First Clinical Experiences with a Novel Non-Contact Mapping System

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Summary

The novel 9 F non-contact multielectrode array (EnSite, Endocardial Solutions Inc.) enables the simultaneous reconstruction of 3360 unipolar endocardiograms. Furthermore, the system allows to localize the position of a conventional ablation catheter in the space using a 5.8 kHz locator signal. First, moving the ablation catheter to well defined sites of the examined chamber, a three-dimensional anatomic computer model is calculated. Next, after the induction of the arrhythmia, the color-coded isopotential maps are projected on the anatomic model. Finally, using the locator signal, the ablation catheter can be led in a previously off-line defined ablation site. Since April 1999, nine patients have been (1 inappropriate sinus tachycardia, 3 atrial tachycardia, 1 WPW-Syndrome, 4 ventricular tachycardia) ablated with the non-contact system. The mapping balloon and ablation catheter were introduced via femoral artery or femoral vein. In the case of supraventricular tachycardia, an additional decapolar electrode was introduced in the coronary sinus. Prior to the inflation of the multielectrode balloon, all patients had been intravenously heparinized. Conclusions: The novel non-contact mapping system is a useful tool in the ablation treatment of "difficult" arrhythmias. The system enables the visualization of activation of focal or reentrant arrhythmias. After initial experiences, the use of the system is feasible and safe. Possible problems are the thickness and the thrombogenity of the mapping catheter.

Key Words

Non-contact mapping, tachycardia, radiofrequency ablation

Introduction

Since its introduction, radiofrequency ablation has become the most powerful technique and the first choice method for the treatment of different arrhythmias [1,2]. Catheter ablation is well established in the treatment of patients with AV-nodal reentrant tachycardia, preexcitation syndrom or typical atrial flutter [3,4]. However ablation therapy of other arrhythmias like focal atrial tachycardia, ventricular tachycardia or atypical atrial flutter is feasible, but it is associated with a relatively low success rate, with high recurrency rates and, in some cases, with a long fluoroscopy time. Extended simultaneous and sequential mapping systems were designed to help electrophysiologists to treat these "difficult" arrhythmias and to visualize the endocardial activation. Simultaneous mapping systems are collecting electrograms from virtually all endocardial target sites at the same time [5,6]. With this technique, a single beat of the tachycardia is theoretically enough to localize the site of origin or the breakthrough site of the arrhythmia. This is very helpful when the patient is hemodynamically unstable or the induction of a sustained arrhythmia is difficult.

Methods

The EnSite® system (Endocardial Solutions Inc., Saint Paul, MN, USA) consists of the multielectrode array (MEA), the patient-interface unit (PIU) and the computer workstation. The MEA, is a 9-F 64-polar electrode wire braid around a fluoroscopy contrast medium filled 7.5 ml balloon (Figure 1). Through a 0.0025-inch break in insulations, each wire records a unipolar far-field ECG. A ring electrode on the proximal shaft of the MEA serves as a reference for unipolar recordings. Upon the collected unipolar electrograms via the electrode wire, the custom made software is able to recon-

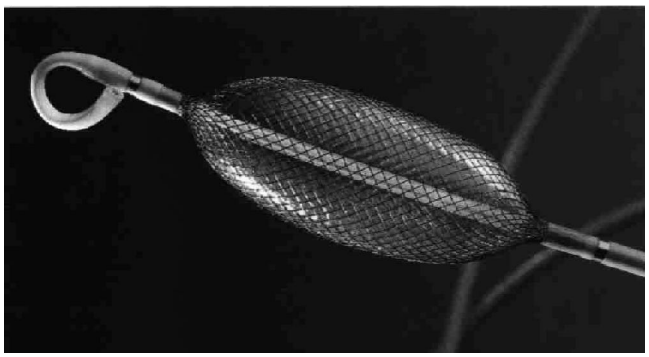

Figure 1. EnSite® catheter with deployed 7.5 ml balloon with braided MEA. During assembly, a laser is used to remove a single spot of insulation on each wire.

struct 3360 virtual endocardial electrograms.

