Use of 3D atrial models to improve signal processing in cardiac electrophysiology

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SUMMARY

Atrial fibrillation (AF) is the most common cardiac arrhythmia, affecting more than 6 million of Europeans. In the recent years new mapping technologies have been developed such as intracardiac mapping by basket catheters, body surface potential mapping by surface electrodes or estimated epicardial mapping by solving the inverse problem of electrocardiology. Together with these mapping technologies, signal processing techniques have been developed in order to identify the mechanism that maintains AF in each individual patient. However, due to the complexity of AF it is difficult to validate such techniques with real patient data.
We make use of cardiac electrophysiological models of the atria in which we induce atrial fibrillation maintained by rotors at different locations of the atria and with different degrees of complexity by introducing remodeling in ion channels and conductances and by inserting non-conducting scars. We later compute body surface potentials by modeling the volume conductor of the torso and applying the Boundary Element Method. After contamination with white noise at different signal to noise ratios, we compute epicardial potentials by solving the inverse problem of electrocardiology by 0 order Tikhonov regularization.
By using these matematical models of atrial electrograms and electrocardiograms we have analyzed which settings (i.e. filtering settings, phase singularity identification and tracking) allow the identification of atrial rotors with the largest sensitivity and specificity at these different scales. By adding uncertainties to the recorded signals and geometries we can also investigate the robustness of different methods for atrial source identification, namely the location of the highest dominant frequencies and phase singularities.