Surface Electrocardiogram Reconstruction Using Intra-operative Electrograms

Hanie Moghaddasi
Circuits and Systems
Delft University of Technology
Delft, The Netherlands
H.moghaddasi@tudelft.nl

Borbála Hunyadi
Circuits and Systems
Delft University of Technology
Delft, The Netherlands
B.Hunyadi@tudelft.nl

Alle-Jan van der Veen
Circuits and Systems
Delft University of Technology
Delft, The Netherlands
A.J.vanderVeen@tudelft.nl

Natasja M.S. de Groot
Department of Cardiology
Erasmus Medical Center
Rotterdam, The Netherlands
N.m.s.degroot@erasmusmc.nl

Richard C. Hendriks
Circuits and Systems
Delft University of Technology
Delft, The Netherlands
R.C.Hendriks@tudelft.nl

ABSTRACT

Atrial Fibrillation (AF) is the most sustained arrhythmia in the heart. On the surface electrocardiogram (ECG), AF is characterised by the irregular RR intervals and by fibrillatory waves or the absence of a P wave. Since AF is a progressive disease, timely and correct detection is crucial for AF treatment. Detailed insight into the areas of arrhythmia-related electropathology can be obtained by analyzing high-resolution (inter-electrode distance 2mm) electrograms (EGMs). However, these measurements are rather invasive. By integration of high-resolution epicardial mapping data and surface ECG data, we hope to learn how different stages of AF represent themselves on the ECG. Eventually this can help to guide to identify areas of electropathology as target sites of ablation therapy on the less invasive ECG. A first step in this direction is to learn how to reconstruct the ECG based on EGM measurements. In practice, however, EGMs are only measured at few atrial locations, not covering the complete atria. An important question therefore is: How can we reconstruct ECG based on the observations from a limited part of the heart? To answer this question, we propose two methods. In the first method, we increase the number of observations from a part of the right atrium (RA) to the whole RA by synchronizing EGMs that are measured at different moments in time based on the local activation time (LAT). In the second method, under the assumption that atrial EGMs measured at different spatial areas are linearly related, the conductivity matrix is estimated for the whole atrium which enables us to reconstruct the ECGs from the limited observations. The second method brings twofold benefits. First, the conductivity matrix can be used as a novel diagnostic tool to detect AF as well as areas of electropathology. Second, it provides a practical solution to reconstruct epicardial potentials from ECGs, non-invasively. The results show that method one increases the reconstruction accuracy. Furthermore, the conductivity matrix reveals the structural differences between sinus rhythm (SR) and AF episodes which could be the first step to interpret the underlying electropathology of AF.

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