The 9-F MEA and the 7-F ablation catheter were introduced via the femoral artery (all VT cases) and via the femoral vein (WPW, inappropriate sinus tachycardia and atrial tachycardias). In the cases of supraventricular tachycardia, an additional decapolar electrode was introduced in the coronary sinus. Prior to the inflation of the multielectrode balloon, all patients had been intravenously heparinized.

With help of an electrical signal generated by the system (locator signal), a conventional ablation catheter can be localized in the heart chamber and also displayed on the computer screen. After placing the MEA and the ablation catheter in the chamber to examine, the landmarks in the chamber (for example in the right atria: vena cava superior and inferior, coronary sinus, tricuspid ring, septum, lateral, anterior and posterior wall) dragging and rotating the ablation catheter are to be defined. Using these marked sites, the software constructs the three dimensional anatomical computer model of the endocardium. In a next step, color-coded isopotential maps are generated based on the registered online (during the tachycardia), and virtual electrograms are calculated. The isopotential maps of the tachycardia beats are then projected off-line (in sinus rhythm) on the anatomical map. After the possible ablation site has been identified by the investigator and marked on the computer screen using the locator signal, the ablation catheter can be navigated without fluoroscopy on the preselected site. In almost all cases, the ablation can be performed in sinus rhythm.

Results

Since April 1999, ten patients have been selected for radiofrequency ablation with the non-contact system. Despite electrical and pharmacological stimulation, one patient with focal atrial tachycardia was not inducible and therefore ablation was not performed. Table 1 shows the clinical characteristics of the remaining consecutive nine patients.

The site of earliest activation (SEA) in our patient with inappropriate sinus tachycardia was in the posterior right atrium, on the ostium of the superior vena cava corresponding the sinus node. Multiple energy applications in this area were needed to reduce the heart rate. Interestingly, after each radiofrequency applications, caudal shifting of the SEA was detectable with the mapping system. Finally, a heart rate reduction from 130 ppm to 90 ppm was achieved. In the other patients with atrial tachycardia, the SEA was identified in the

Number/ Gender	Heart Disease	Age	Diagnosis	Success	Energy Applications	Fuoroscopy Time	Post-Procedure Antiarrhythmics
1/f	none	68	AT	yes	7	19	none
2/f	none	61	iST	yes	23	24	bisoprolol
3/m	none	45	AT	yes	5	14	none
4/m	dCMP	49	VT	yes	14	42	amiodarone
5/m	CAD	67	VT	no	28	32	amiodarone
6/m	none	21	idiopathic VT/VPB	yes/no	22	55	none
7/m	none	46	WPW	yes	8	39	none
8/m	CAD	65	VT	yes	4	34	amiodarone
9/m	none	67	AT	yes	11	15	none

Table 1. Clinical characteristics. All patients with VT had implantable cardioverter defibrillators. The mean age was 54 ± 16 years, the mean fluoroscopy time was 30 ± 14 minutes. The mean follow-up time was 4.8 ± 2 months. (VT = ventricular tachycardia, AT = focal atrial tachycardia, iST = inappropriate sinus tachycardia, VPB = ventricular premature beats, CAD = coronary artery disease, dCMP = dilated cardiomyopathy).

