The Efficacy of Radiofrequency Catheter Ablation for the Treatment of Ventricular Tachycardia Associated With Cardiomyopathy

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We performed radiofrequency catheter ablation (RF ablation) for ventricular tachycardia (VT) in 2 patients with dilated cardiomyopathy (DCM) and 1 patient with arrhythmogenic right ventricular dysplasia (ARVD). Patient 1 had incessant VT associated with DCM. RF ablation was performed where diastolic potentials were recorded and concealed entrainment was demonstrated. VT was terminated by RF ablation. Patient 2 had drug-resistant VT associated with ARVD. RF ablation was performed where perfect pace-mapping was obtained during sinus rhythm, diastolic potentials were recorded and concealed entrainment was demonstrated. VT was terminated by RF ablation. Patient 3 had 2 morphologically distinct VTs associated with DCM. The target for RF ablation was 1 of the 2, which was a drug-resistant type. Perfect pace mapping was obtained where delayed potentials were recorded. As the current strength of pacing was reduced, the QRS complex configuration switched to the other type. This site was thought to be the common slow conduction zone for the re-entry circuit of the 2 types and RF ablation was performed at this site. In these 3 cases, VT did not recur after ablation. RF ablation is effective for the treatment of VT associated with cardiomyopathy.

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Key Words: Radiofrequency catheter ablation; Cardiomyopathy; Ventricular tachycardia; Concealed entrainment

Treatment of recurrent, sustained ventricular tachycardias includes antiarrhythmic drug therapy, electrophysiologically guided ventricular surgery, transcatheter electrical ablation, and automatic implantable cardioverter/defibrillator (AICD) therapy. Patients who have drug-resistant ventricular tachycardia (VT) or who are intolerant of the side-effects of antiarrhythmic drugs even although the drugs effectively suppress those arrhythmias often need nonpharmacologic therapy. The risk of electrophysiologically guided ventricular surgery is high for patients with either low ventricular function or severe noncardiac diseases1-3 It has also been reported that the risk of transcatheter ablation using direct current is high5,5.

There are many reports that radiofrequency catheter ablation (RF ablation) is highly effective in the treatment of idiopathic or bundle branch re-entrant VT9-11 It is reported that RF ablation is effective in the treatment of re-entrant VT with old myocardial infarction if the site of the slow conduction zone, which is a factor in the maintenance of re-entrant VT, is accurately determined and ablated12.

The aim of this study was to evaluate the efficacy and safety of RF ablation for the treatment of recurrent, sustained VT associated with nonischemic organic heart diseases.

Methods

Patient Characteristics

As shown in Table 1, our study included 2 patients with idiopathic dilated cardiomyopathy (DCM) and 1 with arrhythmogenic right ventricular dysplasia (ARVD) whose VT fulfilled the following criteria: (1) failure of antiarrhythmic drug therapy, (2) absence of hemodynamic collapse during VT, (3) documentation of clinically spontaneous sustained VT with a 12-lead
Table 1 Characteristics of Patients, Ventricular Tachycardias and Antiarrhythmic drugs

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<thead>
<tr>
<th>Patient No.</th>
<th>Age (yrs)/sex</th>
<th>Heart disease</th>
<th>LVEF (%)</th>
<th>Ventricular Tachycardia</th>
<th>Antiarrhythmic drugs tried before ablation</th>
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BBB, bundle branch block; CL, cycle length; PE, partially effective; NE, not effective; PA, proarhythmia

electrocardiogram (ECG) recording and (4) reproducible induction of clinical VT.

Electrophysiologic Study

After obtaining written informed consent, electrophysiologic studies were conducted with patients in the post-absorptive and nonsedative states. Antiarrhythmic drugs had been discontinued for a period of more than 5 half-lives in patients 2 and 3. In patient 1, electrophysiologic study and catheter ablation were performed under administration of MS-551 and mexiletine because this drug therapy slowed VT without changing the QRS configuration and causing hemodynamic collapse.

A 7F hexapolar electrode catheter (USCI) was inserted percutaneously into the right subclavian vein and was positioned under fluoroscopy at the right ventricular apex for both recording and stimulating the right atrium and the right ventricle. A 6F quadripolar electrode catheter (USCI) was inserted percutaneously into the right femoral vein and was positioned across the tricuspid valve for recording the His bundle electrogram. For mapping and ablation, a 7F quadripolar deflectable electrode catheter with a large tip (Webster Laboratories) was inserted percutaneously from the right femoral vein and was advanced into the right ventricle in patient 2 and from the right femoral artery into the left ventricle in patients 1 and 3. A 2500-U bolus of heparin was administered intravenously, followed by 500-U/h while the catheter was in the left ventricle.

Intracardiac electrograms with surface electrocardiograms were simultaneously displayed and recorded on a multichannel oscillographic photographic recorder (Omnicorder 8M14, San-ei Co) at a paper speed of 100 mm/sec.

