Biosense Mapping for Ablation of Ventricular Tachycardia in Cardiomyopathy

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Abstract

Using conventional technology, radiofrequency ablation of ventricular tachycardia in cardiomyopathy is frequently unsuccessful because of hemodynamic instability, multiple foci and recurrences. The Biosense CARTO nonfluoroscopic mapping and navigation system, when used to locate the area of the scar or reentry circuit, has the potential to improve the successful ablation, and reduce the rate of recurrence. We report 2 cases here of ventricular tachycardia in cardiomyopathy in which Biosense mapping was useful to identify the area of scar in 1 case, and the area of microreentry circuits in another. Radiofrequency ablation was possible and successful, while the use of conventional mapping was impossible or had recurrence.

Key word : Ventricular tachycardia, Cardiomyopathy, Catheter ablation, Biosense mapping, CARTO System

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Radiofrequency (RF) ablation can eliminate focal ventricular tachycardia (VT) not associated with a diseased myocardium, that is, idiopathic right ventricular outflow tract tachycardia[1] or idiopathic left ventricular tachycardia[2,3]. However, the success of RF ablation of VT in cardio-

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myopathy is limited, and the recurrence rate is frequent[4,5]. VT in cardiomyopathy may have more than one foci, and the hemodynamic instability is frequently found, thus render the mapping difficult if not impossible. Previously, fluoroscopy, along with intracardiac electrogram, has been utilized to localize the catheter for ablation. However, the accuracy of fluoroscopy (even biplane fluoroscopy) in localizing the anatomical boundaries and previous radiofrequency application sites is limited.

The recent development of nonfluoroscopic catheter-based electroanatomical mapping system (CARTO™, Biosense Ltd, Israel) which can create a replica of the anatomy of the cardiac chamber where the tachycardia focus is located, now allows the physician to more precisely locate the arrhythmia focus, or foci, and match it with the anatomy of the heart. It also provides other advantages over fluoroscopic catheter positioning. The system gives the operator three-dimensional, color-coded electroanatomical images, tracks and localizes the mapping catheter tip, and correlates electrophysiological information with a precise endocardial site. The operator can return to the areas of mapping interest and adjacent sites with great precision (<2mm)[6]. The CARTO system may be used to identify and tag areas where the RF energy has been applied, enabling the operator to move the catheter to contiguous sites around the focal origin of the tachycardia for more RF applications as needed to ablate the tachycardia focus. The fragmented electrogram, or double potential or scar area, can be identified and tagged in sinus rhythm, and thus can be used as an anatomical landmark to perform RF ablation when the patient has hemodynamically compromised ventricular tachycardia, and when mapping during VT is impossible[7]. Another advantage of the system is that it can reduce the fluoroscopic time significantly while not increasing the procedure time[8]. We report here the use of CARTO™ Biosense system's help to perform RF ablation in 2 cases of ventricular tachycardia in cardiomyopathy.

METHODS

CARTO System

The details of the system components have been previously published[9,10]. Briefly, the CARTO navigation and mapping system is comprised of a miniature magnetic field sensor, an external ultralow magnetic field emitter (location pad), and a processing unit (CARTO). The location mapping and location reference catheters (NAVISTAR and REF-STAR, Cordis-Webster, Baldwin Park, CA, USA) have electrodes that record unipolar and bipolar signals. Just proximal to the tip electrode lie the magnetic sensors, which are completely embedded within the catheter. Magnetic fields emitting from the location pad are received by the sensor and are transmitted along the catheter shaft to the main processing unit. The location pad is placed beneath the catheterization table and emits ultralow magnetic fields. These fields code the mapping space around the patient's chest with both temporal and spatial distinguishing characteristics. These fields contain the information necessary to resolve the location and orientation of the sensor. We use the CARTO system in conjunction with a conventional computerized electrophysiologic recording system (ART, PRUCKA, NJ,USA).

Catheter Mapping and RF Ablation

A location reference catheter (REF-STAR) is placed on the patient's back at the interscapular area. A 4-pole electrode catheter is introduced *via* the femoral vein and advanced to the right ventricular apex. The bipolar recording from the right ventricular apex or the body-surface ECG is used for the electrical reference ("reference electrogram").

