Rodriguez Model Notes

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Original Ischemia Details (commit `5a98cb9b`)

The `rodriguez4.f` code implements ischemia by modifying five model parameters: `taudiff`, `fatpfactor`, `finhib`, `vcleft`, and `inasfinal`. In the original code, the start of ischemia was hard-coded at 30s, and lasts throughout the simulation. Additional changes take place at 2min and 14min following ischemia. The parameter `taudiff` initially takes the value $100e^1$ (diffusion constant units?), changing to $100e^6$ at the start of ischemia, and finally taking the value $100e^{10}$ at 14min afterward. Both `fatpfactor` and `finhib` are initially zero, increasing linearly to `fatpfinal` and `finhibfinal`, respectively, at 14min after the start of ischemia. The parameter `vcleft` takes a nonzero initial value `vcleftinitial`, and decreases linearly to `vcleftfinal` after 14min of ischemia. After two minutes of ischemia, the parameter `inasfinal` decreases linearly from zero to the value -1.2 (inward current) at 14min after the start of ischemia. Figure 1 illustrates the original ischemia timecourse for each of these parameters, and the resulting action potential duration (to 90% repolarization).

Recovery from Ischemia

A simple strategy to model cardiac tissue recovery after ischemia event is to fully and immediately revert the changes that affect the five ischemia-sensitive parameters. Figure 2 illustrates the timecourse of such recovery following an ischemic event lasting five minutes and 30 seconds.

Recovery from ischemia may also be modeled by reversing, or "mirroring", the changes that occur in the five ischemia-dependent parameters. In this scenario, the direction of the rate of change in each parameter is reversed at the start of recovery, but its magnitude preserved. Figure 3 illustrates the behavior of each parameter and action potential duration under such recovery following six minutes of ischemia.

Yet a third model for recovery from ischemia is "exponential" recovery in each ischemia-dependent parameter. That is, following an ischemia event, each parameter begins to return to its initial value at a first-order rate. The particular rate for each parameter may be tuned. Figure 4 illustrates this type of recovery, assuming that each parameter has recovered by 95% at the end of two minutes.

