Original Article

# Long-Term Follow-Up After Catheter Ablation of Paroxysmal Atrial Fibrillation

## The Incidence of Recurrence and Progression of Atrial Fibrillation

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***Background***—Although catheter ablation (CA) is a standard treatment for atrial fibrillation (AF), its long-term efficacy remains unclear. This study aimed to elucidate the incidences of AF recurrence and of progression from paroxysmal to persistent AF, after CA, in patients with paroxysmal AF.

***Methods and Results***—We examined the incidence of AF recurrence and AF progression in 1220 consecutive patients (mean age, 61 years), with symptomatic paroxysmal AF, undergoing CA, based on extensive pulmonary vein isolation and focal ablation for nonpulmonary vein foci. AF recurrence–free survival probabilities at 5 years were 59.4% after the initial CA and 81.1% after the final CA (average, 1.3 procedures). During a median follow-up period of 47.9 (range, 5.3–123.3) months after the initial CA, AF progressed from paroxysmal to persistent in 15 (1.2%) patients (0.3%/y). The duration of AF history (hazard ratio [HR], 1.03; $P<0.0001$), number of ineffective antiarrhythmics (HR, 1.09; $P=0.005$), and left atrial diameter indexed by the body surface area (HR, 1.05; $P=0.001$) were significant predictors of AF recurrence. Patient age (HR, 1.12; $P=0.0001$) and left atrial diameter indexed by the body surface area (HR, 1.26; $P=0.0006$) were significantly associated with AF progression. Patients aged ≤65 years and with a left atrial diameter indexed by the body surface area of ≤24.0 mm/m$^2$ did not develop AF progression for ≤10 years after the initial CA.

***Conclusions***—Although the long-term follow-up revealed the effect of CA on preventing AF recurrence, repeated CA sessions might be required. The rate of progression from paroxysmal to persistent AF was 0.3%/y. **(*Circ Arrhythm Electrophysiol*. 2014;7:267-273.)**

**Key Words:** atrial fibrillation ■ catheter ablation ■ recurrence



Catheter ablation (CA) is a standard therapy for treating patients with atrial fibrillation (AF).[1–3] However, its long-term outcomes, including the incidences of AF recurrence and progression from paroxysmal to persistent AF, have not been fully elucidated.

**Clinical Perspective on p 273**

## Methods

### Study Population

A total of 1220 consecutive patients (mean age, 61 years; male, n=940) were enrolled in this study between February 2003 and October 2009. The patients were referred to our institution for an initial CA to treat paroxysmal AF (PAF) refractory to antiarrhythmic drugs (AADs). AF was defined as paroxysmal when it terminated spontaneously within 7 days.[4] All patients provided written, informed consent, and our institutional review board approved the protocol.

### Electrophysiological Study

AADs were discontinued for >7 days (amiodarone was discontinued for >1 month) before the ablation; all patients were also effectively anticoagulated for >1 month. A 7F, 20- or 14-pole, 2-site mapping catheter (Irvine Biomedical, Irvine, CA) was inserted through the right jugular vein and positioned in the coronary sinus for pacing, recording, and internal cardioversion.

### CA Technique

The strategy of extensive pulmonary vein isolation (EPVI) has been described previously.[5] Briefly, after a transseptal puncture, pulmonary venography and contrast esophagography were performed to determine the anatomic relationships of the pulmonary vein (PV) ostia, left atrium (LA), and esophagus. An activated clotting time of 250 to 350 seconds was maintained with a continuous infusion of heparin during the procedure. Two circular mapping catheters were placed in the superior and inferior PVs, and the left and right ipsilateral PVs were circumferentially and extensively ablated under fluoroscopic and electrophysiological guidance. Radiofrequency

