A Modified Fitzhugh-Nagumo Model that Reproduces the Action Potential and Dynamics of the Ten Tusscher *et. al* Cardiac Model in tissue.

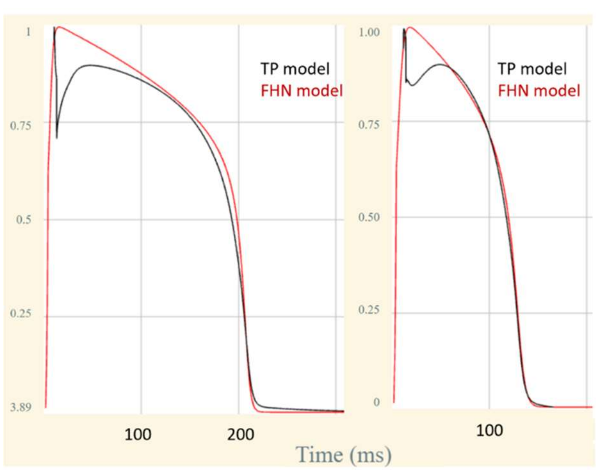
Sierra Rheaume, Hector Velasco-Perez, Darby Cairns, Maxfield Comstock, Ilija Uzelac, Elizabeth M. Cherry and Flavio H Fenton.

Aims: The two-variable Fitzhugh-Nagumo (FHN) model is widely used due to its simplicity; however, it lacks many of the dynamics observed in cardiac experiments that can be reproduced by complex ionic cell models, such as the 19-variable Ten Tusscher-Panfilov (TP) model. We aim to parameterize a modified version of the FHN model to reproduce the dynamics in space of more complex cardiac cell models.

Methods: We combined a series of modifications that previously were applied to the FHN model. In particular, the addition of a nullcline at zero voltage for the fast variable, that eliminates the hyperpolarization of the traditional FHN model. The modification of the slow nullcline from linear to quadratic, which allows alternans behavior and a better fit to experiments and other models. This new model is fitted using PSO (particle swarm optimization) to fit the action potential for a large number of pacing periods so that the restitution of the action potential is matched between the two models.

Results: We created a modified FHN model that matches most of the AP shape of the TP model for a large range of periods, from 900ms down to conduction block, as shown in the figure for two different stimulation periods. When simulated in tissue, the modified FHN model reproduces the spiral-wave dynamics including the rotation period of about 260ms.

Conclusions: We present a simple two-variable model modification of the FHN model that allows direct fitting to the much more complex TP model and reproduces similar dynamics in space, due to matched APD restitution and electrotonic loading given by similar AP shapes. This model allows for faster investigations that can help guide more time-consuming simulations with complex ionic models.



Modified FHN model

$$\dot{u} = u(u-\alpha)(1-u) - v$$

$$\dot{v} = \varepsilon(\delta u(\beta - u)(u+\gamma) - v)$$

Figure: Normalized action potential in time for the TP model in black and the modified (fitted) FHN model in red for two different pacing cycle lengths (BCL). Left for slow and right for faster BCL.