Importance of nonpulmonary vein foci in catheter ablation for paroxysmal atrial fibrillation CP

Kentaro Hayashi, MD, Yoshimori An, MD, Michio Nagashima, MD, Kenichi Hiroshima, MD, Masatsugu Ohe, MD, PhD, Yu Makihara, MD, Kennosuke Yamashita, MD, Schoichiro Yamazato, MD, Masato Fukunaga, MD, Koichiro Sonoda, MD, PhD, Kenji Ando, MD, PhD, Masahiko Goya, MD, PhD

From the Department of Cardiology, Kokura Memorial Hospital, Kitakyushu, Japan.

BACKGROUND Pulmonary vein (PV) isolation is an established treatment strategy for paroxysmal atrial fibrillation (PAF). However, the recurrence rate of PAF is 8% to 37%, despite repeated procedures, and the catheter ablation strategy for PAF with non-PV foci is unclear.

OBJECTIVE The purpose of this study was to assess the PAF ablation strategy for non-PV foci.

METHODS The study included 304 consecutive patients undergoing PAF ablation (209 males, age 63.0 ± 10.4 years) divided into 3 groups: group 1 (245 patients) with no inducible non-PV foci; group 2 (34 patients) with atrial fibrillation (AF) originating from non-PV foci and all the foci successfully ablated; and group 3 (25 patients) with AF originating from non-PV triggers, but without all foci being ablated or with persistently inducible AF.

RESULTS Mean follow-up period was 26.9 ± 11.8 months, and AF recurrence rates since the last procedure were 9.8%, 8.8%, and 68.0% in groups 1, 2, and 3, respectively. There was no statistically significant difference in recurrence rate between groups 1 and 2 ($P = .89$); however, there were statistically significant differences between groups 3 and 1 ($P < .0001$) and groups 3 and 2 ($P < .0001$). The patients in group 2 had an AF-free outcome to equivalent to those who had PV foci in group 1 ($P = .83$).

CONCLUSION Success rates can be improved for PAF ablation if non-PV foci are detected and eliminated.

KEYWORDS Catheter ablation; Atrial fibrillation; Pulmonary vein isolation; Mapping; Nonpulmonary vein foci

ABBREVIATIONS AAD = antiarrhythmic drug; **AF** = atrial fibrillation; **CA** = catheter ablation; **CFAE** = complex fractionated atrial electrogram; **CT** = crista terminalis; **LA** = left atrium; **LAFW** = left atrial free wall; **LAPW** = left atrial posterior wall; **PAF** = paroxysmal atrial fibrillation; **PV** = pulmonary vein; **SVC** = superior vena cava

Introduction

Most ectopic beats that initiate paroxysmal atrial fibrillation (PAF) originate from the pulmonary veins (PVs); thus, pulmonary vein isolation (PVI) has become the established treatment strategy.[1,2] However, the recurrence rate after PVI for PAF still is 8% to 37%, despite multiple procedures.[3–6] Several studies have addressed the importance of non-PV foci in PAF,[3,4,7–9] which tend to be located at sites such as the superior vena cava (SVC), left atrial free wall (LAFW), crista terminalis (CT), coronary sinus ostium, ligament of Marshall, left atrial appendage, and interatrial septum.[4,8,10] Non-PV foci are sometimes difficult to identify and eliminate, with several recent studies reporting that atrial fibrillation (AF) originating from these sources has a worse outcome than AF from PV sources.[3] However, several of

these reports failed to consider whether the non-PV foci had been completely eliminated during the procedures. Therefore, this study aimed to evaluate the impact of catheter ablation (CA) targeting the elimination of PAF foci, specifically those at non-PV sites.

