Idiopathic Left Ventricular Tachycardia Originating from the Mitral Annulus

KOJI KUMAGAI, M.D.,* YASUTERU YAMAUCHI, M.D.,† ATSUSHI TAKAHASHI, M.D.,‡ YASUHIRO YOKOYAMA, M.D.,‡ YUKIO SEKIGUCHI, M.D.,† JUN WATANABE, M.D.,* YOSHITO IESAKA, M.D.,§ KUNIO SHIRATO, M.D.,* and KAZUTAKA AONUMA, M.D.¶

From the *Department of Cardiovascular Medicine, Tohoku University Graduate School of Medicine, Sendai; †Cardiology Department, Musashino Red Cross Hospital, Tokyo; ‡Cardiology Department, Yokosuka Kyosai General Hospital, Kanagawa; §Cardiology Department, Tsuchiura Kyodo Hospital, Ibaragi; and ¶Division of Cardiology, University of Tsukuba Graduate School of Comprehensive Human Sciences, Cardiology Department, Ibaragi, Japan

Ventricular Tachycardia from the Mitral Annulus. ***Background:*** **Radiofrequency catheter ablation (RFCA) can eliminate most idiopathic repetitive monomorphic ventricular tachycardias (RMVTs) originating from the right and left ventricular outflow tracts (RVOT, LVOT). Here, we describe the electrophysiological (EP) findings of a new variant of RMVT originating from the mitral annulus (MAVT).**

Methods and Results: **MAVT was identified in 35 patients out of 72 consecutive left ventricular RMVTs from May 2000 to June 2004. All patients underwent an EP study and RFCA. The sites of origin of the MAVT were grouped into four groups according to the successful ablation sites around the mitral annulus. Group I included the anterior sites (n = 11), group II the anterolateral sites (n = 9), group III the lateral sites (n = 6), and group IV the posterior sites (n = 9). The MAVTs were a wide QRS tachycardia with a delta wave-like beginning of the QRS complex. The transitional zone of the R wave occurred between V1-V2 in all cases. The 12-lead electrocardiogram (ECG) pattern might reflect the site of the origin of MAVTs around the mitral annulus. We proposed an algorithm for predicting the site of the focus and the tactics needed for successful RFCA of the MAVT.**

Conclusions: **We described the EP findings of the new variant of RMVT, MAVT. Most MAVTs could be eliminated by RF applications to the endocardial mitral annulus using our proposed tactics.** *(J Cardiovasc Electrophysiol, Vol. 16, pp. 1029-1036, October 2005)*

ventricular tachycardia, arrhythmia, electrocardiogram, catheter ablation

Introduction

Idiopathic repetitive monomorphic ventricular tachycardia (RMVT) is characterized by frequent short runs of monomorphic nonsustained VT. The sites of origin of the RMVT have been mapped not only to the right ventricular outflow tract (RVOT) but also to the left ventricular outflow tract (LVOT).[1] Moreover, the sites of origin have also been mapped to ventricular sites other than the outflow tracts.[2]

We experienced RMVT that arouse from the mitral annulus (MAVT), in which all cases demonstrated a delta wave-like morphology on the 12-lead electrocardiogram (ECG) and were successfully treated with radiofrequency catheter ablation (RFCA). Although MAVT should be a new variant of RMVT, its electrophysiological (EP) description remains to be addressed. The aim of the present study was to characterize the findings from the 12-lead ECG and endocardial mapping of the MAVT in order to obtain its diagnosis and successful RFCA.

Address for correspondence: Koji Kumagai, M.D., Department of Cardiovascular Medicine, Tohoku University Graduate School of Medicine, 1-1 Seiryou-machi, Sendai, Japan. Fax: 81-22-717-7156; E-mail: kkumagai@cardio.med.tohoku.ac.jp

Manuscript received 5 November 2004; Revised manuscript received 16 March 2005; Accepted for publication 31 March 2005.

doi: 10.1111/j.1540-8167.2005.40749.x

Methods

Study Population

Seventy-two consecutive patients with left ventricular RMVT were investigated under documented informed consent. They were referred to the Yokosuka Kyosai General Hospital for treatment of their left ventricular RMVT from May 2000 to June 2004. All patients had no organic heart disease, including coronary artery, myocardial, or valvular heart disease. We also investigated patients with left-sided manifest Wolff-Parkinson-White (WPW) syndrome because the myocardium around the mitral annulus might be the site of initial activation in both MAVT and left-sided manifest WPW syndrome.

Electrophysiological Study and Ablation Procedure

Pace mapping and activation mapping of the RVMT were performed with a standard recorder and a roving catheter technique as previously described.[3] After induction of the VT, pace mapping was performed during sinus rhythm with the minimal amplitude of the electrical stimulation. We first mapped the RVOT area and pulmonary artery root, and then moved via the retrograde aortic approach to the LVOT area, mitral annulus, and aortic sinus cusps, if necessary. Intravenous infusion of isoproterenol (0.5–4 μg/min) was used to induce the RVMT if necessary.

RF energy was delivered using a 4-mm tip deflectable catheter (EPT5031TL, EP Technologies, Inc., San Jose, CA, USA) and ablation system (EPT1000, EP Technologies). The

tip temperature was maintained at 55°C during the 60 second energy deliveries. The selection of the target sites for ablation was primarily determined by complete or near-complete pace maps with an early local activation time. Successful RFCA sites were considered as the sites of the origin of RMVT.