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current applications were delivered with an 8-mm-tip ablation catheter (Japan Lifeline, Tokyo, Japan) in the temperature control mode, with a target temperature of 55°C (maximum power, 35 W on the LA posterior wall; 40 W at the anterior aspect of the PVs); esophageal temperature was measured during the application.[5] The end point was the elimination or dissociation of PV potentials. After completing the EPVI, ATP (20–40 mg) was injected to unmask any dormant conductions, and those were disconnected.[6] Thereafter, a cavotricuspid isthmus line was created with an end point of bidirectional conduction block.[7] Isoproterenol (5–20 μg/min) was intravenously injected before completing the procedure. If sustained or nonsustained AFs were reproducibly initiated from non-PV foci, they were focally ablated.[8] When non-PV foci were located in the superior vena cava, the superior vena cava was electrically isolated.[9,10] If spontaneous AF did not occur, rapid atrial pacing was performed to induce AF. After an episode of pacing-induced AF was sustained, internal cardioversion was attempted to convert the AF to sinus rhythm (SR). If spontaneous reinitiation of AF occurred, the AF focus was subsequently ablated. Linear ablations (LA roof and bottom or mitral isthmus lines) were performed only when AFs from undetermined origins or macroreentrant atrial tachycardia spontaneously occurred, with an end point of a bidirectional conduction block.[11,12] On completion of the procedure, the end points of EPVI, superior vena cava isolation, and linear ablations were reconfirmed.

### Follow-Up

AADs were not prescribed after the procedure. Patients were prospectively followed-up at 2, 6, 10, 14, 24, 36, and 48 weeks after the procedure, with 12-lead electrocardiograms at each visit and Holter monitoring every 3 months. Thereafter, patients were followed-up every 1 to 3 months at our institution or by a general physician. Symptomatic patients received a 1-month event recorder. Anticoagulation was discontinued after 3 to 6 months in AF recurrence–free patients without risk factors of thromboembolisms. A 1-month blanking period was set, during which atrial tachyarrhythmias were considered to be a transient phenomenon. After this period, the occurrence of atrial tachyarrhythmias lasting >30 seconds, off AADs, was defined as AF recurrence, and recurrent AFs persisting >7 days were defined as AF progression. Repeat ablation was recommended for patients experiencing AF recurrence after the blanking period.

### Statistical Analysis

The data are expressed as mean (SD) for continuous variables or frequencies and percentages for categorical variables. To clarify the clinical predictors of the outcomes, univariate Cox proportional analysis was first performed. Sequentially, all variables with $P<0.20$ in the univariate analysis were included in a multivariate analysis, and hazard ratios (HRs) and 95% confidence intervals (CI) were calculated. LA diameter (LAD) indexed by the body surface area (LADI) strongly correlated with LAD ($r^2=0.59$), and both are predictors of AF recurrence and AF progression in the univariate analysis; LADI, with lower $P$ values, were included in the multivariate analysis. The follow-up period was calculated from the date of the procedure to that of the outcome (AF recurrence, AF progression) or censoring (death and end of follow-up) events. The estimated event-free survival probabilities were calculated using Kaplan–Meier analysis; log-rank statistics were used for group comparisons. $P<0.05$ were considered statistically significant.

## Results

### Patient Characteristics and Clinical Outcomes

Baseline characteristics of the 1220 patients are shown in Table 1. CA, based on EPVI, was performed successfully in all patients (Table 2). Sixty-four (5.2%) procedure-related complications occurred in 1220 procedures (3.9% in 1596 procedures; Table 3): 55 (4.5%) occurred during the initial CA session, 9 (2.7%) occurred during the second session, and none occurred thereafter. No significant association was noted between the incidence of complications and the type or number of procedures.

Figure 1 shows a ladder diagram of the results of CA sessions. During a median follow-up period of 31.5 (range, 1.0–100.5) months, 449 (36.8%) had AF recurrence; 328 of 449

**Table1. Baseline Characteristics (n=1220)**

| | |
|---|---|
| Patient age, y | 61 (10) |
| Sex, female (%) | 280 (23.0) |
| BMI, kg/m$^2$ | 23.6 (2.9) |
| Duration of AF history, y | 5.0 (5.4) |
| SHD, n (%) | 220 (18.0) |
| Hypertension, n (%) | 538 (44.1) |
| Diabetes mellitus, n (%) | 130 (10.7) |
| CHF, n (%) | 85 (7.0) |
| Stroke, n (%) | 93 (7.6) |
| COPD, n (%) | 17 (1.4) |
| $CHADS_2$ score | 0.9 (1.0) |
| HATCH score | 0.8 (1.0) |
| No. of ineffective AADs | 1.8 (1.4) |
| Echocardiography | |
| LAD, mm | 37.8 (5.1) |
| LADI, mm/mm$^2$ | 22.2 (3.5) |
| LVEF, % | 66.2 (7.3) |

Data are presented as n (%) or mean (SD). AADs indicates antiarrhythmic drugs; AF, atrial fibrillation; BMI, body mass index; CHF, congestive heart failure; COPD, chronic obstructive pulmonary disease; LAD, left atrial dimension of end systole; LADI, LAD index; LVEF, left ventricular ejection fraction; and SHD, structural heart disease.

