treat cardiovascular disease. Here we will discuss the fluid dynamics involved in the left ventricle filling and diastolic dysfunction. We also use this opportunity to discuss enabling developments and advancements in experimental fluid mechanics that were needed for this work. Heart diastolic dysfunction is characterized by the impaired filling efficiency of the left ventricle. However, heart compensatory mechanisms and remodeling make diagnosis difficult as well as introduce great challenges that hinder experimental or computational modeling of the associated physics in-vitro. Here, we present results from an investigation of the flow physics of left ventricle filling using primarily clinical measurements. Color M-mode Echocardiography (CMM) and phase-contrast Magnetic Resonance Imaging (pcMRI) Velocimetry are used to characterize in-vivo the velocity fields in healthy and diseased hearts. The diastolic dysfunction appears to be governed by an initial rapid filling wave that is abruptly disrupted due to a reduction of the mitral-to-apical pressure gradient. Based on simple physical principles an automated algorithm and a new diagnostic parameter were developed and validated against traditional clinical diagnostics and were shown to perform with higher fidelity and robustness. Using simple benchtop particle image velocimetry (DPIV) experiments in combination with the clinical data, an explanation for the relationship between the E-wave deceleration, the development of the adverse pressure gradient and the formation of vortices in the LV is proposed.