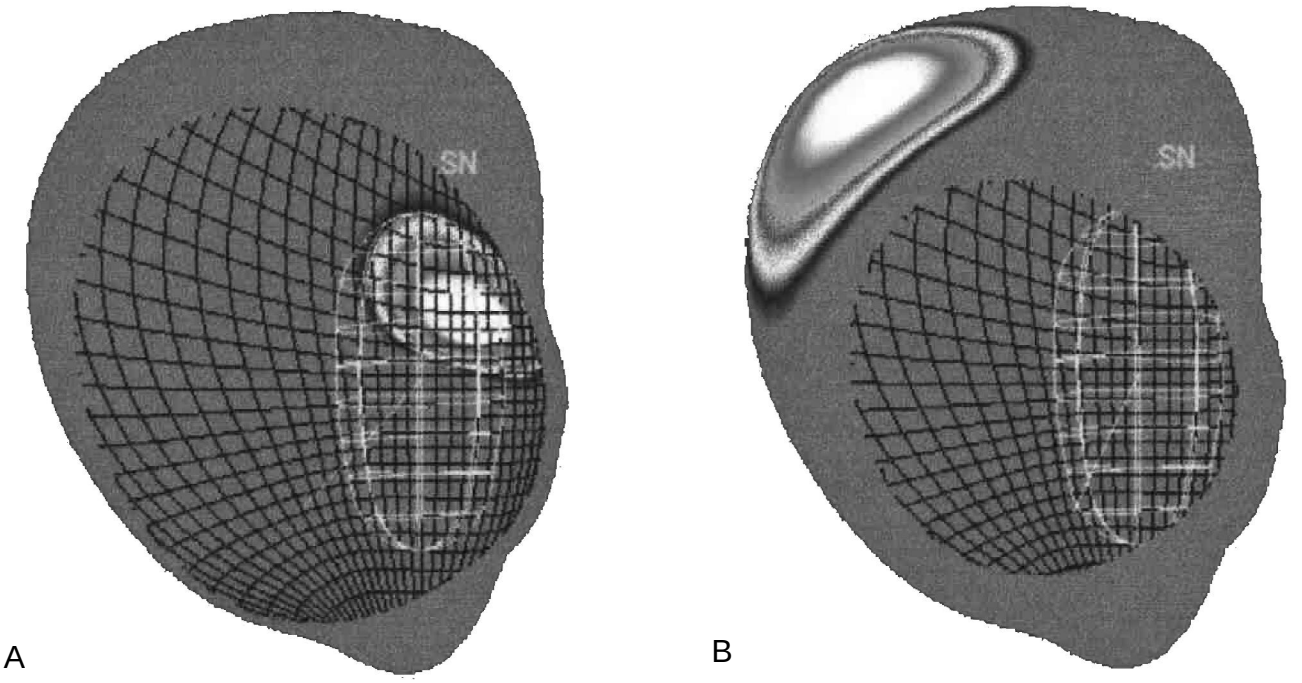

Figure 2. 3-D computer model of the right atrium (with the outline of the MEA) in patient #1. Panel A displays the earliest activation in the posterior sinus node (SN) area during sinus rhythm. Panel B shows the site of earliest activation of the tachycardia on the right free wall.

right atrial free wall (patient #1 and #3) and high atrial septum (patient #9). Figure 2 shows the SEA in our first patient.

In the successful cases of VT, multiple endocardial exit sites (#4 - 3 sites and #8 - 2 sites) were identified with the non-contact system. Both patients had a significant reduction of the tachycardia episodes and up to now no ICD discharges after radiofrequency ablation.

In patient 5, left-sided VT with multiple exit sites resulting in different tachycardias were identified. Despite extended radiofrequency applications, the tachycardia remains inducible.

In patient 6, idiopathic ventricular tachycardia with apical exit site and premature beats with left midseptal exit site were identified. Despite successful ablation of the VT, the focus of the frequent premature beats could not be ablated, possibly due to deep intramural localization of the focus. Figure 3 displays the part of the reentry circuit with the exit site on the apex of the left ventricle.

Patient 7 with WPW-syndrome had a recurrence of the tachycardia after conventional radiofrequency ablation. The atrial insertion part of the right posteroseptal accessory pathway was identified, guided by the locator signal, and successfully ablated.

There were no death or other procedure related complications.

Discussion

This paper outlines our first clinical experiences based on ten cases with a novel non-contact endocardial mapping system.

All selected patients had arrhythmias difficult to ablate using conventional mapping techniques (4 cases with VT, 1 inappropriate sinus tachycardia, 1 right posteroseptal Kent-bundle and 3 focal atrial tachycardia).

The non-contact system using isopotential maps is helpful to visualize activation fronts and understand the mechanism of both focal and reentrant arrhythmias. With this simultaneous mapping system, a single beat of the tachycardia is theoretically enough to calculate the maps. This is a very important feature in the ablation therapy of hemodynamically unstable ventricular arrhythmias. The locator signal can lead the ablation catheter to the off-line marked target site.

