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Original Article

Prophylactic catheter ablation for ventricular tachycardia reduces morbidity and mortality in patients with implantable cardioverter–defibrillator devices

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ABSTRACT

Background: Although the use of implantable cardioverter–defibrillator/cardiac resynchronization therapy device with a defibrillator (ICD/CRT-D) is the principal therapy for patients with life-threatening ventricular tachyarrhythmias/ventricular fibrillation (VT/VF), prophylactic VT ablation may reduce arrhythmic episodes and mortality in patients with an ICD/CRT-D. In this retrospective study, the prognoses among patient groups with different results of attempted VT ablation were compared.

Methods: The study population consisted of 151 consecutive patients with an ICD/CRT-D and structural heart disease. The mean age was 64 ± 9 years, and 63 of the 151 patients were women. Of the 151 patients, 117 cases underwent catheter ablation procedure for elimination of monomorphic VT. The 151 patients were divided into 3 groups based on the results of the ablation or whether ablation was attempted, i.e., success, failure, and not-attempted groups (n=87, 30, and 34, respectively). The event rate of VT/VF and total mortality were compared among the 3 groups.

Results: During a follow-up period of 31 ± 22 months, VT/VF episodes and death occurred in 45 (30%) and 16 (11%) patients, respectively. When comparing the 3 groups, the rates of VT/VF episodes and death were significantly lower in the success group than in the failure and not-attempted groups (16.1%, 46.7%, 50.0%, p=0.0001 and 6.9%, 20.0%, 11.8%, p=0.0213, respectively).

Conclusion: In patients with an ICD/CRT-D implant for VT/VF, prophylactic ablation of monomorphic VT may reduce morbidity and mortality.

1. Introduction

The use of implantable defibrillation devices such as an implantable cardioverter–defibrillator (ICD) or a cardiac resynchronization therapy device with a defibrillator (CRT-D) is the primary therapy for improving prognoses of patients with life-threatening ventricular tachyarrhythmias/ventricular fibrillation (VT/VF) [1]. In the Antiarrhythmics versus Implantable Defibrillators (AVID) study, the superiority of defibrillation therapy was established by comparing prognoses of patients with ICD implantation to that of those who received therapy with class III antiarrhythmic agents such as amiodarone or sotalol for secondary prevention of VT/VF [2]. In patients with implantable defibrillation devices, i.e., an ICD/CRT-D, additional preventive therapy for VT/VF would not be required at least for reducing mortality, although several reports have described the usefulness of preventive therapy for reducing frequent defibrillations [1–3]. Contrarily, several recent reports have documented the correlation between frequent defibrillation shocks and higher mortality in patients with a CRT-D device and congestive heart failure [4]. In such reports, myocardial damage caused by the frequent shocks has been considered the reason for the poorer prognosis [5]; however, the frequent VT/VF episodes may just be a surrogate marker for more serious underlying heart disease, which then determines the prognosis [6]. However, if the former hypothesis is correct, preventive therapy for VT/VF may result in a better prognosis in patients with an ICD/CRT-D. In the present study, we retrospectively analyzed the patients who were implanted with a defibrillation device, i.e., an ICD/CRT-D, and compared their prognoses to those with and without successful VT ablation in order to clarify the role of preventive therapy in those patients.

2. Methods

2.1. Patient population

The study population consisted of 151 consecutive patients with an ICD/CRT-D and structural heart disease. Patients were selected from the 252 consecutive patients who underwent ICD/

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Table 1
Clinical characteristics and outcomes in patients divided into groups according to different results on catheter ablation or whether the procedure was attempted.

	Total	Success	Failure	Not attempted	*p*-value
Patients (*n*)	151	87	30	34	
Age (years)	64 ± 9	64 ± 8	66 ± 9	62 ± 11	0.1713
Gender (F:M)	63:88	40:47	10:20	13:21	0.4304
Underlying heart disease	IHD 79, DCM 28, HCM 8, VHD 29, CHD 4, Others 3	IHD 53, DCM 14, HCM 6, VHD 9, CHD 4, Others 1	IHD 12, DCM 8, HCM 0, VHD 9, CHD 0, Others 1	IHD 14, DCM 6, HCM 2, VHD11, CHD 0, Others 1	0.1852
Device (ICD:CRT-D)	133:18	76:11	28:2	29:5	0.118
LVEF (%)	30 ± 7	31 ± 7	29 ± 5	31 ± 9	0.6843
Amiodarone (*n*)	51 (33.8%)	12 (13.8%)	15 (50.0%)	24 (70.6%)	0.0001*
Follow-up (months)	31 ± 22	35 ± 22	30 ± 21	23 ± 19	0.0846
VT/VF event (*n*)	45 (30%)	14 (16.1%)	14 (46.7%)	17 (50.0%)	0.0001*
Mortality (*n*)	16 (11%)	6 (6.9%)	6 (20.0%)	4 (11.8%)	0.0762

IHD, ischemic heart disease; DCM & HCM, dilated cardiomyopathy and hypertrophic cardiomyopathy; VHD, valvular heart disease; CHF, congenital heart disease; LVEF, left ventricular ejection fraction.