Methods
Study population

In this study, we investigated 304 consecutive patients with drug-refractory, symptomatic PAF who underwent their first CA procedure between September 2009 and June 2011. Patients who had previously experienced AF lasting more than 24 hours or had severe structural abnormalities (2 patients with severe mitral regurgitation and 1 with a huge atrial septal defect) were excluded because we aimed to assess the importance of AF triggers while minimizing the influence of the AF substrates. All patients included in the study were refractory or intolerant to more than 1 antiarrhythmic drug (AAD) before the CA procedure. During the

Address reprint requests and correspondence: Dr. Kentaro Hayashi, Department of Cardiology, Kokura Memorial Hospital, 3-2-1 Asano Kokurakita-ku, Kitakyushu, Japan. E-mail address: sg-kentaro@kf6.so-net.ne.jp.

http://dx.doi.org/10.1016/j.hrthm.2015.05.003

CA procedure, we analyzed ectopic beats initiating AF. The patients were divided into 3 groups on a per protocol basis: group 1 comprised those without any inducible non-PV triggers in each session, including repeat procedures; group 2 comprised those with AF originating from non-PV triggers, with or without PV triggers, and in whom all non-PV triggers had been successfully ablated not later than the final procedures; and group 3 comprised patients with AF originating from non-PV triggers, with or without PV triggers, but in whom it was impossible to identify the location of AF foci definitively and to ablate completely despite repeat procedures. In group 3, we included those cases in which complete elimination of the non-PV triggers had not been possible and those in which we could not identify or ablate the non-PV foci because the AF was only induced a few times. The study was approved by the ethical committee of Kokura Memorial Hospital.

Electrophysiologic study and mapping procedure

AADs were discontinued at least 5 half-lives before CA, except for amiodarone, which was discontinued at least five days before ablation. The presence of LA thrombi was excluded by transesophageal echocardiography. Each patient provided written informed consent to undergo electrophysiologic study in the fasting state under conscious sedation.

The procedure involved inserting a 20-pole catheter through the right jugular vein. The proximal portion was positioned along the SVC and CT, and the distal portion was placed in the coronary sinus. A 10-pole catheter was positioned at the His-bundle area to record the His-bundle potential and to pace the right ventricle.

Following the standard Brockenbrough technique, we introduced two 10-pole circular mapping catheters and an ablation catheter into the LA. We estimated the location of the AF initiation foci using the endocardial atrial activation sequences from the SVC, CT, His bundle, PV, LA posterior wall (LAPW), and coronary sinus catheters (Figure 1). An electroanatomic mapping system (CARTO, Biosense Webster, Diamond Bar, CA; or EnSite, NavX, St. Jude Medical, St. Paul, MN) was typically used to provide additional guidance and to minimize fluoroscopy time.

Induction of ectopic beats initiating AF

We analyzed the initiating foci using electrode catheters when spontaneous ectopic beats initiated AF. When no spontaneous ectopic beats were observed before the PVI procedure, we intravenously injected adenosine triphosphate (ATP, 20–40 mg) to induce AF. After PVI, we used a bolus injection of ATP during continuous infusion of isoproterenol (ISP, 1–5 μg/kg/min) to search for non-PV foci. If AF was not initiated by the ATP and ISP infusion, we induced sustained AF by rapid atrial pacing during ISP infusion, which was terminated by intracardiac defibrillation. After restoration of sinus rhythm, we investigated whether there had been any spontaneous reinitiation of AF. Non-PV foci were defined as the earliest ectopic sites where the ectopic
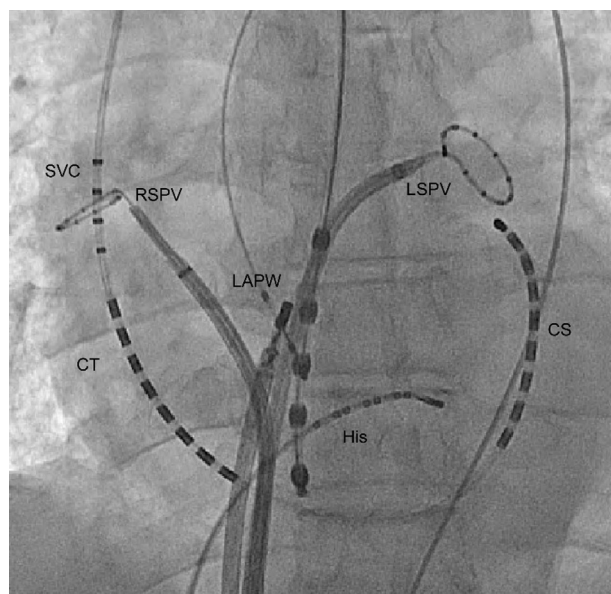

