Rotors drift toward and stabilize in low power regions in heterogeneous models of atrial fibrillation

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Background: Atrial fibrillation afflicts >33 million people worldwide. Success of therapy remains poor and better understanding of the arrhythmia and more effective therapies are needed.
Objective: To study a new energy domain parametrization of electric power for characterization of rotors' drift and stabilization in heterogeneous atrial models.
Methods: Single cell and heterogeneous 2D tissue simulations were performed. Myocytes and myofibroblasts transmembrane kinetics were simulated with the Koivumaki's model. Ionic currents were varied between 75-200% of baseline. Root mean square of the ionic and capacitance power (Pion, Pc) as well as of myocyte-myofibroblasts electrotonic coupling power (Pele) were computed for each model variation over one action potential duration. Tissue simulations were performed with separated and combined presence of IK1 gradient and diffused fibrosis (10%).
Results: Single myocytes showed Pion=40 and Pc=1.25 pW at baseline. Among all ionic currents, Pion and Pc increased the most with IK1 variation (to Pion=64 and Pc=1.6 pW when IK1 doubled), and slightly decreased only by increasing ICaL (to Pion=38 and Pc=1.19 pW when ICaL doubled). Coupling the myocytes to myofibroblasts generated Pele=6 pW and dramatically reduced myocytes power to Pion=8, P_C=0.6 pW for typical 5 coupled myofibroblasts. Finally, 2D tissue simulations were performed for an IK1 and resulting power gradient (other currents effects is overridden by IK1 effect) in absence and presence of fibrosis. Left panel shows that in absence of fibrosis rotors initiated in the high IK1 and power region drifted toward regions with low IK1 and with low Pion and Pc (arrow). However, when diffused fibrosis was included (right panel), power gradients were blunted and rotors stabilized where initiated.
Conclusion: Our study suggests that rotors drift towards and stabilize at low myocytes power region and fibrosis blunts myocytes power gradient effects. New energy domain characterization can improve understanding of rotor dynamics in fibrillation.