

CURRENT RESEARCH SUMMARY

My research effort has been nearly equally divided between vortex dynamics and vascular biofluid mechanics. It is primarily experimental, with some numerical components carried out in collaboration with colleagues.

Wake Vortex Alleviation

The vortex wake, wake turbulence, has a great potential impacting commercial air transport, both from capacity and safety perspectives. We have developed a passive mechanism to alleviate the hazard posed by the vortex wake. The mechanism exploits the asymmetry in the instability of a pair of unequal strength counter rotating vortices. Current studies employ PIV, FV and CFD to investigate the application of the mechanism to particular aircraft geometries. (Prof. Marcus. NASA Ames)

Rotorcraft Vortex Wake

A rotorcraft model is being studied in a towing tank. Simultaneous flow visualization and thrust measurements indicate that as vortex filament instabilities develop, adjacent filaments merge and form thick vortex rings during descent. Periodic shedding of these rings from the wake associated with vortex ring state (VRS) is observed, resulting in nearly periodic extreme peak-to-peak thrust fluctuations. Currently, PIV measurements are underway in the towing tank. (NASA Ames)

Vortex Shielding

Swirling hollow liquid vortices (vortex jacket) are proposed in fusion chambers to protect their first walls and critical elements from the harmful conditions resulting from fusion reactions. In this study, an annular wall jet, or vortex tube, is proposed for shielding and is generated by injecting liquid tangent to the inner surface of the tube both azimuthally and axially. Extensive 2-D stereographic particle image velocimetry (PIV) measurements have just been finished. (In collaboration with Prof. Peterson of NE)

Atherosclerotic Carotid Bifurcation

Flow studies are conducted in two carotid bifurcation flow phantoms, replicating the lumen of the plaque excised from patients. The flow details vary chaotically. Peak wall shear stress (WSS) values are found at the stenotic neck and jet attachment location during peak systole, suggesting endothelial cell erosion, platelet activation, and apoptosis. Minimum WSS values are seen at the recirculation zones downstream of the stenosis, suggesting atherogenesis. (NIH)

Device Design

Interventional devices are now used extensively in the treatment of a wide array of vascular disease. The use of such devices is in a period of rapid growth, and areas of application continue to expand as new devices are devised. In a collaborative effort between clinicians, imaging scientists, and fluid dynamists, we have just started on program to pursue the evaluation of these devices. The goal is to evaluate stent-graft devices for the treatment of abdominal aortic aneurysms. (NIH-UCSF)

SMP Devices

Laser activated shape memory polymers (SMP) are being considered for possible treatment of cardiovascular diseases. We are studying the vascular dynamics of SMP devices for treating aneurysms and aortic diseases. Fluid flow and thermal characteristics of untreated and treated aneurysm models are studied to evaluate the effectiveness of the SMP foams in preparation for animal testing at UCSF. This is a collaborative effort among UCB, UCD, UCSF, and LLNL.

Artificial Blood

Hemoglobin-based oxygen carriers have been studied as a possible temporary blood replacement. We are studying diffusion processes due to blood or hemoglobin flow in small vessels. The goal is to assess chemical and physical parameters needed to design a blood substitute that will deliver oxygen at similar rates to whole blood. (In collaboration with Prof. A. Szeri, with support from Sangart Inc. of San Diego)