Novel electrogram-based features for the classification between paroxysmal and persistent atrial fibrillation during sinus rhythm

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Aim: Atrial fibrillation (AF) is the most common arrhythmia. However, the exact causes are still unclear. The electropathological characteristics derived from intra-operative epicardial measurements, such as conduction delays (CD) and conduction blocks (CB), can be used to assess the severity of AF. In sinus rhythm, however, these parameters do not indicate significant differences between different development stages of AF, such as paroxysmal and persistent AF. Therefore, we propose a methodology to improve the AF severity detection using intra-operative electrograms.
Methods: We propose a model that describes the spatial propagation of action potentials during a single beat on the multi-channel electrogram and the heart tissue conductivity. Using singular value decomposition, we describe different sources of variation in the propagation. Based on this model, we derive two novel features. The first feature employs the singular value decomposition of the electrograms to determine the number of dominant singular values associated with variation in action potential across the atrial region. The second feature extracts the ratio of each singular value to the previous one.
Results: The performance of the features is evaluated by a support vector machine (SVM) classifier using an RBF kernel. The features are extracted from 80 beats of paroxysmal patients and 172 beats of persistent patients. Using a 5-fold cross-validation on the proposed features, we achieved 82.30% accuracy in paroxysmal and persistent AF classification, while using electropathological characteristics (CD and CB), 67.74% accuracy is achieved. Moreover, we achieved a 0.68 Pearson correlation ratio between the number of CBs and our proposed feature. This means that the atrial action potential variation correlates to the atrium's electropathological characteristics as determined by CB and CD, which can help us to unreveal the atrial tissue damages.
Conclusion: Our findings indicate that inspection of the proposed features reveals information about the real substrate underlying AF.