Multilead QT Interval Adaptation to Heart Rate Changes in Atrial Fibrillation: Dealing with the Presence of f-Waves

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Aim: The clinical significance of QT interval adaptation to changes in heart rate has been the subject of much investigation in normal sinus rhythm, but not in atrial fibrillation (AF). The presence of f-waves makes QT delineation in AF a challenging problem. Our aim is to investigate a robust QT delineation strategy based on periodic component analysis (πCA), using ECGs obtained from a simulation model accounting for QT adaptation and thereby making it possible to assess the influence of f-waves on the estimation of QT memory lag.

Materials and methods: A model for simulating multi-lead ECGs (12 standard leads) is used to generate a set of 15 ECGs, each with 3000 beats, where single-lead versus multilead QT delineation, using a wavelet-based delineator, are evaluated for different f-wave amplitudes. The multilead spatial πCA strategy emphasizes the T-wave and attenuates the f-waves before QT delineation takes place. The rate dependence of the repolarization time is modeled by an exponential decay describing how the current QT interval depends on the preceding RR intervals, followed by a hyperbolic regression function modeling the memoryless QT-RR dependence. The time constant that defines the exponential decay is set to τ=25s and the estimation error of τ (e_τ) is computed as a function of f-wave amplitude.

Results: When evaluating the QT-delineation error, e_d, the πCA lead offers better performance at a wide range of f-wave amplitudes (e_{QT}=2.1±4.6 and e_{QT}=1.51±4.2 for high and low f-waves amplitudes) than do the individual ECG leads, which exhibit a decreasing tendency in the delineation error as f-wave amplitude decreases (from 46.54 to 6.8 ms in lead V1). The same behavior is observed in assessment of the QT memory lag.

Conclusion: πCA is a robust strategy for both QT delineation and the assessment of heart rate adaptation in the presence of f-waves.