* Indicates statistical significance.

CRT-D implantation at our institute, and 101 patients with VF but without structural heart disease were excluded, such as patients with Brugada syndrome. The clinical characteristics of the patients are summarized in Table 1. The mean age was 64 ± 9 years, and 63 of the 151 patients were women. The underlying heart diseases were diagnosed on the basis of findings from cardiac catheterization and echocardiography. The left ventricular ejection fraction (LVEF) was determined using left ventriculography in 120 of the 151 patients and by echocardiography in the remaining 31 patients. All studies were performed with the approval of the Clinical Studies and Ethics Committee of Kitasato University Hospital.

2.2. Therapeutic procedure for the management of arrhythmias

Defibrillation devices were indicated for previous VT/VF events in 116 patients (ICD, 113 and CRT-D, 3) or inducible VT/VF in the electrophysiologic study (EPS) in the remaining 35 patients (ICD, 20 and CRT-D, 15). A CRT device was indicated based on a widened QRS interval (> 150 ms) due to left branch block and left ventricular dyssynchrony, which were findings in the echocardiogram [7,8].

The EPS was performed with routine cardiac catheterization for the diagnosis of underlying heart disease. The induction protocol for VT/VF used a standard programmed electrical stimulation protocol, i.e., 1–3 ventricular extra stimuli with 2 basic cycle lengths (400 and 600 ms, routinely), burst-pacing with gradually shortened fixed cycle lengths (667–286 ms, routinely), and an additional infusion of isoproterenol [9]. An evaluation of the preventive effect of the antiarrhythmic agents using programmed electrical stimulation, i.e., EPS-guided therapy, was not indicated in any of the patients in this study population. The decision to use of amiodarone was made empirically in individual patients based on the appearance of ventricular arrhythmias or the history of the defibrillation device.

Catheter ablation was principally indicated for all electrocardiographically documented episodes of ventricular tachycardia (VT) or for electrophysiologically inducible VT observed when the QRS morphology was considered monomorphic; ablation was not attempted in selected cases due to comorbid conditions or patient refusal. When the ablation was performed after device implantation, the ablation session was scheduled at least 2 months after implantation to avoid any device problems associated with the catheter-ablation procedure, such as a lead dislodgement. The first target of the VT ablation was set as the earliest endocardial activation site during the VT. When the ablation of the earliest activation site was ineffective, endocardial substrate mapping using a CARTO system was performed, and a linear or area ablation was performed when the arrhythmogenic substrate could be determined. Epicardial ablation was not performed in this study population. Catheter ablation was performed with a 4-mm-tip ablation catheter in the temperature-control mode. An irrigation-catheter system was used only in selected cases. The patients were divided into 3 groups based on the results of the catheter ablation, as follows: (1) Success group: after ablation, no VT/VF could be induced after completion of the entire induction protocol; (2) Failure group: after ablation, one or more VT/VF morphologies remained inducible; and (3) Not-attempted group: catheter ablation was not attempted because of comorbid medical conditions or patient refusal.

2.3. Observation protocol

After the final therapy was determined, all patients were followed for more than 6 months. During the follow-up period, VT/VF events were identified and stored in the ICD/CRT-D devices. The number of deaths was also recorded during the same follow-up period. The event-free survival from VT/VF and the overall survival were compared among the 3 groups with different results of the catheter ablation, i.e., the success, failure, and not-attempted groups.

2.4. Statistics

All values are expressed as the mean ± standard deviation. The statistical analyses were performed with a one-way ANOVA test using JMP 10 statistical software (SAS Inc., Tokyo, Japan). To compare the event rate among the groups, a chi-square test and log-rank test were used to draw Kaplan–Meyer curves. A *p*-value of < 0.05 was considered significant.

