Study of Oxygen Deprivation on Cardiomyocyte using Electro-chemical Coupled Mathematical Model

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ABSTRACT

Blood flow reduction to the myocardium could result in myocardial ischemia. This also caused severe electrophysiological changes that eventually lead to the development of lethal cardiac arrhythmias. To understand the ischemic event and its association with arrythmia, mathematical modeling in electrophysiology has been widely used and various effects and important relations between electrophysiological parameters have been obtained. However, to date, the effect of the oxygen metabolism to arrhythmia formation has not been well studied. Moreover, no detailed explanation regarding the electrophysiological changes over time resulting from the oxygen reduction has been reported. Hence, the evolving of the electrophysiological changes from the occurrence of ischemic remains to be developed. Therefore, this work aims to investigate the evolution of the electrophysiology during MI using an electro-chemical coupled mathematical model by incorporating the oxygen diffusion on the electrophysiological model of the ventricle tissue based upon the ten Tusscher model. This conceptual work postulates that the incorporation of the oxygen diffusion effect on the ten Tusscher model has resulted in the variation of the parameters values over time from the onset of the ischemic events. These are the decrement of Na^{+}/K^{+} pump ($I_{NaKpump}$) current and intracellular potassium ion (K_i) concentration, and the increment in intracellular sodium ion (Na_i)concentration and intracellular calcium ion (Ca_i) concentration. These ionic changes have caused the action potential duration reduction from 400 ms to approximately 200 ms within three minutes. Through these parameters changes, more detailed mechanisms from the start of the ischemic can be grasp, hence this modelling concept could be used to predict arrhythmia occurrence.

KEYWORDS*: myocardial, ischemia, Ten Tusscher electrophysiology, oxygen concentration*

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