INFLUENCE OF THERMOELECTRIC COUPLING ON ECTOPIC BEATS GENERATED BY MECHANO-ELECTRIC FEEDBACK IN A ONE-DIMENSIONAL CARDIAC FIBER MODEL

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Abstract

The influence of thermal processes on electrophysiology has clearly been underlined by Bini et al. [2], using a FitzHugh–Nagumo-type (FHN-type) model. When the temperature is raised, the action potential duration (APD) has been shown to shorten, while the action potential (AP) amplitude decreases, and the conduction velocity increases [2]. In this research, we investigate the effects of thermoelectric coupling on mechano-electric feedback (MEF), and more specifically, on ectopic beats generated by MEF. To investigate these effects, thermoelectric coupling is introduced in a one-dimensional electromechanical model of a cardiac fiber, which considers excitation-contraction coupling (ECC), as well as MEF.

Keyword: biomechanics

1 Introduction

Ectopic beats are common in cardiac tissue, and under certain conditions can cause significant changes in cardiac tissue properties such as the action potential duration and refractory period duration of cardiomyocytes. On occasion, changes to these properties can induce cardiac arrhythmias such as tachycardia, generated by functional re-entry. The next two sections describe the strategy adopted to examine the effects of thermal processes on ectopic beats generated by MEF.

2 Electromechanical model

Our starting point is a simple model that includes all the key ingredients required to investigate the qualitative electromechanical behavior of cardiac tissue such as ectopic beats induced by mechanical deformation [1,3]. In this model, electrical activation is described by a two-variable FHN-type model. Active tension, generated by electrical activation, is directly coupled to the transmembrane potential to account for the basic delay between the initial fast inward currents and the final actin-myosin contraction [1]. The mechanical behavior of cardiac tissue is modeled by the non-linear stress equilibrium equations governing large deformations. In addition, a Mooney-Rivlin model is chosen to describe the passive mechanical behavior of cardiac tissue. ECC is given by linearly superimposing active stress components, which depend on the active tension computed in the cell model, to the passive ones [1,3]. The influence of contraction on excitation, namely the MEF, is provided by including stretch-activated currents in the well-known monodomain equation [1,3].

3 Influence of thermoelectric coupling

In the present study, we add the approach of thermoelectric coupling proposed by Bini et al. [2] to the electromechanical model previously described. This allows us to qualitatively address the question of the role of thermal processes on ectopic beats generated by MEF.

4 Conclusion

In conclusion, our numerical simulations have suggested that the influence of thermal processes on electrophysiology should be taken into account in further modeling works in order to obtain more realistic behavior of cardiac tissue.

References

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