**Table 2. Details of Multiple CA Sessions**

| | |
|---|---|
| First CA (n=1220, 100%) | n (%) |
| EPVI | 1220 (100) |
| SVCI only | 97 (8.0) |
| Focal only | 105 (8.6) |
| SVCI and focal | 23 (1.9) |
| Linear | 12 (1.0) |
| Second CA (n=328, 26.9%) | n (%) |
| EPVI | 254 (77.4) |
| SVCI only | 54 (16.5) |
| Focal only | 65 (19.8) |
| SVCI and focal | 31 (9.5) |
| Linear | 35 (10.7) |
| Third CA (n=42, 3.4%) | n (%) |
| EPVI | 15 (35.7) |
| SVCI only | 9 (21.4) |
| Focal only | 10 (23.8) |
| SVCI and focal | 7 (16.7) |
| Linear | 15 (35.7) |

A fourth CA was performed in 4 (0.3%) patients: 3 with focal and linear ablations and 1 with only linear ablation. A fifth CA was performed in 2 (0.2%) patients, both with focal and linear ablations. AF indicates atrial fibrillation; CA, catheter ablation; EPVI, extensive pulmonary vein isolation; and SVCI, superior vena cava isolation.

**Table 3. Incidence of Procedure-Related Complications Associated With CA**

| | Incidence in Total 1220 Patients | First CA (n=1220) | Second CA (n=328) | Incidence in Total 1596 Procedures |
|---|---|---|---|---|
| Cardiac tamponade/effusion | 23 (1.9%) | 21 (1.7%) | 2 (0.6%) | 23 (1.4%) |
| Air embolism | 7 (0.6%) | 6 (0.5%) | 1 (0.3%) | 7 (0.4%) |
| TIA/CI | 7 (0.6%) | 4 (0.3%) | 3 (0.9%) | 7 (0.4%) |
| Myocardial infarction | 1 (0.1%) | 1 (0.1%) | 0 (0%) | 1 (0.1%) |
| DVT/PE | 5 (0.4%) | 5 (0.4%) | 0 (0%) | 5 (0.3%) |
| Phrenic nerve injury | 8 (0.7%) | 6 (0.5%) | 2 (0.6%) | 8 (0.5%) |
| Vagal nerve injury | 5 (0.4%) | 5 (0.4%) | 0 (0%) | 5 (0.3%) |
| Pulmonary vein injury/stenosis | 3 (0.3%) | 2 (0.2%) | 1 (0.3%) | 3 (0.2%) |
| Pneumothorax | 2 (0.2%) | 2 (0.2%) | 0 (0%) | 2 (0.1%) |
| Vascular injury | 3 (0.3%) | 3 (0.3%) | 0 (0%) | 3 (0.2%) |
| Total | 64 (5.2%) | 55 (4.5%) | 9 (2.7%) | 64 (3.9%) |

No complications occurred during the third (n=42), fourth (n=4), or fifth CA (n=2). CA indicates catheter ablation; CI, cerebral infarction; DVT, deep vein thrombosis; PE, pulmonary embolism; PV, pulmonary vein; and TIA, transient ischemic attack.

