Noise Quantification and Noise Reduction for Unipolar and Bipolar Electrograms

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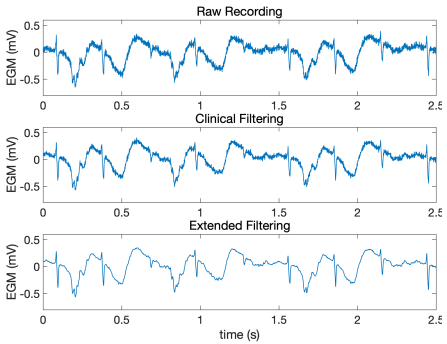
Background: Intracardiac electrogram (EGM) analysis is a cornerstone in the diagnosis of arrhythmia mechanisms. In clinical practice, bipolar EGMs dominate the field due to their low-noise characteristics. Major drawbacks of bipolar EGMs such as the dependency on lead arrangement and a reduced spatial resolution encourage to further investigate unipolar EGMs. However, noise strongly distorts the latter.

Methods: In this study, we quantified and reduced the noise level of unipolar and bipolar EGMs recorded with the IntellaMap Orion catheter and the ultra-high density electroanatomical mapping system Rhythmia HDx. Distinct noise frequencies in the power spectral density were detected with a sliding window of variable width and subsequently removed by notch filtering. The absolute peak to peak voltage remaining in the inactive segments of the EGMs after baseline removal quantified the noise level of the electroanatomical mapping system. An international, multi-center selection of 33 patients undergoing an electrophysiological study due to diagnosed atrial tachycardia served as a broad sample cohort.

Results: The case-specific detection and removal of noise peaks from the power spectral density reduced the median noise level in unipolar EGMs by 30% to 0.076mV compared to standard clinical filtering while maintaining the morphology of atrial activations. With a bipolar noise level of 0.010mV, Rhythmia HDx meets the low noise floor claimed in the system specifications. Distinct noise frequencies at 80Hz and harmonics, 120Hz, 200Hz, 360Hz, and 440Hz presented permanently in each of the cases whereas others showed up only intermittently or in individual cases.



Unipolar EGM: raw, after clinical filtering, and after extended filtering.

Conclusion: We suggest to tailor clinical filter settings to the individual environment in order to reduce the noise level in unipolar EGMs. Low-noise unipolar EGMs allow to exploit their advantages over bipolar EGMs and to further discriminate regions of low voltage to specify diagnosis.