Effects of Long- and Short-term Memory on Action Potential Duration for Atrial Cellular Automata

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Biophysical atrial simulation can improve therapies by simulating different ablative and pharmacological strategies, although their use in clinical practice is limited by their high computational cost. Simpler cardiac automata can achieve acceptable timeframes, calculating the action potential duration (APD) from the previous diastolic interval (DI), although it is necessary to question whether this approach is sufficient for short- and long-term simulations.

Biophysical simulations (Elvira software) were carried out on a rectangular atrial tissue (0.3×20×0.025 cm, 2106 cells, A) using the Coutermanche model. Eleven long-term S1-S2 pacing protocols with 45 sets of 15×S1+S2 activations were simulated, with both increasing and decreasing S2 (100ms to 1000ms in 20ms steps, B) and S1 intervals (300ms to 700ms in 40ms steps). APD at 90% of the amplitude at current (APD^{+1}) and previous (APD^{0}) activation, and DI as time from 90% amplitude to next repolarization, were measured.

Analysis of 7920 simulated activations showed an expected increase of the APD^{+1} with the previous DI interval (C). Influence of short-term memory at long-term simulations was showed as the dependency of APD^{+1} with the previous AP duration (APD^{0}): shorter APD^{0} provoked shorter APD^{+1} (C), and this effect was comparable to the effect on APD^{+1} of previous DI. Prediction of APD^{+1} can be improved when both APD^{0} and DI are used (error of 10±14 ms, D), compared to using DI alone (23±21 ms, $p<<0.001$, D).

Atrial automata should consider short term memory, as duration of previous activations, to accurately estimate posterior APD in long-term simulations, in order to mimic the natural electrophysiological response.