Sensitivity of T-Wave Alternans Identification Algorithms to Residual Physiological Noise Affecting the ECG after Preprocessing

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Residual physiological noise is likely to survive the ECG preprocessing-stage providing the input to T-wave alternans (TWA) identification algorithms. To address the issue as to how and at what extent this residual noise affects TWA detection and quantification, a test was performed here on three different methods known in literature as fast-Fourier-transform spectral method (FFTSM), modified-moving-average method (MMAM), and adaptive-match-filter method (AMFM). These techniques were applied to four synthetic ECG tracings respectively affected by no TWA, stationary TWA, and time-varying TWA characterized by either smoothed-step or sinusoidal trend. These synthetic ECGs were considered in the absence of noise or after adding each one of the six recordings of electrode-motion noise, muscular noise and baseline wandering, belonging to the MIT-BIH noise stress test database (PhysioNet), with normalized maximum amplitude of 50 V or 100 V. In the absence of noise, all three competing methods did not provide false-positive TWA when applied to no-TWA tracings. Stationary TWA was detected and quantified with no error, while, in the presence of time-varying TWA, the FFTSM, the MMAM and the AMFM quantified TWA amplitude with maximum root-mean-square-error (RMSE) of 9 V, 7 V and 3 V, respectively. In the presence of the two considered noise levels, the FFTSM provided the same output as in the absence of noise. Instead, the MAMM and the AMFM quantified TWA with increased RMSE (up to 12 V and 5 V, respectively), and detected false-positive TWA cases in all twelve and one no-TWA tracings, respectively. In conclusion, the FFTSM is robust to noise but has an intrinsic limitation in the precision of TWA quantification in the presence of time-varying TWA. Noise significantly affects the behavior of the MMAM, while the AMFM offers a good compromise between robustness to noise and ability to identify both stationary and time-varying TWA.