The mapping catheter is introduced *via* the femoral vein and advanced into the right ventricle for mapping. The system gates the location of the mapping catheter to a fiducial point in the cardiac cycle and records it in relation to the location of this fixed reference catheter at that time, thus compensating for both patient and cardiac motion. The initial catheter positioning and the acquisition of the first 3-10 data points are aided by fluoroscopic guidance. The catheter is then moved in the respective chamber with little or no fluoroscopy, and the system analyzes its location and presents it in real time.

Using the fixed fiducial point of the reference electrogram (either the ECG or the intracardiac electrogram), the local activation time is determined by subtracting the time of the local activation event recorded by the mapping catheter from the time of the fixed fiducial point. The local activation time is determined at each site from the mapping bipolar intracardiac electrogram filtered between 30-400 Hz. The stability at each point is assessed for both location and local activation time.

RF energy is delivered between the distal electrode (4-mm) of the location mapping catheter and a large patch electrode which is placed on the patient's back from the EPT generator. Impedance measurements are continuously performed during the ablation.

Cases Illustrations

Case 1

Figure 1 shows the EKG of a 37 year old woman with incapacitating scleroderma who presented frequent palpitations and presyncope. Her VT had left bundle branch block/superior axis QRS morphology with the ventricular rate of 122 bpm. Beta-blockers and amiodarone were given but failed to control the recurrences. Echocardiography showed no pericardial effusion and normal LV function. Coronary angiography was unremarkable and RV angiography showed a dilated and poorly contracting RV as shown in Fig. 2. MRI showed fat infiltration of the right ventricular myocardium, and the diagnosis of arrhythmogenic right ventricular dysplasia was confirmed. The first electrophysiologic study demonstrated inducible ventricular tachycardia with the cycle length of 480 ms, and the earliest site of ventricular activation was at the right ventricular apex. RF ablation was performed at this spot that had exact pacemapping and concealed entrainment with long stimulus-QRS interval, and RF terminated the ventricular tachycardia in 5 seconds. Two weeks later, she had recurrences of VT with the same morphology. We used two catheters to map this tachycardia. The first catheter was a standard quadripolar catheter positioned at the right ventricular apex to record the right ventricular electrogram as the reference electrogram and