(73.1%) patients with AF recurrence after the initial CA and 42 of 109 (38.5%) with AF recurrence after the second CA underwent further CA sessions. There were 376 repeat ablations in 328 patients; the 328 patients underwent a second ablation 2.2 (range, 0.1–78.7) months after the AF recurrence occurred following the initial CA and 42 underwent a third ablation 3.8 (range, 0.1–32.6) months after the AF recurrence occurred following the second CA. Ultimately, during a median follow-up period of 38.0 (range, 1.0–100.5) months, 892 (73.1%) patients had 1 CA, 286 (23.4%) had 2 CAs, and 42 (3.4%) had ≥3 CAs. SR was maintained in 990 of 1220 (81.1%) and 1018 of 1220 (83.4%) of overall patients after the second and third CAs, respectively. Among the patients cured by the prior CA(s) and actually undergoing a subsequent CA if the prior session failed, SR was maintained in 990 of 1099 (90.1%) and 1018 of 1032 (98.6%) patients after the second and third CA, respectively. The AF-free survival 5 years after the CA in PAF patients was 59.4% (95% CI, 56.1%–62.5%) after a single procedure and 81.1% (95% CI, 78.4%–83.7%) after multiple procedures (mean, 1.3±0.6 procedures; median, 1; range, 1–5; Figure 2).

## EPVI Quality and Incidence of Non-PV Foci

During the second and third sessions, 254 of 328 (77.4%) and 15 of 42 (35.7%) patients, respectively, experienced LA–PV reconductions that were not identified in subsequent sessions (Table 2).

A total of 524 non-PV foci were identified in 307 (25.2%) patients (median, 1; range, 1–7) throughout the procedures; 118 (9.7%) patients had ≥2 non-PV foci. Non-PV foci occurred in the superior vena cava (150, 12.3%); coronary sinus (42, 3.4%); right atrial posterior wall (19, 1.6%); (right atrial) crista terminalis (55, 4.5%); right anterior wall, including the appendage (18, 1.5%); interatrial septum, including the foramen ovale (109, 8.9%); LA posterior wall (50, 4.1%); LA anterior wall, including the appendage (23, 1.9%); LA roof (23, 1.9%); and LA inferior wall (13, 1.1%).

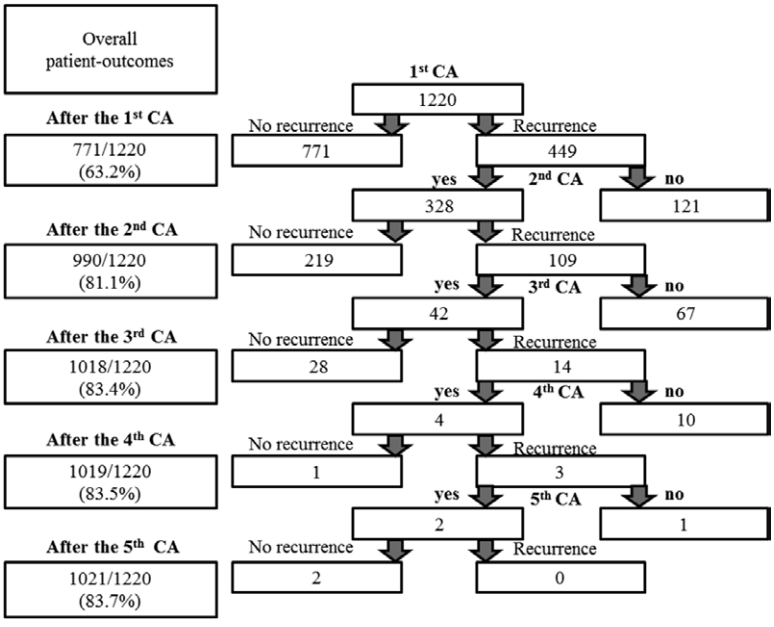


**Figure 1.** A ladder diagram showing the catheter ablation (CA) sessions and outcomes. Overall patient outcomes describes the number of patients out of the overall 1220 patients who maintained sinus rhythm. The sinus rhythm maintenance rate increases remarkably after the second CA and slightly after the third CA.

