Spatio-Temporal Wavefront Isolation: an Approach to Quantify Fibrillation Complexity

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Cardiac fibrillation is a complex arrhythmia whose mechanisms of onset, maintenance and interruption are not completely understood. Quantification of the complexity of fibrillatory processes is an important issue of study since it may help in the understanding of the mechanisms of maintenance of the arrhythmia and for developing better therapies. However, its evaluation is usually restricted to a subjective visual inspection. The purpose of this work is to automate the classification of isochronal maps attending to their organization level. An automatic classification method based on spatio-temporal isolation of activation wavefronts is presented. After detection of activation times in each channel as time instants with the maximum dV/dT, activation volumes were constructed. Activation volumes were split into sub-volumes connected at every time instant. Activation periods, defined as time intervals with a length equal to the dominant cycle length, were classified as type I, II or III based on the quantification of connected sub-volumes. The method was tested on ventricular fibrillation recordings obtained from 17 Langerdorff-perfused rabbit hearts using a 121 multielectrode with (N=9) and without (N=8) perfusion with propranolol. Reproducibility was tested by comparing the results obtained from consecutive two-second segments (5 segments), and significant differences were not found between. The proposed method allowed the detection of changes in complexity caused by propranolol, with an increase in type I activation periods in control vs. propranolol (21.2 vs. 49.9) and a decrease in type II (62.5 vs. 39.4) and type III (16.3 vs. 10.7) activation periods, $p < 0.001$. Therefore, the proposed method appears as a valuable tool for determining the complexity of multichannel recordings obtained during fibrillatory arrhythmias in a fast, automatic and reproducible way.