ORIGINAL ARTICLE

Anti-tachycardia pacing for non-fast and fast ventricular tachycardias in individual Japanese patients: From Nippon-storm study

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Abstract

Background: Anti-tachycardia pacing (ATP) delivered from an implantable device is a useful tool to terminate ventricular tachycardia (VT). But its real-world efficacy for those patients having multiple VTs with varying VT rates has not been fully studied.

Methods: Using the Nippon-storm study database, efficacy of patient-by-patient basis ATP programing for Japanese patients having both non-fast (120-187 bpm) and fast VT (≥188 bpm) was assessed. According to the useful criteria of ≥50% success termination by ATP, patients were divided into three subgroups; success ≥50% for both non-fast and fast VT (both useful), ≥50% only for non-fast VT (non-fast VT useful), or ≥50% for neither non-fast nor fast VT (neither useful).

Results: During a median follow-up of 28 months, ATP terminated 184 of the 203 non-fast VT episodes (91%) and 86 of the 113 fast VT episodes (76%) in all 41 patients. In the patient-by-patient analysis, efficacy of ATP was not different between non-fast and fast VT in most of the patients (36/41 = 88%); 32 patients were in the both useful and four other patients in the neither useful. Neither ischemic nor non-ischemic structural heart disease was associated with the ATP efficacy, whereas LVEF more than 37.0% and non-prescribed amiodarone were characteristics of the patients classified into the both useful.

Conclusions: ATP well terminated both non-fast and fast VT occurring in individual Japanese patients with various structural heart diseases in the real-world device treatment and this finding further supports ATP programing for all device tachycardia detection zones in most patients with multiple VTs.

KEYWORDS
ATP, VT, implantable device, pleomorphism

1 | INTRODUCTION

Recent studies from the United States and European countries[1-4] have demonstrated that modern updated anti-tachycardia pacing (ATP) is highly effective in patients treated with an implantable cardioverter defibrillator (ICD) or a cardiac re-synchronous treatment defibrillator (CRT-D), and these findings are represented in the 2019 update guideline in HRS/EHRA/APHRS/LAHRS.[5] Although ATP is considered safe and useful, most of the previous or recent studies were performed in order to identify the ideal ATP programing and/or to evaluate clinical outcomes of the specific ATP modes. Therefore, the role of ATP in real-world device treatment, where ATP programing is selected by the physician in each institution, has not fully been studied, especially in Japanese patients. In addition, pleomorphic ventricular tachycardia (VT) with various heart rate (HR) occurs in 10%–20% of the device-implanted patients with structural heart disease.[6,7] The effect of ATP on VT termination may not be identical between these pleomorphic VTs because ATP has been reported to be more effective for VT with non-fast HR (>90% success rate) rather than fast HR (70%–90% success rate).[8-11]

Since recent ICD and CRT-D can be programed for multiple interventions based on the HR during the VT and ventricular fibrillation (VT zone, fast VT zone, ventricular fibrillation zone, etc), studying how ATP works for non-fast and fast VT occurring in the same individual in the real-world device treatment would be useful when considering optimal ICD/CRT-D programing in these patients. Therefore, this study was conducted using the NIPPON-storm study database which was performed in 48 centers in Japan (Appendix).[12,13] Patients who had experiences of ATP for both non-fast (120-187 bpm) and fast VTs (≥188 bpm) were chosen from the database, and results of the ATP were assessed on a patient-by-patient basis. Clinical and electrophysiological characteristics for predicting successful ATP-induced termination for both non-fast and fast VT were also examined.

