11th World Congress on Computational Mechanics (WCCM XI)
5th European Conference on Computational Mechanics (ECCM V)
6th European Conference on Computational Fluid Dynamics (ECFD VI)
July 20 - 25, 2014, Barcelona, Spain

ELECTROMECHANICAL CARDIAC ARRHYTHMIAS: EXPERIMENTS, THEORY AND SIMULATIONS

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Key Words: *Theoretical electromechanics, Cardiac Arrhythmias, Numerical simulations*

Cardiac arrhythmias are well known to support auto-sustained electrical rotors (spiral waves) leading to very dangerous life threatening behaviors [1] and large gradients of repolarization represent the main substrate for arrhythmias onset and development. Though recent efforts both from the experimental and theoretical points of view [2], several unknowns remain about the nonlinear dynamics emerging from the multiphysical coupling between electrophysiology and elasticity. Based on experimental evidences of ventricular electrical activations [3], we discuss arrhythmogenic spatiotemporal dynamics with particular reference to cardiac alternans and fibrillation. We characterize epicardial and endocardial layers in terms of electromechanical activation maps highlighting significant differences within the ventricular wall and indicating the underlying predisposition to chaos [4]. We formalize a general theoretical framework for electro-elastic active media specializing the approach to a fine tuned phenomenological model of action potential generation and propagation [5,6]. We consider a hyperelastic fiber-reinforced material model accounting for tissue rotational anisotropy both at the electrical and mechanical levels. We analyze the effects of different boundary conditions and of the mechano-electric feedback (MEF). The numerical model proposed will help understanding the role of electrophysiology and mechanics for soft active media as well as to guide the design of new drugs and devices controlling and preventing arrhythmic events.

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