New technologies in electroanatomic mapping for a better mechanism characterization of supraventricular tachyarrhythmias

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Abstract

Background Provide a brief overview of recent technological advances that can potentially give information for treatment of different kind of arrhythmias. **Methods** In this report, we describe the features of Omnipolar technology (OT) using high density mapping catheter and we report five different scenario in which this new tool can give some important information to understand arrhythmia's substrate and guide the treatment. OT combine three unipolar and two bipolar signals and provides maximum voltage regardless of electrode-wavefront orientation, local wavefront activation direction and local measurements of wave speed: it allow to create a velocity map. **Results** OT has been used to study different types of supraventricular tachycardias. Regarding reentry tachycardias, velocity map has allowed the characterization and definition of the impulse velocity along the dual nodal pathway and the accessory pathways (AP). As regards atrial flutter, it has successfully allowed the definition of the slowest zone of the critical isthmus and radiofrequency (RF) delivery at that point resulted in termination of the arrhythmia. During mapping of the left atrium in sinus rhythm, the velocity map allowed the identification of the course of the Bachmann's bundle, which could potentially play a role during the ablation of persistent atrial fibrillation (AF). **Conclusion** OT and velocity map offer significant advantages in the management of challenging arrhythmias, and can potentially improve the efficacy of the treatment of some arrhythmias such as atrial flutter and AF.

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Keywords

Electroanatomic mapping, omnipolar technology, supraventricular tachycardia, velocity map, case series

Abstract

Background

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Methods

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Results

OT has been used to study different types of supraventricular tachycardias. Regarding reentry tachycardias, velocity map has allowed the characterization and definition of the impulse velocity along the dual nodal pathway and the accessory pathways (AP). As regards atrial flutter, it has successfully allowed the definition of the slowest zone of the critical isthmus and radiofrequency (RF) delivery at that point resulted in termination of the arrhythmia. During mapping of the left atrium in sinus rhythm, the velocity map allowed the identification of the course of the Bachmann's bundle, which could potentially play a role during the ablation of persistent atrial fibrillation (AF).

Conclusion

OT and velocity map offer significant advantages in the management of challenging arrhythmias, and can potentially improve the efficacy of the treatment of some arrhythmias such as atrial flutter and AF.

Introduction

Electroanatomic mappings have assumed a more important role in the treatment of arrhythmias. The technology that underlies their mechanism is based on anatomical reconstruction and in some cases on the analysis of the alterations of the substrate that characterize different arrhythmias. Recently there is a great interest in the modalities of atrial activation and how its modifications can lead to the onset of arrhythmias [1]. Other mapping system has introduced the coherent mapping module that integrates local activation time (LAT) information with vector data that allow the identification of slowing conduction areas in macroreentrant arrhythmias [2]. New Ensite OT combine three unipolar and two bipolar signals and provides maximum voltage regardless of electrode-wavefront orientation, local wavefront activation direction and local measurements of wave speed [3,4]. Using this configuration is it possible to create a wave speed map: a color map coded by conduction velocity value giving value of how fast wavefront is moving. Clinical applications of this new technology are not known. The aim of this report is to describe different kind of possible application of this new technology.

Wolff-Parkinson White syndrome

2.1 Overview

In Wolff-Parkinson-White (WPW) syndrome, an extra electrical pathway between atrium and ventricle causes an abnormal conduction to the ventricles. An AP is an aberrant cardiac muscle bundle that connect the atrium to the ventricle, usually at the atrioventricular (AV) annulus. Majority of AV accessory pathway are make up by working myocardial cells: conduction over those AP is mediated by sodium current with an all or none conduction capacity and non decremental electrical properties.

2.2 Case series

We performed electrophysiological study, catheter ablation and mapping to identify the location of the accessory pathway with velocity map in three patients (2 male, median age 45 yo) with WPW syndrome. First, we started with electrophysiology study to assess the electrical property and the risks of accessory pathway. Then, patients underwent standard local activation time (LAT) mapping with Advisor HD Grid multipolar catheter for localization of AP. Advisor HD Grid was used in order to take advantage of OT and new wave speed map. After AP localization we studied the conduction velocity values registered at the level of the pathway. Normal atrial conduction velocity was found to be 1±0.1 m/s, accessory pathway conduction velocity 2.8±0.02 m/s (Fig 1).

