Comparison of Results of Radiofrequency Catheter Ablation in Patients with Idiopathic and Secondary Ventricular Tachycardia

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İDİYOPATİK VE SEKONDER VENTRİKÜLER TAŞİKARDİ'Lİ HASTALARDA RADYOFREKANS KATETER ABLASYONU SONUÇLARININ KARŞILAŞTIRILMASI

ÖZET

Bu çalışmanın amacı, idiyopatik ve sekonder ventriküler taşikardi (VT)'li hastalarda radyofrekans kateter ablasyonu (RFA) sonuçlarının karşılaştırılmasıdır. Çalışma kapsamına monomorfik VT'li 66 hasta (11 kadın, 55 erkek; ort. yaş. 35.5±15.6 yıl, yaş aralığı 10-75 yıl) alındı. Kırk bir hastada idiyopatik (21 sağ ventrikül çıkış yolu taşikardisi, 20 sol ventrikül taşikardisi) ve 25 hastada sekonder VT (12 iskemik, 5 aritmojenik sağ ventrikül displazisi, 3 dilate kardiyomiyopati, 1 hipertrofik kardiyomiyopati, 2 bundle branch reentrant taşikardi, 1 mitral kapak prolapsusu, 1 post-operatif VT) söz konusu idi. Ortalama semptom süreleri idiyopatik VT grubunda 73.1±77.5 ay ve sekonder VT grubunda 37.0±37.8 ay idi (p<0,03). Idiyopatik VT grubunda daha önce ortalama 2.79±1.54 antiaritmik ilaç, ve sekonder VT grubunda ise ortalama 3.63±1.6 ilaç etkisiz bulunmuştu. Primer başarı oranı idiyopatik VT grubunda %92.6 (38/41 hasta) ve sekonder VT grubunda %80 (20/25 hasta) idi. İşlem esnasında uygulanan akım sayıları, idiyopatik VT grubundaki hastalarda (5.1±5.8), sekonder VT grubuna göre (12.2±10.2) daha az idi (p=0.02). Total işlem süresi idiyopatik VT'de 114.5±43.0 dakika, sekonder VT'de 144.0±75.3 dak bulundu. Hiçbir hastada ciddi komplikasyon oluşmadı. İdiyopatik VT grubundaki hastalara 28.3±19.3 ay, sekonder VT'liler ortalama 50.3±20.7 ay takip edildiler (p<0.01). Nüks oranı idiyopatik VT'lilerde %5.2 (2/38 hasta), sekonder VT grubunda %50 (10/ 20 hasta) idi (p<0.05), bu suretle uzun süreli başarı oranı idiyopatik VT'de %90.2, sekonder VT'de %48 bulundu (p<0.01). Sekonder VT'li hasta grubunda (%36), idiyopatik VT'lilere (%2.4) göre daha sık olarak implante edilebilen kardiyoverter-defibrilatör (ICD) implante edildi (p<0.05). Sonuç olarak, RFA işleminin her iki grupta da etkili ve emin bir metod olduğu, ancak idiyopatik VT'li grupta başarı şansının daha çok, sekonder VT'li grupta nüks oranının daha yüksek ve uzun süreli başarı ihtimalinin daha düşük olduğu ve hastaların önemli bir bölümünde ICD implantasyonu gerekebileceği kanısına varıldı.

Anahtar kelimeler: *ablasyon, idiyopatik, sekonder, ventriküler taşikardi*

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Radiofrequency catheter ablation (RFA) has become a first-line curative therapy in the patients with Wolff-Parkinson-White syndrome [1-6], atrioventricular nodal reentry [7-9] and the other common forms of supraventricular tachycardia [10,11]. Ventricular tachycardia (VT) occurring in the absence of organic heart disease such as idiopathic right ventricular outflow tachycardia or left VT can now be cured by RFA with a high degree of efficacy and safety. Several studies demonstrated that RFA is effective in more than 80% of patients without structural heart disease [12-16]. However, ablation of VT in patients with underlying structural heart disease has not been widely accepted as safe and effective. Low success rates of RFA (65-73%) were reported in patients with sustained and hemodinamically stable secondary VT [17-21]. But this technique is also useful as an adjunct to implantable cardioverter defibrillator (ICD) therapy, especially in a selected patient group [22]. Recently, ICD implantation was accepted as a Class I indication in patients with sustained secondary VT by AHA/NASPE Committee in 1998 [23]. The purpose of this study, which had begun in 1994, was to compare acute and long-term follow-up results of RFA in sixty-five patients with idiopathic and secondary ventricular tachycardia.