Figure 1   Positions of catheters for induction of nonpulmonary vein foci. CS = coronary sinus; CT = crista terminalis; LAPW = left atrial posterior wall; LSPV = left superior pulmonary vein; RSPV = right superior pulmonary vein; SVC = superior vena cava.

beats initiated AF. Any solitary ectopic beat that did not initiate AF was excluded from the analysis.

Catheter ablation

PVI was performed using 2 circular lines encircling the ipsilateral PVs in all 3 groups. We aimed to ablate non-PV foci consecutively in groups 2 and 3. Linear ablation or complex fractionated atrial electrogram (CFAE) ablation was added, as appropriate. We created LA roof and floor linear lesions to prevent roof-dependent atrial tachycardia when 2 PVI circles were too close (within 1 cm). A 3.5-mm or 4-mm open-irrigated-tip ablation catheter (ThermoCool, Biosense Webster, Diamond Bar, CA; or Cool Path, St. Jude Medical, St. Paul, MN) was used. PVI was considered successful in the acute setting if all ostial PV potentials recorded on the circular mapping catheter during sinus rhythm or coronary sinus pacing had been abolished (ie, entrance block). Exit block was confirmed by pacing from a circular mapping catheter with antral pacing from the ablation catheter. When a non-PV focus was identified, we performed limited area ablation of the earliest ectopic sites, LAPW and SVC. For ectopy from the LAPW, we performed a box-shaped linear ablation around the ectopy by creating roof and floor lines. For ectopy from the SVC, we performed SVC isolation from a site proximal to the SVC ectopic focus. We performed linear ablation at the cavotricuspid isthmus in patients with documented or inducible cavotricuspid isthmus–dependent atrial flutter. The end-point of the linear lesions was complete bidirectional conduction block, confirmed by pacing from the appropriate sites.

Power delivery during radiofrequency ablation was adjusted for the ablation site, and the temperature at the ablation catheter as well as the impedance drop was

recorded. An esophageal temperature probe was inserted to monitor and titrate the power delivered to the LAPW.

Follow-up of AF recurrence

Patients were observed in the hospital for 3 days after the procedure before being evaluated in our cardiology clinic at 1 month, 3 months, and every 1 to 3 months after the procedure. AADs were prescribed for 4 to 12 weeks if early recurrence of AF occurred. After that, AADs were discontinued if no AF recurrence was observed.

Patients were scheduled to undergo 24-hour Holter monitoring or 2-week cardiac event recording after the procedure at appropriate times. When patients experienced events suggestive of tachycardia, electrocardiography, 24-hour Holter monitoring, or 2-week cardiac event recording was performed to identify the cause of the clinical symptoms. Any symptomatic or asymptomatic atrial tachyarrhythmias (including atrial flutter and procedure-related atrial tachycardia) were treated as recurrences. The first 3 months after the ablation were considered the blanking period, and the end-point was recurrence of an atrial arrhythmia (defined as an atrial arrhythmic episode lasting for >1 minute) 3 or more months after the ablation. If more than 2 recurrence episodes were documented, patients were encouraged to undergo repeat CA.

Statistical analysis

Results are expressed as mean $\pm$ SD. The demographic and clinical characteristics of the 3 groups were compared by analysis of variance for continuous variables and by either the χ^2 test or the G test for categorical variables. Kaplan–Meier survival analysis with a log-rank test was used to assess the recurrence of AF, and logistic regression analysis was used for multivariate analysis. In all analyses, $P < .05$ was considered significant. Analyses were conducted using Stat-View 5.0 software (SAS Institute, Cary, NC).