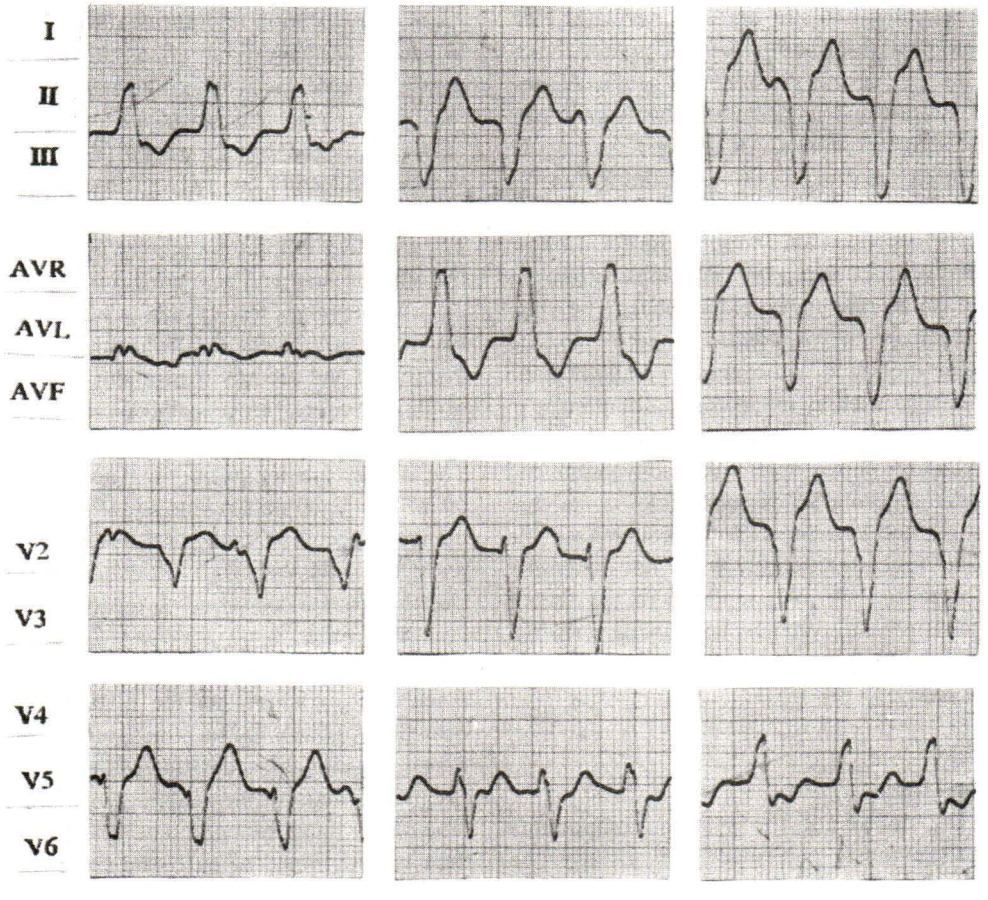

Fig. 1. Twelve lead electrocardiography in patient 1 showed ventricular tachycardia with LBBB and superior axis deviation morphology.

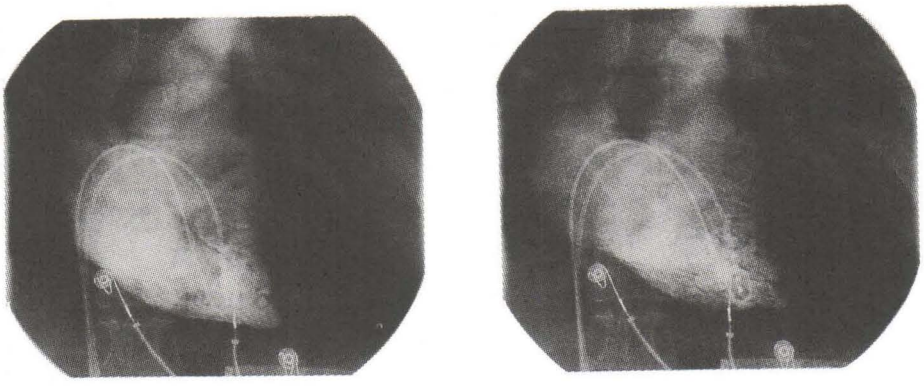

Fig. 2. RV angiography in patient 1 showed dilated RV with poor contraction which were suggestive of arrhythmogenic right ventricular tachycardia.