PATIENTS and METHODS

Patient population: The study population consisted of 66 consecutive patients (11 female, 55 male; mean age 35.5±15.6 years, range 10-75) presented with sustained monomorphic VT between February 1994 and May 2000. Initially, catheter ablation was offered only if spontaneous VT recurred despite antiarrhythmic drug therapy. After that, RFA was offered to all patients who had sustained VT that was sufficiently tolerated hemodinamically to al-

low catheter mapping. During the last 3 years, ICD implantation was the first choice of therapy in patients with organic heart disease.

There were 41 patients in idiopathic VT group and secondary VT group consisted of 25 patients with organic heart disease. The physical examination, ECG, echocardiography, treadmill exercise test or myocardial perfusion scintigraphy, coronary angiography and contrast left ventriculography were performed to all patients, and nuclear magnetic resonance imaging and right ventriculography were done on a selective basis to diagnose the organic heart disease.

Written or verbal informed consent was obtained from all patients before the electrophysiologic study and ablation procedure.

Electrophysiologic study: The electrophysiologic study was performed with the patients in the fasting state, and at least 72 hours after discontinuation of all antiarrhythmic agents. With the use of standard techniques, two or three quadripolar electrode catheters (5-6F, Josephson, Bard or Medtronic) were placed at the right ventricular apex, right ventricular outflow tract, and/or His bundle region. The surface ECG leads and intracardiac electrograms were recorded on an optic disk in a Bard EP system. All bipolar electrograms were filtered between a bandpass of 50 to 600 Hz.

Midazolam was administered intravenously during the procedure if needed for sedation.

Pacing was performed with a stimulator (Medtronic). Programmed ventricular stimulation was carried out at a current strength of twice diastolic threshold and a pulse width of 0.5 ms. The inducibility of ventricular tachycardia was assessed by programmed ventricular stimulation with one to four extrastimuli at the right ventricular apex and right ventricular outflow tract, using basic drive cycle lengths of 400 and 500 or 600 ms.

Ablation procedure: Right or left ventricular mapping and ablation were performed with a 7F, quadripolar electrode catheter that had an interelectrode spacing of 2/5/2 mm, a deflectable tip, and a 4-mm (Marinr, Medtronic) or 8-mm (Blazer T, EP Technologies) distal electrode with a thermistor for monitoring temperature at the electrode-tissue interface. The catheter was inserted percutaneously into a femoral vein or artery. Mapping was initiated in the right ventricle if the VT had a left bundle branch block pattern and in the left ventricle if it had right bundle branch block pattern.

Initially, 5000 units of heparin was administered intravenously after placement of the catheters and a maintenance dose of 1000 units was applied every hour during the ablation procedure.

The criteria used to select a target site for ablation of ventricular tachycardia included concealed entrainment, identification of an isolated mid-diastolic potential, identification of the earliest presystolic endocardial activation during ventricular tachycardia, and pace mapping [12,17,24-27]. The last two methods were applied for the patients with idiopathic VT, and Purkinje potential recorded during VT was also used to identify the successful ablation site in patients with idiopathic left ventricular tachycardia. Generally, concealed entrainment was the first mapping technique used in patients with secondary VT.

The radiofrequency energy was delivered as a continuous unmodulated sine wave at a frequency of 500 kHz (Atakr or EP Technologies) between the distal electrode of the ablation catheter and a large adhesive skin electrode that was placed over the posterior chest. The temperature monitored from the electrode tip was adjusted to ~60-70° C or a maximum RF current of 45 to 50 Watts. Once this end point was reached, the application of energy was continued for at least 20 seconds. If ventricular tachycardia did not terminate, the energy application was stopped and mapping was continued at other sites; if ventricular tachycardia did terminate, the energy application was prolonged to 60 120 seconds. The inducibility of VT was assessed by programmed ventricular stimulation with one to four extrastimuli at the right ventricular apex and right ventricular outflow tract using drive cycle lengths 400 and 500 or 600 ms before and after isoproterenol infusion (1-5 µg/min). Thirty minutes after ablation of VT, the absence of inducible VT was confirmed before removing all catheters and sheats. After ablation, patients were monitored in an intensive care unite for 24 to 48 hours.