2 | SUBJECTS AND METHODS

2.1 | Registration

The Nippon-storm study was organized by the Japanese Heart Rhythm Society (JHRS) and Japanese Society of Electrocardiology. Website registration of patients was conducted in 48 Japanese device implanting centers, and the JHRS collected data from participating physicians. In Nippon-storm study, device treatment specialists authorized by JHRS were employed in all institutions, and on a patient-to-patient basis, an appropriate ATP-mode was chosen in each patient and the outcomes were followed. The Nippon-storm study was conducted in accordance with the Helsinki Declaration and approved by the institutional review board of each institution. All patients gave written informed consent to participate in this study. According to the guidelines for implantation of an ICD/CRT-D,[14] indication and purpose of implantation were determined by attending device treatment specialists of each center. The details of the overall study design and main results of the Nippon-storm study have previously been published elsewhere.[12,13]

2.2 | Study subjects

In the NIPPON-storm study, 1570 patients (1274 patients with structural heart disease and the other 296 patients without) were enrolled from 48 centers in Japan. Of these, 41 patients (34 male and 7 female) satisfied all the following criteria; presence of structural heart disease, experiences of ≥1 episode of ATP both for non-fast VT with a HR of 120-187 bpm and fast VT with a HR of ≥188 bpm, and had completed submission of the requested data for analysis (Table 1). Among the 41 patients, a subset of 18 patients (16 male and 2 female) had ≥2 episodes of ATP both for non-fast and fast VT (Table 1).

2.3 | ICD programing

In the Nippon-storm study, the ICD/CRT-D programing including ATP modes such as intervals for VT detection, burst or ramp pacing mode, pacing sequence number, percent shortening of ATP as the reference to VT cycle length, etc was not predetermined, and was selected and programed at the device specialists' discretion in each institution based on their patients' clinical and electrophysiological backgrounds. However, in all patients, at least more than one train of ATP was programed for non-fast and fast VT before shock.

2.4 | Definitions

The cut-off values of the non-fast (120-187 bpm) and fast VT (≥188 bpm) were based on the previous studies.[1,2] ATP-induced VT termination indicated that basic rhythm was resumed following the ATP therapy: immediate termination or termination following several beats of arrhythmia after ATP therapy.[15] For the assessment of efficacy on a patient-by-patient basis, ATP is considered to be useful if the ATPs terminated more than 50% of the episodes either for non-fast or fast VT (useful criterion).[16] This was because most of the patients in this study experienced multiple ATP episodes. In this study, the patients who satisfied the useful criterion (≥50% success) both for non-fast and fast VT were classified into the both useful subgroup, and the other patients in whom this criterion was met only for non-fast VT were placed into non-fast VT useful subgroup. There were no patients in this study in whom the useful criterion was met only for fast VT. The remaining patients who did not satisfy this criterion either for non-fast or fast VT were classified into the neither useful subgroup.

2.5 | Data analysis

Clinical parameters were presented and ATP-induced VT terminability was assessed. The analysis was repeated for both the entire group of 41 patients and the subset of 18 patients with ≥2 episodes of ATP for both non-fast and fast VT, and the results were compared with each other. This was because outcome from only a single VT episode may not be appropriate to estimate the clinical usefulness of ATP for VT.

TABLE 1 Baseline characteristics of the patients in this and the Nippon-storm study

