Modeling the Onset of Cardiac Instability using Probabilistic Cellular Automata

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Abstract

 Probabilistic Cellular Automata (PCA) are mathematical models that represent spatially discrete systems as two-dimensional grids of neighboring lattice nodes. We used a PCA with nearest-neighbor interactions to simulate calcium release inside cardiac myocytes to model cardiac instability, a precursor to heart attacks. The states of the nodes are either “on” or “off” according to rules that incorporate randomness. The number of “on” states represents the overall activation of the system, and oscillations in this value indicate instability. The amplitude of these oscillations was studied as a function of the strength of nearest neighbor interactions. For small lattice size, there was a steady, gradual increase in amplitude as interaction strength grew. For large lattice size, the amplitude increase was sudden and sharp. Similar patterns were observed with changes in aspect ratio of the lattice. The results suggest that as the lattice became larger and less oblong, a critical value threshold for onset of oscillations became defined. These simulations helped us understand the dynamics of cardiac myocytes under actual conditions of biological variability and can lead to new hypotheses for future trials.