Long term follow-up: All antiarrhythmic drugs were discontinued in successful cases. Aspirin (300 mg) was administered to all patients for 3 months. Follow-up visits were scheduled for all patients every 3-4 months at the outpatient clinic. A successful long-term clinical result was defined as the absence of any signs or symptoms of VT.

Statistical analysis: All values are expressed as the mean ± SD. Continuous variables were compared using the Students' t test for unpaired data, and categorical data were compared by chi square analysis. A probability value less than 0.05 was considered significant.

RESULTS

Electrophysiologic study and mapping revealed that 21 of the 41 patients who presented with idiopathic VT had right ventricular outflow tachycardia and 20 had left ventricular tachycardia. In the secondary VT group (n=25), 12 patients had ischaemic heart disease, 5 had arrythmogenic right ventricular dysplasia (ARVD), 1 had hypertrophic cardiomyopathy, 3 had dilated cardiomyopathy, 2 had bundle branch reentry, 1 had mitral valve prolapse and 1 had postoperative tachycardia. The main characteristics of patients were shown in table 1. Two patients in secondary VT group had previously undergone implantation of ICD before the ablation procedure.

The comparison of technical data related to the procedure was shown in Table 2. The mean number of RF pulses delivered in the 41 patients in idiopathic

Table 1. The main characteristics of 66 patients with VT before ablation

Total n=43	Idiopathic VT (N: 41)	Secondary VT (VT: 25)	P
Age (years)	31.2±12.1	41.6±18.7	0.01
Male/female	32/9	23/2	
Symptom duration (months)	73.1±77.5	37.0±37.8	0.03
Previously used antiarrhythmic drugs counts	2.79±1.54	3.63±1.6	NS

Table 2. The technical data during the EPS and RFA

	Idiopathic VT (N: 41)	Secondary VT (VT: 25)	P
Duration of sheats and catheter replacement (min)	16.2±4.3	18.6±10.8	NS
Duration of electrophysiologic study (min)	16.4±10.0	24.6±26.5	NS
Duration of ablation (min)	50.0±39.8	58.8±59.8	NS
Post-RFA duration (min)	35.2±15.8	58.8±59.8	NS
Total procedure duration (min)	114.5±43.0	144.0±75.3	NS
Fluoroscopy time (min)	23.9±22.1	28.2±17.9	NS
Mean temperature (°C)	55.6±6.0	58.9±6.5	NS
Maximum temperature (°C)	61.8±7.6	69.5±4.2	NS
Mean power (Watts)	55.5±5.7	58.5±6.5	NS
Maximum power (Watts)	61.8±7.6	69.5±4.2	NS
The number of RF energy application	5.1±5.8	12.2±10.2	0.02

VT group (5.1±5.8) was significantly lower than the 25 patients in secondary VT group (12.2±10.2) ($p<0.02$).

Thirty-eight of 41 VT's (92.6%) targeted for ablation in idiopathic VT group and 20 of 25 VT's (80%) in secondary VT group were no longer inducible by programmed ventricular stimulation at the end of the ablation session. There was no statistically significant difference between two groups with respect to acute success (Table 3). No serious procedure-related complications (death, myocardial infarction, stroke, emboli, pericardial tamponade and heart block) occurred in any patient.

Follow-up: Patients were followed for a mean of 28.3±19.3 months in idiopathic VT group and 50.3±20.7 months in secondary VT group ($p<0.01$). Significantly more recurrences occured in secondary VT group: Over the follow-up period, 2 of 38 patients (5.2%) in idiopathic VT group and 10 of 20 patients (50%) in secondary VT group developed spontaneous VT ($p<0.05$).

Table 3. The acute and long-term results in both groups.

	Idiopathic VT (N: 41)	Secondary VT (VT: 25)	P
Primary success	38/41 (92.6%)	20/25(80%)	NS
Serious complications	0	0	
Follow-up (months)	28.3±19.3	50.3±20.7	<0.01
Recurrence rate	2/38 (5.2%)	10/20 (50%)	<0.05
Reablation success	1/2	2/2	
Long-term success	37/41 (90.2%)	12/25 (48%)	<0.05
ICD implantation	1/41 (2.4%)	9/25 (36%)*	<0.05
Late death	0	1/25 (4%)	

Abbreviations: VT: ventricular tachycardia, NS: Not significant, ICD: Implantable cardioverter defibrillator

The long-term success rate of RFA was significantly better in idiopathic VT group: VT was eliminated in 37 of 41 patients (90.2%) in idiopathic VT group and in 12 of 25 patients (48%) in secondary VT group ($p<0.05$). ICD was implanted in 1 (2.4%) of 41 patients in idiopathic VT group, although it was required in 9 (36%) of 25 patients in secondary VT

group. This difference was statistically significant ($p<0.05$).