Endocardial Mapping Study

The mapping procedure to detect an appropriate site for ablation included pace mapping during sinus rhythm, endocardial activation mapping, identification of diastolic potentials and pacing interventions during VT. Pace mapping was performed at the cycle length of the clinical tachycardia. The exit site of VT was considered if the paced QRS configuration was identical to the clinical one in a 12-lead ECG recording.

After the pace mapping, VT was induced by programmed right ventricular stimulation. The stimulation protocol included the application of up to 2 extra stimuli during sinus rhythm and paced cycle lengths of 600 and 500 msec with a current strength twice the diastolic threshold.

Endocardial activation-sequence mapping was performed to record the earliest endocardial activity and
Fig 1. Case 1. (A) Recording during sustained VT with a cycle length of 450 msec. Three surface electrocardiographic leads (I, II, V1) and endocardial electrogams from the high right atrium (HRA), His bundle (HBE) and left ventricle (LV). dis, distal recording from a quadripolar catheter; prox, proximal recording. Continuous diastolic potentials were recorded 210 msec before the onset of the QRS complex. (B) Pacing from LV dis was performed at a cycle length of 400 msec. The stimulus to the QRS interval was 210 msec.

diastolic potentials during VT. When diastolic potentials were recorded during VT, we measured the interval between the diastolic potential (dp) and the onset of the QRS complex (dp-V). Pacing was performed to induce concealed entrainment at a site within the ventricle where diastolic potentials could be recorded. Characteristics of concealed entrainment are that (1) pacing performed during VT causes a paced QRS wave that is identical to the VT wave on a 12-lead ECG, (2) there is a long interval between a pacing stimulus and ventricular activity, and (3) the QRS complex rate accelerates to a rate identical to the paced rate. During concealed entrainment, we also measured the interval between pacing stimulus (st) and ventricular activation (V) resulting from that stimulus, st-V. The sites where concealed entrainment could be demonstrated were used as primary targets in selecting the RF ablation site.

Ablation Protocol

Catheter ablation was performed with the large-tip catheter used for the mapping procedure. The distal electrode of the mapping catheter was attached to a radiofrequency generator (HAT 200S, Osypka) and was used as a cathode. A large patch electrode was placed on the left side of the back. Radiofrequency current was delivered between the distal electrode and the patch electrode for 30—60 sec with energy of between 30 and 35 W.

Results

Patient 1

A 53-year-old man was admitted to our hospital in August 1993 because of sustained monomorphic VT
with DCM. On admission, he had many episodes of an incessant form of VT despite various treatment regimens. During left ventricular mapping, diastolic potentials were recorded from the distal pair of electrodes of the catheter positioned at the site recording the earliest endocardial ventricular activity. Catheter position was at the anterolateral wall in the left ventricle. The duration of dp-V was 210 msec (Fig 1A). At this site, pacing at the cycle length of 400 msec did not change the QRS complex configuration (Fig 2) and the st-V interval was 210 msec, which was equal to the dp-V interval (Fig 1B). As concealed entrainment was demonstrated, catheter ablation was performed at this site. After several seconds, current delivery at a power setting of 30 W terminated VT (Fig 3) and then ablation was continued for up to 30 sec. Thirty minutes after an additional application for 30 sec, VT could no longer be induced. Twenty-three months after the procedure, the patient is free of recurrences of VT under the same administration.

**Patient 2**

A 66-year-old woman was referred to our hospital in November 1993 because of sustained VT associated with ARVD. She had already been implanted with an AICD because of syncope in December 1991, but she continued to experience frequent attacks of slow VT without hemodynamic collapse. These ventricular tachycardias could not be terminated by injection of antiarrhythmic drugs. She also dreaded or feared
AICD shocks. Taking all factors into consideration, treatment by catheter ablation was chosen. The ablation was performed in the absence of antiarrhythmic medication. During sinus rhythm, a delayed potential was recorded from the distal pair of electrodes of the mapping catheter positioned at the right ventricular free wall (Fig 4). Pacing at a cycle length of 600 msec at this site produced the same QRS complex configuration as during VT (Fig 5). Then VT at a cycle length of 410 msec was induced by programmed right ventricular stimulation. During VT, a diastolic potential was recorded at this site 195 msec before the onset of the QRS complex (Fig 6A). At this site, pacing at a cycle length of 380 msec did not change the QRS complex configuration (Fig 7). The st-V interval of 195 msec was equal to the duration of dp-V (Fig 6B). As the criteria of concealed entrainment were fulfilled, catheter ablation was performed at this site. After several seconds, current delivery at a power setting of 35W terminated VT (Fig 8) and then ablation was continued for another 30 sec. VT was no longer induced, and 20 months after the procedure the patient is free from recurrences of slow VT although the AICD delivered a few shocks for syncope owing to VT with hemodynamic collapse.