ECG Analysis

The 12-lead ECG was characterized using several parameters including the standard parameters, intrinsicoid deflection time,[4] and polarity of the delta wave-like segments of the QRS complex during the MAVT. The intrinsicoid deflection time was defined as the interval measured from the earliest ventricular activation to the peak of the R wave in lead V2. The polarity of the delta wave-like morphology was categorized as "positive," "negative," or "isoelectric" according to the delta wave morphologies observed in WPW syndrome.[5] The delta wave-like morphologies of the MAVT were compared to highly preexcited delta waves during the shortest 1:1 conduction in patients with left-sided manifest WPW syndrome.

All measurements were performed by two independent observers blinded to the successful ablation sites using digitized tracings with calipers allowing a 1 msec resolution at a screen speed of 100 mm/sec and with the signals amplified to 10 mm/mV. We adopted the mean values of these measurements as the data. If the interobserver difference was more than 5 msec, the final decision was made by a joint meeting of the observers.

Statistical Analysis

Continuous data are expressed as mean ± SD. The mean values were compared using the Student's unpaired *t*-test. A value of $P < 0.05$ was considered statistically significant.

Results

Frequency of MAVT in RMVT Originating from the Left Ventricle

We identified 35 patients with MAVT (24 men and 11 women, mean age: 53 ± 14, range: 16–69 years of age) out of 72 consecutive patients with RMVT originating from the left ventricle. Thus, MAVT accounted for 49% of the left ventricular RMVT. MAVT was diagnosed by the EP findings and successful RFCA sites addressed later. They were all symptomatic and suffered from recurrent episodes of palpitations that occurred several times a day for 3.1 ± 1.5 years. The MAVTs were usually refractory to a mean of 1.6 ± 0.5 antiarrhythmic drugs including mexiletine, lidocaine, and metoprolol. Other sites of origin of the left ventricular RMVT were the coronary cusps (Cusps-VT, 34 cases: 18 women and 16 men; mean age: 59 ± 17 years, range: 21–82) and inferoseptal sites (3 cases). There was no significant difference in the age distribution between the MAVT and Cusps-VT cases.

Sites of Origin and Characteristics of the 12-Lead ECG in MAVT

The MAVT was a wide QRS tachycardia with a delta wave-like beginning of the QRS complex. Figure 1 shows all the sites of origin of the MAVT, which were conveniently grouped into four groups according to the successful ablation site around the mitral annulus. Group I included the anterior sites (n = 11), group II the anterolateral sites (n = 9), group III the lateral sites (n = 6), and group IV the posterior sites (n = 9). According to the sites of origin, Table 1 summarizes the electrocardiographic characteristics of the MAVT. The MAVT appeared to have a wider QRS complex (177 ± 19 msec) than that of RVOT or idiopathic left ventricular VT reported previously.[6] In lead I, an S wave was dominant in groups I–III while an R wave was dominant in group IV (Fig. 2A-D). In lead aVF, an R wave was dominant in groups I–III while an S wave was dominant in group IV (Fig. 2A-D). When comparing groups II and III, an S wave in lead I and V6 was deeper in group III than in group II and an R wave in lead aVF was significantly greater in group II than in group III (1.9 ± 0.3 vs 1.3 ± 0.3 mV, $P < 0.05$). The R wave in lead aVF ≥1.6 mV identified group II with a 100% sensitivity and 83% specificity. Group I did not usually have an S wave in V6 (10/11), but all those in groups II–IV had S waves in V6 (91% sensitivity and 92% specificity). According to the successful ablation sites, only 1 patient with an Rs pattern in lead V6 was classified with group I MAVT that might distribute in the boundary region of the aortic and mitral annuli. The transitional zone of the precordial R wave in groups II–IV was at V1, and that of group I was at V1 (73%) or V2 (27%). The polarity of the delta wave-like morphology in the inferior leads in groups I–III exhibited positive while that in group IV exhibited negative.

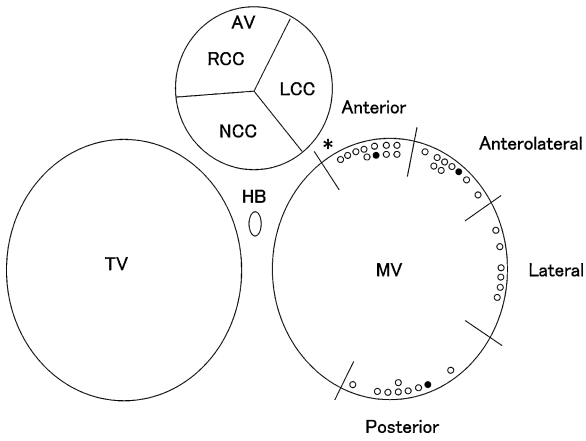

Figure 1. *All sites of origin of the MAVT in the present study are illustrated. The mitral annulus is divided into four areas. The three closed circles indicate the recurrence cases. The asterisk represents the region corresponding to the left fibrous trigone. LCC = left coronary cusp; RCC = right coronary cusp; NCC = noncoronary cusp; AV = aortic valve; MV = mitral valve; TV = tricuspid valve; HB = His bundle region.*

