Induction of Action Potential Propagation in Completely Isolated Viable Tissue Embedded in a Myocardial Infarct Through the Mechanism of Action Potential Tunneling

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Engraftment of viable, electrically functional cells into a myocardial infarct as a method for restoring functionality is currently a topic of active research interest. Cells implanted in this way can form gap junction connectivity with each other, but often do not connect well with the surrounding tissue outside the infarct. [1] We have conducted a computer simulation study using a bidomain model of cardiac electrophysiological dynamics to study an idealized version of this situation. Specifically, we find that a circularly-shaped region of excitability representing the engrafted cells can be depolarized and can support action potential propagation even when the region has absolutely no gap junction connectivity with the surrounding region. This is possible through "action potential tunneling," a mechanism previously studied by Barr and Plonsey [2] in a two-fiber model. We show that action potentials can cross both line-shaped and ring-shaped barriers containing no gap junctions by means of this mechanism in fully 2D (and by trivial extension, 3D) systems. We find that the effectiveness of the mechanism is strongly dependent on the height of the firing threshold above the resting state and action potential upstroke velocity (i.e., dVm/dt max). The mechanism is also found to be much more effective when the isolated region is circularly shaped (as an infarct typically is) than when the barrier is line-shaped, apparently due to the former's much more favorable source-sink balance.