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The Role of Computational Methods in Understanding Cardiac Electrogram Genesis on a Cell-by-Cell Scale

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Cardiac muscle contraction is determined by excitation waves propagating in the heart tissue. If healthy, the excitation is rhythmic and driven by the sinoatrial node. Pathologically altered cardiac tissue, e.g. due to ageing, has different electrophysiological properties that may support unwanted arrhythmic wave propagation. In vivo, the cardiac substrate can be characterised using mapping catheters measuring electrograms (EGMs) and sources of potentially abnormal excitation spread can be identified. With computational models, detailed inferences about the mechanisms behind excitation propagation can be made. While studies on EGM genesis in homogenised models, averaging over several hundreds of cardiac cells, exist, microstructural cardiac excitation dynamics and their impact on EGMs has not been studied as thoroughly yet. This study exploits the Extracellular-Membrane-Intracellular (EMI) [1] model to reproduce cardiac excitation dynamics on a cell-by-cell level to investigate EGM genesis.

Excitation travels faster along the longitudinal direction, which corresponds to the preferential largest extension of the myocytes than in transversal direction. We study both propagation types and calculate EGMs from them to analyse differences between them and how they compare to homogenised model simulations as well as clinically measured EGMs. EGMs are biphasic in healthy tissue, where the extrema correspond to the approaching and departing wave, respectively, which is well reproduced in homogenised models. Here, the rather sinuous path the excitation wave has to undergo microscopically in the intertwined myocyte alignment translates into (micro-)fractionations in the EGMs. This pilot study exploits numerical and computational methods to form a basis for a better understanding of EGM genesis in cardiac tissue as in e.g. [2] in 2D.

REFERENCES

- [1] A. Tveito *et al.*, *Modeling Excitable Tissue: The EMI Framework*, ser. Simula Springer Briefs on Computing. Springer International Publishing, 2020.
- [2] K. H. Jæger *et al.*, “From millimeters to micrometers; re-introducing myocytes in models of cardiac electrophysiology,” *Frontiers in Physiology*, vol. **12**, p. 763584, 2021.