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Coupled Models for Soft Biological Tissue Disorders

This Special Issue contains a collection of 14 original research articles and 4 review articles on ''Coupled Models for Soft Biological Tissue Disorders''. Several physiological and pathological processes encountered in micro-heterogeneous soft biological tissues are based on phenomena driven by different mechanisms such as mechanical and biological, but also others such as chemical, electrical and thermal mechanisms. Hence, coupled models have the potential to better predict and understand such processes, and to analyze long-term effects that may be greatly influenced by changes in, for example, the mechanical, biological or chemical environment associated with tissue disorders. In addition, physiological and pathological processes span multiple scales in length, time and energy and depend on knowing how proteins or cells behave in isolation and in their interaction with surrounding tissues to generate function at a higher level.

Computational methods offer the potential to simulate multi-scale and coupled processes, and to realistically predict (patho)physiological functional interactions. For example, an appropriately developed finite element model may provide information that would otherwise be difficult to obtain from experiments, and would increase our ability to address coupled problems of academic, industrial, and clinical importance. In the last two decades computational methods have significantly advanced our knowledge of the development of aneurysms, atherosclerosis, fracture and wound healing, and of medical device implantations and their prognosis. Clinical applications of powerful coupled models when combined with computational methods may lead to improved diagnostics and treatment of tissue disorders, surgical planning and intervention. Also to optimized cell culture conditions in tissue engineering (for example, density and spatial distribution of cells), improved scaffold properties (for example, permeability, internal geometry), and better medical devices.

More than half of the papers in this Special Issue deal with coupled models which relate to the cardiovascular system, in particular to arteries and the heart. The first 9 papers deal with the artery; starting with a review article on bio-chemo-mechanical models of vascular mechanics, two papers focus on aneurysmatic walls, a further three papers deal with plaque formation and development, angiogenesis and vascular growth and remodeling in a subject-specific geometry, followed by a study of catheter induced alterations in pulse wave velocity in anesthetized mice and two studies on LDL transport within an artery. Then there are three papers related to the heart, in particular to atrial fibrillation, calcium and arrhythmogenesis and to coupled simulation of heart valves. The next paper deals with a model for cortical folding considering microscopic axonal growth. Two papers on the modeling of wound healing in soft biological tissues and on the coupled cell proliferation and regulation in tissues lead to one paper which deals with the computational modeling of tumor initiation. The next paper investigates the effects of supercoiling on the mechanical and permeability properties of collagen IV networks which are essential for the maintenance and regulation of blood filtration in the kidneys. The final contribution listed uses a quadri-phasic mixture model to estimate the diffusion coefficient of sodium and chloride. In this collection of articles several modeling approaches are employed including computational modeling.

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We, as Guest Editors, hope that this Special Issue will be informative and stimulating, and will serve as a basis for the field to advance the modeling of complex coupled processes. Finally, we would like to thank all the reviewers who contributed to the overall quality of this issue, and Professor Kyriacos A. Athanasiou for giving us the opportunity to compile this Special Issue.

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