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The treatment of pathologies, biotransport, and fluid–structure interaction problems in biomechanics

Seungik Baek[1] · **Mohan Anand**[2]

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Development of patient-specific modeling has emerged as the key driver of medical research during the past decade. Design of many medical devices and prediction of disease progression require biomechanical assessment as to their suitability for a patient, given specific data such as age and anatomical images. For instance, medical devices and surgical procedures include ventricular assist devices and balloon angioplasty in the cardiovascular system, and presbyopia for cataract treatments in the ocular system. While components of the human body influence bidirectional interactions between tissue and blood and between solid constituents and interstitial flow, these problems are still modeled separately by solid, blood, and interstitial fluid, in which those interactions can be neglected: such biological systems will be analyzed by both solid and fluid biomechanics communities. In this special issue, we highlight advanced articles that were presented on the above problems from either a solid mechanics perspective or from a fluid mechanics perspective, and also those which account for the interaction between solid and fluid.

We begin with a review of transcatheter aortic valve implantations (TAVIs) from Vy et al., which is a promising new procedure for aortic valve replacement. Patient-specific simulations are few and far between, and this article summarizes from causes, the standard treatment to TAVIs as a recent alternative and the challenges involved for interested readers. We continue the series on solid mechanics with an article from Wilkes and Reilly on a pre-tensioned finite element model that takes account of patient-specific factors such as age and geometrical parameters on decreased ability of ocular accommodation in presbyopia. Perspective to arterial adaptation, constrained mixture approach is becoming popular but most studies are based on hyperelastic models. Mythravaruni and Ravindran have presented a constrained mixture model that describes growth and remodeling of soft tissues in response to an external torsion, which simultaneously attributes stress-mediated remodeling and viscoelastic response.

Progression of atherosclerosis is related to fluid mechanics and local variables like wall shear stress, and direction changes of flow. The special issue presents two articles which are devoted to a medical problem that is leading to high mortality in the modern world. Gharahi et al. presents a CFD study of flow in real-life geometries of the carotid artery bifurcation reconstructed from MRI images. Nandakumar and Anand have presented a CFD study of blood flow in a multiple stenosed rigid-walled channel so as to document the effect of multiple stenosis on wall shear stress. Finally, an energy-based computational analysis by Zakerzadeh et al. estimates both elastic and dissipative parts during fluid–structure interaction which occurs during blood flow in arteries.

We hope the readers will find these articles informative, and of high quality in advanced mathematical and nonlinear problems in soft tissue, biofluid and biotransport biomechanics. We also thank all the reviewers who provided constructive critiques and suggestions, contributing to this special issue.

✉ Seungik Baek
sbaek@egr.msu.edu

[1] Michigan State University, East Lansing, MI, USA

[2] IIT Hyderabad, Sangareddy, Telangana 502285, India