Analysis of the Use of the BPS Model to Simulate Ischemia-induced Hyperkalemia

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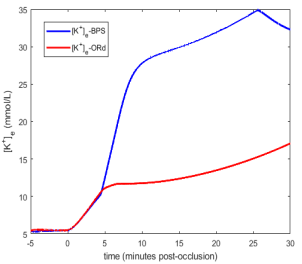
This study aimed to focus on the ability of BPS model for representing the physiological effects of acute ischemia, specifically hyperkalemia. The performed simulation lasts for 35 minutes. The first 5 minutes represent the normoxia and the following 30 minutes represent acute ischemia. All the simulations are done at single cell level at 1Hz with the BPS model. BPS model is an action potential model of ventricular cardiomyocyte, which could overcome the problem of the previous action potential models in terms of inverse APD-$[Ca^{2+}]_e$ dependence. To adopt the model to our desired aim, some ischemic parameters were implemented into BPS model based on the work done by Ferrero et al., in 2023.



Time course of extracellular potassium in the simulated isolated cardiomyocyte exposed to 30 minutes of acute ischemia using the BPS (blue) and ORd (red)

Following the implementation of the ischemic parameters into the model our first simulations of the acute ischemia revealed a different time course of extracellular potassium with respect to the gold standard, O'Hara-Rudy model. BPS model did not demonstrate the expected triphasic trend. During the first 5 minutes from onset of ischemia the models behave in the same way. However, after this time point BPS continues to extrude more K^+ ions and reaches 27mmol/L while at this moment ORd model had been plateaued at 12 mmol/L. This extrusion even continues further and with a slight increase reaches to 35 mmol/L at around 25th minutes of simulated acute ischemia then followed by a decrease.

In-depth analysis, revealed a complete interruption of calcium induced calcium released procedure at 4.4th minute, which can be associated to the appearance of the first delayed after depolarization at 4.4th minutes of simulated acute ischemia.

To conclude, the stunning point of BPS model, representing the DAD, could count as a limitation of the model for studying the acute ischemia since it causes an APD prolongation and non-physiological behavior of extracellular potassium concentration.