Characteristics	Present study		Nippon-storm study (n = 1274)
	All patients (n = 41)	Subset patients[a] (n = 18)	
Age, years	65.9 ± 11.2	67.4 ± 12.1	65.1 ± 12.2
Male/Female	34 (83)/7 (17)	16 (89)/2 (11)	967 (76)/307 (24)
Ejection fraction, %	36.3 ± 17.2	33.2 ± 17.0	38.1 ± 17.0
Basic rhythm, sinus / Af or AF	34 (83)/7 (17)	14 (78)/4 (22)	1000 (79)/274 (22)
Indication, primary / secondary prevention	19 (46)/22 (54)	8 (44)/10 (56)	638 (50)/636 (50)
Structural heart disease			
IHD	12 (29)	6 (33)	482 (38)
DCM	11 (27)	5 (28)	342 (27)
HCM	8 (20)	2 (11)	204 (16)
Cardiac sarcoidosis	4 (10)	1 (6)	60 (5)
Others	6 (15)	4 (22)	186 (15)
NYHA, I/II/III/IV	14 (34)/13 (32)/13 (32)/1 (2)	6 (33)/8 (44)/4 (22)/0	375 (29)/482 (38)/365 (29)/52 (4)
Electrical storm	20 (49)	13 (72)	84 (7)
ECG parameters			
Heart Rate, beats/min	64.8 ± 12.4	62.2 ± 9.0	66.4 ± 14.6
QRS duration, ms	133.3 ± 36.3	133.9 ± 45.5	131.8 ± 35.8
QT interval, ms	439.3 ± 50.5	457.3 ± 55.0	447.3 ± 55.0
CTR, %	56.4 ± 6.4	56.7 ± 8.6	56.4 ± 6.7
BNP, pg/mL	485.0 ± 564.3	381.1 ± 360.2	514.5 ± 776.3
Creatinine, mg/dL	1.26 ± 0.64	1.18 ± 0.55	1.39 ± 1.60
Medication			
Beta-blocker	30 (73)	14 (78)	887 (70)
Amiodarone	15 (37)	10 (56)	513 (40)
ACEI or ARB	18 (44)	8 (44)	750 (59)

Abbreviations: ACEI, angiotensin converting enzyme inhibitor; Af, atrial fibrillation; AF, atrial flutter; ARB, angiotensin II receptor blocker; BNP, brain natriuretic peptide; CTR, cardio-thoracic ratio; DCM, dilated cardiomyopathy; HCM, hypertrophic cardiomyopathy; IHD, ischemic heart disease; NYHA, New York Heart Association functional classification.

The numbers are presented as mean ± standard deviation, and numbers in parentheses indicate the percentage of each parameters.

[a]Subset of patients had ≥2 episodes of ATP both for non-fast and fast VT.

We also examined the following parameters, including age, gender, left ventricular ejection fraction (LVEF), basic rhythm, either primary or secondary prevention of cardiac events, either ischemic or non-ischemic heart disease, NYHA-classification, episodes of electrical storm, ECG parameters, serum brain natriuretic peptide and creatinine, and medication, to determine whether any of them were predictors for ATP-induced VT termination for both non-fast and fast VT.

2.6 | Statistical analysis

The data are presented as mean ±standard deviation. ATP success rates among the three subgroups were compared by analysis of variance (ANOVA) and the Scheffe multiple-range post hoc test, where appropriate, using SPSS software version 26 (SPSS Institute Inc). A P value <.05 was considered statistically significant. Univariate analysis was performed to assess the successful predictors for ATP therapy. The association between success results of ATP and the HR during the VT was assessed using generalized estimating equations (GEE) analysis.[1,2] Receiver operating characteristic (ROC) analysis was used to obtain the optimal predictive values for the potential predictors.

3 | RESULTS

3.1 | Patient characteristics

The mean age of the 41 patients was 65.9 ± 11.2 year old and their LVEF was 36.3 ± 17.2% at the time of device implantation (Table 1). Basic characteristics of the study patients are given in Table 1. Beta-blockers were prescribed in 30 (73%) patients, and angiotensin-converting enzyme inhibitor (ACEI) or angiotensin II receptor

blocker (ARB) was used for 18 (44%) patients. Amiodarone was prescribed for 15 (37%) patients. Other measurements including 12-lead ECG are given in Table 1. The clinical and electrophysiological characteristics appear similar between all 41 patients and the subset of 18 patients in the present study, as well as the 1274 patients with structural heart disease assigned into the main Nippon-storm study[12] (Table 1). However, a statistical assessment was inapplicable among the three groups, because the 18 patients are a subset of all 41 patients in this study, and the 41 patients are themselves a subset of the 1274 patients of the Nippon-storm study.

Electrical storm occurred in 20 of all 41 patients (49%), and in 13 of the 18 subset patients (72%) in this study (Table 1). By contrast, electrical storm was observed in 84 of the 1274 patients (6.6%) with structural heart diseases in the NIPPON-storm study. The large number of patients with electrical storm in this study is most likely due to the inclusion criteria of this study (patients having 1≥ episode of ATP for both non-fast and fast VT).

