Estimating Respiratory Modulation in Atrial Fibrillation Using a Convolutional Neural Network

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Aims: The autonomic nervous system (ANS) can initialize and maintain but also terminate atrial fibrillation (AF). Currently, there is a lack of methods to estimate ANS activity from ECG data of subjects in AF. In the present study, we investigate the feasibility of estimating ANS-induced respiratory modulation in AV nodal conduction properties in a simulation study.

Methods: A convolutional neural network (CNN) is trained on simulated data, corresponding to what can be acquired from 1-min ECG segments. Simulated RR series are generated using an AV node network model with refractory period (R) and conduction delay (D) dependent on the stimulation history and respiratory modulation defined by the amplitude a_{resp} and frequency f_{resp}. The respiration signals are extracted from sinusoidal signals with the frequency f_{resp} and added noise to mimic ECG-derived respiration signals, using the periodic component analysis (πCA). The AFR is used both as input to the CNN and as model parameter to generate the atrial impulse series entering the AV node. The CNN is trained to predict a_{resp} using simulated data from 100 000 unique model parameter sets, with a_{resp} ranging from 0-0.2, where a_{resp}=0.2 corresponds to an increase and decrease of R and D by up to 20%.

Results: An example of simulated RR series and respiration signal resembling a clinical data is displayed in Fig. 1. The respiration signal extraction based on πCA can both extract the respiration signal and estimate the respiration frequency without prior knowledge under the assumption that the respiratory modulation is the most periodic component in the EDR signals. The CNN can estimate a_{resp} with an RMSE of 0.0274 in simulated data.

Conclusion: Our simulation results suggest respiratory modulation in AV node conduction can be estimated from ECG data, which may be valuable in personalized AF treatment. Further studies are needed to validate the estimates.

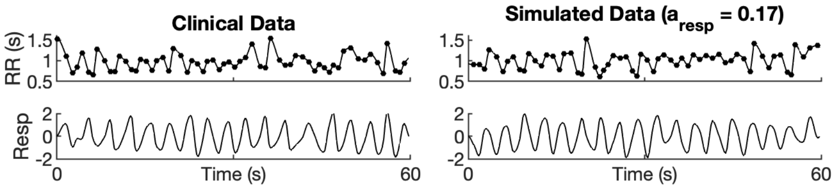

Figure 1. Example of clinical and simulated RR series and respiration signals.