However, the "ideal" ablation site of a given arrhythmia remains uncertain. The post-ablation shift of a previously defined exit site is a common phenomenon,

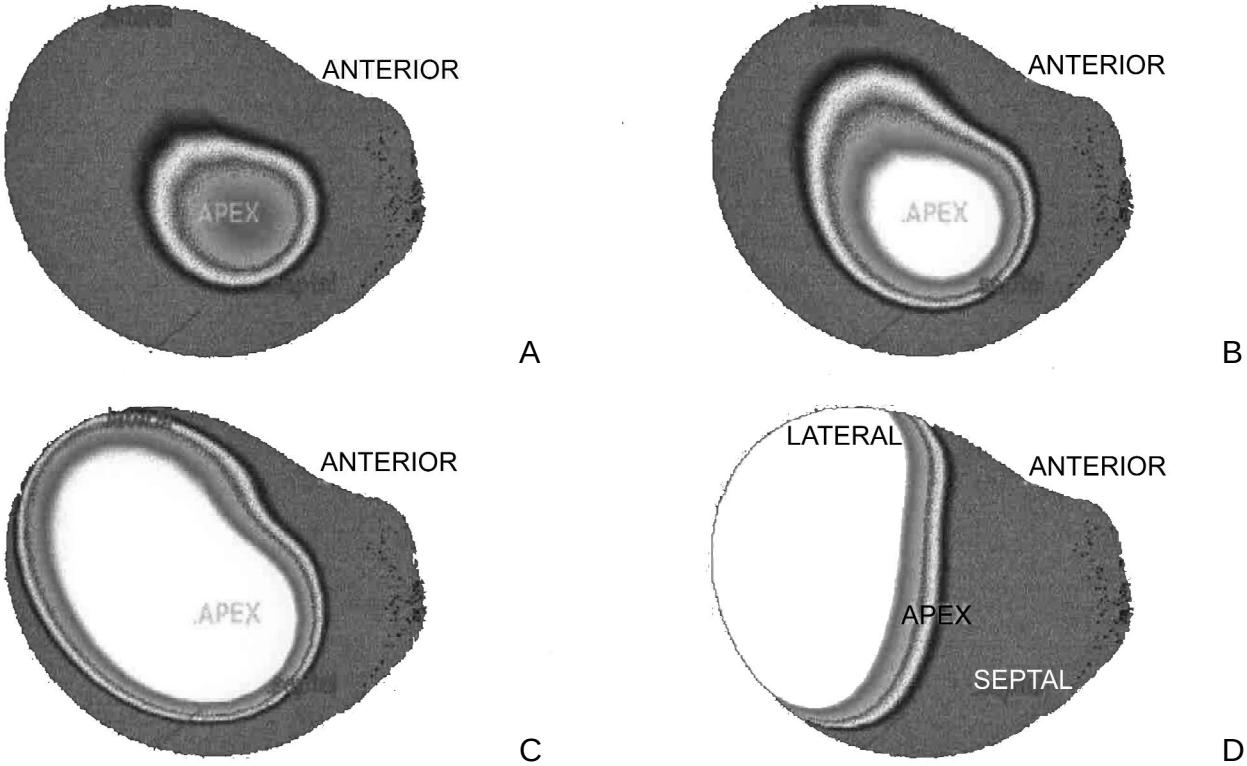

Figure 3. 3-D computer model of the left ventricle in apical view. Panel A shows the breakthrough site of the VT in the apex. Panels B,C,D display the spreading activation of the reentry in the lateral wall.

especially in case of VT in patients with ischaemic cardiomyopathy. This may also be responsible for the high recurrence rate in these cases. In our opinion, the relatively long fluoroscopy time can be reduced with growing experiences. Possible vascular complications like pulmonary embolism or stroke were not observed in this series.

In conclusion, the non-contact mapping system is feasible and safe in the treatment of different atrial and ventricular arrhythmias.

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