# Novel Score to Predict Very Late Recurrences After Catheter Ablation of Atrial Fibrillation

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**Various predictors of atrial fibrillation (AF) recurrence have been shown based on the baseline characteristics before catheter ablation (CA). This study aimed to develop a novel scoring system for predicting very late recurrences of AF (VLRAFs) after an initial CA, taking the postprocedural clinical data into account and reassessing VLRAFs in 12-month patients' condition using previously known preprocedural predictors of AF recurrences. We retrospectively studied 327 patients who underwent an initial CA with freedom from AF for over 12 months. We elucidated the predictors of VLRAFs and created a new score to predict VLRAFs in the discovery AF cohort (n = 181). Thereafter, we investigated whether the new scoring system could accurately predict VLRAFs in the validation AF cohort (n = 146). In the discovery AF cohort, VLRAFs were observed in 53 patients (29%) during the follow-up period (mean follow-up duration: 55 months). The univariate and multivariate Cox proportional-hazards model demonstrated that non-pulmonary vein foci, early recurrences of AF (ERAFs), atrial premature contraction (APC) burden ≥ 142/24 hours, and minimum prematurity index of the APCs ≤ 48% were associated with VLRAFs after CA. We created a new scoring system to predict VLRAFs, the n-PReDCt score (non-pulmonary vein: 1 point, early recurrences of AFs (Recurrences of AF in early phase after CA): 1 point, APC burden ≥ 142/24 hours: 1 point, and minimum prematurity index (= Coupling interval) of the APCs of ≤ 48%: 1 point). The n-PReDCt score was significantly associated with VLRAFs by a Kaplan-Meier analysis in the discovery AF and validation AF cohorts (p < 0.0001 and p < 0.0001, respectively).**  **(Am J Cardiol 2021;141:49−55)**

The outcomes of catheter ablation (CA) of atrial fibrillation (AF) have improved dramatically, however, the cumulative AF recurrence continues to increase with a longer follow-up.[1] Several scoring systems predicting AF recurrences after CA have been developed based on the preprocedural status.[2−6] However, after CA of AF, cardiac function may improve and cardiac chamber size may decrease.[7,8] Recently, it was reported that an analysis of the follow-up 24-hour Holter electrocardiogram (ECG) was useful to predict AF recurrence.[9−11] The aim of this study was to elucidate the risk factors of AF recurrences after CA based on the pre- and/or postprocedural clinical data and the various examinations 12 months after CA and to create a new scoring system to predict the long-term outcomes after CA.

## Methods

The study included consecutive symptomatic AF patients who underwent an initial CA at Osaka Rosai Hospital between January 2011 and August 2017. All patients underwent transthoracic echocardiography before and 12 months after the CA and underwent 24-hour Holter ECG 12 months after the CA. Recurrence of AF was defined as any atrial tachyarrhythmia lasting more than 30 seconds except for during the blanking period (3 months). Patients were excluded from this study if they had a recurrence of AF within 12 months after the CA, or required antiarrhythmic drug beyond the blanking period. Recurrence of AF within 3 months and after 12 months was defined as an early recurrence of AF (ERAFs) and very late recurrences of AF (VLRAFs), respectively. The study patients were divided into 2 groups: a discovery AF cohort (from January 2011 to December 2014) to investigate the predictors of VLRAF to develop the predictive scoring system of VLRAF and a validation AF cohort (from January 2015 to August 2017) to verify the new scoring system.

AF type was categorized as paroxysmal AF if it self-terminated within <1 week, persistent AF if it lasted ≥1 week and < 1year or required antiarrhythmic drugs or direct current cardioversion to restore sinus rhythm, and long-standing AF if it lasted ≥ 1 year.[12] Underlying heart disease was defined as a previous myocardial infarction, previous percutaneous coronary intervention, dilated cardiomyopathy, hypertrophic cardiomyopathy, valvular heart disease, or previous cardiac surgery. Valvular heart disease included mitral regurgitation, aortic regurgitation, aortic stenosis,

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See page 54 for disclosure information.

