Estimating the Influence of Cardiac Motion on Simulations of Electrical Excitation

Stefan Fruhner*, Harald Engel and Markus Bär

Fak. II - Institut für Theoretische Physik, EW 7-1, Technische Universität Berlin, Berlin, Germany

In simulations realistic heart models often include detailed physiological knowledge about ionic dynamics of cardiac cells and accurately account for anatomical details like fibre orientation or heterogeneity of heart tissue. Additionally describing the feedback between propagating waves of electrical activity and cardiac contraction might be essential for a deeper understanding of the mechanism of cardiac arrhythmias like tachycardia and fibrillation.

Using time resolved magneto-resonance images two-dimensional finite-element meshes have been generated in order to perform simulations of waves of electrical activity propagating in a beating human heart. Therefore, the intracellular and extracellular domain are treated separately. This approach is commonly known as bidomain approach. Cardiac motion is extracted from the images by following a set of control points visualised using a tagged MRI protocol.

Different ionic cellular models have been applied to analyse the differences between a static and a moving heart. To characterize these differences in simulations the activation times of the excitation have been computed. These are given as the time difference between initial stimulation and the first activation of some region. For the moving heart, in some regions activation times up to 20 ms smaller than in the static case have been obtained. At the same time other regions became activated 25 ms later. The impact of cardiac motion can also be demonstrated in artificially generated biosignals like the electrocardiogram (ECG).

The approach also offers the opportunity to calculate the mechanical stresses during cardiac contraction from experimental data without using detailed models on calcium dynamics and stress-activated channels in cardiac myocytes.