Biomedical Engineering

Lecture Series Seminar

Numerical modeling approaches for optimizing cardiovascular devices and for enhancing cardiovascular disease diagnostics

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Numerical simulations combined with either experimental techniques or clinical visualizing modalities can be effectively used to facilitate the optimization of cardiovascular devices or to augment medical diagnostics.

Recipients of most prosthetic cardiovascular devices require mandatory anticoagulation to mitigate the risk of cardioembolic stroke. Optimization of these devices may facilitate reducing their thrombogenic potential to a level that minimizes or even eliminates the need for complex anticoagulation therapy. The use of a Device Thrombogenicity Emulator (DTE) methodology, which introduces cutting edge numerical simulations interfaced to an experimental system to measure platelet activation induced by blood flow in cardiovascular devices using an innovative platelet activity state (PAS) assay, will be presented. Its application for optimizing the thrombogenic performance of devices (prosthetic heart valves, ventricular assist devices, and the total artificial heart- TAH) will be demonstrated and discussed. Aspects of numerical simulations, including transient non-Newtonian turbulent blood flow simulations (URANS), Direct Numerical Simulations (DNS), and discrete particles dynamics (DPD) multiscale modeling approach, will be presented.

Additionally, the use of Fluid Structure Interaction (FSI) modeling will be presented for the prediction of the risk of rupture in abdominal aortic aneurysms (AAA) and in vulnerable plaques (VP), based on patient specific geometry reconstructions obtained with CT scans and intravascular ultrasound (IVUS). It demonstrates how the diagnostics of cardiovascular pathologies can be enhanced by the combination of advanced numerical simulations with clinical visualizing modalities.