3. Results

3.1. Results of the catheter ablation and grouping

Catheter ablation was attempted to eliminate 192 foci of monomorphic VT in 117 of the 151 patients (mean foci per patient, 1.6 ± 0.7), and ablation was not attempted in the remaining 34 patients due to comorbid VF in 23, severe heart failure in 7, and patient refusal in 4. These patients comprised the “not-attempted” group. The ablation session was performed before the device implantation in 37 of the 117 patients and after the device implantation in the remaining 80 patients. Even when ablation was performed after the implant was in place, there were no serious problems, such as a lead dislodgement caused by the

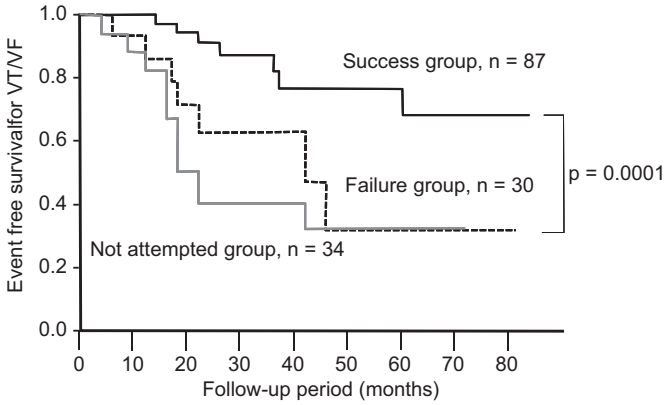

Fig. 1. Event-free survival for VT/VF events. This figure exhibits the event-free survival curves for patients with VT/VF in the 3 groups divided according to the results after ablation for VT or whether they underwent the procedure. The event-free survival for arrhythmic events was significantly higher in the success group than in the other 2 groups. See text for details.

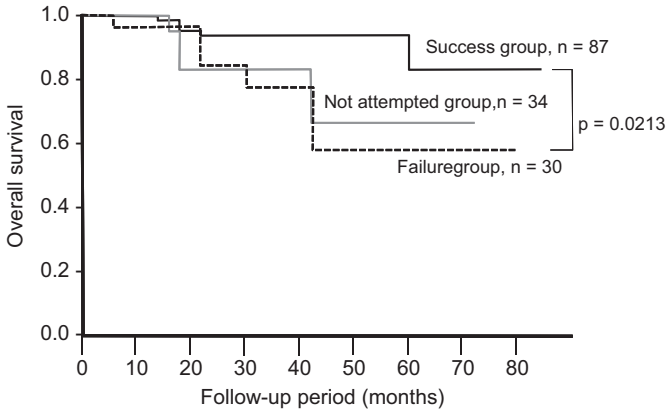

Fig. 2. Overall survival. This figure exhibits the survival curves for the total mortality in the 3 groups with different results following the attempted ablation of VT. The overall survival was significantly higher in the success group than in the other 2 groups. See text for details.

ablation procedure. In 5 of the 80 patients who underwent ablation after implantation, ablation was planned to eliminate the frequent episodes of VT caused by electrical storms. Out of 117 patients with documented and inducible VT who underwent an ablation session, all of the episodes of VT became non-inducible in 87 patients and one or more episodes of VT remained inducible in the remaining 30 patients; these were classified as "success" and "failure" groups, respectively. There were no differences among the 3 groups in terms of the clinical background, except for the incidence of amiodarone use (Table 1).

3.2. Follow-up and events

At least 6 months of follow-up was completed in all patients, and the mean follow-up period was 31 ± 22 months. During the follow-up period, death occurred in 16 of the 151 (11%) patients. The cause of death was worsening heart failure in 13, malignancy in other organs in 2, and a cerebral infarction in 1 patient. There was no difference in the death rate among the 3 groups. During the same follow-up period, VT/VF episodes were observed in 45 of the 151 (30%) patients. There was a significant difference in this rate of arrhythmic events among the groups, with the rate of VT/VF episodes being lower in the success group than in the other 3 groups (Table 1).

In the Kaplan–Meier curves, the event-free survival from VT/VF was significantly higher in the success group than in the other 2 groups (Fig. 1). Additionally, the overall survival was higher in the success group than in the other 2 groups (Fig. 2).

4. Discussion

The present retrospective study, which evaluated the prognoses of patients with ICD/CRT-D and catheter ablation, revealed several interesting findings. First, all documented or inducible monomorphic VT could be successfully ablated in 87 of the 117 patients in whom catheter ablation was attempted. Second, no serious problems with the implanted device, such as lead dislodgement, occurred in any 80 of the 117 patients in whom ablation was performed after device implantation. Third, when comparing the patient groups with the different results of the ablation, i.e., the success, failure, and not-attempted groups, there was no significant difference in clinical background, except for the incidence of amiodarone use. Finally, when comparing the Kaplan–Meier curves of these 3 groups, the morbidity, i.e., the rate of VT/VF events, and mortality were significantly lower in the success group than in the other 2 groups.