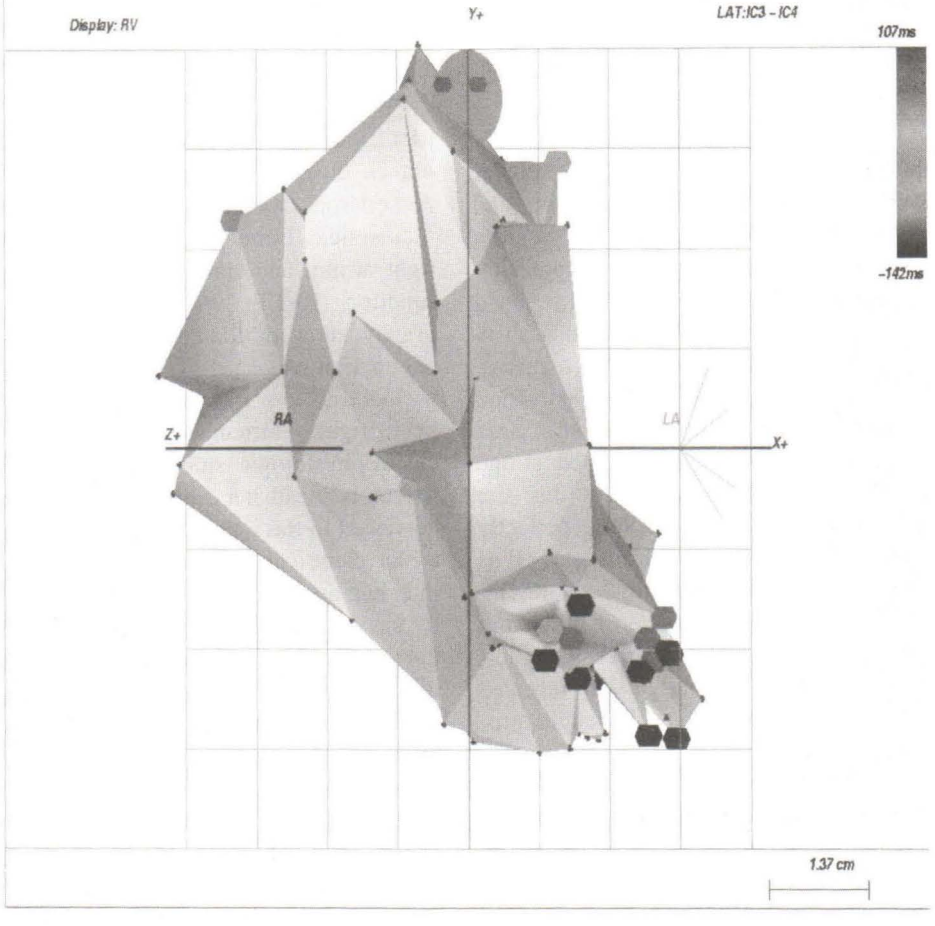

Fig. 3. Biosense mapping showed reentry circuit of ventricular tachycardia in patient 1 at the right ventricular apex. Red dots were the site of radiofrequency ablations.

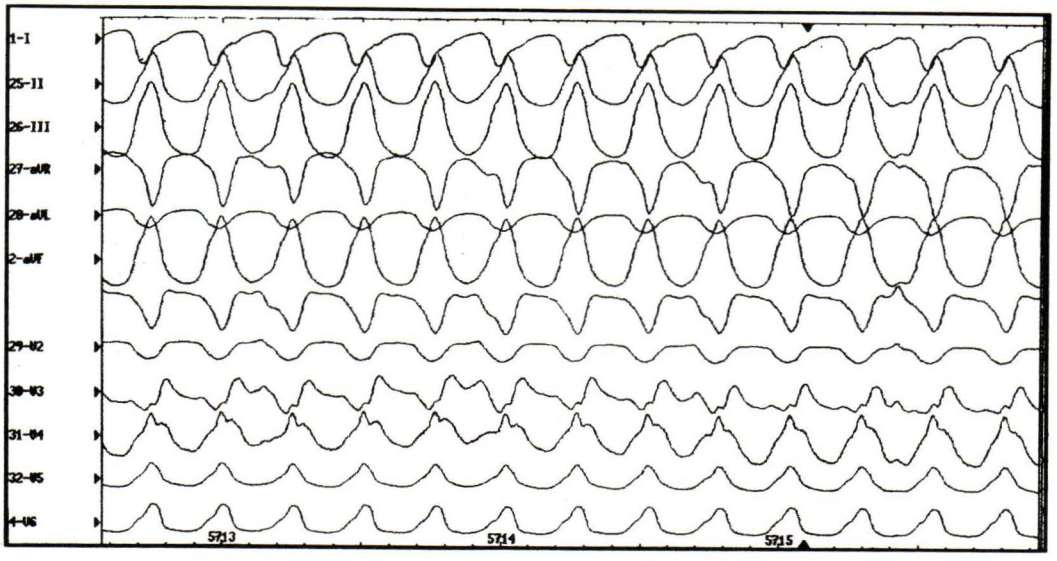

Fig. 4. Twelve lead electrocardiography in patient 2 showed ventricular tachycardia with LBBB and superior axis deviation morphology.

