A Novel Model of Electrical Action Potentials of Teleost Fish Ventricular Myocytes

Hamsa N Naser*, Henggui Zhang

University of Manchester
Manchester, UK

Introduction: Mathematical modelling, combined with experimental approaches, has become a powerful method for investigating the heart functions. So far, different models of cardiac electrical activities of variant species have been developed, however, models of fish cardiomycytes are less developed. Given the prominent problem of global warming, sea temperature changes will have significant impact on the development of cardiac arrhythmias in the fish heart, leading to their sudden death, which may impose a heavy burden to the economy of the society. This study aimed to develop a biophysically detailed computer model for the teleost fish ventricular myocytes in warm acclimation (18°C).

Methods: A set of Hodgkin-Huxley (HH) formulations has been developed for the major ion currents (including the fast sodium current (I_{Na}), L-type calcium current (I_{CaL}), rapid delayed rectifier potassium current (I_{Kr}) and time-voltage dependent inward rectifier potassium current (I_{K1})) that were based on experimental data from different teleost species.

Results: A novel biophysically detailed mathematical model for the electrical action potential (AP) of the teleost fish ventricular myocytes in warm acclimation has been developed. With a series of supra-threshold stimuli (amplitude of -41 pA/pF; duration of 10 ms and time interval (between two successive stimuli) of 1000 ms), the model is able to generate a sequence of action potentials (APs) with a resting potential of -71 mV, action potential duration at 90% repolarisation of 308 ms, maximal upstroke velocity of 55 V/s and amplitude of 81 mV. These characteristics of the (APs) matched quantitatively to experimental data.

Conclusion: A new validated mathematical model for the AP of the teleost fish ventricular cells has been developed, which can be further used to investigate possible effects of raising water temperature on the fish heart functions.