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and tricuspid regurgitation with a moderate or severe grade and mild mitral stenosis.

All procedures were performed in accordance with the relevant guidelines. All patients signed a written informed consent for the CA and use of the clinical data related to the CA. The study was performed according to the Declaration of Helsinki. This study was approved by our institutional review committee of Osaka Rosai Hospital.

The ablation procedure was performed by a well-known approach as previously described (See the supplementary methods of procedure). After the completion of the PV isolation, isoproterenol (4 to 20 $\mu$g/min) was infused and adenosine triphosphate (40 to 60 mg) was injected rapidly. When AF was induced by a focal trigger derived from non-PV region, we defined it as non-PV foci. Based on the findings derived from intracardiac electrodes placed in the right lateral wall, superior vena cava, and coronary sinus, the origin of non-PV foci was identified by the ablation catheter or multi electrodes catheter. Non-PV foci were ablated aggressively.

Follow-up visits of our hospital were scheduled at 1, 3, 6, 12, 24, 36, 48, and 60 months. Twelve-lead ECGs were recorded at every visit and 24-hour Holter ECGs were scheduled at 6, 12, 24, 36, 48, and 60 months. Most patients underwent 12-lead ECGs at their primary clinic once a month. Patients were educated to take a pulse in the morning and the evening at the discharge. If the patients feel suggestive of arrhythmia or notice arrhythmia after a discharge, they can use healthcare providers at any time, including nearby clinics and our hospital. An ECG was performed at each additional visit, and 24-hour Holter ECG monitors and/or event recorders were performed as needed.

The 24-hour Holter ECG was analyzed automatically by an SCM-8000 (Fukuda Denshi Co., Ltd., Tokyo, Japan). Atrial premature contraction (APCs) were defined as narrow QRS complexes appearing >30% earlier than expected when compared with the previous RR interval during normal sinus rhythm. The following parameters were measured: the APC burden, number of the longest APC runs (≥2 beats), and minimum prematurity index of the APCs. The APC burden was defined as the number of APCs per 24 hours. The prematurity index of the APCs was calculated as the percentage of the coupling intervals of the APCs to the mean RR intervals of the 20 normal beats immediately preceding the APCs.

Parametric and non-parametric variables were presented as the mean ± standard deviation and the median and interquartile range, respectively. Categorical variables were described as the counts and percentage. Continuous variables were compared using the Student's *t* test and categorical variables using the Chi-square test or Fisher's exact test. Nonparametric variables were compared by the Wilcoxon rank-sum test. To investigate the predictors of VLRAFs, the previously known predictors of AF recurrence, including age (≥ 60/65 years), gender category, nonparoxysmal AF, smoking, coronary artery disease, long term kidney disease, left ventricular ejection fraction < 50% before/after CA, left atrial diameter ≥ 43 mm/47 mm before/after CA, bundle branch block 12 months after CA, APC burden 58 or 124/24 hours, longest APC run ≥ 5, or minimum prematurity index of the APCs ≤ 48% derived from the analysis of 24-Hour Holter ECG 12 months after CA,[2–6,9–11] were also analyzed in univariate Cox regression model. The variables with a p-value < 0.05 in univariate analysis were entered simultaneously in a multivariate Cox regression analysis. One point was assigned to the variables with a statistical significance in the multivariate analysis. The AF free survival curves for the patient subgroups were estimated by the Kaplan-Meier method and were compared with the Log-Rank test. A p <0.05 was considered statistically significant. The statistical analyses were performed using JMP version 13.0.0 software (SAS Institute Inc., Cary, North Carolina).

## Results

The baseline characteristics of all study patients (n = 327) are shown in Table 1.

In the discovery AF cohort (n = 181), the mean follow-up duration was 55 ± 20 months. VLRAFs occurred in 53 patients (29%) (VLRAFs group). The baseline characteristics and postprocedural clinical follow-up variables are shown in Table 2 and Table 3, respectively.

