Correlation-based Estimation of Activation Frequency in Intracardiac and ECG signals during Atrial fibrillation

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Estimation of the atrial Cycle Length (CL) can help to identify atrial regions sustaining atrial fibrillation (AF), although the complexity of AF patterns possess a challenge. This work explores correlation-based methods to estimate atrial CL in intracardiac (EGM) and electrocardiographic (ECG) signals.

In 4 AF patients, we collected 6-seconds N=2560 EGMs and N=1920 ECG signals, using simultaneous 64-poles basket catheter to 48-electrodes body surface system. In N=96 EGM traces, atrial CL was visually annotated. Two correlation-based method were used to estimate atrial rate in EGM/ECG signals: 1. the local maxima of the signal autocorrelation; 2. the median time difference between local maxima in the convolution of the signal with a template (100ms of the same signal), averaging medians between N=5, 10, 20 random templates (A). Simultaneous EGM and ECG signals were compared by accounting the percentage of intracardiac CLs that were present in any of the 48 ECG CLs with a deviation lower than 5 ms.

The autocorrelation provided local maxima corresponding to the correct CL (A up), although some signals with beat-to-beat variations showed secondary local maxima at incorrect CLs (A middle, ~15 act. in 3 s. ≠ 329 ms) which could be solved by the convolution-based method (A down, 195 ms). Autocorrelation-based method showed a relative error or 31±16% respect EGM annotations, whereas convolution-based methods showed relative errors lower than 20% (fig. B, p<0.05). Simultaneous intracardiac vs non-invasive CL metrics (fig. C) also indicated that convolution-based method with 5 templates had the highest agreement between EGM and ECG CLs (97±5%) compared to the autocorrelation method (91±8%) or using more templates.

Convolution-based methods using templates of the same signals allowed an accurate estimation of the atrial CL for both intracardiac and non-invasive electrocardiographic signals. This method may help to stratify and guide therapies based on the presence of high-frequency AF drivers.