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Regional conduction velocity calculation from clinical multichannel electrograms in human atria

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Abstract

Background: During atrial fibrillation, heterogeneities and anisotropies result in a chaotic propagation of the depolarization wavefront. The electrophysiological parameter called conduction velocity (CV) influences the propagation pattern over the atrium. We present a method that determines the regional CV for deformed catheter shapes, which result due to the catheter movement and changing wall contact.

Methods: The algorithm selects stable catheter positions, finds the local activation times (LAT), considers the wall contact and calculates all CV estimates within the area covered by the catheter. The method is evaluated with simulated data and then applied to four clinical data sets. Both sinus rhythm activity as well as depolarization wavefronts initiated by stimulation are analysed. The regional CV is compared with the fractionation duration (FD) and peak-to-peak (P2P) voltages. A speed of 0.5m/s was defined to create the simulated LAT.

Results: After analyzing the simulated LAT with clinical catheter spatial coordinates, the median CV of 0.5m/s with an interquartile range of 0.22 and exact CV direction vectors were obtained. For clinical cases, the CV magnitude range of 0.08m/s to 1.0m/s was obtained. The P2P amplitude of 0.7mV to 3.7mV and the mean FD from 40.79ms to 48.66ms was obtained. The correlation of 0.86 was observed between CV and P2P amplitude, and 0.62 between CV and FD.

Conclusion: In this paper, a method is presented and validated which calculates the CV for the deformed catheter and changing wall contact. In an exemplary clinical data set correlation between regional CV with FD and the P2P voltage was observed.

Highlights:

- Regional CV calculated for stable catheter positions and individual cardiac excitation.
- The algorithm works for different catheter shapes and changing wall contact.
- The algorithm has been benchmarked with simulated data.
- A novel method to identify critical, slow conducting substrate.

Keywords:

Conduction velocity, intracardiac mapping, contact electrodes, local activation time, sinus rhythm.

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Introduction

The atrial substrate is heterogeneous and anisotropic in nature. Patients suffering from atrial fibrillation (AFib) or atrial flutter (AFlut) show additional heterogeneities and anisotropies due to fibrosis or functional blocks. This promotes the initiation and maintenance of AFlut or AFib. Regional analysis is important in order to get the physiological and pathological understanding of the atrial disease and to identify promising ablation sites. For the better understanding of the regional substrate, parameters such as tissue fibrosis, electrogram (EGM) fractionation, propagation patterns are under analysis [1][2][3][4]. Research has been carried out in order to understand the mechanism of cardiac arrhythmias resulting from various heterogeneities [5].