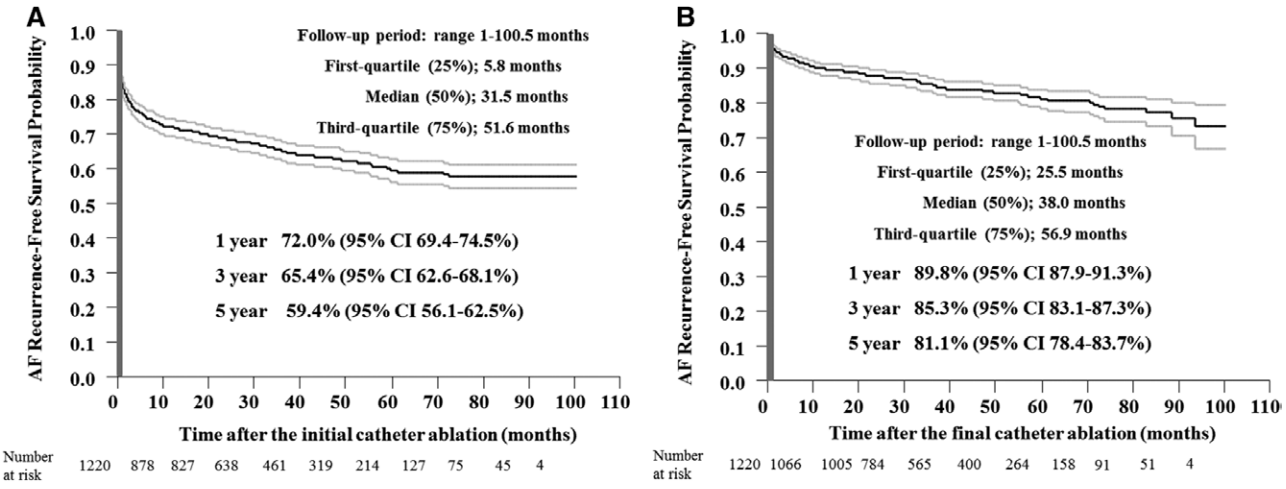


**Figure 2.** Atrial fibrillation (AF) recurrence–free survival probabilities and 95% confidence intervals (CIs) after the initial (**A**) and final (**B**) catheter ablation (CA); AF recurrence–free survival probabilities 5 years after the initial and the final CA were 59.4% and 81.1%, respectively; 73.1% had 1 CA, 23.4% had 2 CAs, 3.1% had 3 CAs, 0.2% had 4 CAs, and the remaining 0.2% had 5 CAs. AF-recurrence–free survival probabilities after the second and third CA were demonstrated in Figures in the Data Supplement.

## Clinical Predictors of AF Recurrence After the Initial CA

A multivariate Cox proportional analysis revealed that the duration of AF history (HR, 1.03; 95% CI, 1.02–1.05; $P<0.0001$), number of ineffective AADs (HR, 1.09; 95% CI, 1.03–1.16; $P=0.005$), and LADI (HR, 1.05; 95% CI, 1.02–1.07; $P=0.001$) were significant predictors of AF recurrence after the initial CA (Table 4).

## AF Progression From Paroxysmal to Persistent AF

During a median follow-up period of 47.9 (range, 5.3–123.3) months after the initial CA, PAF progressed to persistent AF in 15 patients (1.2% of all patients; 7.5% of those with AF recurrence; average AF progression rate, 0.3%/y). Moreover, 11 of them eventually shifted to permanent AF. The AF progression–free survival probabilities at 3, 5, and 7 years were 99.7%, 99.0%, and 96.0% (Figure 3A).

## Clinical Predictors of AF Progression

Multivariate Cox proportional analysis revealed that age (HR, 1.12; 95% CI, 1.04–1.22; $P=0.001$) and LADI (HR, 1.26; 95% CI, 1.11–1.44; $P=0.0006$) were significantly associated with AF progression (Table 5).

A sensitivity–specificity analysis, using a receiver operating characteristic curve, identified the cutoff values for age