Results

Baseline and electrophysiologic characteristics

The study included 304 patients (age 63.1 ± 10.4 years, 209 males) divided into 3 groups: group 1 (245 patients), group 2 (34 patients), and group 3 (25 patients) according to the criteria defined in the Methods. The presence of PV foci was not considered in our definition of grouping. All patients underwent CA procedures for drug-refractory symptomatic AF, with 419 CA procedures performed among them. A second procedure was necessary in 100 patients (32.9%), a third procedure in 13 patients (4.3%), and more than 3 procedures in 1 patient (0.3%). Among patients without non-PV foci at the time of the first session, non-PV foci were newly identified at the second procedure in 17 patients and at the third procedure in 3 patients (Figure 2). Baseline and electrophysiologic characteristics of the 3 groups are listed in Table 1. There were no significant differences in the demographic or echocardiographic profiles.

Catheter ablation

Electrical PVI was complete for all patients. If LA–PV reconnections were present, PVI was accomplished during repeat procedures. In group 1, an LA roof line was created after PVI in 28 patients, and an additional LA floor line was created in 22 patients to prevent roof-dependent atrial flutter. In groups 2 and 3, ablation of the non-PV foci was attempted in addition to PVI for all patients. Ablation of non-PV foci was primarily by limited focal area ablation, segmental SVC isolation, LA roof line creation, and additional LA floor line creation, as summarized in Table 2. Mitral isthmus lines and CFAE ablation were rarely performed. In group 2, radio-frequency pulses were successfully applied to eliminate the non-PV foci. In group 3, we aggressively searched for non-PV foci and intensively ablated them. However, it was difficult to identify the precise foci because of the low inducibility, or elimination was difficult because of multiple
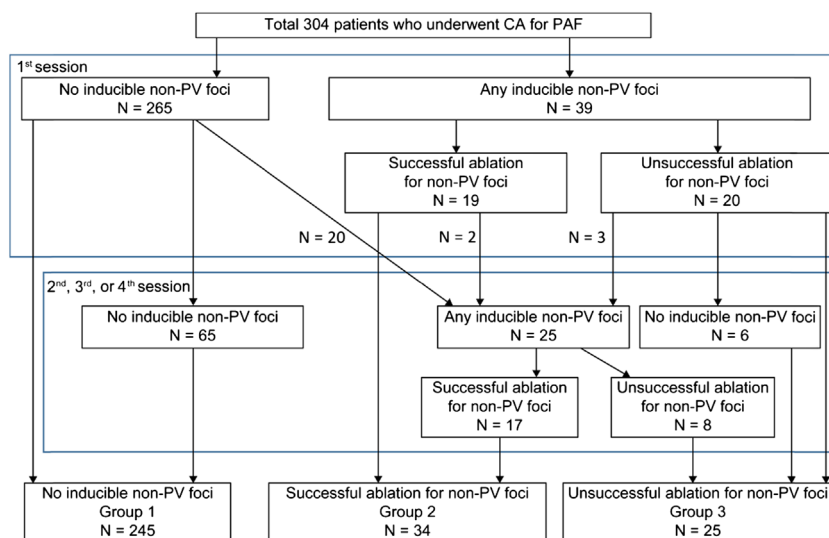

Figure 2 Study design and patient flow. CA = catheter ablation; PAF = paroxysmal atrial fibrillation; PV = pulmonary vein.