Subgroup Analysis

Idiopathic Ventricular Tachycardia

Right ventricular outflow tachycardia (RVOT): RVOT was diagnosed in 21 (13 male, 8 female) patients. Isoproterenol infusion was necessary to induce sustained VT during electrophysiologic study in 15 of these 21 patients. In 2 patients, sustained VT could not be induced by programmed stimulation, and ventricular premature beats or runs were used to achieve mapping and ablation of the arrhythmia focus. The ablation procedure was successful in 18 of 21 patients (85.7%). Recurrence was observed in 1 (5.5%) patient, and the second session was also successful.

Idiopathic left ventricular tachycardia: Successful ablation was achieved in all 20 (19 male, 1 female) patients. The earliest ventricular activation site during VT was identified at the posteroapical left ventricular septum in 18 patients, and at the left ventricular outflow tract in 2 patients. A high-frequency, presystolic potential (Purkinje potential) preceding the onset of QRS by 6 to 52 ms was identified during the VT at the successful ablation site in all patients with idiopathic left ventricular tachycardia (Figure 1A-D). One of these patients had incessant idiopathic left ventricular tachycardia in spite of optimal medical treatment, and after successful ablation no recurrence occurred during the follow-up of 5 years without any medication. In another patient with left ventricular outflow VT, tachycardia recurred after initial successful ablation, and ICD implantion was preferred instead of reablation because the patient had already survived an episode of cardiac arrest. This patient received appropriate shocks due to VT or ventricular fibrillation after ICD implantation.

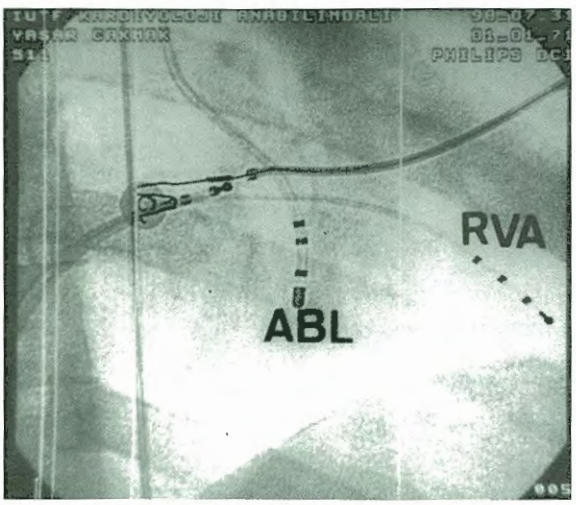

Figure 1A. Case #5 Posteroanterior view of left ventricle. *ABL: Ablation catheter, RVA: Right ventricular apex catheter.*

