ECG-based Assessment and Therapeutic Implications of AV Nodal Conduction Dynamics During Atrial Fibrillation

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Background: The conduction properties of the atrioventricular (AV) node have a significant impact on the heart rate during persistent atrial fibrillation (AF) and can be modulated using β-blockers or calcium channel blockers. These drugs have different physiological effects and are often selected empirically. Hence, an improved understanding of how these drugs affect the AV node conduction properties may contribute to personalized treatment of AF.

Methods: We propose a novel methodology for estimating the refractory period and conduction delay dynamics of the fast pathway (FP) and slow pathway (SP) of the AV node from 24-hour ambulatory ECG recordings. Our approach comprises a network model of the AV node, a problem-specific genetic algorithm, and an approximate Bayesian computation algorithm for estimating the Bayesian posterior distribution of the AV node properties. In addition, the short-term variability in the resulting AV node property trends was quantified using the Kolmogorov-Smirnov (KS) distance between adjacent segments.

Results: We analyzed 24-hour ECG recordings at baseline from 51 patients with persistent AF. The resulting refractory period and conduction delay trends for one patient are shown in Fig 1, where the maximum of the posterior distribution is marked as dots, and the 5% and 95% credibility regions as filled background. Further, relationships between the estimated AV node properties and response to rate control drugs were found. Specifically, a moderate correlation between short-term variability of the FP refractory period at baseline and reduction in heart rate during treatment with verapamil (ρ=0.31, $p < 0.05$) and metoprolol (ρ=0.48, $p < 0.005$) were found.

Conclusion: Model-based analysis enables non-invasive, patient-specific characterization of the AV node conduction properties that could potentially assist in treatment selection.

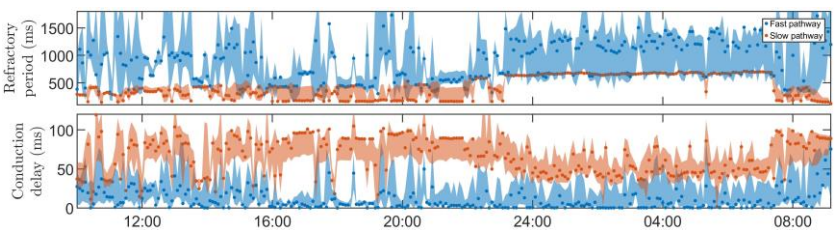

Fig 1. The estimated refractory period (top) and conduction delay (middle) for the maximum of the posterior (dotted) and the 95% and 5% credibility region (filled) for the FP (blue) and SP (red) for one example patient.