Automatic ECG-based Discrimination of 20 Atrial Flutter Mechanisms: Influence of Atrial and Torso Geometries

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Aims: Atrial flutter (AFl) is a common reentrant atrial tachycardia driven by different self-sustaining electrophysiological mechanisms. To terminate this arrhythmia and re-establish the sinus rhythm, intracardiac mapping and catheter ablation are often performed without prior knowledge of the mechanism perpetuating AFl in an individual patient, likely prolonging the procedure time of these invasive interventions. This study sought to discriminate 20 different AFl mechanisms and to analyse the influence of atrial and torso geometry for the success of such discrimination, using machine learning on the non-invasive 12-lead electrocardiogram (ECG) signals.

Methods: 20 different AFl mechanisms were simulated using a fast marching approach coupled to numerical field calculation on 8 atrial models with two orientational variants each and were propagated into 8 torso models via forward solution, resulting in 2,512 sets of 12-lead ECG signals. 151 features were extracted from the signals from different domains (e.g., time, frequency, entropy, recurrence analysis). Three classification procedures have been implemented: random set classification; leave-one-atrium-out (LOAO); and leave-one-torso-out (LOTO). Several classification algorithms were tested after selection of the most informative features.

Results: A radial basis neural network classifier achieved test accuracy of 89.84 %, 88.98 %, and 59.82 % for the random set classification, LOTO, and LOAO, respectively. The most discriminative feature was the F-wave duration (74 % test accuracy with a single feature classification).

Conclusion: Machine learning approach can potentially identify a high number of different AFl mechanisms using the 12-lead ECG. The classifier generalized well regarding unseen torso geometries, but rather poor regarding atrial anatomies. Therefore, more than the 8 atrial models used in this work should be included during training, due to the significant influence that the atrial geometry has on the ECG signals and thus on the resulting classification. This non-invasive method can help to identify the optimal ablation strategy for patients.