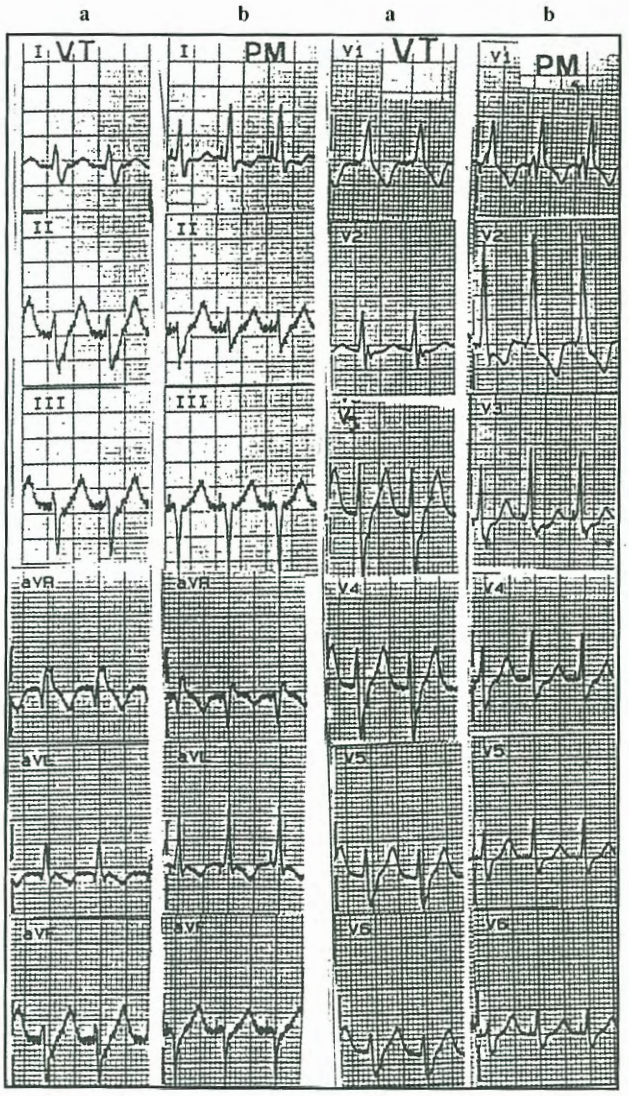

Figure 1B. Case #5 12/12 pace matching of VT (RBBB, CL: 380 msec, superior axis). *VT: Ventricular tachycardia B/a, PM: Pace mapping B/b*

Secondary Ventricular Tachycardia

Coronary heart disease: The ablation was successful in 8 of 12 patients with coronary heart disease. ICD was implanted due to the recurrence of VT in 2