EP Study and RFCA

Sustained RMVT (cycle length of 335 ± 102 msec) was induced in 3 of 35 patients by an intravenous isoproterenol infusion. Nonsustained RMVT or repetitive monomorphic ventricular premature contractions (VPCs) occurred spontaneously or were induced by an intravenous isoproterenol infusion (0.5 to 4 μg/min) in other patients. VT entrainment was not observed in any of the sustained VT episodes. MAVT

TABLE 1

Results During Ventricular Tachycardias That Originate from the Mitral Annulus (MA-VTs) Ablation

	Origin	Intrinsicoid /QRS	Lead I	aVF	S wave in V6	Transitional zone	Polarity of inferior leads	Prepotential	Vo-QRSo (msec)
1	A	80/160	rs	R	R	v2	+	+	46
2	A	100/180	rS	R	R	v1	+	+	20
3	A	120/200	Rs	R	R	v1	+	+	26
4	A	80/180	rS	R	R	v1	+	+	27
5	A	100/1 90	rS	R	R	v1	+	+	26
6	A	90/180	rS	Rs	R	v1	+	+	31
7	A	100/180	S	R	R	v1	+	+	9
8	A	100/200	rs	R	Rs	v1	+	+	90
9	A	90/160	S	R	R	v2	+	+	30
10	A	100/160	rS	R	R	v1	+	+	45
11	A	80/160	S	R	R	v2	+	+	25
1	AL	80/160	rS	R	R	v1	+	−	32
2	AL	80/160	S	R	Rs	v1	+	+	26
3	AL	80/180	rS	R	Rs	v1	+	+	32
4	AL	60/120	qsr	R	Rs	v1	+	+	25
5	AL	80/160	rS	R	Rs	v1	+	−	29
6	AL	120/180	S	R	Rs	v1	+	−	37
7	AL	120/180	S	R	Rs	v1	+	+	40
8	AL	120/180	rS	R	Rs	v1	+	−	16
9	AL	120/180	rS	R	Rs	v1	+	+	32
1	L	90/180	S	R	Rs	v1	+	+	22
2	L	100/200	S	R	Rs	v1	+	+	27
3	L	100/200	rS	R	RS	v1	+	+	0
4	L	8O/180	S	R	Rs	v1	+	+	37
5	L	100/200	S	R	rS	v1	+	+	20
6	L	50/160	rS	R	rS	v1	+	−	26
1	P	100/160	R	S	rS	v1	−	+	23
2	P	90/180	R	rS	Rs	v1	−	+	32
3	P	120/220	R	S	Rs	v1	−	+	40
4	P	127/180	R	S	Rs	v1	−	−	28
5	P	98/147	R	rS	Rs	v1	−	−	26
6	P	120/182	R	rS	Rs	v1	−	+	46
7	P	98/176	R	S	R	v1	−	+	32
8	P	127/202	R	S	Rs	v1	−	−	0
9	P	120/180	R	S	Rs	v1	−	+	23

A = anterior site of mitral annulus; AL = anterolateral site of mitral annulus; L = lateral site of mitral annulus; P = posterior site of mitral annulus; Vo-QRSo = interval from the electrogram at the ablation site to the QRS onset.

could not be induced by programmed ventricular stimulation or ventricular burst pacing. It could be terminated by a bolus injection of adenosine triphosphate (10–40 mg) as an acute response in the electrophysiology laboratory.

In all patients with MAVT, pace mapping was useful for determining the RFCA sites. Successful RFCA was achieved at a perfect (12/12) or near-perfect (10–11/12) match site as shown in Figure 3A. We explored a site in which both the atrial and ventricular potentials were recorded beneath the mitral valve, and accompanied by a prepotential. The earliest ventricular electrogram (V) at the successful ablation site preceded the onset of the QRS by 29 ± 15 msec. A low-amplitude presystolic potential (prepotential) was frequently found during VT or VPCs at the successful ablation sites (29/35, 83%) as shown in Figure 3B.

RFCA successfully eliminated the MAVT (Fig. 3C) in all patients with 1 ± 0.5 (range and median values are suitable) RF applications. The position of the ablation catheter was verified by fluoroscopy, and confirmed by the endocardial ECG in which the atrial/ventricular ratio of the amplitude was less than 1. No complications of the RFCA were documented, but 3 patients (8%) had recurrence during the follow-up period of 24 ± 14 months.

A Comparison with Left-Sided WPW Syndrome and Cusps-VT

There may be common characteristics between MAVT and left-sided manifest WPW syndrome in terms of the QRS morphology. Twenty-two consecutive patients with left-sided manifest WPW syndrome (9 women and 13 men; mean age: 44 ± 18 years, range: 16–71) were studied. The sites of the accessory pathways identified by the successful RFCA were the anterolateral (n = 8), lateral (n = 7), and posterior (n = 7) sites. In patients with left-sided WPW syndrome, the shape of the QRS complexes with highly preexcited delta waves were well matched with those of the MAVT that originated from corresponding sites of origin as shown in Figure 4. The transitional zone of the precordial R wave occurred in leads V1-V2 in all patients with left-sided WPW syndrome, and the QRS complex in V6 exhibited an Rs pattern in patients with anterolateral accessory pathways and RS pattern in patients with lateral and posterior accessory pathways. Patients with anterolateral and lateral accessory pathways had an inferior axis while patients with posterior accessory pathways showed had a superior axis. There was no difference in the intrinsicoid deflection time between the MAVT and

