3D Model and Simulation of Atrial Reentry Mechanism and Supraventricular Tachycardia

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Background: Disturbances of the cardiac conduction system causing reentry mechanisms above the atrioventricular (AV) node are induced by at least one accessory pathway with different conducting properties and refractory periods. This work aims to further develop the already existing and continuously expanding Offenburg heart rhythm model to visualise the most common supraventricular reentry tachycardias to provide a better understanding of the cause of the respective reentry mechanism.
Methods: Modelling and electrical field simulations of the AV nodal reentrant tachycardia (AVNRT), AV reentrant tachycardia (AVRT), atrial flutter (AFL) and catheter ablation were performed using the software CST from Dassault Systèmes. The simulation of the slow-fast AVNRT is to be achieved by the modelling of a dual AV node. The modelling of an accessory pathway between the left atrium and left ventricle for the simulation of an AVRT was also implemented. The common type I counterclockwise AFL with a 2:1 heart block is achieved by integrating a macro-reentry circuit in the right atrium.
Results: The static and dynamic simulations of the impulse propagation in the heart in the individual disease patterns clearly visualise the supraventricular reentry mechanisms. The most informative results were obtained in the simulation of AVRT. The clarity of the provided results is especially remarkable in the relatively small volume of the AV-node in combination with the rapidly rotating impulse. The rotating impulse in the macro-reentry circuit of the simulated AFL provided more abstract results. The simulation of the rotating impulse in the right atrium delivered less accurate results; an exact localization of the impulse at any moment during a "rotation" was not possible. Nevertheless, the motion of a rotation is visible.
Conclusions: Electrical field simulations of AVNRT, AVRT and AFL with different supraventricular reentry mechanisms are possible with the Offenburg heart rhythm model. The static and dynamic electrical field simulation may be used to optimize the catheter ablation of supraventricular tachycardia.