Table 1   Patient characteristics

	Group 1 (N = 245)	Group 2 (N = 34)	Group 3 (N = 25)	P value
General characteristics				
Female/male	71/174	11/23	13/12	NS
Age (years)	63.0 ± 10.7	64.8 ± 9.3	61.1 ± 9.6	NS
$CHADS_2$ score	0.9 ± 1.0	1.0 ± 1.2	0.9 ± 1.0	NS
CHA^2DS_2–VASc score	1.8 ± 1.5	1.9 ± 1.5	2.2 ± 1.6	NS
Hypertension	119 (48.6%)	12 (35.3%)	13 (52%)	NS
Diabetes	31 (12.6%)	6 (17.6%)	2 (8%)	NS
Stroke/transient ischemic attack	21 (8.6%)	3 (8.8%)	2 (8%)	NS
Chronic heart failure	9 (3.7%)	2 (5.9%)	1 (4%)	NS
Cardiomyopathy	11 (4.5%)	0	1 (4%)	NS
Vascular disease	22 (9.0%)	1 (2.9%)	1 (4%)	NS
Coronary artery disease	16 (6.5%)	1 (2.9%)	0	NS
Sick sinus syndrome	32 (13.1%)	5 (14.7%)	3 (12%)	NS
Echocardiographic parameters				
Left atrial dimension (mm)	38.9 ± 5.4	38.3 ± 5.5	38.5 ± 7.0	NS
Left atrial volume/body mass index	31.6 ± 11.1	30.6 ± 13.3	28.8 ± 7.6	NS
Left ventricular ejection fraction (%)	65.3 ± 7.2	65.5 ± 5.1	64.9 ± 6.7	NS
E/Ea	11.6 ± 4.6	12.6 ± 6.2	12.0 ± 6.8	NS
Follow-up (months)	27.1 ± 11.7	24.2 ± 13.0	28.7 ± 11.7	NS

Ea = early diastolic velocity of the septal mitral annulus.

non-PV foci under the induction protocols. During the ablation procedure, pericardial effusions developed in 2 patients in group 1 and in 1 patient in group 3; they were resolved by pericardiocentesis. No procedures were aborted.

Recurrence of AF

Mean follow-up after the last procedure was 26.9 ± 11.8 months. During this period, 121 patients (39.8%) had recurrent AF after a single ablation procedure. Recurrence rates were 32.7% for group 1, 67.6% for group 2, and 88.0% for group 3 after a single ablation procedure. In total, 115 repeat ablation procedures were performed in 100 patients (32.9%), and the overall recurrence rate was 14.5% after multiple procedures (1.4 ± 0.6 ablation procedures per patient). No roof-dependent atrial tachycardias occurred during the follow-up period. Moreover, multivariate analysis revealed that linear ablation was not an independent predictor of AF recurrence, with unsuccessful ablation of non-PV foci being the only independent predictor in that analysis (Table 3).

Kaplan–Meier survival analysis revealed that the AF recurrence rate after the last procedure (Figure 3) was significantly higher in group 3 than in groups 1 (68.0% vs 9.8%, P < .0001) and 2 (68.0% vs 8.8%, P < .0001).

Figure 4 shows the Kaplan–Meier curves for AF recurrence after the last procedure between the patients in group 2 and group 1 with PV foci. Of note, no significant differences in AF recurrence were observed between the 2 groups (P = .89).

Incidence and distribution of PV and non-PV foci

In groups 1, 2, and 3, the PV foci occurred in 42.9% (n = 105), 44.1% (n = 15), and 60.0% (n = 15), respectively (not significant). In group 1, 57.1% of patients (n = 140) had no evidence of foci and successfully underwent PVI. In this subgroup, the AF recurrence rate was 11.4%, and there were no significant differences compared with that of the patients with PV foci in group 1. The overall incidence of non-PV triggers was 19.4% (n = 59). Table 4 summarizes the distribution AF foci per group. In group 3, they were located in the LAFW/LA roof (n = 1), SVC (n = 2), and CT/right atrium (n = 1); however, other non-PV foci remained indefinitely in all cases.

Regarding the AF originating from different triggers, 8 of 105 patients (7.6%) had recurrence because of PV triggers, 2 of 15 (13.3%) because of SVC triggers, 1 of 6 (16.7%) because of LAFW triggers, 1 of 7 (14.3%) because of CT triggers, and 1 of 5 (20%) because of interatrial septum

Table 2   Characteristics of the ablation procedures

	Group 1 (N = 245)	Group 2 (N = 34)	Group 3 (N = 25)	P value
Sessions	1.3 ± 0.5	1.8 ± 0.7	1.8 ± 0.8	<.0001
Superior vena cava isolation	6 (2.5%)	16 (47.1%)	4 (16%)	<.001
Limited area ablation for non-PV foci	0	16 (47.1%)	8 (32%)	<.001
LA roof line	28 (11.4%)	15 (44.1%)	10 (40%)	<.001
LA floor line	22 (9.0%)	14 (41.1%)	8 (32%)	<.001
Mitral isthmus line	0	0	1 (4%)	NS
CFAE ablation	1 (0.4%)	1 (2.9%)	1 (4%)	NS
CTI block line	155 (63.3%)	27 (79.4%)	15 (60%)	NS

CFAE = complex fractionated atrial electrogram; CTI = cavotricuspid isthmus; LA = left atrium; PV = pulmonary vein.