Among the 20 clinical variables, the univariate and multivariate Cox regression analysis showed that 4 variables (non-PV foci, ERAFs, APC burden ≥ 142/24 hours, and minimum prematurity index of the APC ≤ 48%) were associated with VLRAFs (Table 4). Post 12-month left ventricular ejection fraction < 50% was excluded from multivariate analysis because this study included only 1 such patient.

We created a new scoring system to predict VLRAFs, the n-PReDCt score (1 point: each variable; non-PV, ERAFs (Recurrences of AF in Early phase after CA), APC burden, and minimum prematurity index (= Coupling interval) of the APCs ≤ 48%). The distribution of the n-PReDCt is shown in Figure 1. The incidence of VLRAFs for each n-PReDCt score is shown in Figure 2. Compared with a n-PReDCt score of 0, the odds ratio for VLRAFs was 5.57 (95% confidence interval: 2.07 to 14.97, p = 0.0002), 5.02 (95% confidence interval: 2.52 to 10.00, p < 0.0001), and 19.68 (95% confidence interval: 5.46 to 70.92, p < 0.0001) for n-PReDCt scores of ≥ 1, ≥ 2, and ≥ 3, respectively. The sensitivity, specificity, positive predictive value, and negative predictive value of the n-PReDCt scores of ≥ 1, ≥ 2, and ≥ 3 were 0.906, 0.367, 0.372, and 0.904 (≥ 1), 0.692, 0.703, 0.486, and 0.841 (≥ 2), and 0.321, 0.977, 0.850, and 0.776 (≥ 3), respectively. Kaplan-Meier curves for each n-PReDCt score are shown in Figure 3.

In the validation AF cohort (n = 146), patient's clinical baseline characteristics are shown in Table 1. The mean follow-up duration was 35 ± 9 months and VLRAFs occurred in 22 patients (15%). The distribution of n-PReDCt scores is shown in Figure 1. The incidence of VLRAFs for each n-PReDCt score is shown in Figure 2. Compared with a n-PReDCt score of 0, the odds ratio for VLRAFs was 2.94 (95% confidence interval: 0.94 to 9.21, p = 0.059), 7.02 (95% confidence interval: 2.55 to 19.53, p < 0.0001), and 13.6 (95% confidence interval: 3.91 to 47.33, p < 0.0001) for n-PReDCt scores of ≥ 1, ≥ 2, and ≥ 3, respectively. The sensitivity, specificity, positive predictive value, and