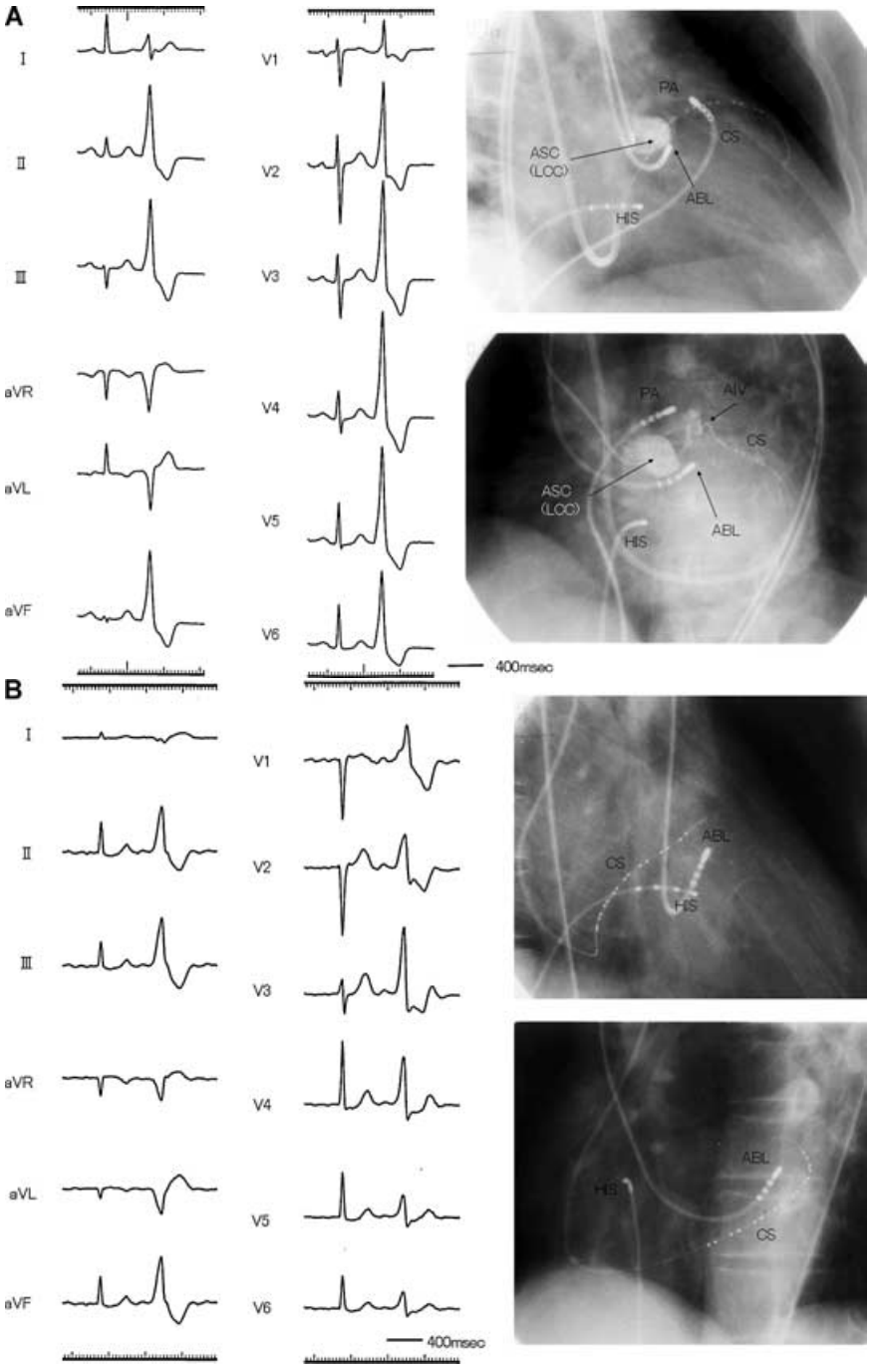

Figure 2. *Twelve-lead electrocardiogram and catheter position at the successful ablation site (RAO35° and LAO45°). A: In group I MAVT (anterior), the location of the ablation catheter is just below the anterior aspect of the mitral annulus. Aortography reveals the aortic sinus cusps (ASC). B: In group II MAVT (anterolateral), the location of the ablation catheter is at an anterolateral site just below the mitral valve. C: In group III MAVT (lateral), the location of the ablation catheter is at a lateral site, just below the mitral valve. D: In group IV MAVT (posterior), the location of the ablation catheter is at a posterior site just below the mitral valve. MV = mitral valve; ASC = aortic sinus cusps; LCC = left coronary cusp; PA = pulmonary artery; CS = coronary sinus; His = His bundle region; RVA = right ventricular apex; AIV = anterior interventricular vein; ABL = ablation catheter.*

highly preexcited delta waves (99 ± 13 vs 97 ± 21 msec, P = ns).