3.2 | Overall outcomes

During a median follow-up of 28 months (range, 23-33), 316 ATP episodes of either non-fast or fast VT were observed in the 41 patients. Among them, 203 episodes were for non-fast VT (162 ± 16 bpm) whereas the other 113 episodes were for fast VT (206 ± 18 bpm). Average number of the non-fast and fast VT episodes in each patient was 5.0 ± 5.1 (range, 1-25) and 2.8 ± 3.6 (range, 1-22) times, respectively. Most of the VTs were distributed in the HR range of 140-219 bpm whereas only a small number of VTs were in the HR range of 120-139 bpm and >220 bpm (12.3%, 39/316 VTs) (Figure 1).

The subset of 18 patients with ≥2 episodes of ATP both for non-fast and fast VT demonstrated 99 non-fast VT episodes (5.5 ± 3.8 times in each patient) and 79 fast VT episodes (4.4 ± 5.0 times in each patient).

3.3 | Efficacy of ATP therapy

ATP successfully terminated 184 of the 203 non-fast VT episodes (91%) and 86 of the 113 fast VT episodes (76%) in the 41 patients. The ATP-induced terminability was higher in non-fast than in fast VT (*P* = .001). As shown in Figure 1, success rate of ATP therapy was near or above 70% throughout the range of HR during the VT. Success rate of ATP was 80%–98% for the VT between 120 and 189 bpm, while only 67%–79% for VT above 190 bpm (Figure 1).

About 32 patients (78%) satisfied the useful criterion (>50% success) both for non-fast and fast VTs (both useful subgroup), 4 other patients (10%) satisfied the useful criterion neither for non-fast nor for fast VT (neither useful subgroup), while the remaining 5 patients (12%) met the criterion only for non-fast but not fast VT (non-fast VT useful subgroup) (Figure 2). There were no patients in whom ATP was useful for fast VT but not for non-fast VT.

When the same analysis was performed for the subset of 18 patients (≥2 episodes of ATP for both non-fast and fast VT), 14 patients (78%) were in the both useful subgroup and 2 patients (11%) were in the neither useful subgroup, whereas the remaining 2 patients (11%) were in the non-fast VT useful subgroup (Figure 2). These distributions of the patients into the three subgroups were almost identical between all 41 study patients and the subset of 18 patients (both useful subgroup; 78% vs 78%, non-fast VT useful subgroup; 12% vs 11%, neither useful subgroup; 10% vs 11%) (Figure 2).

3.4 | Predictors for successful ATP therapy

As given in Table 2, no statistical differences were observed in any clinical parameters among the three subgroups except for the serum creatinine. Serum creatinine was higher in the neither useful subgroup than in the other two subgroups (both useful and non-fast VT useful subgroups). GEE analysis revealed no
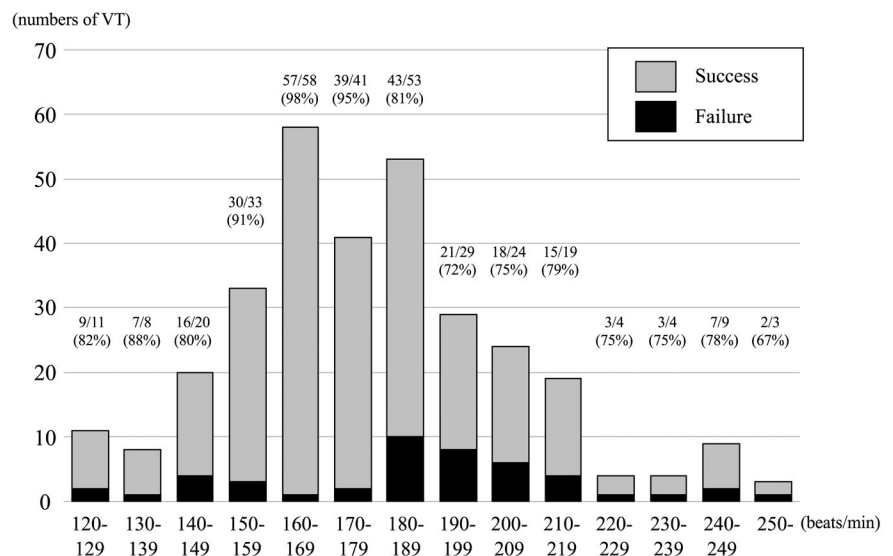