Table 1
Clinical characteristics of all patients

| Variable | All patients N = 327 | Discovery AF cohort N = 181 | Validation AF cohort N = 146 | p value |
|---|---|---|---|---|
| Age (years) | 66 ± 9 | 65 ± 8 | 66 ± 11 | 0.183 |
| Female | 94 (29%) | 57 (31%) | 37 (25%) | 0.221 |
| Paroxysmal AF | 226 (69%) | 135 (75%) | 91 (62%) | 0.017 |
| Persistent AF | 67 (21%) | 31 (17%) | 36 (25%) | 0.094 |
| Long-standing AF | 34 (10%) | 15 (8%) | 19 (13%) | 0.165 |
| Body weight (kg) | 65 ± 12 | 65 ± 12 | 65 ± 12 | 0.696 |
| Body mass index (kg/m$^2$) | 24 ± 4 | 24 ± 4 | 24 ± 4 | 0.851 |
| Prior congestive heart failure | 34 (10%) | 14 (8%) | 20 (14%) | 0.080 |
| Hypertension | 175 (54%) | 103 (57%) | 72 (49%) | 0.171 |
| Diabetes mellitus | 51 (16%) | 26 (14%) | 25 (17%) | 0.495 |
| Cerebral infarction | 21 (6%) | 13 (7%) | 8 (5%) | 0.530 |
| $CHADS_2$ score | 1.0 ± 0.9 | 0.9 ± 0.9 | 1.1 ± 1.0 | 0.050 |
| $CHA_2DS_2$-VASc score | 2.2 ± 1.4 | 2.1 ± 1.4 | 2.2 ± 1.5 | 0.456 |
| Underlying heart disease | 68 (21%) | 37 (20%) | 31 (21%) | 0.861 |
| Coronary artery disease | 29 (9%) | 21 (12%) | 8 (5%) | 0.053 |
| Dilated cardiomyopathy | 13 (4%) | 8 (4%) | 5 (3%) | 0.645 |
| Hypertrophic cardiomyopathy | 6 (2%) | 1 (1%) | 5 (3%) | 0.054 |
| Valvular heat disease | 16 (5%) | 10 (6%) | 6 (4%) | 0.553 |
| Long term kidney disease | 47 (14%) | 28 (15%) | 19 (13%) | 0.528 |
| Baseline echocardiography | | | | |
| LVDd (mm) | 48 ± 4 | 48 ± 4 | 48 ± 4 | 0.446 |
| LVDs (mm) | 30 ± 4 | 29 ± 4 | 30 ± 5 | 0.322 |
| LVEF (%) | 67 ± 8 | 68 ± 8 | 66 ± 9 | 0.030 |
| LA diameter (mm) | 43 ± 6 | 43 ± 6 | 43 ± 6 | 0.163 |
| Medications before the procedure | | | | |
| Prior antiarrhythmic drug | 73 (21%) | 43 (24%) | 30 (21%) | 0.488 |
| Beta blocker | 119 (36%) | 58 (32%) | 61 (42%) | 0.069 |
| ACEI/ARB | 103 (31%) | 59 (33%) | 44 (30%) | 0.634 |
| Procedural parameters | | | | |
| Cavotricuspid isthmus Ablation | 297 (91%) | 166 (92%) | 131 (90%) | 0.537 |
| Superior vena cava isolation | 16 (5%) | 9 (5%) | 7 (5%) | 0.941 |
| Atrial tachycardia ablation | 15 (5%) | 8 (5%) | 7 (5%) | 0.916 |
| Non-PV foci | 45 (14%) | 32 (18%) | 13 (9%) | 0.018 |

AF = atrial fibrillation; ACEI = angiotensin converting enzyme inhibitor; ARB = angiotensin receptor blocker; LA = left atrium; LVDd = left ventricular end-diastolic diameter; LVDs = left ventricular end-systolic diameter; LVEF = left ventricular ejection fraction; PV = pulmonary vein.

negative predictive value of the n-PReDCt scores of ≥ 1, ≥ 2, and ≥ 3 were 0.818, 0.395, 0.194, and 0.925 (≥ 1), 0.727, 0.726, 0.320, and 0.938 (≥ 2), and 0.364, 0.960, 0.615, and 0.895 (≥ 3), respectively. The Kaplan−Meier survival curve showed a significant difference in the VLRAF between each n-PReDCt score (Figure 3).

## Discussion

In this study, we produced a new simple scoring system to predict VLRAFs based on not only the preprocedural parameters but also postprocedural clinical data and 12-month examinations. The main findings of this study were as follows: (1) non-PV foci, ERAFs, APC burden ≥ 142/24 hours, and minimum prematurity index of the APCs ≤ 48% were independent predictors of VLRAFs, (2) we developed a new scoring system (n-PReDCt score) to predict VLRAFs, and (3) the n-PReDCt score was verified to be significantly associated with VLRAFs in the validation AF cohort.

PV isolation is an effective treatment for most paroxysmal AF originated from pulmonary vein, but not effective for AF originated from non-PV region (non-PV foci), which is observed in about 16% of de novo AF patients.[13] Non-PV foci often are unmappable and have been shown to be significantly associated with AF recurrence.[14,15] Currently, the presence of non-PV trigger would be a risk factor of VLRAF. However, the complete elimination of non-PV foci has been shown to result in a good outcome (AF free rate: 91%).[16] Therefore, if an accurate mapping and ablation for non-PV foci is established, the outcome after CA would be improved, resulting in non-PV foci no longer being a predictor of VLRAF.

