Cardiac Bioelectricity & Arrhythmia Center (CBAC) Presents:

The Tangling of Three Dynamical Systems in the Heart: Interactions of the Electrical, the Ca\(^{2+}\) Signaling, and the Contractile Systems

Monday, April 27, 4:30 p.m. - 5:30 p.m.
Whitaker Hall, Rm. 218, Danforth Campus

Hors d’oeuvres Reception After the Seminar in Whitaker Hall, Rm. 319
The Tangling of Three Dynamical Systems in the Heart
Interactions of the electrical, the Ca^{2+} signaling, and the contractile systems

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ABSTRACT

Cardiac excitation-contraction is controlled by three dynamic systems – the electrical system, the Ca^{2+} signaling system, and the contractile system. In the classic paradigm, electrical excitation controls Ca^{2+} signaling which, in turn, controls muscle contraction. Early work focused on investigating each dynamic system in isolation. However, recent studies show that defects in the contractile system can feedback to disrupt Ca^{2+} signaling system and cause electrical arrhythmias. We have developed innovative techniques and new methods to study the interaction of these dynamic systems. (1) The action potential (AP)-clamp sequential dissection method enables recording of multiple ionic currents under AP-clamp in the same cell; this helps understanding how the inward and the outward currents counterbalance to shape the AP profile. (2) The self-AP-clamp with Ca^{2+} cycling method enables us to study how the Ca^{2+} transient regulates ionic currents during AP and how Ca^{2+} dysregulation disrupts ionic balance to cause arrhythmogenic activities. (3) Recently we developed the ‘Cell-in-Gel’ system that allows embedding single cells in a 3-D viscoelastic hydrogel to mimic the in vivo mechanical environment of the heart. When the cardiomyocyte contracts in-gel, the elastic gel matrix deforms and imposes longitudinal tension, transverse compression, and surface traction on the cell. We found that when myocytes contract under mechanical load, the systolic Ca^{2+} transient is increased to enhance contractility (contributing to the Anrep effect). However, excessive load can cause arrhythmogenic Ca^{2+} activities and contractile dysfunction. I will present our work on using these new techniques to study feedback interactions between the electrical, the Ca^{2+} signaling, and the contractile systems that control cardiac function in health and diseases.