The "exponential" recovery model leads naturally to a fully exponential model for the changes that occur at both the onset and recovery from ischemia. Figure 5 illustrates the fully exponential model, where the time constant was selected such that the changes to ischemia-dependent parameters are 95% effective at 14 minutes from the start of ischemia.
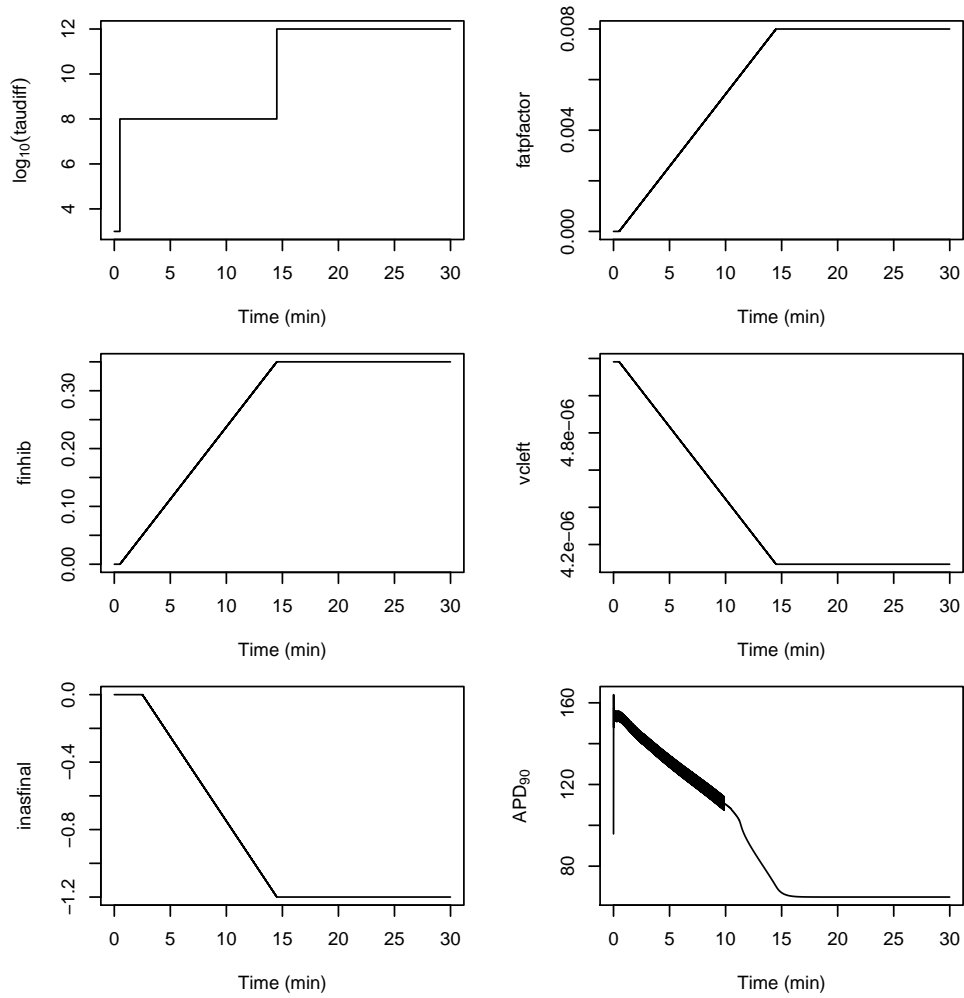
