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DEVELOPMENT OF A NEW SYSTEM OF IMPEDANCE MAPPING FOR ELECTRICAL ABLATION OF VENTRICULAR ARRHYTHMIAS IN HUMANS: A TRANSLATIONAL APPROACH

Juan M. Cinca Cuscullola
Institut de Recerca Hospital de la Santa Creu i Sant Pau
Xavier Rosell Ferrer
Escola Tècnica Superior d'Enginyeria Industrial - Universitat Politècnica de Catalunya

1. Summary of the project

Catheter electrical ablation is an elective procedure for the treatment of severe ventricular arrhythmias in patients with myocardial infarction. The procedure requires an accurate delineation of the borders of the necrotic zone as these are often the site of arrhythmia origin and therefore the ablation target. Nowadays, recognition of the necrotic zone is based on the detection of low-voltage local electrograms, but the amplitude of these potentials may vary according to the direction of the cardiac activation with respect to the recording site.

Myocardial electrical impedance is an intrinsic property of the heart that is probably not dependent on the cardiac rhythm. Moreover, in previous studies we have found that measurement of myocardial impedance allows detection of structural alterations such as acute myocardial ischemia and chronic infarct scar.

Therefore, the aim of this project was to develop a bioimpedance system able to allow identification of infarct scar areas during the procedure of electrical ablation of ventricular arrhythmias in patients with chronic myocardial infarction.

This is a multidisciplinary translational study. The bench phase of the project was developed on a swine model of chronic (1-month) myocardial infarction induced by catheter balloon occlusion of the left anterior descending coronary. Mapping of local endocardial electrograms guided by electromagnetic cardiac navigator CARTO® was performed to delineate the infarcted region. In addition, simultaneous point-by-point measurement of the module and phase angle of the myocardial electrical impedance was obtained. The accuracy of these two systems to identify the location and extension of the infract scar was evaluated by merging the data with the location and distribution of the infarcted area assessed by gadolinium enhancement in cardiac magnetic resonance.

The clinical phase of the project was carried out in a series of patients undergoing electrical ablation of post-infarction ventricular arrhythmias. The objective of this phase was to construct a bioimpedance system for clinical use and to simultaneously record mapping of voltage electrogram and tissue impedance.

2. Results obtained

1) The magnitude of the module and phase angle of myocardial electrical impedance correlates with the amount of fibrotic tissue contained within the infarcted region.

2) Detection of the infarct scar by measuring the myocardial electrical impedance is more robust than the current assessment based on the voltage of local electrograms. This is based on the fact that the voltage of the electrograms varied when we experimentally modified the cardiac rhythm (i.e. from sinus rhythm to right ventricular pacing). By contrast, impedance data did not change.

3) We constructed a certified system for measuring myocardial impedance in patients undergoing electrical arrhythmia ablation. The clinical use of this system was approved by the Agencia Española del Medicamento y Productos Sanitarios.

4) We have obtained simultaneous point-by-point measurement of the voltage of local electrograms and myocardial electrical impedance in patients undergoing ablation of post-infarction arrhythmias.

5) We have registered a patent entitled "Systems and Methods for Evaluating Infarcted Myocardial Tissue by Measuring Electrical Impedance During Cardiac Cycle" with reference PCT / EP2016 / 056933.

3. Relevance and potential future implications

This project has made it possible to develop a new diagnostic technique able to on-line recognize areas of infarct scar during electrical ablation procedures. This technique is based on the intrinsic myocardial electrical impedance characteristics and has the advantage of not being influenced by changes in cardiac rhythm during the procedure in contrast to the current electrograms voltage approach. Therefore, implementation of both electrograms voltage and myocardial impedance data into the cardiac navigation systems will refine the detection of infarcted areas and, ultimately, the success of post-infarction ventricular arrhythmia ablation in patients.

This project has opened two new working lines of our group:

1) A transference collaborative agreement with Biosense Webster, a worldwide leader in cardiac navigation systems, to implement our bioimpedance methodology into their CARTO® system in order to guide the electrical ablation procedures in patients

2) Assessment of the yielding of our bioimpedance system in the detection of fibrotic tissue in a swine model of atrial myocardial infarction purposely developed recently in our laboratory. This technique will be useful in the ablation of atrial fibrillation, the most frequent arrhythmia diagnosed in clinical practice.

4. Scientific bibliography generated by the project

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Amoros-Figueras, G., Jorge, E., Garcia-Sanchez, T., Bragos, R., Rosell-Ferrer, J., Cinca, J. Detección de la heterogeneidad de la cicatriz de infarto mediante una nueva técnica basada en medidas de bioimpedancia durante el ciclo cardíaco. Rev Esp Cardiol. 2016:69 Supl 1:395 5021-7.