Table 3 Multivariate predictors of atrial fibrillation recurrence

Variable	Hazard ratio (95% confidence)	P value
Age	1.00 (0.95–1.04)	.72
Sex	0.46 (0.19–1.11)	.09
Left atrial volume/body mass index	0.98 (0.95–1.02)	.36
Performed linear ablation	1.39 (0.47–4.12)	.56
Unsuccessful ablation of nonpulmonary vein foci	25.5 (7.67–84.6)	<.0001

triggers. There were no AF recurrences because of coronary sinus ostium, persistent left SVC, or ligament of Marshall triggers in group 2.

Discussion
Most PAF ablation procedures are performed anatomically by isolating all of the PVs at the antrum. However, recurrent AF occasionally is related to non-PV foci even when all 4 PVs are successfully isolated. This study demonstrated that application of radiofrequency energy in non-PV areas was an effective and safe treatment of PAF and emphasized the importance of detecting and eliminating non-PV foci.

Main findings
First, we found that the AF recurrence rate was significantly higher in patients with AF originating from non-PV foci and in those in whom the non-PV triggers were incompletely eliminated. Second, there was no significant difference in AF recurrence rates between patients in whom only PV foci were detected and those with non-PV foci that were all successfully ablated. Third, each AF recurrence rate among the various AF foci will be low if we can detect and ablate them.

Incidence and distribution of non-PV foci
In the present study, we only treated AF-initiating ectopic beats as non-PV foci, even if AF was only induced a few times during the induction test. Using these criteria, 19.4% of patients had non-PV foci, with SVC triggers being the most common (5.6%). Previous reports have either considered

non-PV foci to include frequent ectopic beats that did not induce AF or excluded non-PV foci that could not be accurately mapped.[3,4,9] Clinically, it is not always possible to identify the non-PV source with our current mapping tools because sometimes only 1 ectopic beat initiates AF or because non-PV foci cannot be reproducibly induced, even with dedicated induction. To our knowledge, this is the first report to include only non-PV foci that induced AF together with non-PV foci that could not be mapped precisely. We did this to evaluate the impact of CA that aimed to eliminate PAF-inducing foci, including the non-PV foci.

Patient and electrophysiologic characteristics for AF from non-PV areas
It is possible that the higher recurrence rate in the patients from group 3 was observed because of additional remodeling of the atria compared with patients in groups 1 and 2. In a previous report, the non-PV foci of the left atria (LA) were implicated in higher AF recurrence rates because, unlike right-sided ectopy, left-sided non-PV ectopy is related to anatomic or electrical remodeling.[4] According to other reports, the presence of non-PV triggers may reflect a greater degree of atrial anatomic remodeling in patients who have an enlarged left atrial diameter, resulting in poorer outcomes.[3,11] In our cohort, there were no significant differences in with regard to age, LA dimension, LA volume, ejection fraction, E/Ea, or heart failure morbidity rates among the 3 groups. Thus, there was no apparent evidence of anatomic remodeling in patients from group 3 compared to the other groups in the study. According to a previous
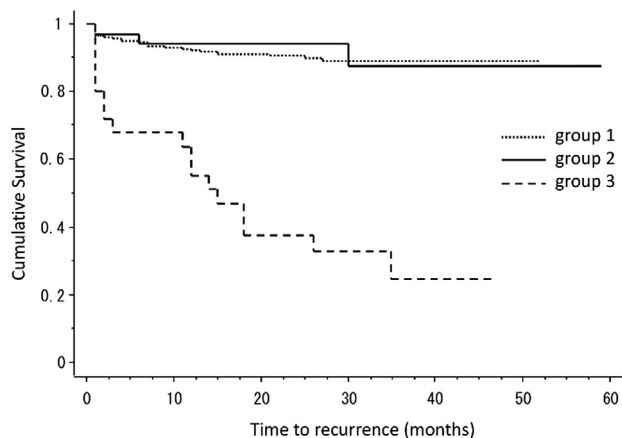