Many studies have reported that ERAFs are strongly associated with late recurrences of AF.[3,17] In most patients with ERAFs, the reconnections of PV are confirmed during the repeated procedures.[18] ERAFs strongly reflect the presence of reconnected PV conduction and the potential to cause recurrences of AF.

Gang et al[9] and Inoue et al[10] reported that the APC burden of 142/24 hours or 58/24 hours was associated with AF recurrence after CA, respectively. However, our study demonstrated that the APC burden of 142/24 hours was associated with VLRAFs. These 2 studies included patients with

Table 2
Clinical characteristics of the patients in the discovery AF cohort

| Variable | VLRAFs group N = 53 | NoVLRAFs group N = 128 | p value |
|---|---|---|---|
| Age (years) | 65 ± 8 | 65 ± 8 | 0.836 |
| Female | 23 (43%) | 34 (27%) | 0.029 |
| Paroxysmal AF | 36 (68%) | 99 (77%) | 0.192 |
| Persistent AF | 11 (19%) | 20 (16%) | 0.597 |
| Long-standing AF | 6 (11%) | 9 (7%) | 0.354 |
| Body weight (kg) | 64 ± 13 | 65 ± 12 | 0.396 |
| Body mass index (kg/m$^2$) | 24 ± 4 | 24 ± 4 | 0.643 |
| Prior congestive heart failure | 7 (13%) | 7 (5%) | 0.090 |
| Hypertension | 34 (64%) | 69 (54%) | 0.203 |
| Diabetes mellitus | 7 (13%) | 19 (15%) | 0.774 |
| Cerebral infarction | 2 (4%) | 11 (9%) | 0.226 |
| $CHADS_2$ score | 1.0 ± 0.8 | 0.9 ± 0.9 | 0.818 |
| $CHA_2DS_2$-VASc score | 2.3 ± 1.2 | 2.0 ± 1.4 | 0.300 |
| Underlying heart disease | 12 (23%) | 25 (20%) | 0.639 |
| Coronary artery disease | 8 (15%) | 13 (10%) | 0.356 |
| Dilated cardiomyopathy | 3 (6%) | 5 (4%) | 0.609 |
| Hypertrophic cardiomyopathy | 0 (0%) | 1 (1%) | 0.404 |
| Valvular heart disease | 1 (2%) | 5 (4%) | 0.467 |
| Long term kidney disease | 9 (17%) | 19 (15%) | 0.719 |
| Baseline echocardiography | | | |
| LVDd (mm) | 48 ± 4 | 49 ± 4 | 0.313 |
| LVDs (mm) | 29 ± 4 | 29 ± 4 | 0.815 |
| LVEF (%) | 67 ± 8 | 69 ± 7 | 0.340 |
| LA diameter (mm) | 44 ± 6 | 42 ± 6 | 0.113 |
| Medications before the procedure | | | |
| Prior antiarrhythmic drug | 13 (25%) | 30 (23%) | 0.876 |
| Beta-blocker | 21 (40%) | 37 (29%) | 0.164 |
| ACEI/ARB | 17 (32%) | 42 (33%) | 0.923 |
| Procedural parameters | | | |
| Cavotricuspid isthmus Ablation | 50 (94%) | 116 (91%) | 0.393 |
| Superior vena cava isolation | 5 (9%) | 4 (3%) | 0.092 |
| Atrial tachycardia ablation | 2 (4%) | 6 (5%) | 0.797 |
| Non-PV foci | 14 (26%) | 11 (9%) | 0.003 |

VLRAFs = very late recurrences of AF; the other abbreviations were shown as Table 1.

