Continuous Wavelet Transform–Based Fragmentation in Ventricular Tachycardia Substrates

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Introduction: In post-ischemic ventricular tachycardia treatment, intracardiac electrogram (EGM) fragmentation is widely used to identify abnormal ventricular potentials (AVPs). Fragmentation is computed in the time domain as the number of changes of slope in the EGM waveform. However, this approach may not fully reflect pathological dynamics manifesting differently across multiple frequency components. In this work, we propose exploring fragmentation analysis in the time-frequency domain, through Continuous Wavelet Transform (CWT), to investigate the capability of this approach to capture more clearly EGM fragmentation.

Methods: We used the ARGO dataset (1716 EGMs @1000 Hz, 2.5 s each), manually labelled by an expert consensus as physiological (776) or AVP (940). Each signal was denoised and windowed to extract a 350 ms segment around the reference beat. A CWT analysis was then applied using the Daubechies2 mother wavelet up to 20th scale. For each scale, fragmentation was computed as the number of peaks of the absolute CWT coefficients exceeding a scale-specific threshold. The proposed CWT-based fragmentation index (fr_{CWT}) was obtained by summing all the scale-level fragmentations. Its discriminative performance between physiological EGMs and AVPs was compared against time-domain fragmentation (fr_{time}), evaluating the Area Under the Receiver Operating Characteristic Curve (AUC), and statistically by the Wilcoxon rank-sum test and the Hellinger distance (H).

Results: The proposed fr_{CWT} achieved an AUC of 0.98 ($p < 0.0001$) with H of 0.88, whereas the fr_{time} yielded an AUC-ROC of 0.91 ($p < 0.0001$) with H of 0.62. CWT analysis provided a substantial improvement with respect to the time-domain approach, even in terms of statistical class separation, for the computation of a fragmentation index.

Conclusions: The proposed fr_{CWT} index achieves near-optimal discriminative performance between physiological EGMs and AVPs, suggesting that the integration of time-frequency fragmentation into automated AVP detection pipelines could potentially improve ablation target identification in clinical practice.