Atrio-ventricular nodal reentrant tachycardia (AVNRT)

Overview

Dual AV node physiology characterizes the normal AV node function, and the presence of dual AV node pathways can be demonstrated in most individuals. Although the potential substrate for AVNRT (dual pathways) is normally available, only a minority of normal individuals develop AV nodal reentry. In fact reentry requires other conditions, first of all refractoriness over the two pathways and the presence of a synchronous trigger. Tipically dual pathways have different capacity of conduction and refractoriness (slow and fast).

Case series

Patients who have AVNRT generally have dual atrioventricular nodal physiology and the ability for a reentrant arrhythmia to occur involving the atrioventricular (AV) node. Patients in general have a fast pathway in which normal conduction proceeds down during sinus rhythm. However, patients with AVNRT have one or more slow pathways or additional circuits near the coronary sinus and connected to the AV node that are capable of electrical conduction. In the most common or "typical form" of AVNRT, patients become stuck in a reentrant loop with conduction proceeding down the slow pathway as the anterograde limb of the circuit and back up the fast pathway as the retrograde limb. Wave speed map can be useful to give numeric value of how fast or slow are the two pathways for patients with dual atrioventricular nodal physiology. We studied two patients presenting to our institution for ablation of AVNRT. First, we started with electrophysiology study to assess the presence of dual nodal pathways and then we used Advisor HD Grid to characterize the conduction velocity of the slow and fast pathways in sinus rhythm. Normal atrial conduction velocity was found to be 1±0.1 m/s and slow pathway 0.9±0.1 m/s. We compared standard voltage map and wave speed map indentifiyng the slow pathway localization (Fig 2).

Atrial flutter

Overview

Atrial flutter are one or the most commons atrial arrhythmia. Atrial flutter are classified in typical, who are cavotricuspid isthmus (CTI)-dependent, and atypical. The electrophysiological substrate underlying CTI-dependent atrial flutter has been shown to be macroreentry around the tricuspid valve annulus. In most cases typical atrial flutter have counterclockwise direction around tricuspid valve annulus, in a minority of patients, the direction is clockwise. In both cases the ablation target is bidirectional block through CTI.

Atypical or non isthmus-dependent atrial flutter and atrial macroreentry requires fixed or functional block and regions of slow conduction. This is the result in the most cases of catheter ablation or surgery that involves right or left atriotomies.

Case series

We report 6 cases of atrial flutter (3 atypical, 3 typical) mean age 66.67±9 years. Patients underwent catheter ablation and atrial mapping with the new Ensite X system, using the HD Grid. We compared the standard local activation map (LAT) of the critical isthmus (Figure 3a) with the slowest conduction zone identified with OT (Figure 3b). In patients with atypical flutter critical isthmus were identified in LA roof, in mitral isthmus and in LA posterior wall, near left superior pulmonary vein ostium. Mean velocity value for CTI was 1.08 ± 0.3 m/s, mean velocity value for LA atrial flutter critical isthmus was 9.86 ± 7.26 m/s. The conduction velocity map was used to identify areas of slow conduction throughout the isthmus and wave velocity values of 0.45 +- 0.3 m/s were found to discriminate critical areas of the flutter circuits. The mean LAT map area values are 3.89 +- 2.22 cm2 and the slowest conducting zone identified by OT has a mean area of 1.26 +- 0.82 cm2. A single RF delivery at the slowest site of critical isthmus resulted in rapid cessation of the arrhythmia in all cases.

Atrial fibrillation

Overview

Pulmonary vein isolation (PVI) represents the primary target of current catheter ablation techniques for the treatment of atrial fibrillation. However, PVI has proven to be effective in paroxismal AF, in patients with persistent and long standing persistent AF this seems not enough to obtain a high efficacy [5,6,7]. Recently, some studies have shown that Bachmann's bundle plays a significant role in the genesis of AF and its ablation leads to increase efficacy in terms of AF-free survival at follow up [8].

