A Biophysical Model of Atrial Fibrillation to Simulate the Maze III Ablation Pattern

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Atrial fibrillation (AF) is the most common cardiac arrhythmia. The Maze III ablation procedure consists of creating lines of conduction block in the atria according to a specific pattern to interrupt reentry pathways. Although a high success rate was reported, many clinical complications had been observed. An ideal pattern should be able to prevent AF with a limited number of lines. Advanced computer technology allows develop sophisticated biophysical models, which allow the simulation of the mechanisms involved in AF and opens up innovative approaches to simulate potential treatments. In this work we simulated the Maze III pattern in a tridimensional model of human atria and evaluated its efficacy for termination of an AF episode. For this purpose, we developed a 3D model of human atria, which includes the electrophysiological heterogeneity, anisotropy and fibers orientation. The electrophysiological changes caused by AF (electrical remodeling) were incorporated into a mathematical model of atrial cell and integrated in the anatomical model. An episode of AF was generated by ectopic activity in the left pulmonary veins. Unipolar pseudo-electrograms were computed in different regions of the atria. The ablation lines of the Maze III procedure were applied after 10 seconds of AF. The ectopic focus generated reentrant activity leading to fibrillatory conduction. The width of the vulnerable window for reentry was 16 ms. Figure-of-eight reentries, rotors, collisions and wave breaks were observed. The pseudo-electrograms obtained show variability in size and shape during simulated AF. When we applied the Maze III ablation pattern, the AF was finished after 200 ms. The results have been consistent with several cases reported by clinical studies. The developed model can be implemented to improve ablation patterns in order to find an ideal pattern to allow ending the arrhythmia with the least number of lines of ablation.