Investigating excitation conduction in the atrioventricular node and Purkinje network using computer simulation

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We have been studying the excitation conduction in the cardiac conduction system, including the atrioventricular (AV) node and Purkinje network, which was found by Dr. Sunao Tawara. In this symposium, we will discuss our simulation studies of the AV node and Purkinje networks. (1) AV node. One of the important roles of the AV node is to adjust the ventricular rate during high-rate excitation in the atrium, such as atrial tachycardia and fibrillation. Using a multicellular model with two conduction pathways, we simulated excitation conduction in the AV node and demonstrated that the AV node could protect ventricles from high frequency excitation in the atria. Our simulations showed that calcium channel blockers, digitalis, and beta-blockers could control the ventricular rate. (2) Purkinje network. Recent studies have shown that a loss of the expression and function of gap junctions can impair excitation conduction in the His-Purkinje system related to ventricular arrhythmia. We constructed anatomical models from the His bundle to the ventricular tissue via the Purkinje networks with multiple conduction pathways and simulated the effect of decreasing the gap junction conductance corresponding to mutations in connexin on excitation conduction. At lower gap junction conductances, conduction blocks at Purkinje fibers junctions were observed frequently. As a result, reentrant beats occurred. When one of the reentrant circuits was ablated, reentrant beats did not persist in many cases as a consequence of altering dynamics in excitation conduction. Our models may be useful to analyze complex conduction patterns in the cardiac conduction system.