Improving omnipolar electrogram reconstruction: an animal model study

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Funding Acknowledgements: Type of funding sources: Public grant(s) – EU funding. Main funding source(s): [1] National Research Program, Ministerio de Ciencia e Innovación, Spanish Government [2] Instituto de Salud Carlos III

Background: Cardiac arrhythmias are a significant cause of morbidity and mortality worldwide. The characterization of cardiac tissue’s electrophysiological substrate is crucial for the diagnosis and treatment of these conditions. High-density (HD) electrode arrays, such as the Advisor™ HD Grid Mapping Catheter and Sensor Enabled™ (SE), are commonly used to examine cardiac tissue locally and create activation maps. However, the current method for reconstructing omnipolar EGMs, a novel technique claimed to be orientation-independent, has limitations. The enhancement of this reconstruction methodology has the potential to improve the accuracy and reliability of electrophysiological mapping. This, in turn, can have a positive impact on patients suffering from cardiac arrhythmias, ultimately leading to better clinical outcomes.

Purpose: We propose a novel reconstruction method to estimate omnipolar EGM that overcomes the angle dependence weakness of the current method to enhance the reconstruction of electrophysiological signals.

Methodology: Prior experiments were conducted on isolated rabbit hearts using a 128-electrode array with electrodes spaced 1mm apart over the ventricular epicardium. Four-electrode cliques were designed from these experiments, with different inter-electrode distances as depicted in Figure 1A, to reconstruct the current and novel omnipolar configurations. Metrics were designed to assess the quality of the electrogram signals, including the bipolar loop area and the ratio of the bipolar components of the omnipole (see fig. 2). The bipoles were calculated from unipolar electrograms, and the signal was corrected with a 45º offset in the cross. The propagation angle was then detected, and the local activation time (LAT) was estimated.

Results: In the bipole plots, it was observed that the morphology of the bipolar loop becomes distorted with an increase in the inter-electrode distance, becoming thinner for distances less than 2mm. There is a direct relation between the areas in the bipolar loop and the inter-electrode distance (see Figure 2A). Furthermore, the values of the area in the cross are always comparable to the best-performing triangular clique. For the ratio of bipoles, the relation is inversely related to distance (see Figure 2B). Similarly, the performance of the cross is comparable to the best-performing triangular omnipole.

Conclusion: This study highlights the importance of accurate reconstruction of omnipolar EGMs for the diagnosis and treatment of cardiac arrhythmias. To achieve precise reconstruction, inter-electrode distances smaller than 2mm are recommended. The proposed reconstruction method based on the cross configuration is more accurate and robust to wavefront propagation, provided that the recommended distance criterion is met. This study opens up new possibilities for the design of new devices and practices in the clinic.
Figure 1:

A. A.1 Grid of the coordinates of the equispaced electrodes (inter-electrode distance = 1 mm). A.2 Configurations of the clique; left traditional triangular configurations to reconstruct the omnipole, right proposed one. B: Omnipoole with its corresponding components represented for the estimation of 1. area, and 2. ratio.

Figure 2.

A. Distribution of values of the areas generated by the bipolar loops. B. Distribution of values for the normalised relation between the components of the omnipoole.