Machine Learning Models Trained with Simulations Predict the Site of Origin of Outflow Tract Ventricular Arrhythmias from Multi-centic Databases

Ruben Doste, Miguel Lozano, Guillermo Jimenez, Lluis Mont, Antonio Berruezo, Diego Penela, Oscar Camara, Rafael Sebastian

University of Oxford
Oxford, UK

In order to determine the site of origin (SOO) in outflow tract ventricular arrhythmias (OTVAs) before an ablation procedure, several algorithms, based on electrocardiogram (ECG) feature analysis, have been developed, although their accuracy is still limited.

We propose the use of electrophysiological simulations of OTVAs to train a Support Vector Machine to predict the SOO of an ectopic beat (LV vs RV). We generated a database of simulated 12-lead ECGs (2496) from the most typical OTVA SOO in 16 patient-specific geometries. A cross-validation process was included to evaluate the SVM model. Following, two clinical OTVA ECG databases from different hospitals (test1 = 324 and test2 = 31 patients) were used as test-sets to assess the generalization of the proposed approach. Two types of input data were considered: raw-signal and feature-based. From the simulated 12-lead ECG, we analysed the importance of each lead, obtaining the best ones for the training process (V2 lead in our case). For feature-based analysis, we used entropy-based methods to rank the obtained features. We compared using simulated data for training rather than real ECG, or mixing real and simulated signals.

The results show that both raw signals and features were good candidates for predicting the SOO in OTVA (see Table 1), with high cross-validation accuracies on simulated data. Generalization of the network trained on simulated data was good for the test1 dataset, but less satisfactory for the test2 cases (with the feature-based approach being more robust than using raw signals), likely due to the reduced number of testing samples in the latter. Using simulated data for training was critical to obtain good SOO predictions compared to real data alone (0.91 vs 0.52 accuracies on test2, respectively), without improvement when mixing them. Results should be extended to determine the exact localization of the SOO within each ventricle.

Results of the SVM model

Representation	Acc (test1)	Acc (test2)	Acc(CV, nfold=5)
Raw (only V2)	0.90	0.68	0.94
Features	0.85	0.81	0.96