to stimulate the ventricle to induce tachycardia. The second catheter was a NAVISTAR catheter introduced into the right ventricle for mapping and ablation. Activation mapping during tachycardia was performed using the "hot and cold approach"- close toward the arrhythmia focus, the color coded activation sequence was red or yellow; further away from the arrhythmia focus, it was blue or magenta. Figure 3 is a map showing the earliest activation wavefront during tachycardia as red; this area represented the arrhythmia focus situated at the right ventricular apex. Pacemapping at this site showed that the paced QRS morphology perfectly matched those of clinical VT in all leads, as well as concealed entrainment with long stimulus-QRS interval which was obtained at this spot. RF ablation was performed around this area and successfully terminated the tachycardia. VT recurred with repeated stimulation but the tachycardia cycle length progressively lengthened from 519 ms to 632 ms. RF ablation was repeated around this area and finally no arrhythmia was induced. She was discharged uneventfully and no recurrence was detected on subsequent follow-up.

Case II

A 53-year-old man presented frequent palpitations and syncope. Twelve lead electrocardiographies during the attack showed that he had ventricular tachycardia rate >200/min with left bundle branch block/right inferior axis deviation (Fig. 4). Amiodarone was given but failed to prevent the recurrence. Echocardiography showed enlarged right atrium and right ventricle with impaired LV function (LVEF 39%). Right ventricular angiography showed dilated right ventricle with poor contraction and aneurysmal dilatation of right ventricular outflow tract compatible with arrhythmogenic right ventricular dysplasia (see Fig. 5). The electrophysiologic study was performed with the use of two catheters, one quadripolar catheter was advanced to the right ventricular apex and was used as an electrical reference for activation sequence mapping and for tachycardia induction. Double ventricular stimulation at the right ventricular outflow tract induced hemodynamically compromised (systolic BP <30 mmHg) VT and the patient had to be cardioverted immediately. A NAVISTAR catheter was then advanced to map the right ventricle during sinus rhythm. The voltage map was created to show the area of the scar, which was found at the anterior part of right ventricular outflow tract. Linear lesion was then performed from the pulmonic valve to the area of low voltage. After creating this line, no arrhythmia was induced even with triple stimuli at the right ventricular outflow tract and apex with the use of isoproterenol. He was free of symptoms for

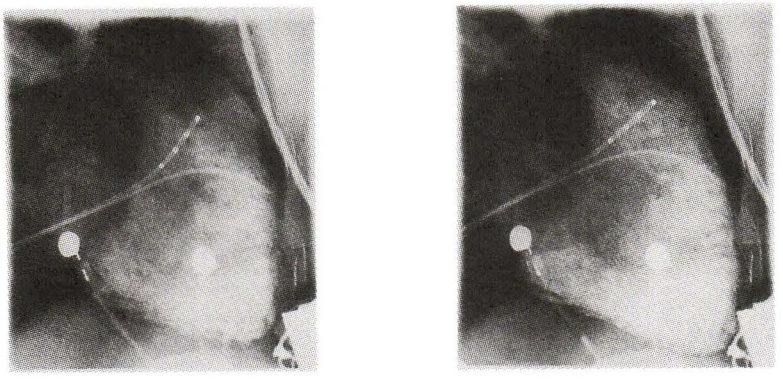

Fig. 5. RV angiography in patient 2 showed enlarged and poorly contracting right ventricle which were suggestive of arrhythmogenic right ventricular dysplasia.

the 7-month period of follow-up with amiodarone 100 mg taken orally every other day.

DISCUSSION

These two case examples demonstrate the usefulness of the CARTO system to guide mapping and RF ablation of VT in cardiomyopathy without using much fluoroscopy. Conventionally, these two cases should be treated with automatic implantable cardioverter defibrillator (AICD) whose efficacy has been proved to be significantly better than antiarrhythmic medication[11,12]. Link et al[13] reported 12 cases of arrhythmogenic right ventricular dysplasia who were treated with AICD and found that the frequency of appropriate therapy is high (8 out of 12 patients) supporting the use of AICD in this disease. The implantation of AICD in the first patient was considered impossible because of the very severe nature of scleroderma, and the second patient refused the treatment of AICD due to economic problems. Both patients failed antiarrhythmic medications including betablockers and amiodarone. Previous conventional RF ablation in the scleroderma patient was successful but had early recurrence even with achieving many of the criteria of successful RF ablation, i.e., exact pacemapping, earliest ventricular activation time >-30 ms, concealed entrainment, long stimulus-QRS interval and disappearance of ventricular tachycardia within 10 seconds of RF application[14]. RF ablation was not possible in the second case because of hemodynamic instability.

