

A next-generation mathematical model for drug-eluting stent

Yifan Wang

University of California Irvine

Nov 4, 2021

Abstract

We propose a novel Navier-Stokes-Biot fluid-structure interaction (FSI) model to study the interaction between an incompressible, viscous Newtonian fluid and a poroelastic artery treated with a drug-eluting stent. The artery wall's permeability depends on the volumetric change of its pore size. The FSI model is coupled to a set of advection-reaction-diffusion equations defined on moving domains to study the interaction between the blood flow, a stented coronary artery, and time-dependent pharmacokinetics of drug absorption. A monolithic approach is used to solve the proposed problem numerically. Nitsche's method is employed to enforce one of the coupling conditions at the moving poroelastic structure interface. Stability analysis is presented, providing conditions on the Nitsche's penalty parameter under which the scheme is unconditionally stable. Using 3D simulations, five commercially available coronary stents were considered with two different pharmacokinetics to show how stent geometry and the type of coating impact the biomechanical environment, the local hemodynamics, and the concentration of the pharmacological agents within the vascular wall and artery lumen. It is found that stent implantation changes the permeability properties of the arterial wall and local hemodynamics, which may be responsible for the so-called edge effect, i.e., sub-optimal reduction in restenosis rates near the edges of drug-eluting stents. This is a joint work with Sunčica Čanić, Martina Bukać, Josip Tambača, and David Paniagua.