FIGURE 1 Heart rate (HR) of the non-fast and fast ventricular tachycardia (VT). The numbers of each bar graph indicate the successful treatment of anti-tachycardia pacing (ATP)
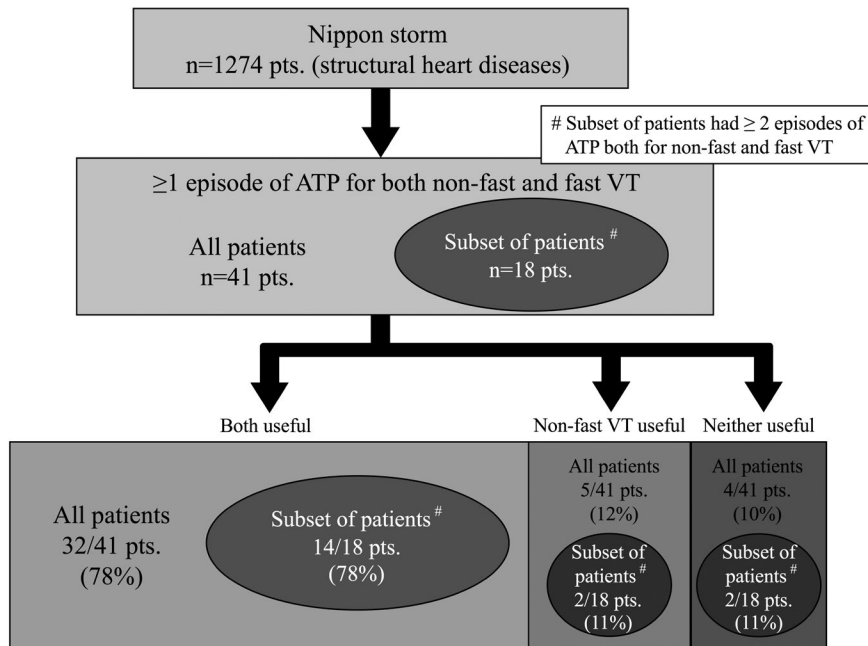
FIGURE 2 Schematic representation of individual patient-based assessment of the ATP therapy. An abbreviation: Pts=patients