The 12-lead ECG pattern in group I MAVT was similar to that of the Cusps-VT. The Cusps-VT displayed a left bundle branch block pattern in 26 patients and right bundle branch block pattern in 8 patients with an inferior axis and early transition in precordial leads in V1–V3. The site of the origin of the Cusps-VT was at the left coronary cusp region in 32 patients, and right coronary cusp region in 2 patients. No S waves in lead V6 were observed in either group I MAVT (except 1 patient) or Cusps-VT, while the amplitude of the R wave in lead aVF in group I MAVT was significantly smaller than that for the Cusps-VT (1.9 ± 0.6 vs 2.2 ± 0.3 mV, $P < 0.05$). The intrinsicoid deflection time and QRS complex duration in the MAVT were significantly greater than that in the Cusps-VT (98 ± 19 vs 73 ± 16 msec, $P < 0.001$, 177 ± 19 vs 149 ± 16 msec, $P < 0.001$, respectively).When comparing group I MAVT and the Cusps-VT, an intrinsicoid deflection time ≥85 msec identified group 1 MAVT with a 71.4% sensitivity and 91% specificity.

Discussion

We described the EP characteristics of a new variant of left ventricular RMVT, that is, MAVT. The MAVT had a delta wave-like morphology and arose from the mitral annulus.

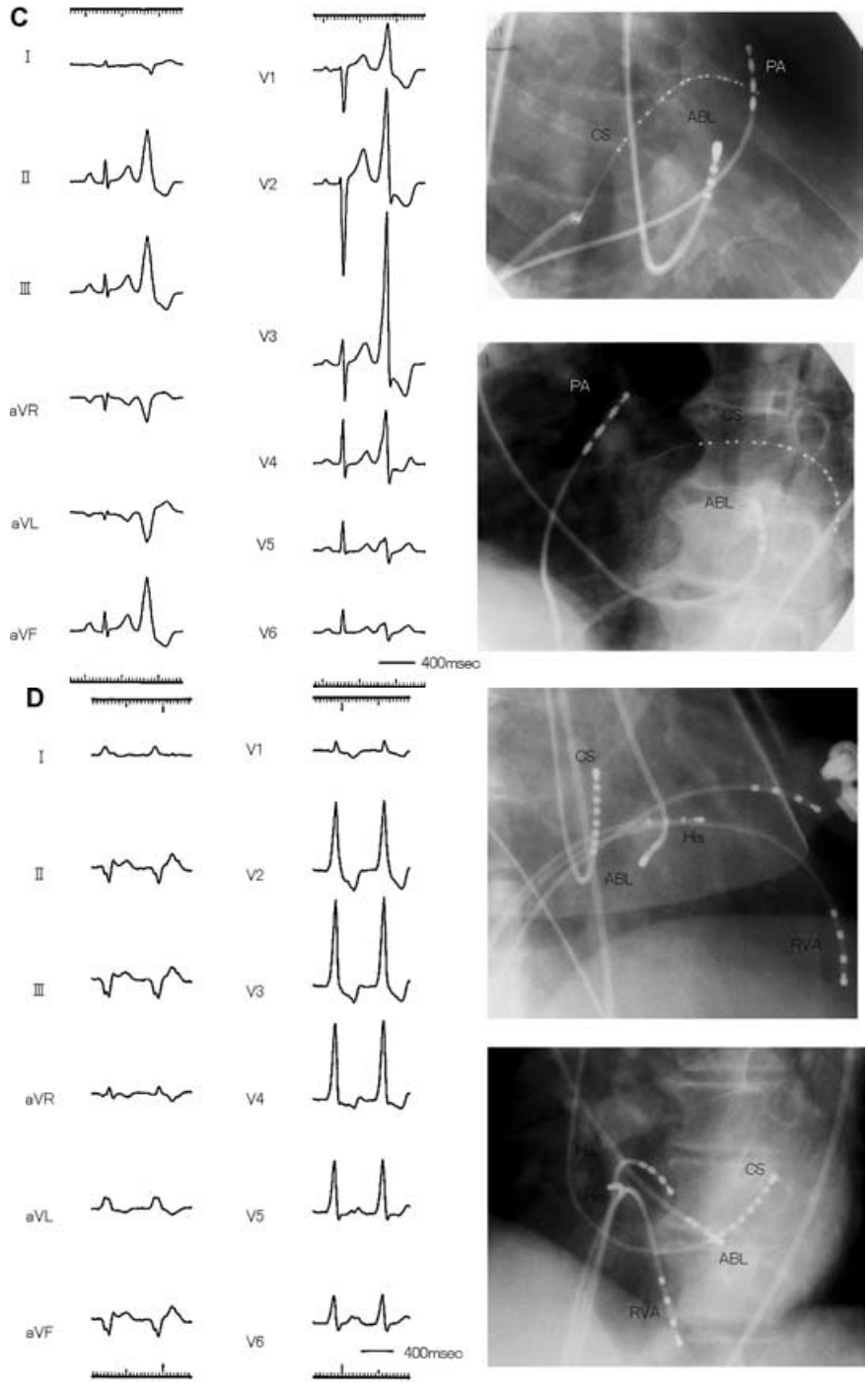

Figure 2. *Continued.*

The MAVT was sensitive to isoproterenol and ATP, but insensitive to programmed pacing or burst pacing. No entrainment was observed with the sustained MAVT. These findings support a mechanism of triggered activity rather than a reentrant mechanism. All MAVTs were successfully treated with RFCA despite a few recurrences.

