Automatic Generation of Bi-ventricular Models of Cardiac Electrophysiology for Patient Specific Personalization using Non-invasive Recordings

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Introduction: Personalized *in silico* models of cardiac EP based on non-invasive recordings, such as the MRI, body surface potential maps (BSPM) or 12 lead ECG, are considered of pivotal importance in clinical modeling applications. Efficient, automated workflows compatible with clinical time scales are desired to rapidly construct adaptive models and steer spatially dependent simulation inputs without operator intervention.
Objective: We aimed to develop an automated workflow for image-based generation of bi-ventricular (BV) cardiac EP and torso models capable of rapidly simulating body surface potential maps (BSPM) independent of user interaction.
Methods: A conforming torso and four-chamber heart segmentation was generated from clinical MRI scans using semi-automated approaches. A tetrahedral finite-element mesh was generated at 1 mm resolution automatically. A BV mesh was extracted and the torso coarsened. Universal ventricular coordinates (UVC) were computed to incorporate a rule-based fiber architecture, define anatomical regions used to control heterogeneities as well as navigation and sizing of stimulation sites of earliest activation on the endocardium. Timing of the sites and conduction velocity in the myocardium were also parameterized. Extracellular epicardial potential distribution was recovered from a reaction-eikonal model using a pseudo-bidomain approach and projected with a boundary element method for BSPM reconstruction.
Results: Meshing of the conforming torso and heart lasted approximately 2 hours. The subsequent construction of the model architecture and torso for simulation lasted approximately 11 minutes. Simulation of a single BSPM depolarization was possible from the created model.
Discussion: Efficient generation of adaptable and personalized cardiac EP models is a key ingredient in any clinical model utilization. The workflow integrated recently-developed technologies to fully automate model generation and modification of input parameters. As the cardiac EP model is therefore functionalized with respect to input parameters, parameterization workflows based on stochastic sampling or learning techniques can be used for personalization.