TABLE 2 Comparison of clinical parameters among the three subgroups

	Both useful (N = 32)	Non-fast VT useful (N = 5)	Neither useful (N = 4)	ANOVA P value
Age, years	65.6 ± 10.5	59.2 ± 14.0	76.8 ± 5.8	.057
Male / Female	27 / 5	3 / 2	4 / 0	.256
Ejection fraction, %	39.6 ± 17.8	25.6 ± 9.1	23.5 ± 3.4	.066
Basic rhythm, sinus / Af of AF	27 / 5	3 / 2	4 / 0	.256
Indication, primary / secondary prevention	14 / 18	3 / 2	2 / 2	.786
IHD / NIHD	9 / 23	1 / 4	2 / 2	.589
NYHA, I/II/III/IV	13/8/10/1	1/3/1/0	0/2/2/0	.530
Electrical storm (%)	14 (43.8)	4 (80.0)	2 (50.0)	.320
ECG parameters				
Heart Rate, beats/min	62.9 ± 10.5	75.4 ± 21.6	66.5 ± 5.8	.103
QRS duration, ms	131.5 ± 36.8	145.8 ± 41.8	131.5 ± 31.3	.723
QT interval, ms	440.6 ± 50.6	435.6 ± 62.8	433.5 ± 46.2	.953
CTR, %	56.4 ± 5.8	59.1 ± 9.9	53.5 ± 5.7	.436
BNP, pg/mL	445.6 ± 480.1	411.0 ± 330.4	892.7 ± 1212.4	.320
Creatinine, mg/dL	1.18 ± 0.56[*]	1.05 ± 0.38[**]	2.15 ± 0.86[***]	.009
Medication (%)				
Beta-blocker	24 (75.0)	3 (60.0)	3 (75.0)	.791
Amiodarone	9 (28.1)	3 (60.0)	3 (75.0)	.100
ACEI or ARB	12 (37.5)	3 (60.0)	3 (75.0)	.265
VT heart rate (GEE adjusted), beat/min				
Slow-VT	167 (163-170)	152 (138-166)	173 (162-184)	.059
Fast-VT	205 (200-210)	207 (192-222)	199 (197-201)	.115

Abbreviations: GEE, generalized estimating equations; NIHD, non-ischemic heart disease.

[*]P = .011 for both useful vs neither useful.; [**]P = .026 for non-fast VT useful vs neither useful. Other abbreviations as in Table 1.

difference in the HR during the VT of non-fast and fast VT among the three subgroups. The distribution of patients with ES among the three subgroups was not different either. Because of the small number of patients, the same analysis was not attempted in the 18 patients with ≥2 episodes of ATP both for non-fast and fast VT.
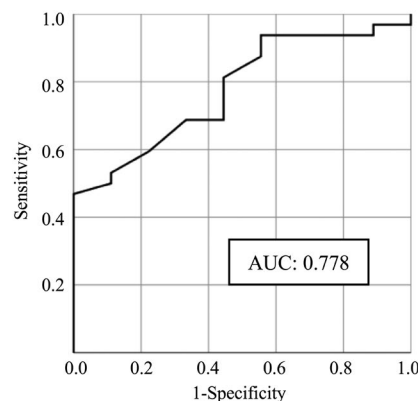
To clarify the characteristics of the patients classified into the both useful subgroup, univariate analysis was performed between the 32 patients in the both useful subgroup and the remaining 9 patients either in non-fast useful or neither useful subgroup. As the results showed, higher values of LVEF and non-prescribed amiodarone were the characteristics of the patients in whom ATP was useful both for non-fast and fast VT (Table 3). Receiver operating characteristic (ROC) analysis revealed that 37.0% of LVEF was the value in predicting successful ATP-induced termination both for non-fast and fast VT (sensitivity=46.9%, specificity=100%) (Figure 3).

TABLE 3 Univariate analysis of predictors for successful ATP therapy

	OR	95% CI	P value
Age	0.988	0.922-1.060	.741
Male	1.543	0.245-9.700	.644
Ejection fraction	1.105	1.004-1.216	.042
Basic rhythm (sinus rhythm)	1.543	0.245-9.700	.644
Indication (secondary prevention)	1.607	0.363-7.122	.532
IHD	0.783	0.160-3.821	.762
NYHA (1 increment)	0.715	0.303-1.685	.443
Electrical storm	0.389	0.082-1.836	.221
ECG parameters			
QRS duration	0.994	0.974-1.014	.561
QT interval	1.002	0.987-1.018	.753
CTR	0.995	0.885-1.119	.933
BNP	0.999	0.998-1.001	.405
Creatinine	0.440	0.147-1.313	.141
Medication			
Beta-blocker	1.500	0.303-7.432	.619
Amiodarone	0.196	0.040-0.955	.044
ACEI or ARB	0.300	0.063-1.427	.130

Abbreviations: CI, confidence interval; OR, odds ratio. Other abbreviations as in Tables 1 and 2.

