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The Effect of Action Potential Duration and Conduction Velocity on Cardiac Pumping Efficacy: Simulation Study

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Abstract : Slowed myocardial conduction velocity (CV) and shortened action potential duration (APD) due to some reason are associated with an increased risk of re-entrant excitation, predisposing to cardiac arrhythmia. That is because both of CV reduction and APD shortening induces shortening of wavelength. In this study, we investigated quantitatively the cardiac mechanical responses under various CV and APD using multi-scale computational model of the heart. The model consisted of electrical model coupled with the mechanical contraction model together with a lumped model of the circulatory system. The electrical model consisted of 149.344 numbers of nodes and 183.993 numbers of elements of tetrahedral mesh, whereas the mechanical model consisted of 356 numbers of nodes and 172 numbers of elements of hexahedral mesh with hermite basis. We performed the electrical simulation with two scenarios: 1) by varying the CV values with constant APD and 2) by varying the APD values with constant CV. Then, we compared the electrical and mechanical responses for both scenarios. Our simulation showed that faster CV and longer APD induced largest resultants wavelength and generated better cardiac pumping efficacy by increasing the cardiac output and consuming less energy. This is due to the long wave propagation and faster conduction generated more synchronous contraction of whole ventricle.

Keywords : conduction velocity, action potential duration, mechanical contraction model, circulatory model
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