Beat-to-beat In Silico Assessment of AV-nodal Conduction Dynamics during AF

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Background: The refractory period (RP) and the conduction delay (CD) of the atrioventricular (AV) node play a crucial role in regulating the heart rate during atrial fibrillation (AF). Assessing short-term variations in these conduction properties could provide novel information for improved diagnosis and treatment optimization on an individual basis.

Methods: We propose a methodology comprising a network model of the AV node, a particle filter, and a smoothing algorithm to quantify the conduction properties for each heartbeat. The methodology was evaluated using simulated data and applied to endocardial recordings from five patients in the Intracardiac Atrial Fibrillation Database (PhysioNet).

Results: Estimated RP and CD matched the simulated ground truth values with a mean absolute error (± std) for each heartbeat of 181±158 ms for RP in the fast pathway (RP^{FP}), 123±109 ms for CD in the fast pathway (CD^{FP}), 51±53 ms for RP in the slow pathway (RP^{SP}), and 153±161 ms for CD in the slow pathway (CD^{SP}). Furthermore, the resulting RP and CD trends from the endocardial recordings for one patient are shown in Fig 1.

Conclusion: The beat-to-beat assessment of AV node conduction properties enable detection of high-frequency changes in AV nodal conduction, potentially offering insights for personalized treatment strategies during AF. This constitutes a novel research tool in itself, and provides an important step toward ECG-based assessment in short-term variations in AV node conduction.

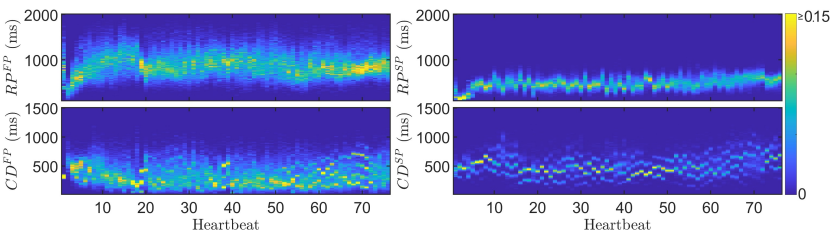

Fig 1. Estimated conduction properties for patient 1, where values ≥ 0.15 are presented with the brightest color for ease of visualization.