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. In this study, we examine the effects of thermal processes on ectopic beats generated by mechano-electric feedback (MEF).

Influence of thermoelectric coupling on ectopic beats generated by mechano-electric feedback (MEF) in a one-dimensional cardiac fiber model

Model

\[
\frac{\partial V}{\partial t} = \frac{\partial}{\partial X^M} \left( \sqrt{C^{MN}} \frac{\partial V}{\partial X^N} \right) + \eta(T) \left[ f(V, w) - I_s \right]
\]

\[
f(V, w) = V(a - V)(V - 1) - w
\]

\[
I_s = g(V - 1) \sqrt{C - 1} H(C - 1)
\]

\[
\frac{\partial w}{\partial t} = \varepsilon_{p}(T)(kV - w)
\]

\[
\frac{\partial T_a}{\partial t} = \varepsilon_{s}(V - T_a)
\]

\[
\frac{\partial}{\partial X^M} \left( S^{MN} \frac{\partial X^i}{\partial X^N} \right) = 0
\]

\[
S^{MN} = S_{p}^{MN} (C^{MN}) + S_{a}^{MN} (C^{MN}, T_a)
\]

- MEF via stretch-activated currents \( I_s \)
- Excitation-contraction coupling by linearly superimposing active stress components \( S_{p}^{MN} \) to the passive ones \( S_{p}^{MN} \)
- Thermoelectric coupling via temperature-dependent functions introduced in the electrophysiology model

Results

Increasing temperature

1. Period between 2 ectopic beats decreases when the temperature is raised (Fig.1 and Fig.2)
2. Ectopic beats are not generated anymore when the temperature exceeds a critical value (Fig.3)

Conclusions

Numerical simulations highlight the influence of thermoelectric coupling on MEF. This influence is significant for ectopic beats generated by MEF. The influence of thermal processes on electrophysiology should be taken into account in further modeling works.

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