Sites of Origin and Characteristics of the 12-Lead ECG in MAVT

MAVT was characterized by a relatively wide QRS complex and delta wave-like morphology in the 12-lead ECG. The transitional zone of the R wave occurred between V1-V2 in all cases, and the other characteristics are shown in Table 1. Although the precise sites of the origin of the MAVT should be determined by an EP study and/or RFCA, our data indicated that the 12-lead ECG pattern suggests the sites of the origin of the MAVT around the mitral annulus as shown in Figure 5. One blinded observer performed a validation of the ECG algorithm. An 85% accuracy in the origin of the MAVT was achieved. In the present study, however, we focused only on the MAVT that have not yet been studied. We did not include other variants of idiopathic VT such as right or left outflow tract VT in the ECG algorithm. This algorithm was not challenged with a large number of RMVTs, and it must be refined in a future study.

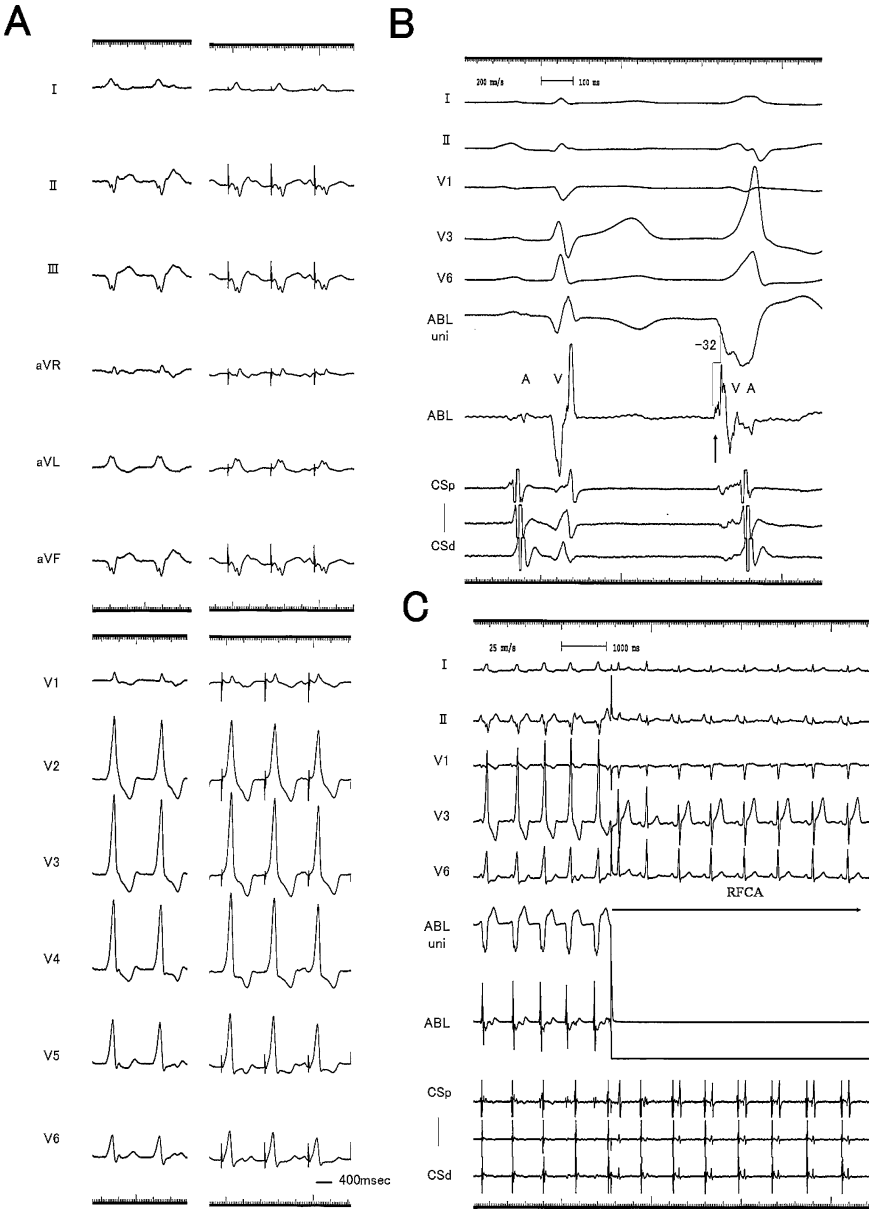

Figure 3. *The ECG recordings during the EP study are shown. A: A pace map with a near-perfect match. B: The earliest activation (pre-potential, arrow) preceded the QRS onset by 32 msec during a PVC. A = atrial potential; V = ventricular potential. C: Elimination of the ventricular tachycardia immediately after the delivery of radiofrequency current. Note that the spike represents the noise deflection on the delivery of radiofrequency current. ABL = ablation catheter; uni = unipolar electrogram; CSp and CSd = proximal to distal sites of the coronary sinus.*

Delta Wave-Like Morphologies of the MAVT

Accessory pathways in WPW syndrome usually attach to the subepicardial surface of the ventricle.[5] Thus, the formation of the delta wave-like beginning of the QRS suggested that the sites of the origin of the MAVT were located in the subepicardium. The morphological concordance of WPW syndrome to the MAVT increased with rapid atrial pacing in which the accessory pathway dominantly contributed to the atrioventricular conduction. Moreover, the intrinsicoid deflection time and QRS duration of the MAVT were greater than that of the Cusps-VT. This also supported the theory that the MAVT originated from deep inside the subendocardium or epicardium.[7,8]

The delta wave-like morphology was not specific to MAVT, and Rodrigez et al.[6] reported that 6 of 48 idiopathic VTs had a delta wave-like onset of the QRS. Five originated from the RVOT, and one from an infero-posterior site of the LV. Thus, the delta wave-like onset of the QRS in the RMVT may indicate that the sites of the origin were deep in the myocardial wall, which were not specific to MAVT. There are a few reports that RMVT actually originates from the subepicardial myocardium,[9] but there have been no reports that MAVT definitely originated from the subepicardial myocardium.

