Classification and Location of Atrial Arrhythmic Mechanisms with Body Surface Potential Mapping

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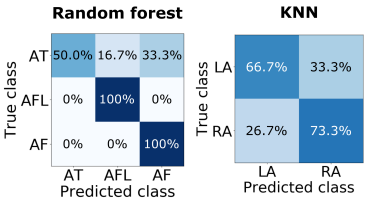
Objective: atrial tachycardia (AT), flutter (AFL) and fibrillation (AF) are common arrhythmias associated with deterioration of hemodynamics, significant morbidity and mortality. Non-invasive localization of their driving sources (ectopic focus, macro-reentry and functional rotors, respectively) by body surface potential mapping (BSPM) may be useful to define an optimal treatment strategy. We aimed to classify the arrhythmic mechanisms and their locations from dominant frequency (DF) and phase singularity points (SP) features.

Methods: 93 1-second segments obtained from 19 simulations (4 AT, 4 AFL and 11 AF) of 567-lead BSPMs were used to generate DF maps and estimate the atrial driving frequencies with the highest DF (HDF). Arrhythmia classification: 7 features were extracted from DF maps biased on the general DF distribution, its organization index (OI) and characteristics from segmented regions with |DF-HDF| $\leq$1 Hz. SPs connected along time and their histograms were used for extracting 6 features representing the rotational activity. Driver location from left vs. right atrium (LA vs. RA): the torso was divided into four quadrants (anterior and posterior, each divided in left and right sides) and 3 features (mean OI and percentages of HDF and SPs) were extracted from each one (total 12). Classification with 5-fold cross validation was performed with three algorithms in each task: least squares, K-nearest neighbors (KNN) and random forests. The robustness of the feature extraction and classification to reduced spatial resolution was tested using 6 BSPM layouts (252 to 16 leads).

Results: the best arrhythmia classification results were obtained with the random forests classifier (depth 2, 40 trees), with balanced accuracy of 83.3% (Figure, left). For mechanism location classification, KNN (K=3) had the best performance (balanced accuracy 70%; Figure, right). Accuracies were similar for all lead layouts.



Best classification results for arrhythmias (left) and mechanism location (rigth)

Conclusions: this is the first study, to the extent of the authors' knowledge, to classify AT, AFL and AF and their drivers' locations using BSPM. Other techniques and features are under evaluation to improve classification.