MODELING CARDIAC FUNCTION AND DYSFUNCTION

NATALIA A. TRAYANOVA

Abstract. Simulating cardiac electrophysiological function is one of the most striking examples of a successful integrative multi-scale modeling approach applied to a living system directly relevant to human disease. Today, after nearly fifty years of research in the field and the rapid progress of high-performance computing, we stand at the threshold of a new era: anatomically-detailed tomographically-reconstructed models that integrate from the ion channel to the electrophysiological interactions in the intact heart are being developed. This presentation discusses how such models hold high promise for interpretation of clinical and physiological measurements in terms of cellular mechanisms; for improving the basic understanding of the mechanisms of dysfunction in disease conditions, such as reentrant arrhythmias, myocardial ischemia, and heart failure; and for the development and performance optimization of medical devices. Specific examples of the state-of-the-art in cardiac integrative modeling are presented, including 1) improving ventricular ablation procedure by using MRI reconstructed heart geometry and structure to investigate the reentrant circuits formed in the presence of an infarct scar; 2) developing a new out-of-the box high-frequency defibrillation methodology; and 3) understanding the contributions of non-myocytes to cardiac function and dysfunction.

Keywords: model of the heart, reaction-diffusion equations, image-based model.

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Johns Hopkins University
E-mail address: ntrayanova@jhu.edu