RFCA of MAVT

In the present study, all MAVT patients were successfully treated with RFCA. In addition to a perfect or near-perfect match of the pace map, we tried to find a site in which both the atrial and ventricular potentials were recorded at sinus rhythm, and accompanied with a prepotential at VPC or VT. So far, the success rate of the RFCA of the RMVT with a delta wave-like onset has not been high. Rodrigez et al.[6] reported that the success rate for RFCA was only 33% in RMVT with a delta wave-like onset while it was 93% for RMVT without a delta wave-like onset. Thus, our tactics for the RFCA may work in MAVT.

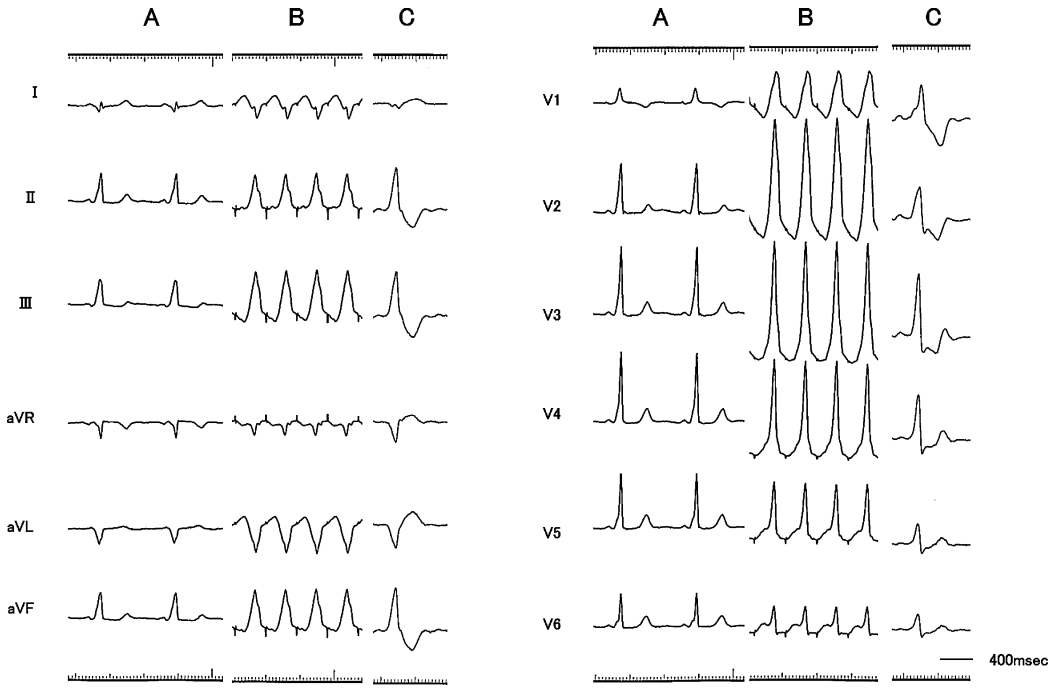

Figure 4. *The QRS pattern of the WPW syndrome during sinus rhythm. The location of the accessory pathway is an anterolateral site (A), maximum rapid atrial pacing with 1:1 conduction (B), and QRS pattern of the MAVT originating from an anterolateral site (C). Note the similar QRS complex morphologies between that for the MAVT and that for highly preexcited delta waves of WPW syndrome.*

The ventricular prepotential was observed at the mitral annulus in this present study. This potential preceded the QRS complex and may work as a marker for successful RFCA. The mechanism of the prepotential in the MAVT remains unknown. Ouyang et al.[10] described that a low-amplitude, high-frequency potential preceded the onset of the QRS complex in patients with Cusps-VT. This potential might suggest a slow conduction area between the ventricle and aortic sinus cusps.

In 3 patients, the RFCA acutely terminated their MAVT; however, they had recurrences. This may indicate that their focuses were too deep to ablate with the endocardial approach. Actually, the earliest endocardial activation time during the VT was 0 msec in two cases. However, MAVT recurrence was observed in a patient with a prepotential that preceded the QRS complex by 25 msec, which might not be explained by the depth of the focus.

