Electromechanical Coupling in Cardiomyocytes Depends on Its Electrotonic Interaction With Fibroblasts. Simulation Study

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Cardiac fibroblasts are interspersed within mammalian cardiac tissue. Being mechanically passive fibroblasts have own changeable membrane potential. They communicate electrically with cardiomyocytes via gap junctions and thus may affect electrical and mechanical activity of the latter. This influence may be analyzed in mathematical models. Mathematical models for the interaction of fibroblasts with cardiomyocytes developed earlier allowed anyone to study only electrical responses of both cardiomyocytes and fibroblasts to their electrical interaction. In this work, we simulated the fibroblast effects on the cardiomyocyte mechanics during afterloaded contractions.

For the modelling of the fibroblast-cardiomyocyte electrical interaction we used the MacCannell2007. We have earlier developed the TP+M model, which combines ten Tusscher-Panfilov (TP) model with the module of the cardiomyocyte mechanical activity from the Ekaterinburg-Oxford electromechanical model. The TP+M model reveals electromechanical coupling and mechano-electric feedbacks in the cardiomyocytes. We substitute the original TP model with the TP+M one in the MacCannell2007 model find out. The number of identical fibroblasts coupled to the single cardiomyocyte was varied in numerical experiments from 1 to 5. Isometric and isotonic modes of the cardiomyocyte contraction were simulated.

We obtained significant changes in cardiomyocyte action potential duration, isometric force and load-dependent relaxation with an increase in the number of fibroblasts connected with the cardiomyocyte. We showed that the bigger the number of fibroblasts electrically coupled to the cardiomyocyte, the lower its mechanical activity. We also considered in the model effects of the fibroblasts on the mechano-electric feedbacks in the cardiomyocyte.