Figure 1: Timecourse of ischemia-dependent parameters and action potential duration in the original model of Rodriguez et al.
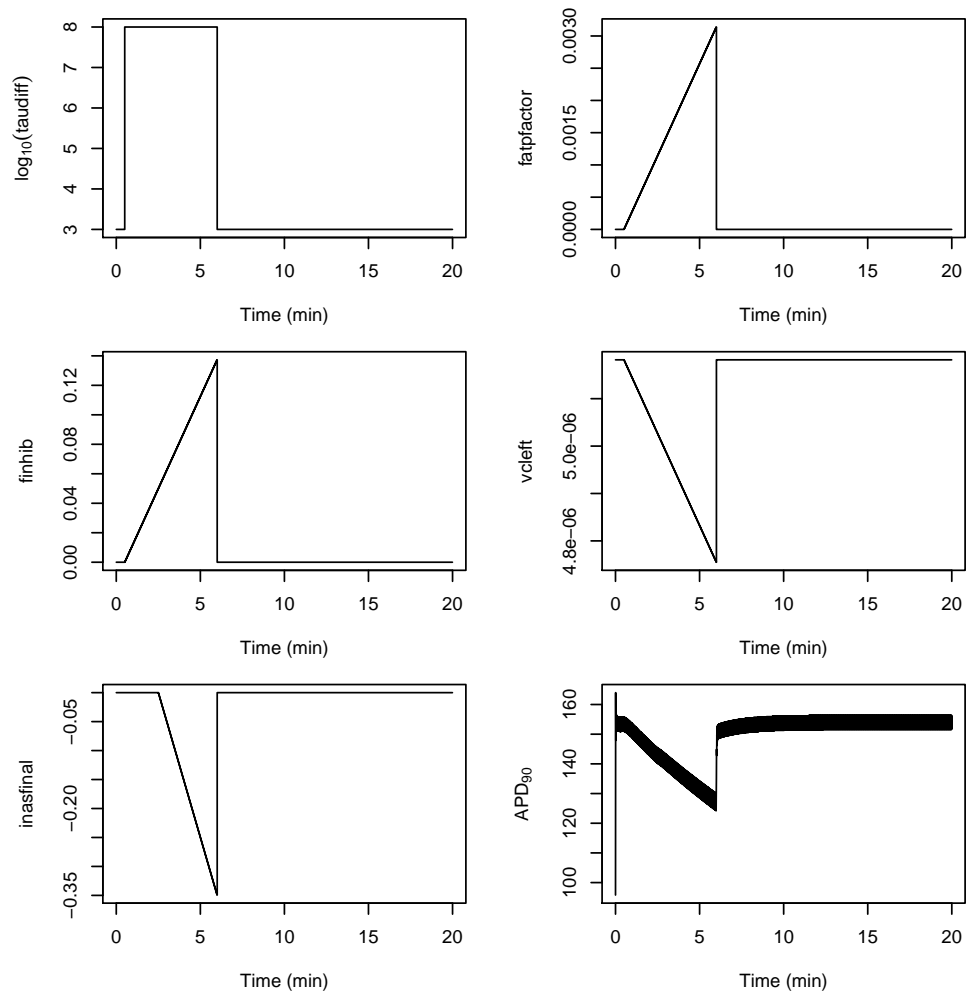
Figure 2: Timecourse of ischemia-dependent parameters and action potential duration with instantaneous recovery from ischemia at time six minutes, using a modified version of the Rodriguez model.
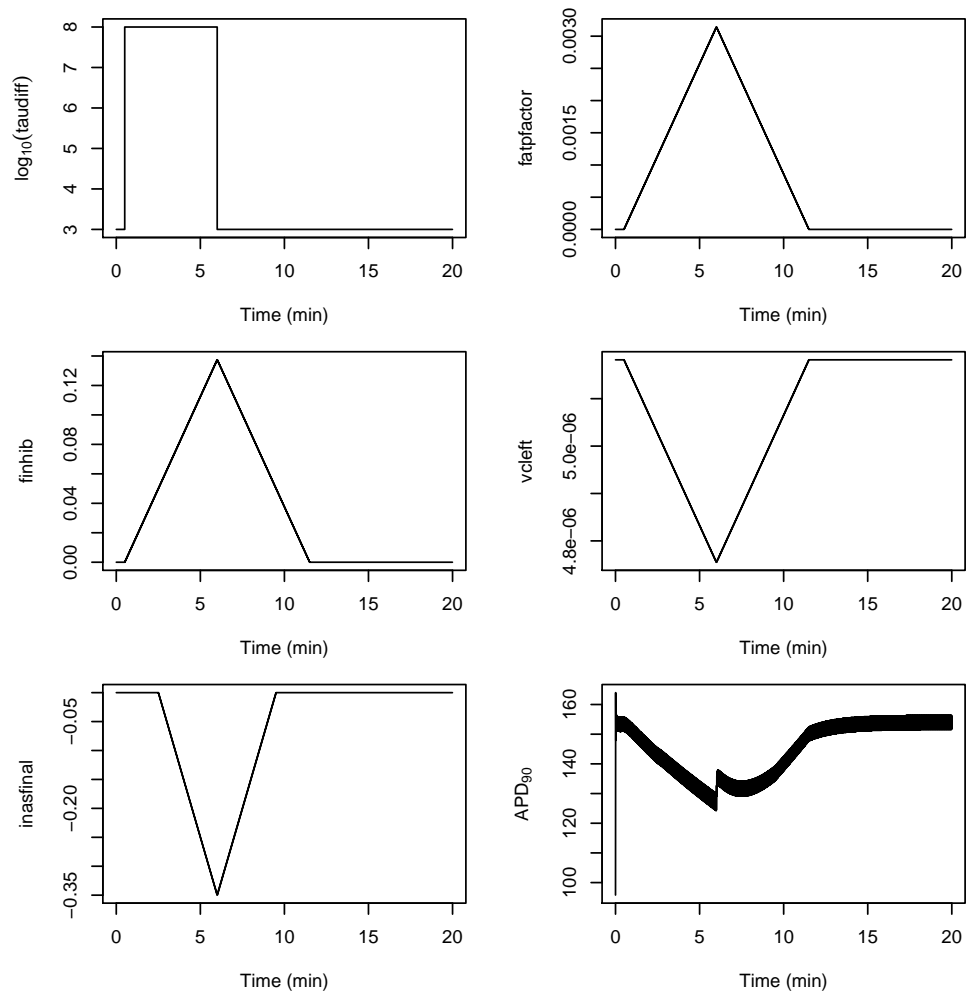
Figure 3: Timecourse of ischemia-dependent parameters and action potential duration with "mirror" type recovery following six minutes of ischemia.