**Table 4. Clinical Predictors of AF Recurrence After the Initial CA Session**

| | Univariate | | | Multivariate* | | |
|---|---|---|---|---|---|---|
| | *P* Values | HR | 95% CI | *P* Values | HR | 95% CI |
| Patient age, y | 0.61 | 1.00 | 0.99–1.01 | | | |
| Sex, female | 0.31 | 1.12 | 0.90–1.38 | | | |
| BMI | 0.45 | 0.99 | 0.96–1.02 | | | |
| Duration of AF history, y | <0.0001 | 1.03 | 1.02–1.05 | <0.0001 | 1.03 | 1.02–1.05 |
| SHD | 0.01 | 1.34 | 1.07–1.67 | 0.13 | 1.2 | 0.94–1.52 |
| Hypertension | 0.75 | 0.97 | 0.90–1.17 | | | |
| Diabetes mellitus | 0.06 | 1.32 | 0.99–1.73 | 0.09 | 1.29 | 0.96–1.70 |
| CHF | 0.23 | 1.23 | 0.87–1.70 | | | |
| Stroke | 0.59 | 1.10 | 0.77–1.51 | | | |
| COPD | 0.3 | 0.65 | 0.23–1.40 | | | |
| $CHADS_2$ score | 0.25 | 1.06 | 0.96–1.16 | | | |
| HATCH score | 0.46 | 1.03 | 0.94–1.13 | | | |
| No. of ineffective AADs | 0.0005 | 1.12 | 1.05–1.18 | 0.005 | 1.09 | 1.03–1.16 |
| Echocardiography | | | | | | |
| LAD, mm | 0.005 | 1.03 | 1.01–1.04 | | | |
| LADI, $mm/m^2$ | 0.0003 | 1.05 | 1.02–1.08 | 0.001 | 1.05 | 1.02–1.07 |
| LVEF, % | 0.78 | 1.00 | 0.99–1.02 | | | |

AADs indicates antiarrhythmic drugs; AF, atrial fibrillation; BMI, body mass index; CHF, congestive heart failure; CI, confidence interval; COPD, chronic obstructive pulmonary disease; HR, hazard ratio; LAD, left atrial dimension of end systole; LADI, LAD index; LVEF, left ventricular ejection fraction; and SHD, structural heart disease.

*Variables with a $P<0.20$ in the univariate Cox proportional analysis were included in the multivariate analysis.

(65 years) and LADI (24.0 mm/m$^2$) to optimize the capability of predicting AF progression. AF progression was predicted by age (>65 years), with a sensitivity of 73% and specificity of 65%, and by LADI (>24.0 mm/m$^2$), with a sensitivity of 87% and specificity of 73%. The areas under the curve for an age of 65 years and LADI of 24.0 mm/m$^2$ were 0.73 and 0.83, respectively. Patients were stratified by using these parameters (Figure 3B). Patients aged ≤65 years and with LADI of ≤24.0 mm/m$^2$ did not develop AF progression for ≤10 years after the initial CA.

## Discussion

### Incidence of AF Recurrence

According to several studies of long-term AF ablation efficacy,[2,13–16] success rates usually drop within 1 year and gradually decrease thereafter; this tendency was maintained after both initial (single) and final (multiple) procedures. In addition, repeat procedures usually improve the outcomes. A systematic review and meta-analysis demonstrated that the long-term success rates of CA in patients with PAF were 54.1% (95% CI, 44.4%–63.4%) after a single procedure and 79.0% (95% CI, 67.6%–87.1%) after multiple procedures (average, 1.45 procedures).[16] The present study describes a similar incidence of AF recurrence and the necessity of repeat ablation. From the findings of the present study, ≥1 repeat CA is required, and a third CA may be acceptable for better outcomes. A discussion of CA outcomes should consider various clinical parameters, including the patient population, types of AF, CA strategies, ablation catheter types, AAD use after CA, follow-up frequencies and intensities, blanking period definitions, procedural success definitions, and the availability and timing of repeat procedures.[2,13–17]

In the present study, similar to previous reports,[2,13,16,18] electric reconduction between PVs and LA is considered the major mechanism of AF recurrence; moreover, complete electric disconnection between the PVs and LA is thought to be a minimal, but critical, requirement for the best outcomes of CA of PAF. A careful and repetitive reconfirmation during the procedure may facilitate this outcome.

### Clinical Predictors of AF Recurrence After the Initial CA

We focused on PAF to minimize the heterogeneity within the study population. Thus, we demonstrated that the duration of AF history, number of ineffective AADs, and LADI were significant predictors of AF recurrence after the initial CA. The predictive value of the AF history duration on AF recurrence remains controversial[14,19,20] because the duration of a patient's AF history may not always be equivalent to the actual length of the AF episode and, hence, might not reflect disease severity such as atrial remodeling. However, the larger population size and longer follow-up period of this study showed an affinitive association between the AF history duration and AF recurrence. In the present study, the number of ineffective AADs was a significant predictor of AF recurrence; few other reports have examined this parameter as a predictor of AF outcome.[21,22] Most patients were referred to our institution after the failure of intensive treatment involving a variety of AADs (median, 2; range, 1–8), suggesting that the number of ineffective AADs may have been an indicator of the disease severity. The significant association between LA size and AF recurrence after CA is described in the literature[2,15] and is in accordance with our findings. The use of LADI instead of LAD corrects for body size heterogeneity between individuals, which may provide a better correlation with atrial remodeling.