Table 3
Clinical follow-up variables in the discovery AF cohort

| Variable | VLRAF group (N = 53) | NoVLRAF group (N = 128) | p value |
|---|---|---|---|
| Within 3 months after the procedure | | | |
| ERAF | 21 (40%) | 25 (20%) | 0.006 |
| Post 12 months | | | |
| Medication | | | |
| Beta-blocker | 11 (21%) | 15 (12%) | 0.125 |
| Echocardiography | | | |
| LVDd (mm) | 48 ± 4 | 48 ± 4 | 0.740 |
| LVDs (mm) | 29 ± 4 | 29 ± 3 | 0.930 |
| LVEF (%) | 69 ± 7 | 71 ± 4 | 0.077 |
| LA diameter (mm) | 42 ± 5 | 41 ± 6 | 0.277 |
| Laboratory data | | | |
| BNP (pg/ml) | 27 [17−44] | 40 [18−82] | 0.130 |
| eGFR (ml/min/1.73m$^2$) | 71 ± 17 | 70 ± 14 | 0.863 |
| 24-hour Holter ECG | | | |
| APC burden (%) | 300 [98−1348] | 0.123 [51−277] | < 0.001 |
| Maximum Number of APC runs | 5 [3−11] | 4 [0−7] | 0.052 |
| Minimum prematurity index of the APCs (%) | 46 [43−50] | 51 [48−55] | < 0.001 |

APC = atrial premature complex; BNP = brain natriuretic peptide; eGFR = estimated glomerular filtration rate; ERAF = early recurrences of atrial fibrillation; the other abbreviations were shown as Tables 1 and 2.

antiarrhythmic drugs during the Holter ECG (19 patients [15%] and 82 patients [22%], respectively), whereas no patients received any antiarrhythmic drugs in our study. The antiarrhythmic drugs may have affected the results of APC burden. Therefore, the absolute value of APC burden per 24 hours predicting the VLRAFs is still debatable.

Capucci et al[19] demonstrated that the coupling interval of APCs triggering AF was significantly shorter than that of isolated APCs. The short coupled APCs have been shown to be also associated with the initiation of AF after a bradycardia event, which means an increased vagal tone.[20] Kanda et al[21] reported that the APCs triggering AF had a shorter coupling interval than those of non-AF-triggers at the electrophysiological study during the CA. Recently, we demonstrated that the APCs with a prematurity index ≤ 48% during the 12-month Holter ECG is an significant predictor of VLRAFs.[11]

The previous scoring systems for predicting an AF recurrence were produced on the basis of preprocedural variables. The APPLE score (left atrial diameter ≥ 43 mm, persistent AF, age > 65 years, estimated glomerular filtration rate <60 ml/min/1.73m$^2$, and left ventricular ejection fraction < 50%) was shown to be a good predictor of a 1-year AF recurrence after CA.[4] The AF recurrence rate according to the APPLE score was 19% (score 0), 28% (1), 39% (2), and 52% (≥3), whereas that of our study cohort was 31% (score 0), 13% (1), 34% (2), and 14% (≥3). This discrepancy may be explained by few patients in our study had risk factors for the APPLE score. The CAAP-AF score, including the age, type of AF, LA diameter, gender, number of failed antiarrhythmic drugs, and coronary artery disease, was shown to be an accurate predictor of 2-year outcomes after CA.[5] The ATLAS score (age > 60 years, type of AF, left atrial volume index, female gender, and smoking) correlated well with the long-term outcomes.[6] Since our study did not include all predictors of the CAAP-AF and ATLAS scores, we could not evaluate those score. However, the age > 60 years, type of AF, coronary artery disease, and smoking which was a part of predictors in those scores, were not associated with VLRAFs in our study. The MB-LATER score (male, bundle branch block, and left atrial diameter ≥ 47 mm, type of AF, and an ERAFs) was a predicting score of VLRAFs including the features of the 12-lead ECG.[3] Because bundle branch block reflects left ventricular dysfunction,[22] the MB-LATER score may be suitable for a cohort that includes a large number of patients with left ventricular impairment. However, in our cohort, a bundle branch block was very rare (4 patients [2%]) and was not an independent predictor of VLRAFs.