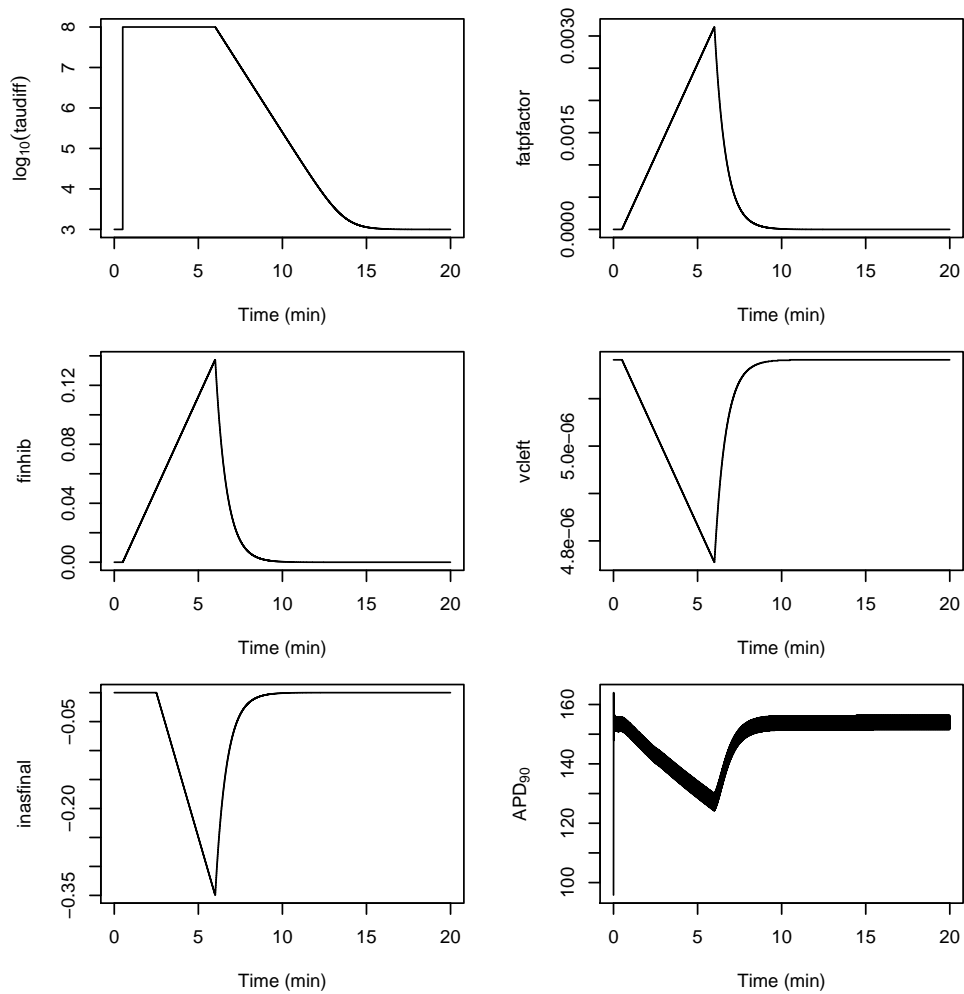
Figure 4: Timecourse of ischemia-dependent parameters and action potential duration with "exponential" type recovery following six minutes of ischemia.
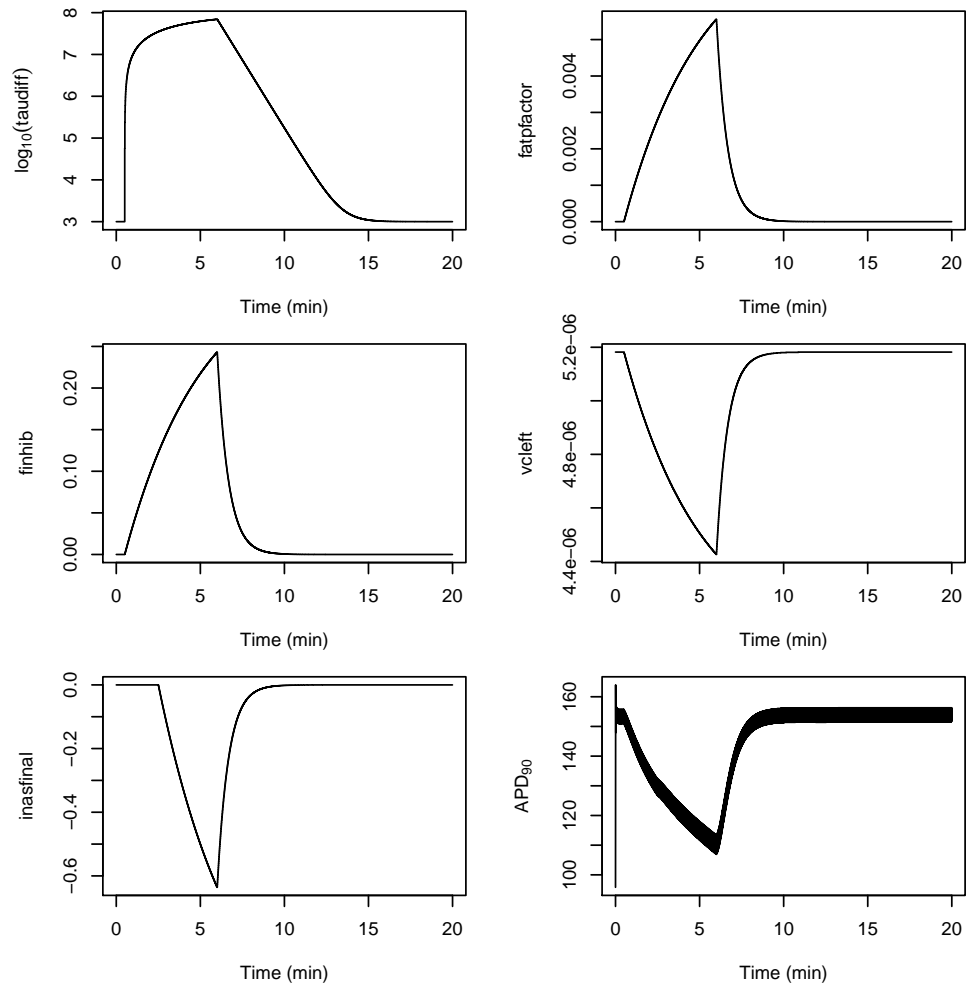
Figure 5: Timecourse of ischemia-dependent parameters and action potential duration with a fully exponential model for the onset and recovery from ischemia (6 min duration).