5.2 Case series

In twelwe patients undergoing AF ablation, voltage map and velocity map of the left atrium in sinus rhythm were registered using HD Grid. The mean age of the patients was 55.5 +- 11.5 yo, 4 (33.3%) were male. Mean left atrial volume was 31.8 +- 8.9 ml/m2. Voltage map showed no areas of fibrosis (< 0.05 mV). The velocity map registered a mean left atrial velocity of 1+-0.1 m/s. Pulmonary vein antra conduction velocity mean value was 1.2 +- 0.4 m/s. In the anterior portion of the LA, a greater mean conduction velocity than the other zone of the LA was recorded (1.7+-0.3 m/s) (Figure 4). This area corresponds to the area where Bachmann bundle run. No variations in impulse speed were noted respect to age and gender.

Conclusions

OT is a promising technology that allows a better characterization of arrhythmias regardless of the position of the catheter to the direction of the arrhythmia and that can find application both in the treatment of supraventricular and ventricular arrhythmias. It also allows quantitative analysis of the conduction velocity and that can be applied in the characterization of macro-reentrant arrhythmias. Electroanatomical mapping has made possible to treat complex arrhythmias that previously were not possible with transcatheter ablation. The technology is constantly updated and the knowledge of the systems used by electrophysiologists and the collaboration with technicians and engineers assumes an increasingly important role.

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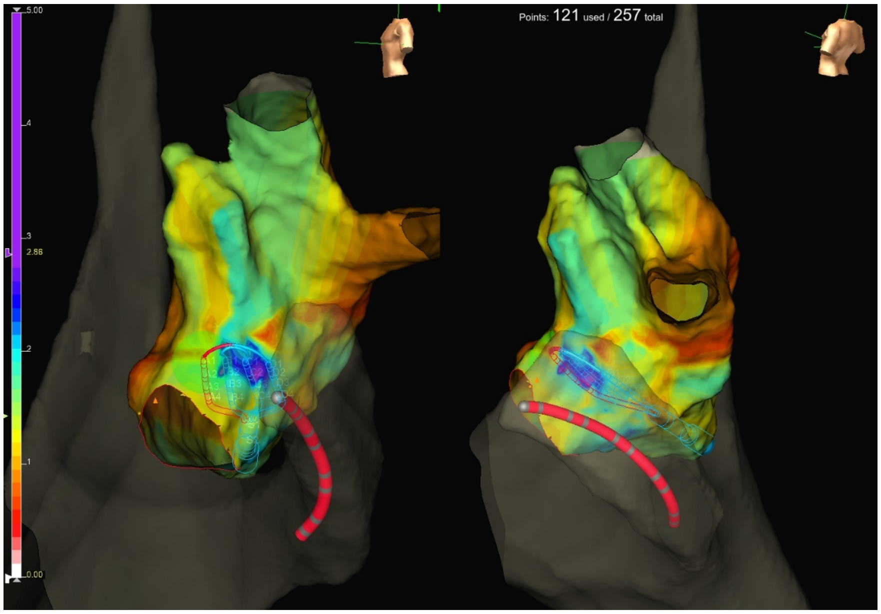

Fig 1. Localization of AP using velocity map. AP has higher spped conduction (violet zone) than other zone

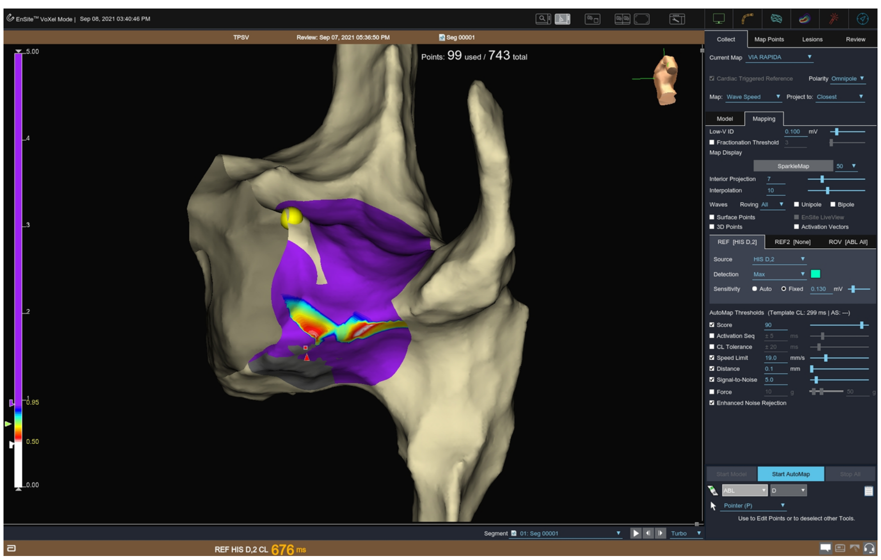

Fig 2. Localization of AV node slow pathway using velocity map. Slow pathway has lower speed conduction (red zone) than the other zone. Yellow dot tag His bundle.

