# Engineering a biological pacemaker using canine ventricle myocytes: a simulation study

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**Aims**: The treatment for cardiac pacemaker dysrhythmias and dysfunctions by implanting electric pacemakers is limited by some shortcomings, such as limited battery lifetime. Recently, an engineered biological pacemaker (BPM) by gene transfer technologies to turn non-pacemaking into pacemaking cells has been proposed as a potential alternative. However, there is no quantitative protocol to guide the generation of BPM. In this study, we investigated the integral action of the funny channel current ($I_f$) and inward-rectifier potassium channel current ($I_{K1}$) in the generation of BPM.

**Methods**: A new model for the canine funny current $I_f$ was developed from experimental data and incorporated into the canine ventricular single cell model. The channel conductance of $I_f$ and $I_{K1}$ was changed in a wide range to make the ventricular model successfully generate stable pace-making action potentials. A 1D tissue model of the ventricle strand was also developed to determine the minimum length of BPM to produce a successful conduction .

**Results**: The channel conductance range of $I_f$ and $I_{K1}$ for generating stable pacing action potentials was measured. To engineer a BPM with AP features similar to those of the native pacemaking cells, the scaling factors of the channel conductances of $I_{K1}$ and $I_f$ was set to 0.015 and 0.005 respectively, whilst the channel conductances of $I_{CaL}$ and $I_{Na}$ were increase by 1.5 times of the original values. In the 1D model, a minimal length of 7.19 mm for the BPM strand was required to ensure a successful conduction with a cycle length of 1000 ms.

**Conclusion:** Changes in $I_f$ and $I_{K1}$ modulated the spontaneous cardiac pacing, providing a quantitative parameter map for the two currents to generate BPM. A critical minimal size of BPM tissue is needed to ensure a successful conduction of excitation waves generated by BPM.