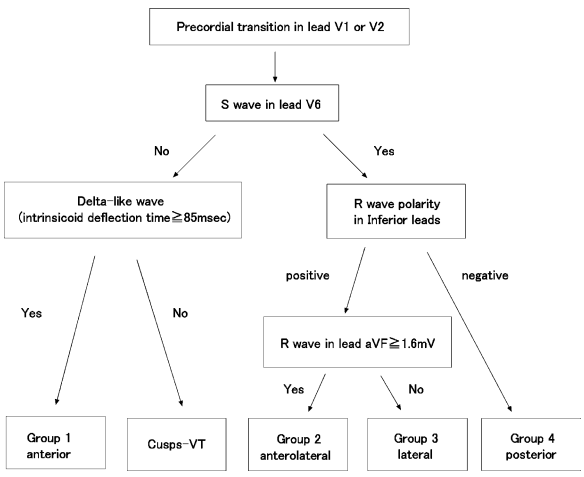

Figure 5. *Stepwise ECG algorithm for presuming the sites of the origin of the MAVT.*

Study Limitations

Idiopathic VT with the site of the origin in the LVOT is rare.[2,11-14] In this present study, we could not identify patients with LVOT due to the small number of patients. The sites of the origin in the group I MAVT might have been distributed along the boundary region of the aortic and mitral annuli (left fibrous trigone) to the anterior aspect of the mitral annulus. It is likely that some of group I MAVTs might have overlapped with the LVOT VT that originated from the aortomitral continuity (left fibrous trigone) out of all the other origins.[11-14] We could not differentiate those using the findings in the present study. In addition, at the MA-aortic junction, the left atrial wall does not join the left ventricular wall, but is attached to the aorta.[15] This site was not the origin of the MAVT.

Conclusions

We described the EP findings of a new variant of RMVT, MAVT. The MAVT exhibited a delta wave-like morphology. Most MAVT could be eliminated by RF applications to the endocardial mitral annulus under the tactics we proposed.

References

1. Coggins DL, Lee RJ, Sweeney WW, Chein WW, Van Hare G, Epstein L, Gonzalez R, Griffin JC, Lesh MD, Scheinman MM: Radiofrequency catheter ablation as a cure for idiopathic tachycardia of both left and right ventricular origin. J Am Coll Cardiol 1994;23:1333-1341

2. Varma N, Josephson ME: Therapy of idiopathic ventricular tachycardia. J Cardiovasc Electrophysiol 1997;8:104-116.
3. Hachiya H, Aonuma K, Yamauchi Y, Igawa M, Nogami A, Iesaka Y: How to diagnose, locate, and ablate coronary cusp ventricular tachycardia. J Cardiovasc Electrophysiol 2002;13:551-556.
4. Berruezo A, Mont L, Nava S, Chueca E, Bartholomay E, Brugada J: Electrocardiographic recognition of the epicardial origin of ventricular tachycardias. Circulation 2004;109:1842-1847.
5. Arruda MS, McClelland JH, Wang X, Beckman KJ, Widman LE, Gonzalez MD, Nakagawa H, Lazzara R, Jackman WM: Development and validation of an ECG algorithm for identifying accessory pathway ablation site in Wolff-Parkinson-White syndrome. J Cardiovasc Electrophysiol 1998;9:2-12.
6. Rodrigez LM, Smeets JLRM, Timmermans C, Wellens HJJ: Predictors for successful ablation of right and left- sided idiopathic ventricular tachycardia. Am J Cardiol 1997;79:309-314.
7. Kaltenbrunner W, Cardinal R, Dubuc M, Shenasa M, Nadeau R, Tremblay G, Vermeulen M, Savard P, Page PL: Epicardial and endocardial mapping of ventricular tachycardia in patients with myocardial infarction: Is the origin of the tachycardia always subendocardially localized? Circulation 1991;84:1058-1071.
8. Nagasawa H, Fujiki A, Usui M, Mizumaki K, Hayashi H, Inoue H: Successful radiofrequency catheter ablation of incessant ventricular tachycardia with a delta wave-like beginning of the QRS complex. Jpn Heart J 1999;40:671-675.
9. Stellbrink C, Diem B, Schauerte P, Ziegert K, Hanrath P: Transcoronary venous radiofrequency catheter ablation of ventricular tachycardia. J Cardiovasc Electrophysiol 1997;8:916-921.
10. Ouyang F, Fotuhi P, Ho SY, Hebe J, Volkmer M, Goya M, Burns M, Ants M, Ernst S, Cappato R, Kuck KH: Repetitive monomorphic ventricular tachycardia originating from the aortic sinus cusp: Electrocardiographic characterization for guiding catheter ablation. J Am Coll Cardiol 2002;39:500-508.
11. Callans DJ, Menz V, Schwartzman D, Gottlieb CD, Marchlinski FE: Repetitive monomorphic tachycardia from the left ventricular outflow tract: Electrocardiographic patterns consistent with a left ventricular site of origin. J Am Coll Cardiol 1997;29:1023-1027.
12. Yeh SJ, Wen MS, Wang CC, Lin FC, Wu D: Adenosine-sensitive ventricular tachycardia from the anterobasal left ventricle. J Am Coll Cardiol 1997;30:1339-1345.
13. Shimoike E, Ohba Y, Yanagi N, Hiramatsu S, Ueda N, Haruyama T, Kaji Y, Kanaya S, Fujino T, Niho Y: Radiofrequency catheter ablation of left ventricular outflow tract tachycardia: Report of two cases. J Cardiovasc Electrophysiol 1998;9:196-202.
14. Markowitz SM, Litvak BL, Ramirez EA, Arellano EA, Markisz JA, Stein KM, Lerman BB. Adenosine-sensitive ventricular tachycardia: Right ventricular abnormalities delineated by magnetic resonance imaging. Circulation 1997;96:1192-1200.
15. Wit AL, Fenoglio JJ, Wagner BM, Bassett AL: Electrophysiological properties of cardiac muscle in the anterior mitral valve leaflet and the adjacent atrium in the dog. Circ Res 1973;32:731-745.