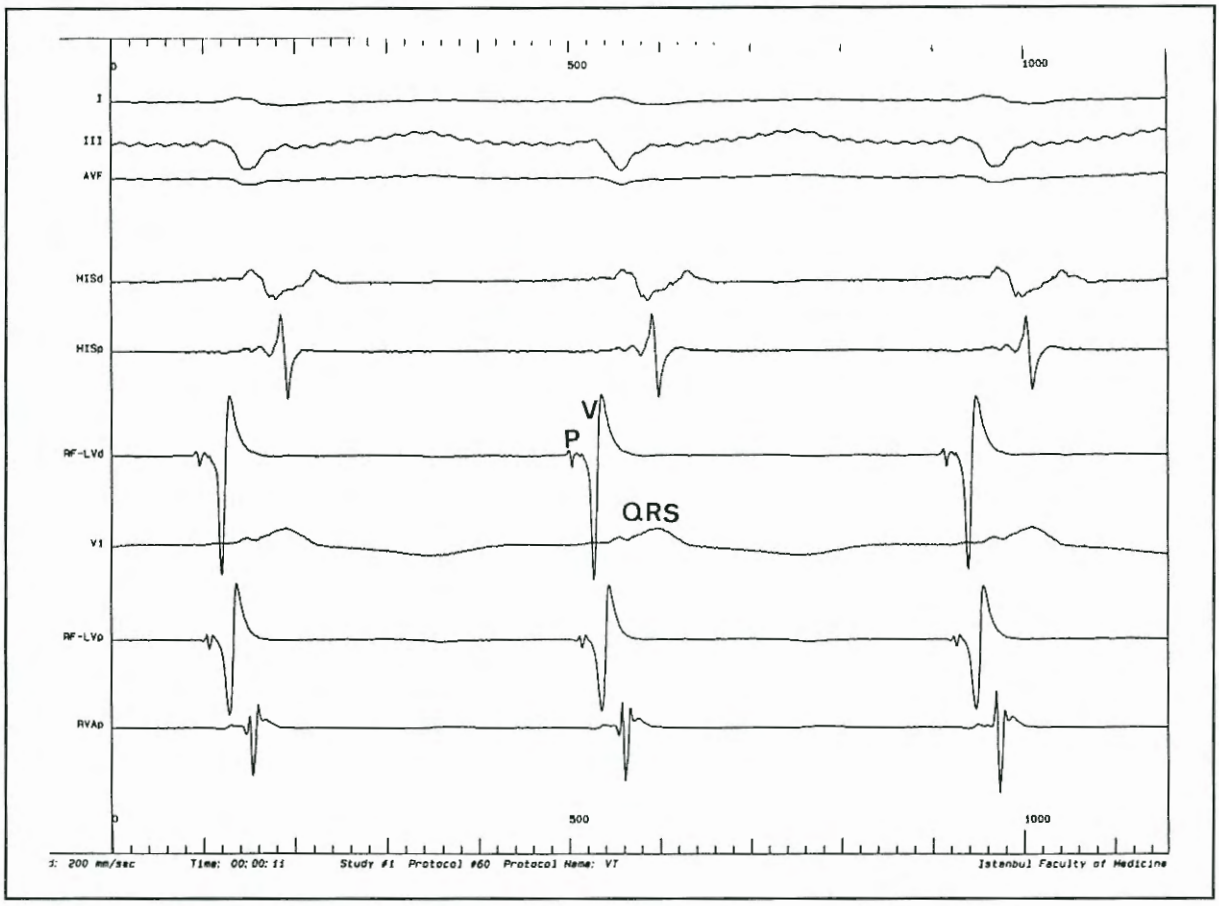

Figure 1C. Case #5 The simultaneous recordings of surface electrocardiogram and intracardiac deflections. The local ventricular deflection (Purkinje-P potential) onset precedes surface QRS onset by 40 msec. V: Ventricular deflection.

patients and following unsuccessful ablation in another 3 patients. In one case, incessant VT developed two years after previous ICD implantation, however it was successfully eliminated by ablation, and the patient remained asymptomatic during the 3-years' follow-up period (Figure 2).

Arrythmogenic right ventricular dysplasia (ARVD): There were 5 (4 male, 1 female) patients with ARVD. The ablation procedure was successful in 3 of them. In one case, very frequent VT attacks leading to syncope could be modified by ablation, and ICD implantation became possible. Only one attack of ventricular tachyarrhythmia occured in this patient during the 3-years follow-up. ICD was also implanted to another patient after an unsuccessful ablation attempt. No recurrence developed in this group.

Dilated cardiomyopathy: There were 3 male patients with dilated cardiomyopathy. In one of these cases ventricular tachycardia/fibrillation storm and incessant VT developing 2 years after ICD implantation was successfully eliminated by ablation, and the patient was asymptomatic during the 3-years' follow-up period (Figure 3). VT recurred two years after successful ablation in another patient with dilated cardiomyopathy. ICD implantation or cardiac transplantation was not possible due to financial limitations, and despite antiarrhythmic drug therapy including amiodarone, the patient suddenly died due to ventricular tachyarrhythmia. In the third patient, VT had not recurred after successful ablation.

Bundle branch reentrant tachycardia: Two (1 male, 1 female) patients with bundle branch reentrant tachycardia were successfully ablated. During the follow-up of 2-3 years, no recurrence of any type of VT occurred.

The procedure was also successful in a patient with mitral valve prolapse, in a patient with hypertrophic cardiomyopathy, and in a patient operated due to

Figure 1D. Case #5 A few seconds of energy delivery, ventricular tacyhcardia (VT) returned to sinus rhythm (SR). A: Atrial deflection, H: His deflection, V: Ventricular deflection.

ventricular septal defect. ICD was implanted to the last two patients because of recurrences of VT or development of a new and very fast VT, respectively.

DISCUSSION

The findings described in this report demonstrate that VT in patients with and without structural heart disease (idiopathic VT) can be safely eliminated with RFA. Furthermore, RFA successfully eliminated VT's originating from several locations, including right ventricular outflow tract, right or left ventricle. The frequency of spontaneous VT in this study suggests that an early cure and low recurrence rate is likely to be an indicator of long-term cure as well. The mechanism responsible for VT in patients without structural heart disease is not known and may be multiple [28,29]. However, it has been previously demonstrated that the presumed mechanism of VT did not alter the ablation success [30].

The radiofrequency catheter ablation of idiopathic VT was reported to be successful in more than 80% of patients [12-16]. In this study, the high efficacy of RFA in idiopathic VT group confirmed and exten-