The n-PReDCt score differs from the previous scoring system[2–6] in that it focuses on the various postprocedural parameters to investigate the predictors of VLRAF. The previous scoring systems based on preprocedural

Table 4
Univariate and multivariate Cox regression analysis of factors affecting VLRAF after CA

| Variable | Univariate | | Multivariate | |
|---|---|---|---|---|
| | Hazard ratio (95% confidence interval) | p value | Hazard ratio (95% confidence interval) | p value |
| Age ≥ 60 years | 1.37 (0.713−2.888) | 0.363 | | |
| Age ≥ 65 years | 0.99 (0.576−1.722) | 0.974 | | |
| Female | 1.58 (0.910−2.712) | 0.106 | | |
| Non paroxysmal AF | 1.72 (0.949−3.009) | 0.073 | | |
| Smoker | 1.10 (0.500−2.159) | 0.801 | | |
| Coronary artery disease | 1.17 (0.507−2.348) | 0.697 | | |
| Long term kidney disease | 1.37 (0.623−2.692) | 0.409 | | |
| EF < 50% before CA | 3.71 (0.605−12.086) | 0.132 | | |
| LA diameter ≥ 43 mm before CA | 1.60 (0.892−2.777) | 0.112 | | |
| LA diameter ≥ 47 mm before CA | 1.10 (0.641−1.903) | 0.732 | | |
| Non-PV foci | 4.87 (2.790−8.407) | < 0.001 | 2.82 (1.532−5.114) | 0.001 |
| ERAF | 2.51 (1.419−4.345) | 0.002 | 2.15 (1.171−3.872) | 0.014 |
| Bundle branch block 12 months after CA | 0.76 (0.043−3.484) | 0.780 | | |
| EF < 50% 12 months after CA | 16.67 (2.605−60.315) | 0.007 | | |
| LA diameter ≥ 43 mm after CA | 1.11 (0.521−2.125) | 0.779 | | |
| LA diameter ≥ 47 mm after CA | 1.45 (0.835−2.482) | 0.186 | | |
| APC burden ≥ 58/24 hours | 1.76 (0.900−3.853) | 0.102 | | |
| APC burden ≥ 142/24 hours | 2.91 (1.617−5.552) | < 0.001 | 2.495 (1.350−4.870) | 0.003 |
| Longest APC run ≥ 5 | 1.48 (0.859−2.566) | 0.159 | | |
| Minimum prematurity index of the APCs ≤ 48% | 3.619 (2.067−6.563) | < 0.001 | 2.42 (1.171−4.565) | 0.004 |

CA = catheter ablation, the other abbreviations were shown as Tables 1-3.

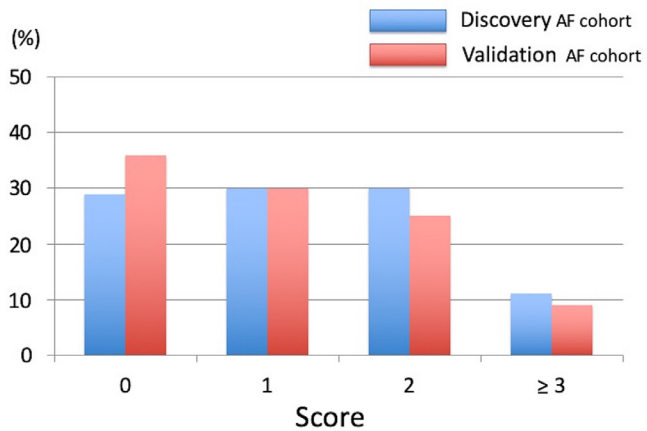


Figure 1. Distribution of the n-PReDCt scores in the discovery AF and validation AF cohorts. AF= atrial fibrillation.