Figure 3 Kaplan–Meier survival curves showing the significant differences in rates of freedom from atrial fibrillation between groups 1 and 3 and between groups 2 and 3. P = .8942 for groups 1 and 2; P < .0001 for group 1 and 3; P < .0001 for groups 2 and 3 (log-rank).
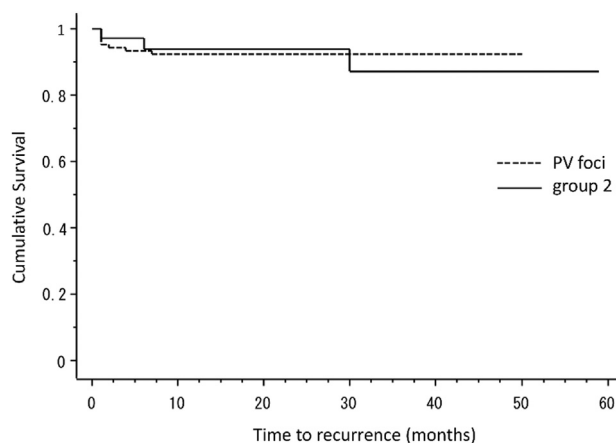

Figure 4 Kaplan–Meier survival curves showing no significant differences in rates of freedom from atrial fibrillation between group 2 and patients with pulmonary vein (PV) foci in group 1. P = .8316 (log-rank).

Table 4   Distribution of the foci of atrial fibrillation

	PVs	SVC	LAPW	CT	IAS	CSO	PLSVC	LOM
Group 1 (N = 245)	105	-	-	-	-	-	-	-
Group 2 (N = 34)	15	15	6	7	5	3	2	1
Group 3 (N = 25)	15	2	1	1	-	-	-	-

CSO = coronary sinus ostium; CT = crista terminalis; IAS = interatrial septum; LAPW = left atrial posterior wall; LOM = ligament of Marshall; PLSVC = persistent left superior vena cava; PV = pulmonary vein; SVC = superior vena cava.

report, non-PV foci were more frequent in women[3]. Although there were no significant differences among the 3 groups in our cohort, women did tend to have a high morbidity of non-PV foci ($P = .08$). This may indicate that we should take extra care when assessing the presence of non-PV foci in women during CA.

Impact of eliminating non-PV foci in PAF patients
The mid- to long-term freedom from AF recurrence after CA for PAF is reported to be 63% to 92%.[3–6] In this follow-up cohort, the overall freedom from AF recurrence was 60.2% after a single procedure, which improved to 85.5% after multiple procedures. Additionally, several studies indicated that non-PV sources account for 16% to 28% of PAF,[3,4,7–9] whereas the overall incidence of non-PV triggers was 19.4% in this study. Both of these results were comparable to the previous reports, indicating that our induction protocols and ablation procedures were justified.

According to recent reports of the long-term efficacy of cryoballoon ablation, the rates of freedom from AF were 65.1% to 76.9% despite repeat procedures.[12,13] Compared with our results, these reports suggest that it is impossible to eliminate AF in approximately 20% of cases with non-PV foci.

In groups 2 and 3 combined, the AF recurrence rate in those patients with persistent non-PV foci after the last procedure was 33.9%, which was similar to that previously reported (37%).[4] However, many previous reports did not consider whether the non-PV foci had been completely eliminated during the procedures, which is an important consideration when evaluating outcomes.

A previous report indicated that the major etiologies for AF recurrence included reconnections of isolated PVs and recovery from previously ablated PV triggers.[14] However, we found no significant differences among the 3 groups in the incidences of PV triggers (group 1: 42.9%; group 2: 44.1%; group 3: 60.0%; not significant) or LA–PV reconnections in second ablations (group 1: 98.6%; group 2: 95%; group 3: 100%, not significant). Thus, the PV triggers did not influence the discrepancy in recurrence rates among the 3 groups. In our cohort, the incidence of PV triggers was relatively low (44.4%) because we only induced AF with ATP before PVI to proceed with CA for PAF efficiently.