The mechanism of arrhythmia in the scleroderma patient was reentry because the arrhythmia was reproducibly induced and terminated with programmed ventricular stimulation, and concealed entrainment was demonstrated. The biosense mapping showed a well-defined early activation site (red area) surrounded by later activation time which is characteristic of focal arrhythmia. These findings suggested that the mechanism was microreentry. The ability of the CARTO system to store the earliest ventricular activation site and ablation sites facilitated the ablation and reduced the recurrence which occurred previously. The mechanism of the arrhythmia in the second case was scar-related reentry, and the termination of the tachycardia was achieved when RF ablation was applied from the area of the scar to an anatomical boundary, which in this case was the pulmonic valve. The unique ability to localize and store the sites of RF application by the CARTO system greatly facilitated the localization of any defect in the ablation line as in the case of atrial flutter ablation[7]. Although mapping during ventricular tachycardia was impossible due to hemodynamic instability, the voltage map of the Biosense system enabled us to identify the area of the scar at the right ventricular outflow tract and enabled us to perform the radiofrequency ablation even in the sinus rhythm. This same approach has been used in the case of ventricular tachycardia in coronary artery disease as described by Nakagawa et al[7].

SUMMARY

The Biosense CARTO mapping system is a novel nonfluoroscopic electroanatomical mapping system. The ability to associate electrophysiological data with the spatial anatomy of the heart has the advantage of providing added value to the understanding of the mechanisms involved in the genesis of arrhythmia, assisting the design of ablation strategies and enables us to deliver RF energy in a precise and accurate manner, thus improving the success rate and reducing the recurrence with less fluoroscopic time.

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การใช้ไบโอเซนส์ ในการรักษา ventricular tachycardia ด้วยการจี้ด้วยคลื่นไฟฟ้าความถี่สูงผ่านสายสวนหัวใจ

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การจี้ด้วยคลื่นไฟฟ้าความถี่สูงผ่านสายสวนหัวใจเป็นการรักษาการเต้นหัวใจผิดจังหวะวิธีใหม่ซึ่งได้ผลดีในผู้ป่วย supraventricular tachycardia อย่างไรก็ตามในการรักษาผู้ป่วยโรคกล้ามเนื้อหัวใจที่เกิด ventricular tachycardia การรักษาด้วยวิธีดังกล่าวได้ผลไม่ดีเนื่องจากการเปลี่ยนแปลงทาง hemodynamic, มีจุดกำเนิดหลายจุดและมีการเกิดซ้ำได้สูง การใช้เทคนิคการทำ mapping โดยใช้ biosense mapping สามารถทำให้ทำการรักษาได้ดีขึ้น โดยสามารถหาตำแหน่งของรอยแผลเป็นหรือ reentry circuit ได้แน่นอน ผู้รายงานได้นำเสนอผู้ป่วย 2 รายที่เป็น ventricular tachycardia ที่เกิดขึ้นในโรค arrhythmogenic right ventricular dysplasia และใช้ biosense mapping ได้ผลดีในการรักษา ผู้ป่วยรายแรกการใช้ biosense mapping ทำให้สามารถหาตำแหน่งของรอยแผลเป็น และผู้ป่วยรายที่ 2 สามารถหาตำแหน่งของ microreentry ได้ การจี้ด้วยไฟฟ้าความถี่สูงในผู้ป่วยทั้ง 2 รายได้ผลสำเร็จและไม่มีการเกิดซ้ำ

คำสำคัญ : biosense mapping, การจี้ด้วยไฟฟ้าความถี่สูง, โรคกล้ามเนื้อหัวใจ, ventricular tachycardia

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