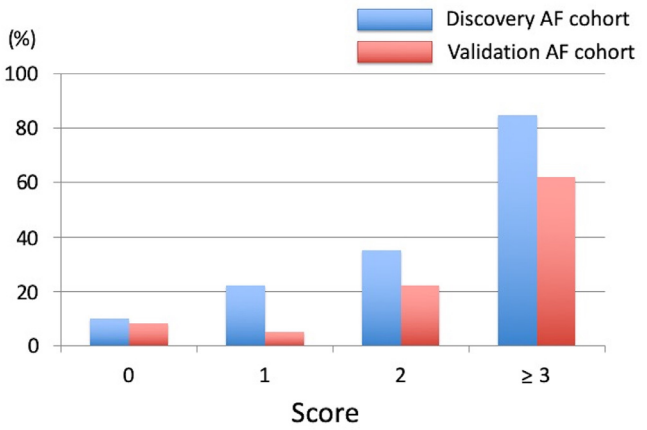


Figure 2. Incidence of VLRAFs for each n-PReDCt score. AF = atrial fibrillation.

parameters were not associated with VLRAF in this study. For some patients, the echocardiographic parameters may improve after the CA. It is important to stratify the risk of VLRAFs in combination with the pre- and post-procedural predictors. Therefore, we believe that the n-PReDCt score is useful in those patients with negative for the previous scoring systems. Since AF burden is associated with an increased risk of an ischemic stroke,[23,24] patients with low n-PReDCt score may be at low risk of thromboembolic events. Therefore, the n-PReDCt score would be to help make the decisions to discontinue anticoagulation in the selected patients, including the patients with a high risk of bleeding, or scheduled surgical procedure. Finally, since AF-free survival in the patients with a high n-PReDCt score (3 or 4) is steady decline, those patients should be closely follow-up.

In conclusion, this study demonstrated that a non-PV foci, ERAFs, APC burden ≥ 142/24 hours, and minimum prematurity index of the APCs ≤ 48% were independent risk factors of VLRAFs after CA. The n-PReDCt score based on the postprocedural parameters were strongly associated with VLRAFs.

## Authors' contributions

All authors substantially contributed to the work and met the authorship criteria as follows:

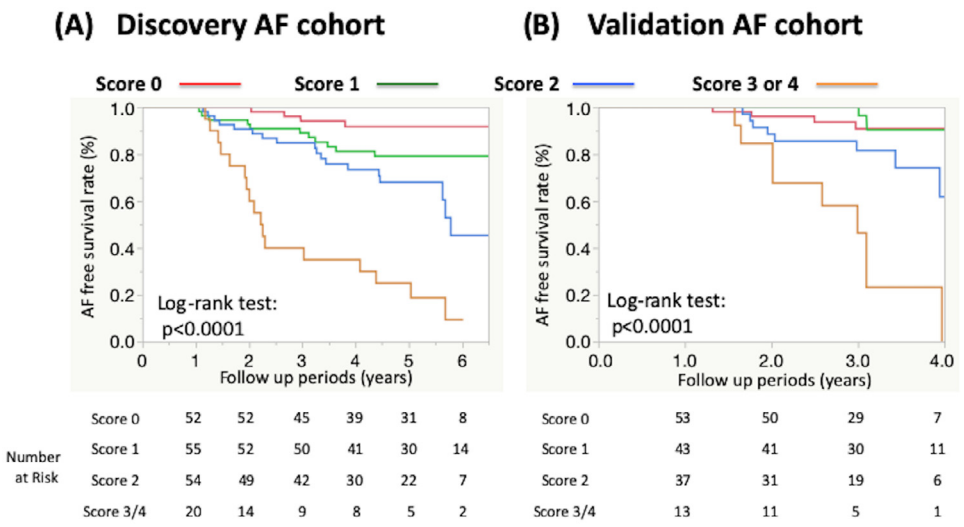


Figure 3. Kaplan-Meier curves of the freedom from AF after CA for each n-PReDCt score in the discovery AF cohort (A) and validation AF cohort (B). AF = atrial fibrillation.

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## Disclosures

The authors have no conflicts of interest to disclose.

## Supplementary materials

Supplementary material associated with this article can be found in the online version at https://doi.org/10.1016/j.amjcard.2020.11.008.

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