J Comput Sci Syst Biol 2016, 9:5 (Suppl)
http://dx.doi.org/10.4172/0974-7230.C1.015

Gap junction adaptation as a basis of cardiac memory: A computational study

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The phenomenon of cardiac memory refers to the property of cardiac tissue where the effect of an external electrical activation outlasts the duration of presentation of stimulus by a significant margin. The Gap junction (GJ) serves as key players in the cardiac memory effect. The memory effect shows in a cell pair as a lasting change in phase difference between the oscillations of two autorhythmic type of cardiac cells. It is demonstrated in grid models also where an external input presented for prolonged duration induces long term changes in activation pattern of the grid. These lasting changes are reflected in a computed Electrocardiogram. The physiological validity of the mechanism of adaptation of GJs is inspired from the results of learning and memory in neuroscience and the same is compared with the cardiac case. Just as neuronal signaling is mediated by synapses, the cardiac cells electrically interact with each other via GJs. The activity dependant adaptation of synaptic strength is generally considered an important biological substrate of learning and memory in the brain. The GJ conductance varies as a function of membrane voltages of the cells and hence found to depend on junctional voltage between a pair of coupled cells. It evinces interest to link between biophysics of GJs with the voltage sensitive dynamics of GJ channel and explains how the dynamics of GJs is compatible with biophysics of GJs. Parallels between activity dependant synaptic changes and electrical response pattern of GJ conductance, GJ dynamics can be interpreted as learning dynamics and forge to advocate a radical rethinking of the role of GJs in cardiac memory and cardiac function.

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