Patient 3

A 53-year-old man was referred to our hospital in December 1993 because of attacks of sustained VT associated with DCM. He had had a permanent cardiac pacemaker implanted in 1990 for symptomatic bradycardia with atrial fibrillation. On admission, he had 2 types of VT, type A and type B (Fig 9, left). After admission, type A did not recur with improvement of congestive heart failure. However, type B remained resistant to antiarrhythmic therapy. Ablation therapy was applied to type B. During pacing rhythm, a delayed potential was recorded from the distal pair of electrodes of the mapping catheter at the posterobasal wall of the left ventricle. Pacing at a cycle length of 440 msec at this site showed the same QRS complex.
configuration as during type A VT. As the current strength of pacing was gradually reduced, the configuration of the QRS complex switched from type A to type B (Fig 9, right). This phenomenon was recognized reproducibly. Intracardiac electrograms showed that the duration of st-V was prolonged from 90 msec to 250 msec with type A changing to type B (Fig 10). As we thought that the catheter was positioned at a common slow conduction zone for the re-entry circuit of both type A and type B, ablation was performed at this site. After application of radiofrequency current at a power of 30 W for 30 sec, VT of type B could no longer be induced. Thirty minutes after the application, no type of VT could be induced. Seventeen months after the procedure, the patient is free from recurrences without antiarrhythmic drugs.

Complications
No complications were observed in these 3 cases.

Discussion
RF ablation has become the primary means of treating paroxysmal supraventricular tachyarrhythmia. Moreover, it has been reported that RF ablation is useful for treating idiopathic VT. However, the clinical significance of ablation therapy for VT associated with organic heart diseases remains disputed because these types of VT are hemodynamically unstable because of low ventricular function or are often of multifocal origin. Morady et al. reported that the success rate of RF ablation was 73% in drug-resistant VT associated with coronary artery disease. They suggested that RF ablation for hemodynamically stable VT might be feasible as an adjunctive therapy in selected patients with coronary artery disease. Some authors have reported the efficacy of catheter ablation using direct current for VT associated with...
Cardiomyopathy\textsuperscript{5,25,26} However, there have been few studies on the efficacy of RF ablation for VT associated with cardiomyopathy is limited\textsuperscript{27,28}

In general, recording the earliest endocardial activation\textsuperscript{4,19} diastolic potentials\textsuperscript{17} and identifying the slow conduction zone in the re-entrant circuit\textsuperscript{18,20} as well as obtaining perfect pace mapping\textsuperscript{19} are considered necessary for determination of a successful site in ablation for VT. On the other hand, it has been reported that recording of the earliest endocardial activity and best pace mapping may not always be necessary for successful ablation.

In patients 1 and 2, diastolic potentials were consistently recorded during VT at the site where the earliest
ventricular activation was recorded. Pacing during VT at this site resulted in acceleration of the QRS complexes to the pacing rate without changing the QRS complex configuration. The st-V interval was equal to the dp-V interval during VT. These findings, including the concealed entrainment phenomenon, should indicate that this site is the critical slow conduction zone caused by myocardial injury.23,24

As an alternative explanation, the findings discussed above might be brought about as a result of pacing at an alternative pathway in the slow conduction zone, not at the critical zone of slow conduction. However, the findings observed in these patients definitely indicated the concealed entrainment phenomenon in the critical slow conduction because RF ablation successfully terminated VT.

In patient 3, pacing at the site where delayed potentials were recorded resulted in the same QRS complex configuration as with the st-V delay of 90 msec seen in type A and, when the current strength of pacing was reduced, the configuration of the QRS complexes caused by pacing switched from type A to type B along with prolongation of the st-V interval from 90 msec to 250 msec. This meant that pacing with a high current might have stimulated the slow conduction zone of type A because in this zone both the conduction velocity and the threshold were high, whereas pacing with a low current might have selectively stimulated the slow conduction zone of type B, whose conduction velocity was markedly slow but whose threshold was low. In this case, we thought that this site was the common critical slow conduction zone for both types A and B because VT did not recur after ablation.

Limitations

It is thought that RF ablation is effective if the target of ablation is located in the endocardium but not if the target is located in the myocardium or epicardium. Antiarrhythmic drugs are necessary after ablation and were not discontinued in patient 1 because RF ablation was performed under antiarrhythmic medication. A new type of VT could occur because cardiomyopathy is a progressive myocardial disease. Based on these facts, we believe that selecting the right patients is a very important factor in successful ablation.

Conclusions

RF ablation for the treatment of recurrent, sustained VT associated with DCM and ARVD was performed in 3 patients. Ventricular tachycardia was ablated successfully and did not recur for 17–23 months. RF ablation is effective for the treatment of VT with cardiomyopathy in selected patients, and it is thought that the concealed entrainment phenomenon is the most important factor in determining the ablation site.

References

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