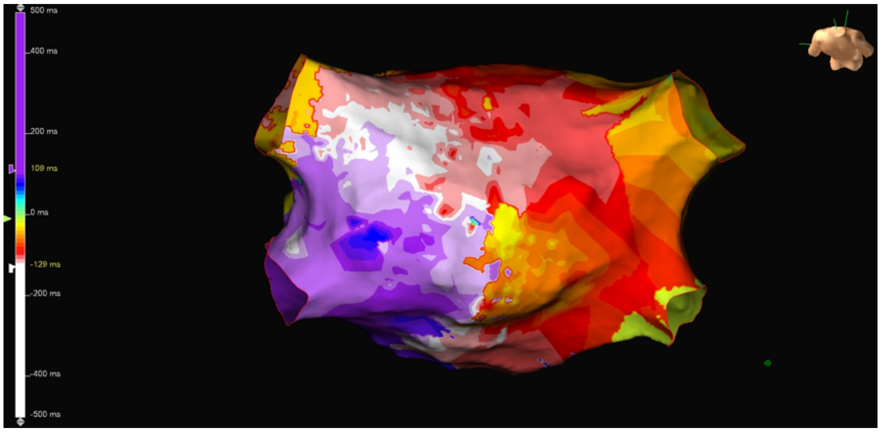

Fig 3. Critical isthmus (white arrows) of LA atrial flutter on activation map (A) and slowdown zone of critical isthmus identified through velocity map (B). RF delivery in that zone results in cessation of the arrhythmia

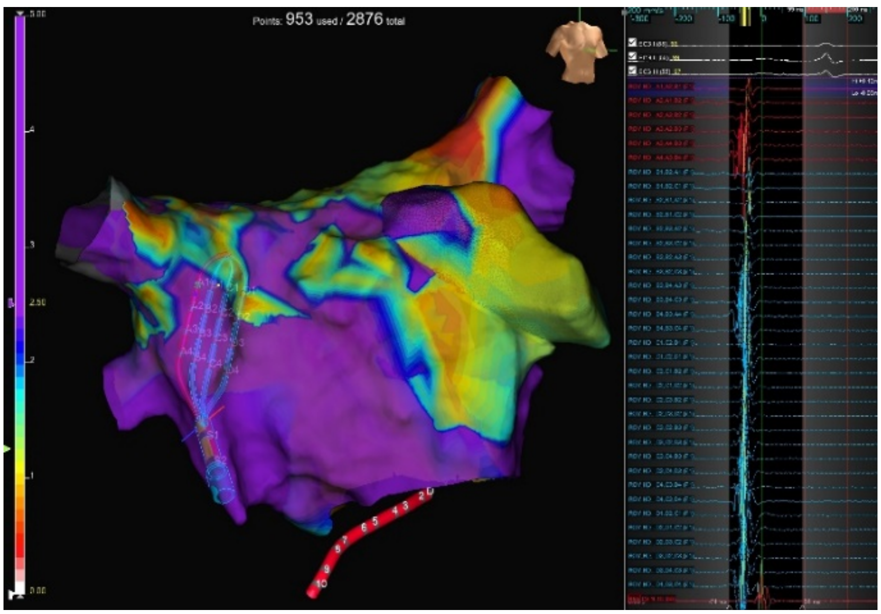

Fig 4. Velocity map of LA in sinus rhythm representing greater velocity conduction in the area of Bachmann's bundle run

Compliance with ethical standard

Conflict of Interest: A.D.R. is a consultant for Abbott. All other authors declared no conflicts of interest.

Ethical approval: Yes

Informed consent: Yes

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