Investigating Respiratory Rate Estimation During Paroxysmal Atrial Fibrillation Using an Improved ECG Simulation Model

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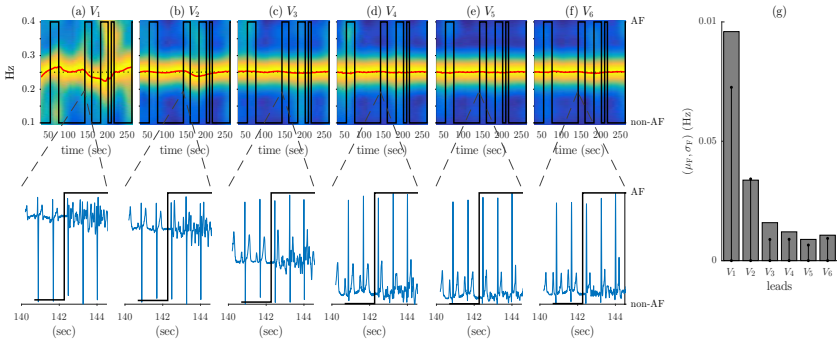
The present study addresses the problem of respiratory rate estimation from ECG-derived respiration (EDR) signals during paroxysmal atrial fibrillation (AF). Novel signal-to-noise ratios between various components of the ECG including the influence of respiration, measured by QRS ensemble variance, the amplitude of fibrillatory waves (f-waves), and the QRS amplitude are introduced to characterize EDR performance. Using an improved ECG simulation model accounting for morphological variation induced by respiration, the results show that 1. the error in estimating the respiratory rate increases as a function of the time spent in AF, 2. the leads farthest away from the atria, i.e., V_4, V_5, V_6, exhibit the best performance due to lower f-wave amplitudes, 3. lower errors in leads with similar f-wave amplitude are due to a more pronounced respiratory influence, and 4. the respiratory influence is higher in V_2, V_3, and V_4 compared to other precordial leads.



Example of respiratory rate estimation. The time–frequency spectrum of the EDR signals obtained from the leads (a)–(f) V_1–V_6. The estimated respiratory rate is displayed with a red solid line, while the reference respiratory rate with a black dotted line. An excerpt of the simulated ECG signal is displayed below each time–frequency spectrum. The AF episodes (right axis) are indicated with a black solid line. (g) The mean μ_F and standard deviation σ_F of the absolute error between reference and EDR rate, denoted with tildes and lines, respectively.