### Incidence of AF Progression

In the present study, the AF progression rate was as low (1.2% during the 48-month follow-up, 0.3%/y) as in previous studies describing AF progression rates after CA therapy (1.5%–3.0% during mid- to long-term follow-up).[13,18,23] In contrast, other studies[24–26] have indicated rates of 5.5% to 15%/y under pharmacological therapy, which is far worse than the current findings. Moreover, 1 report of a 6-year outcome after a single CA procedure demonstrated that AF progressed to permanent AF in 10 (9.8%) of 102 patients with PAF during a mean follow-up of 50 months.[27] These observations are nonrandomized and from separate trials but do suggest that CA is better than pharmacological therapy and repeat procedures are better than single procedures for preventing AF progression, possibly because of the

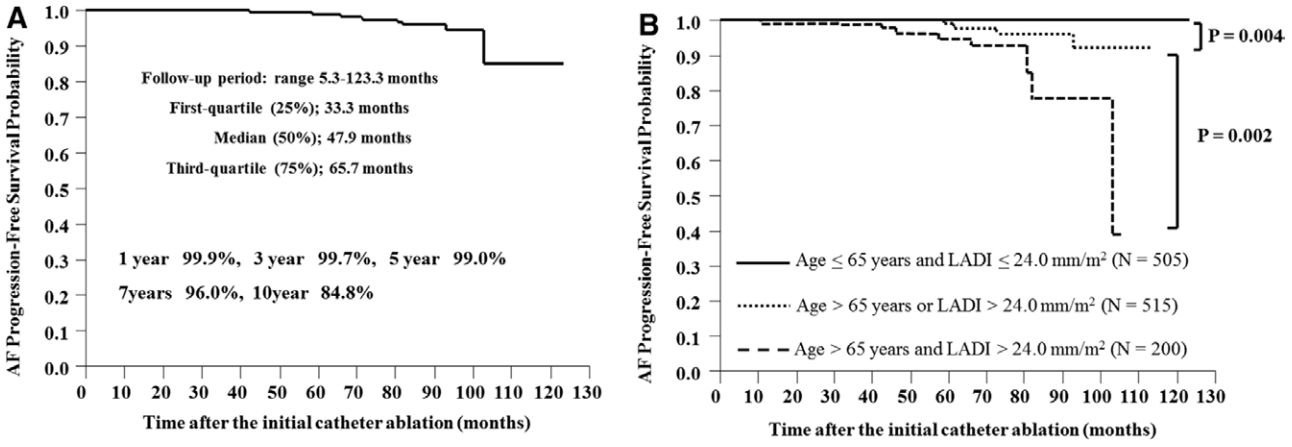


**Figure 3.** Atrial fibrillation (AF) progression–free survival probabilities after the initial catheter ablation (**A**). Patients are stratified by age and left atrial diameter indexed by the body surface area (LADI); the optimized cutoff values for age (65 years) and LADI (24.0 mm/m$^2$) are identified by a sensitivity–specificity analysis by using a receiver operating characteristic curve (**B**).

