MULTISCALE AND INTEGRATIVE MODELING

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1. Introduction

Computational biofluid dynamics has undergone a tremendous evolution in the last ten years. Thanks to increasing computational resources and novel and sophisticated software tools, fluid dynamic problems, which wee hard to be undertaken ten years ago, are now easily addressed. Indeed, simulations involving millions of unknowns can now be run on desktop computers. As happens in these cases, borders are then moved farther and research explores new applications. Accordingly, in the last years the research interest has focused on new topics involving multiscale problems, multiphysics problems, and, more generally, problems wherein data from multiple different sources are integrated into the biofluid-dynamic framework (also indicated as hetherogeneous integrative modeling).
In March 2010, the Annals of Biomedical Engineering journal has published the position papers of the sixth international bio-fluid mechanics symposium and workshop held in 2008 at Caltech. These papers can be considered a reference viewpoint and describe efficaciously the emerging scenario. In particular, as written by Maria Siebes and Yiannis Ventikos (2010), "the need for comprehensive, integrative models is gaining recognition. The terms ''multiscale'' and ''multiphysics'' are adequately descriptive of the direction this effort is taking". In this context, an important contribution is provided by advances in imaging techniques; indeed, "continued progress in imaging helps reveal mechanisms and provides diagnostic possibilities that have not been available before".
What described has to be framed in the context of personalized healthcare, a paradigm based on the detailed comprehension of the patho-physiology of the tissue and/or organ under examination, with the aim of attaining a more efficacious treatment of the patient disease. Personalized healthcare requires realistic modeling tools able to tackle and couple disparate length and timescales often extending from the investigation of molecular interactions, characterized by nanometers lengths and femtosecond timescales, to the clinical observation of the pathology manifestation and evolution, which often involves regions of interest of the order of centimeters and timescales ranging from milliseconds to weeks. A realistic description of the disease also implies the ability to describe all the relevant physics involved, such as chemical interactions and reactions, within the fluid and between the fluid and the wall, electrical phenomena involved in muscular contraction onset, and wall fluid interaction phenomena. All these factors may be strictly interlaced and concur in the determination of the disease expression and progress.