4 | DISCUSSION

The main findings of this study were (1) patient-by-patient basis ATP programing by device treatment specialists was useful both for non-fast and fast VT in 78% of individual Japanese ICD/CRT-D patients with structural heart disease, (2) more than 37% of LVEF and/or non-prescribed amiodarone were characteristics of higher ATP efficacy both for non-fast and fast VT, and (3) neither ischemic nor non-ischemic structural heart disease was associated with the efficacy of ATP.

4.1 | ATP and VT termination

Different from the United States and European countries, non-ischemic heart diseases account for a larger percentage of Japanese ICD/CRT-D patients.[17] In this study, 71% of the patients (29/41) had various non-ischemic heart diseases (Table 1), while neither ischemic nor non-ischemic structural heart disease was associated with the results of ATP-induced VT termination. In addition, proportions of ischemic and non-ischemic heart disease were similar among the three subgroups (both useful subgroup, non-fast VT useful subgroup, and neither useful subgroup) (Table 2). Regardless of the type of structural heart disease, most likely mechanism of VT associated with any structural heart disease is considered to be reentry with an excitable gap.[18] ATP at an appropriate pacing rate can enter the reentry circuit and interrupt the circulating wave and/or break down the reentry circuit itself, which results in successful termination of VT.[19] Therefore, it seems reasonable that ATP is equally useful for patients with either ischemic or non-ischemic heart disease,[20,21] although some studies suggest slightly higher ATP efficacy in non-ischemic heart disease.[1,2]

4.2 | ATP for multiple VTs with varying VT-HR

In this study, compared with the fast VT episodes (76%: 86/113), ATP more frequently terminated the non-fast VT episodes (91%: 184/203) (P = .001), and these results were compatible with previous studies using a well-organized study protocol with predetermined ATP programing.[1,2,8,9] In PainFREE Rx II trial, Wathen et al reported on the efficacy and safety of ATP for fast VT (≥ 188 bpm) in 634 ICD patients,

FIGURE 3 Receiver operating characteristic (ROC) analysis. ROC analysis indicated that the predictive value of left ventricular ejection fraction (LVEF) for successful anti-tachycardia pacing (ATP) both for non-fast and fast VT was 37.0%. Area under the curve (AUC), sensitivity, specificity, positive and negative predictive values, and accuracy are shown in the figure

Optimal LVEF predictive value, %	37.0
Sensitivity, %	46.9
Specificity, %	100
Positive predictive value, %	100
Negative predictive value, %	34.6
Accuracy, %	58.5

and the ATP terminated 229 of the 284 fast VT episodes (80.6%).[1] Anguera et al compared the effectiveness of single and multi-sequence ATP for fast VT (188-240 bpm) using the database of Umbrella trial.[2] As the results showed, the success rate of termination increased from 77.1% by the first ATP to 91.1% following the multi-sequence ATPs. For VT with non-fast HR, much higher success rates of ATP therapy have been reported in several other studies (usually ≥90%).[8-11] In our patient-by-patient analysis using the useful criterion (≥50% success), ATP was considered to be useful for both non-fast and fast VT in most of the patients (32/41 = 78%) (Figure 2). As percent distribution of the patients into each subgroup was almost identical between all 41 patients and the subset of 18 patients with ≥2 episodes of ATP both for non-fast and fast VT (both useful subgroup; 78% vs 78%, non-fast VT useful subgroup; 12% vs 11%, neither useful subgroup; 10% vs 11%) (Figure 2), this high ATP efficacy may be applicable for patients with multiple non-fast and fast VTs regardless of the number of VT episodes.

The clinical impact of this study may be limited because ATP programed as the first intervention from ICD/CRT-D for both non-fast and fast VT has become common. However, there is still limited information regarding how the ATP works for non-fast and fast VT in the same individuals. Our patient-by-patient basis analysis from the database of the NIPPON-storm study showed reasonably high ATP efficacy for both non-fast and fast VT in the same individual. Therefore, we think this study could provide some additional information on this subject; namely, the effects of ATP for multiple VTs in the same individual.

