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Nonlinear Dynamical Analysis of Fibrillation[1] JOHN A. KERIN, Department of Physics, Georgetown University, JUSTIN M. SPORRER, Department of Neurosurgery, Shands Hospital, University of Florida, DAVID A. EGOLF, Department of Physics, Georgetown University — The development of spatiotemporal chaotic behavior in heart tissue, termed fibrillation, is a devastating, life-threatening condition. The chaotic behavior of electrochemical signals, in the form of spiral waves, causes the muscles of the heart to contract in an incoherent manner, hindering the heart's ability to pump blood. We have applied the mathematical tools of nonlinear dynamics to large-scale simulations of a model of fibrillating heart tissue to uncover the dynamical modes driving this chaos. By studying the evolution of Lyapunov vectors and exponents over short times, we have found that the fibrillating tissue is sensitive to electrical perturbations only in narrow regions immediately in front of the leading edges of spiral waves, especially when these waves collide, break apart, or hit the edges of the tissue sample. Using this knowledge, we have applied small stimuli to areas of varying sensitivity. By studying the evolution of the effects of these perturbations, we have made progress toward controlling the electrochemical patterns associated with heart fibrillation.

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