In addition, the presence of non-PV foci in our cohort was associated with a higher AF recurrence rate after the first CA (67.6% for group 2 and 88.0% for group 3). However, providing the non-PV foci were precisely detected and eliminated, the presence of non-PV foci was not associated with recurrence after the last procedure. Moreover, AF

originated from various non-PV foci in group 2, and each AF recurrence rate for AF originating from these different foci was low.

Our results indicate 2 important facts. First, it is difficult to map all non-PV triggers in a single procedure. Second, it is important to detect and eliminate all AF foci. Furthermore, if we were able to detect and eliminate non-PV foci, they did not influence the AF recurrence rate, and we could expect improved outcomes.

It remains true that the long-term outcomes after CA in patients with long-standing persistent AF patients are unsatisfactory.[15] Therefore, it may be necessary to abolish all non-PV foci if we are to improve the outcomes of PAF ablation procedures and prevent the progression of PAF into persistent AF.

Study limitations
This study was performed on a per protocol basis. It is common for repeated procedures to be performed because of AF recurrence, and, as indicated in this study, occasionally it is difficult to find all non-PV foci in a single procedure. Therefore, we analyzed on a per protocol basis instead of an intention-to-treat basis to evaluate the importance of non-PV foci ablation. We analyzed our cohort on an intention-to-treat basis as a sensitivity analysis, and the results are consistent with those obtained by a per protocol basis approach (data not shown).

The true incidence of AF recurrence in our population was uncertain because we focused on PAF, and sometimes it was difficult to detect patients with asymptomatic attacks. However, we attempted to maximize the detection rate for AF recurrence by carefully analyzing medical histories and performing 24-hour Holter monitoring or 2-week cardiac event recordings.

CFAE[16,17] and LA linear[18] ablation are other recognized treatment approaches for PAF. In previous studies, non-PV triggers were found to be associated with the presence of CFAE.[19] However, whether these results can be repeated in other studies is unknown. The effect of LA linear ablation on PAF also is controversial,[18] and the superiority of additional linear ablation is uncertain. We did not perform aggressive linear or CFAE ablation because of the possibility of preventing late occurrences of LA tachycardia. Therefore, we could not compare the effects between focal ablation and linear or CFAE ablation for non-PV foci in this study.

Conclusion
CA that targets non-PV foci is effective when foci have been identified. Therefore, it is important to detect any non-PV

foci and eliminate them during ablation if we are to prevent avoidable AF recurrence.

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CLINICAL PERSPECTIVES

The recurrence rate of paroxysmal atrial fibrillation (PAF) is 8% to 37% despite repeated pulmonary vein (PV) isolation, and the catheter ablation (CA) strategy for PAF with non-PV foci is unclear. Clinically, identifying the non-PV source with available mapping tools may not be possible because occasionally only 1 ectopic beat initiates AF or because non-PV foci cannot be reproducibly induced, even with dedicated induction. To our knowledge, this is the first report to include only non-PV foci that induced AF with non-PV foci that could not be mapped precisely. Our goal was to evaluate the impact of CA performed for eliminating PAF-inducing foci, including non-PV foci. We found that the AF recurrence rate was significantly higher in patients with AF originating from non-PV foci and in those in whom the non-PV triggers were incompletely eliminated. However, no significant difference was observed in the AF recurrence rates between patients in whom only PV foci were detected and those with non-PV foci that were successfully ablated. Moreover, no significant differences were observed in AF recurrence rates among the various AF foci, including non-PV foci. We propose that the success rates for PAF ablation can be improved if all non-PV foci are detected and eliminated. Our results are clinically applicable to improve CA outcomes in PAF. We emphasize that there are patients suffering from AF induced by non-PV foci; therefore, it is important to detect any non-PV foci and eliminate them during ablation to prevent avoidable AF recurrence.