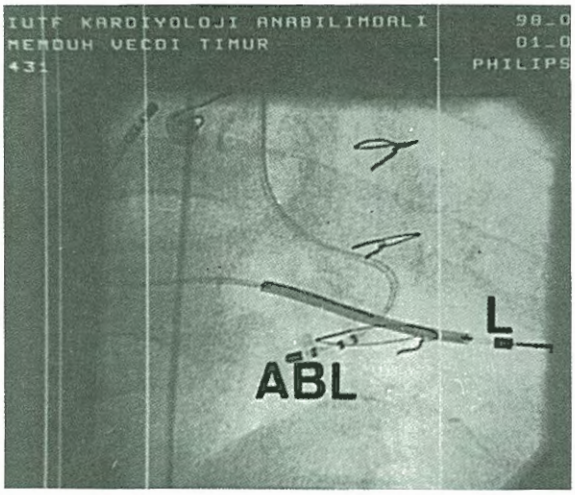

Figure 2. A patient with incessant VT due to coronary heart disease. Two years after ICD implantation incessant VT developed in spite of antiarrhythmic drugs therapy including amiodarone and resulted in multiple device shocks. The arrhythmic focus was localized to the inferobasal region of left ventricle close to the inferior aneurysm. After the ablation VT returned to sinus rhythm. No recurrence developed during follow-up of 3-years. ABL: Ablation catheter, L: Implantable cardioverter defibrillator (ICD) lead.

ded those of previous reports of catheter ablation of VT in patients without structural heart disease.

In this study, the low success rate of 48% in the secondary VT that occurs in the setting of coronary artery disease or other secondary causes suggests that this type of VT may be less amenable to catheter ablation than when it is idiopathic. The presence of scar tissue, a large reentry circuit [31,32] or an intramural or epicardial location of the reentry circuit [33,34] could potentially contribute to diminished successful outcome when VT ablation is attempted in patients with coronary artery disease. In addition, the reason for the failure of ablation in secondary VT group may simply have been inadequate localization of an appropriate target site due to inaccurate mapping in scarred ventricles or a location of the VT focus or pathways at sites deep in the endocardium. Overall success rate of RFA in secondary VT group was lower, and the first attack of VT may lead to sudden cardiac death in these patients. Thus, ICD have become a mainstay of therapy for patients with life-threatening ventricular arrhythmias and structural heart disease [35-39], and ICD implantation was accepted as a Class I indication in patients with spontaneous sustained secondary VT by AHA/NASPE Committee [23].

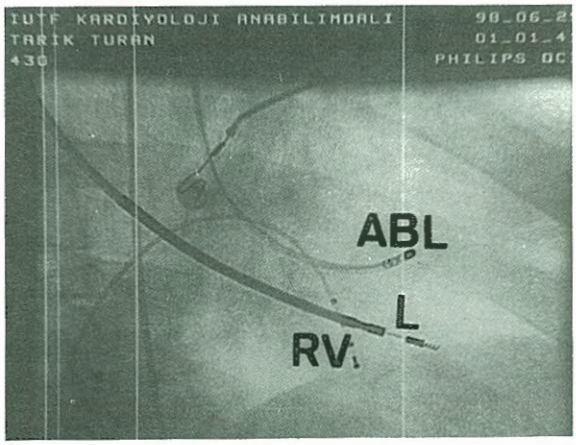

Figure 3. A patient with incessant VT due to dilated cardiomyopathy. Two years after ICD implantation incessant VT developed in spite of antiarrhythmic drugs therapy including amiodarone and resulted in multiple device shocks. The arrhythmic focus was localized to the anterolateral region of left ventricle. After the ablation VT returned to sinus rhythm. No recurrence developed during follow-up of 3-years. ABL: Ablation catheter, L: Implantable cardioverter defibrillator (ICD) lead, RV: Right ventricular apex catheter.

Some patients with an ICD still have frequent episodes of VT despite concomitant antiarrhythmic therapy resulting in numerous shocks or antitachycardia pacing therapies. On the other hand, some patients may have sustained slow VT below the ICD detection rate cut-off [35,36]. Sometimes the natural progress of VT may change after ICD implantation, and incessant VT may develop. VT can be ablated successfully in this group of patients [22]. In our series, incessant VT developing 2 years after ICD implantation in two patients with organic heart disease was successfully eliminated by ablation, and these patients were asymptomatic during the 3-years follow-up period. In another patient with arrythmogenic right ventricular dysplasia, very frequent VT attacks leading to syncope could be modified by ablation and ICD implantation became possible.

In our series, two patients with bundle branch reentrant tachycardia were successfully ablated without recurrence of VT. Although ablation of the right bundle branch eliminates the bundle branch reentrant tachycardia, these patients may be under risk for other serious ventricular arrhythmias, which may necessitate additional antiarrhythmic drug therapy or ICD implantation for some patients [40].

In conclusion, RF ablation is an effective and safe procedure in both groups, although the success rate

is higher in patients with idiopathic VT. The recurrence risk is significantly higher and long-term success is lower in secondary VT, and implantation of an ICD may be required in a significant proportion of these patients.

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