EFFECTS OF MECHANO-ELECTRIC FEEDBACKS ON THE CARDIAC BIOELECTRICAL ACTIVITY: A SIMULATION STUDY

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Abstract. The aim of this study is to investigate by means of numerical simulations the effects of myocardial deformation due to muscle contraction on the bioelectrical activity of the cardiac tissue. The three-dimensional electro-mechanical model considered consists of the following four components: the quasi-static anisotropic finite elasticity equations for the deformation of the cardiac tissue; the active tension model for the intracellular calcium dynamics and cross-bridge binding; the anisotropic Bidomain model [1] for the electrical current flow through the tissue; the membrane model of ventricular myocytes, including stretch-activated channels. In order to take properly into account the mechano-electric feedbacks (MEFs), the electrical current flow is described by the Bidomain model on the deformed tissue. We derive a novel formulation of the Bidomain model in the reference configuration, where MEFs appear not only in the conductivity tensors but also in a convective term depending on the deformation rate. The numerical simulations are based on our finite element parallel solver, which employs Multilevel Additive Schwarz preconditioners [2] for the solution of linear systems arising from the discretization of the Bidomain equations and Newton-Krylov-Algebraic Multigrid methods for the solution of the non-linear systems arising from the discretization of the finite elasticity equations.

Keywords: cardiac electro-mechanical coupling, anisotropic Bidomain model, finite elasticity, Additive Schwarz preconditioners, Newton-Krylov solvers

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