4.3 | Predictors for successful ATP for both non-fast and fast VT

As has been suggested in previous studies,[1,10,20] ATP was more effective in patients with higher LVEF values, and a relatively high LVEF of 37% was a value for identifying the both useful subgroup in this study. In patients with advanced cardiac dysfunction, it is easy to imagine that ATP may deteriorate the VT into polymorphic VT or ventricular fibrillation, which ATP is unable to terminate. As reported by Harrison et al,[10] ATP was less effective in patients taking amiodarone in this study. The precise reason for this result is uncertain, but amiodarone slows the conduction velocity and prolongs the refractory period of the myocardium. Therefore, excitable gap in the reentry circuit can be widened by its conduction velocity slowing effect. It is reasonable that the wider an excitable gap is, the higher chance with which ATP enters into the circuit, resulting in the entrainment of the VT.[22-24] But the entrained VT may resume after cessation of ATP unless the ATP is applied with an appropriately short cycle length,[19,22] and this may have been a cause of the less effective ATP in these patients. It is also possible that amiodarone had been prescribed for patients with a history of more severe VT episodes.

In comparing the three subgroups, serum creatinine was higher in the patients classified into the neither useful subgroup. However, it seems to be inappropriate to reach a certain conclusion based on this small number of patients (4 patients). Nevertheless, it is reasonable that high serum creatinine is associated with multiple organ dysfunction including the cardiovascular system, which could be related to the non-favorable results of ATP.[25]

4.4 | Clinical implications

Patient-by-patient ATP programing by device treatment specialists is highly effective both for non-fast and fast VT occurring in individual Japanese patients, and this finding further supports ATP programing in multiple HR ranges during VT (VT zone and fast VT zone, etc) as the first intervention for heterogeneous patient population in the real-world device treatment.

4.5 | Limitations

First, this study was performed using the Nippon-storm study database, and ICD and/or CRT-D was programed at the physicians' discretion in each institution. The Nippon-storm study had been designed to study the outcomes of the real-world device treatment in Japan but not to explore ideal ATP programing for VT, and detailed information about the ATP programing was not collected. Therefore, the average number of ATP sequences that resulted in success or failure for each subgroup was unable to be examined. The results of each ATP attempt were not analyzable either. Programing-specific differences in the ATP therapy for non-fast and fast VT were unable to be examined in this study. However, up-to-date ATP-programing such as a longer detection interval or multiple ATP sequences, etc is considered to be important, as suggested in several previous studies (including MADIT-RIT, ADVANCE III trials, etc).[3,4,26,27] Presence or absence of syncope events during VT was also un-analyzable. Second, it is possible that during the treatment, ATP altered the HR during the VT from non-fast to fast VT zone, and vice versa. However, this information was not available from the NIPPON-storm study, and the HR during the VT before attempting any interventions was used for analysis in each VT episode. Third, although Nippon-storm study is one of the largest ICD/CRT-D studies in Japan, the number of subjects in our study was small, because we focused on specific patients who had experienced ATP for both non-fast and fast VT episodes. Therefore, a detailed analysis, including possible differences in each subgroup and type of non-ischemic heart disease, was not available, and much larger studies will be required. In patients with multiple VT episodes, VT rate differences among multiple episodes in the non-fast or fast VT detection zones may affect the results of ATP for VT termination. However, for the same reasons, it would be inappropriate to obtain any certain conclusion regarding this subject from the present study.

5 | CONCLUSIONS

Regardless of either ischemic or non-ischemic structural heart disease, patient-by-patient basis ATP programing by device specialists

is effective for termination of both non-fast and fast VT in individual Japanese patients. Therefore, ATP can be the first therapeutic intervention for multiple VTs in most patients with structural heart disease who have been treated with an implantable device.

CONFLICT OF INTEREST

No financial support was received for this study from any specific company except the Japan Arrhythmia Device Industry Association.

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