

Changes in Signal Morphology of Hand-held ECG Devices with Dry Electrodes

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Introduction: Devices for measuring ECG on a large scale, like handheld or wearable single-lead devices, gain importance in diagnosis of cardiac arrhythmia, such as atrial fibrillation (AF). They typically depend on simple and easily applicable, dry electrode realizations. The electrode characteristics play a crucial role and need to exhibit low impedance and high signal-to-noise ratio to provide a robust measurement and reliable signal quality. Dry electrodes and their respective signal conditioning circuits often implement a high-pass characteristic, which has potentially significant influence on the ECG signal morphology and thus on the diagnostic capabilities and possible misdiagnosis by clinical experts.

Methods: We implemented a MATLAB Simscape-based model to simulate the electrode-skin interface of dry electrodes and the corresponding ECG measurement pathway to investigate the influence of skin impedance, geometric factors and electrical circuitry on the signal morphology of an Eindhoven I-lead heart cycle prototype. We then performed synchronized measurements with the commercially available ECG device MyDiagnostick and a Philips patient monitor MX800 for reference purposes to compare both ECG data with respect to the identification of AF-specific landmarks in the signal morphology, which are basically irregular R-R intervals and the absence of P-waves.

Results: The simulation results indicate a significant reduction of the signal amplitude by about one decade in the entire parameter space. Additionally, and more importantly, the simulation also revealed a significant signal deformation manifested in an increasingly biphasic P-wave with reduced amplitude, a negative S-peak and an inverted T-wave. From the real measurements, we can deduce that depending on the individual skin impedance the P-wave are only hardly detectable in the ECG stick measurements. These results suggest that ECG recordings from large screening devices should be treated with caution when using commonly used algorithms for diagnostic purposes, such as deep neural networks trained on clinical ECG data.