4.1. Catheter ablation and defibrillation devices in patients with VT/VF

Both catheter ablation and defibrillation device implants are important non-pharmacological therapies in patients with life-threatening ventricular arrhythmias [5,10]. From the point of view of the therapeutic quality, catheter ablation may be superior, at least for the purpose of achieving better patient quality of life (QOL) because it is a preventive therapy. However, because the success rate of catheter ablation for VT is limited [11], device implantation should be considered superior for avoiding mortality. The AVID study has clearly shown the superiority of cardioverter–defibrillator devices in comparison to preventive therapy, but the preventative therapy in this trial was pharmacological therapy using the class III antiarrhythmic agents, amiodarone and sotalol [2]. In accordance with this agreement and recent guidelines [12], we used a therapeutic strategy that placed device implantation as the first-line therapy in this retrospective observational study. However, the addition of catheter ablation was not meaningless and demonstrated a substantial benefit, even in patients with prior device implantation. Several reports have documented the benefit of catheter ablation in avoiding frequent episodes of VT after electrical storms in cases of VT/VF with an ICD/CRT-D [13]; we performed ablation sessions for this same clinical situation in 5 of the 117 patients in whom we attempted catheter ablation.

When a catheter ablation is scheduled after device implantation, potential problems with the device, especially lead dislodgements caused by the ablation procedure, should be avoided, in particular, during the ablation of a right ventricular focus. Conversely, the implanted lead might limit the control of the ablation catheter; therefore, the order of the scheduling of the therapeutic interventions is important. When the ablation had to be performed after the device implantation, we scheduled the session at least 2 months after the device implantation, and these procedures did not cause any problems. Therefore, catheter ablation can be considered a procedure that may be performed safely, even in cases with a preceding device implantation.

4.2. Role of catheter ablation in patients with defibrillation devices

Although life-threatening ventricular arrhythmias can be eliminated by the action of implantable defibrillation devices in patients with VT/VF, frequent defibrillation shocks will decrease the patient's QOL and may also result in shortening the battery life

of the device [14]. Ablation will be useful for avoiding frequent shock in cases with electrical storms, as described above. In contrast, several reports have documented the relationship between frequent defibrillation shocks and a worse prognosis in patients with left ventricular dysfunction [6]. The mechanism of this relationship might be explained by hypothesizing that frequent arrhythmias represent a more serious form of heart failure, but another explanation might be that the frequent defibrillation shocks cause injury to the ventricular muscle [15]. If the latter hypothesis correct, a reduction in arrhythmic events will lead to a better prognosis in those patients with defibrillation devices by preventing myocardial injury. In the present study, we attempted to eliminate monomorphic VT in 117 of the 151 cases with an implanted defibrillation device, and ablation was performed for prophylactic purposes in at least 112 of the 117 cases. Thus, the success group exhibited a lower rate of morbidity and mortality in comparison to the failure and not-attempted groups. This result corroborates a previous report [16]. Because the cause of death included worsening heart failure in most (13/16) of the patients, these results may indicate the preventive effect of a successful ablation for cardiac mortality through the preservation of left ventricular function.

However, because of the retrospective observational nature of this study, the VT ablation attempts were not randomized, thus the unsuccessful results, i.e., the failure or not-attempted groups, may indicate a more complicated arrhythmogenic substrate. The success group had the lowest incidence of amiodarone use compared with all 3 groups (Table 1). Although the decision to use of amiodarone depended partly on the result of ablation itself, the reduced need for amiodarone in the success group may indicate that this group may have initially included patients with a better prognosis. Therefore, the unsuccessful results may play a role as surrogate markers of more severe underlying heart disease. Reddy et al. reported that prophylactic ablation would be effective in reducing the morbidity, but not mortality, of patients in a study designed as a randomized prospective study [17]. The difference among the preceding reports and our present study may depend on the difference in the study designs. The true effect of prophylactic VT ablation in patients with defibrillation devices should be evaluated in a future study with a larger number of patients.

5. Conclusions

We compared the prognoses of patients with ICD/CRT-D device implants, among patient groups with different results of the catheter ablation for VT. In the log-rank analysis, the patients with a successful result of the VT ablation exhibited lower morbidity and mortality in comparison to those with unsuccessful results, i.e., the failure or not-attempted groups. Prophylactic ablation of monomorphic VT may reduce the occurrence of morbidity and mortality in patients with VT/VF and an ICD/CRT-D implantation.

Conflict of Interest

There was no financial support from any specific company for this study or any conflict of interest, and all compounds or products were used with approval.

Acknowledgment

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