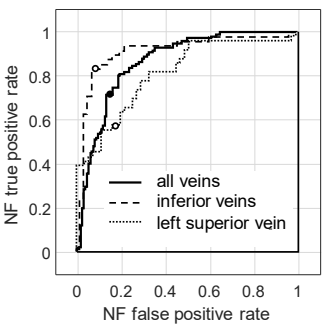
Classification of Farfield and Nearfield Intracardiac Signals from the Pulmonary Veins using Machine Learning

Vincent Schlageter*, Adrian Luca, Florian Spies, Antonio Madaffari, Michael Kühne, Stefan Osswald, Jean-Marc Vesin, Christian Sticherling, Sven Knecht

University Hospital Basel, Basel, Switzerland
Swiss Federal Institute of Technology, Lausanne, Switzerland

Intracardiac bipolar electrograms (EGM) comprise nearfield (NF) and farfield (FF) signals. For the treatment of atrial fibrillation, the discrimination between left atrial (LA) FF and pulmonary vein (PV) NF is of fundamental importance to confirm pulmonary vein isolation (PVI). This study aims at developing an algorithm to discriminate, from a single heartbeat, PV-NF from LA-FF signals within the PVs during PVI. This algorithm may provide a real-time confirmation of complete PVI (absence of PV-NF).

We retrospectively analysed EGM during PVI using the cryoballoon technology and a decapolar circular diagnostic catheter (Achieve, Medtronic) of 42 patients. Signals were manually classified based on the disappearance of the PV-NF signal during PVI as local PV-NF or LA-FF. Features were calculated for the two sets of signals using a 60-ms window. The powers in different frequency bands were calculated using FFT for the lead with the highest power in the high frequency band 150-350 Hz suggesting the closest NF signal. Supervised machine learning models were trained with 4-fold cross-validation. Overall predictive accuracy, as well as NF false discovery rate (leading to unsafe excessive ablation), were used to select the best classifier.



We analysed 261 signals from within the PVs (73 from the left inferior PV, 104 from the left superior, 55 from the right superior and 29 from the right inferior). The highest predictive accuracy of 79% was obtained with a SVM (quadratic) model including the signals from all veins. The two best features were the power in the high frequency band and the maximal bipolar voltage of the signal. Including more features like wavelet decomposition did not improve the overall accuracy.

The classifier accuracy depends on the location of the vein. Classification is more accurate for the inferior veins (positive prediction value of 86%) and lower for the left superior vein (75%) due to its close proximity of the LA appendage, with NF false discovery rate of 5% and 27% respectively. ROC curves in the figure show that a training strategy taking into account the differences between the veins location could improve the individual results.