



Electroanatomic Mapping: The 21st Century Approach to Treating Cardiac Arrhythmias

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Catheter ablation using radiofrequency energy was developed in the late 1980s and was described in the literature in 1991 [1,2]. Within a short time the procedure gained acceptance and became widely practiced because of the high success rate and reduced complication rate assured by this titrable and controllable energy [3]. This ablation method was applied to treat the most common focal arrhythmias, like atrioventricular nodal pathways and atrioventricular pathways in patients with Wolff-Parkinson-White syndrome. Using the accepted electrophysiology mapping methods, ablation was attempted for other less common arrhythmias, such as atrial and ventricular tachycardia, where the mapping and subsequently the ablation were more difficult. Moreover, an unusual anatomy may complicate the ablation procedure [4]. For these reasons, new mapping methods were suggested to facilitate the ablation procedure. First, using a large number of electrodes distributed evenly on an expandable basket catheter enhanced electrophysiological mapping [5]. The use of these catheters, although initially embraced with high expectations [6], was technically difficult and complex and was finally abandoned.

During the early 1990s, a new technique to map heart chambers was suggested by Ben-Haim and co-workers [7,8]. This method utilized an innovative idea to locate the catheter tip using an ultralow magnetic field generated by external devices called location pads. This field was detected by a miniature sensor embedded in the tip of the catheter, resembling a regular ablation catheter. By collecting a certain number of points on the surface of the cardiac chamber, both the anatomy and the electrical activation pattern could be simultaneously and virtually reconstructed [7,8]. With this technique, the heart chamber wall can be visualized without any obstacle and the reproducible catheter tip can be returned to the same spot with three-dimensional accuracy. Since the anatomic structure and the electrical activity can be superimposed, the anatomic location and the activation time of that spot can be determined accurately. This technique is called CARTO. Following animal studies the method was applied to the management of human arrhythmias. Originally, several arrhythmias were treated using CARTO. Atrial tachycardia was the first established indication for this type of mapping; however, the added value of the CARTO to the regular electrophysiology

mapping in this arrhythmia was still limited [9,10]. Atrial flutter has become a frequently encountered arrhythmia and is easily manageable with ablation. While most cases can be effectively cured with conventional mapping methods, especially after the introduction of extended tip electrodes, a small percentage did not succeed even after repeated attempts of ablation. The reason for this failure could be incorrect diagnosis, inaccurate mapping, or incomplete ablation lines. In these cases, the electroanatomic mapping could facilitate the diagnostic procedure and help evaluate the integrity of the ablation line [11,12]. A third indication is ablation of ventricular tachycardia. Two different approaches were proposed: one for hemodynamically stable arrhythmias, where the mapping and ablation is similar with the ablation of focal atrial tachycardia. A particular type of ventricular tachycardia is that originating in a distinct focus in the outflow tract of the right ventricle. Usually this tachycardia is approached similarly to the supraventricular tachycardia; however, this procedure is not without potentially severe complications. For this reason, more careful and accurate mapping is helpful. Electroanatomic mapping can locate the tachycardia focus and contribute to more accurate delivery of energy, avoiding ablation of undesired locations [13]. The second type of ventricular tachycardia, mapped and ablated, is geared for patients with arrhythmogenic right ventricular cardiomyopathy [13,14]. Since the location of these tachycardia substrates may be anywhere in the right ventricle, the electroanatomic mapping helps in the location of the tachycardia substrate. The third ventricular tachycardia that needs to be ablated is that originating in a large scar anywhere in the left or right ventricle [15,16]. The pathway responsible for this arrhythmia may be buried in that scar. Anatomic mapping of this scar obviates repeated induction of a hemodynamically compromising arrhythmia, which may result ultimately in destabilization of the patient. Long linear lesions were created in the area of the scar in the attempt to ablate also the responsible pathway. The feasibility of this type of anatomic ablation is not possible without electroanatomic mapping [15,16].

A new and interesting application is focal ablation of the initiating arrhythmia in idiopathic ventricular fibrillation [17]. Although this type of ablation was used in patients with a large

number of episodes requiring appropriate implantable cardioverter defibrillation therapies, it may launch a very important field for the new mapping systems [17]. Other experimental applications were also reported. The same group that describes, in this issue of *IMAJ*, their cumulated experience during the last 10 years performed one of these studies [14]. This group was one of the pioneers in the use of electroanatomic mapping. Although the volume of their procedures is not high, their contribution to developing and implementing this important tool in the field of clinical electrophysiology is considerable [18]. Their results are also not significantly inferior to those of high volume centers.

Finally, electroanatomic mapping has been applied for the safe and successful treatment of atrial fibrillation [19]. For the first time, CARTO mapping enabled effective anatomic mapping of the left atrium and insulation of the pulmonary veins at the atrial insertion without endangering the vein itself. While electrophysiological mapping of the pulmonary vein-left atrium connection was feasible, it was associated with a significantly high incidence of pulmonary vein stenosis and a high recurrence rate. With electroanatomic mapping of the left atrium and the pulmonary veins, the ablation lines could be performed at the atrial site without endangering the veins. When the two approaches were compared, the electroanatomic was significantly superior. Moreover, electroanatomic mapping enabled ablation also in patients with chronic permanent atrial fibrillation [20]. In these patients, it may not be enough to isolate the pulmonary veins, and debulking of the enlarged left atrial mass may be required to ensure a successful outcome.

In conclusion, electroanatomic mapping has opened the door for ablation in almost all types of cardiac arrhythmias encountered in clinical electrophysiology. Clearly, the near future belongs to this non-pharmacologic approach for the treatment of cardiac arrhythmias.

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If you give me six lines written by the most honest man, I will find something in them to hang him

Cardinal Richelieu (1585-1642), French statesman who greatly increased the absolute authority of the Crown and France's power in Europe. He ruthlessly suppressed any opposition.