Arrhythmic3D: A Fast Automata-based Tool to simulate and Assess Arrhythmia Risk in 3D Ventricular Models

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Patients that have suffered a myocardial infarction are at lifetime high risk for sudden cardiac death (SCD). The so-called slow conducting channels (SCC) that extend throughout the infarct scar region are known to help in the initiation and maintenance of ventricular tachycardias (VT). However, it is difficult to stratify non-invasively their arrhythmogeneity based on imaging features from MRI.

We have developed Arrhythmic3D, an automata-based solver which allows to simulate cardiac activation sequences in 3D models, and takes into account the dynamic properties of human myocardium in healthy and pathological conditions, including action potential duration (APD) restitution, conduction velocity restitution, APD memory, electrotonic-effects and source-sink electrical effects (safety factor).

Using an S1-S2 protocol, Arrhythmic3D can simulate spiral wave activity in tissue with the properties of the underlying ionic model mimicked (see Fig. 1A). We carried out a simulation study in a patient-specific ventricular model that included a segmented scar (border and core zones), and compared the results of Arrhythmic3D and ELVIRA (a biophysically-based finite element cardiac solver). Using a virtual pace-mapping protocol, we triggered the clinical monomorphic VT supported by SCC (see Fig. 1B), with full mechanistic agreement between both solvers. Using a mesh of 2.6 Million elements to compare both solvers, a simulation of 1200 ms took 7h in the biophysical solver on a 64 cores (2.3 GHz) machine, versus 76s on Arrhythmic3D on a dual-core laptop (2.9 GHz) one, which makes it transferable to clinical environments.