Biomed Tech 2012; 57 (Suppl. 1) © 2012 by Walter de Gruyter · Berlin · Boston. DOI 10.1515/bmt-2012-4341

Simulating extracellular microelectrode recordings on cardiac tissue preparations in a bidomain model

M. W. Keller, G. Seemann, O. Dössel, Institute of Biomedical Engineering, Karlsruhe Institute of Technology, Karlsruhe, Germany, publications@ibt.kit.edu

Introduction

Microelectrode recordings are the gold standard to experimentally investigate electrical activity in cardiac tissue preparations. To analyze extracellular signals in-silico, monodomain simulations of intracellular space and subsequent forward calculations of extracellular potential are usually conducted. A major drawback of this method is that the simulated cardiac cells are not coupled to the extracellular space and therefore are not influenced by surrounding conductivities. In order to receive a more realistic model of interdependencies at the electrode tissue interface, bidomain simulations including realistic values of metal and tissue conductivity were performed.

Methods

The cubic voxel based 3D simulation setup included a layer of cardiac tissue surrounded by blood (σ= 0.7 S/m). A microelectrode was placed in the center of the tissue patch. Except for the distal part the surface of the microelectrode was electrically insulated against the blood. Extracellular conductivity of cardiac tissue was set to 0.199 S/m and intracellular conductivity was adjusted to 0.5 S/m in order to match a conduction velocity of 0.7 m/s. Finite element bidomain simulations were performed using the Courtemanche et al. model for atrial cells. Extracellular and electrode potentials were evaluated with a temporal resolution of 0.1 ms. Unipolar electrograms were calculated as difference between electrode potential and four ground electrodes located in the blood.

Results

Simulated extracellular potentials had a biphasic morphology and a maximum amplitude of 5 mV. Electrical interaction between the electrode and cardiac cells could be identified by decreased action potential amplitudes in tissue near the electrode tip and a bent curvature of the excitation front.

Conclusion

The biphasic morphology of the simulated signals matched the shape of real signals reported in literature. Parameters as intra- and extracellular potentials and currents are hardly accessible during experiments. Using the simulation, these parameters can be recorded and analyzed to extract further information.