**Table 5. Clinical Predictors of the AF Progression After the Initial CA Session**

| | Univariate | | | Multivariate* | | |
|---|---|---|---|---|---|---|
| | *P* Values | HR | 95% CI | *P* Values | HR | 95% CI |
| Patient age, y | 0.0002 | 1.13 | 1.06–1.23 | 0.001 | 1.12 | 1.04–1.22 |
| Sex, female | 0.35 | 1.70 | 0.53–4.83 | | | |
| BMI | 0.02 | 0.80 | 0.66–0.96 | 0.23 | 0.89 | 0.73–1.08 |
| Duration of AF history, y | 0.76 | 0.98 | 0.87–1.07 | | | |
| SHD | 0.49 | 1.55 | 0.43–4.57 | | | |
| Hypertension | 0.74 | 0.84 | 0.28–2.33 | | | |
| Diabetes mellitus | 0.67 | 0.66 | 0.04–3.30 | | | |
| CHF | 0.15 | 2.91 | 0.64–9.50 | 0.89 | 1.15 | 0.14–9.96 |
| Stroke | 0.98 | 1.03 | 0.06–5.17 | | | |
| COPD | 0.23 | 4.64 | 0.25–23.9 | | | |
| $CHADS_2$ score | 0.28 | 1.31 | 0.78–2.03 | | | |
| HATCH score | 0.12 | 1.45 | 0.90–2.18 | 0.83 | 0.93 | 0.43–1.72 |
| No. of ineffective AADs | 0.77 | 0.95 | 0.66–1.29 | | | |
| Echocardiography | | | | | | |
| LAD, mm | 0.005 | 3.42 | 1.46–7.60 | | | |
| LADI, $mm/m^2$ | <0.0001 | 1.29 | 1.16–1.41 | 0.0006 | 1.26 | 1.11–1.44 |
| LVEF, % | 0.31 | 0.73 | 0.45–1.37 | | | |

AADs indicates antiarrhythmic drugs; AF, atrial fibrillation; BMI, body mass index; CHF, congestive heart failure; CI, confidence interval; COPD, chronic obstructive pulmonary disease; HR, hazard ratio; LAD, left atrial dimension of end systole; LADI, LAD index; LVEF, left ventricular ejection fraction; and SHD, structural heart disease.

*Variables with a $P<0.20$ in the univariate Cox proportional analysis were included in the multivariate analysis.

higher incidence of SR maintenance. An appropriate EPVI and focal ablation of non-PV foci seems to play a primary role in maintaining SR and consequently reducing AF progression; a randomized study may help this issue to be elucidated.

### Clinical Predictors of AF Progression

In the current study, aging and increased LA size defined as LADI were found to be independent predictors of AF progression. Aging and LA size are significantly associated with AF progression in most relevant reports.[23–26] In addition, several studies have documented that age and LA size are associated with atrial fibrosis,[26,28,29] which may result in increased, nonuniform anisotropy and local conduction heterogeneity,[30] thus playing a key role in promoting the perpetuation of AF.[29,30] In addition, we demonstrated that patients could be stratified before the initial CA by combining these 2 parameters (age [65 years] and LADI [24.0 $mm/m^2$]).

### Limitations

This study was subject to limitations inherent in a retrospective design. However, the clinical and demographic characteristics, ablation data, and follow-up outcomes were prospectively collected, and the population number was large, helping to offset such limitations. Second, an 8-mm tip, nonirrigation catheter was used, instead of a 3.5-mm tip irrigation catheter, because of its availability in Japan during the study period. Third, inducing non-PV AF foci under the burst pacing and isoproterenol infusion may be associated with a risk of inducing nonclinical AF foci or unmasking clinical AF foci. Fourth, cavotricuspid isthmus was routinely ablated in all patients with PAF. However, this ablation was not performed for expected beneficial effects on preventing AF recurrence.[31] Fifth, although all patients were strictly educated about the follow-up, surveillance might have varied according to the presence or absence of symptoms, the institution or physician where they were followed after 48 weeks, and the timing of their usual medical visits after 48 weeks (every 1–3 months). Finally, the survival curve after the final CA may include potential statistical limitations; it is a mixture of several curves with different start times; and the definition of final procedure will change as more patients undergo subsequent procedures, which depends on the length of follow-up.

### Conclusions

CA, based on an EPVI and non-PV focal ablation, is an effective strategy for preventing AF recurrence and AF progression during a long period. However, this may require repeat CA sessions. In addition, this study demonstrated that the duration of AF history, number of ineffective AADs, and LADI were useful predictors of AF recurrence, whereas age and LADI predicted AF progression.

## Disclosures

None.

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## CLINICAL PERSPECTIVE

Although catheter ablation (CA) is a standard treatment for atrial fibrillation (AF), its long-term efficacy remains unclear. This study describes single center, long-term outcomes, including AF recurrence and progression from paroxysmal to persistent AF, in a large number of patients with paroxysmal AF who underwent CA. AF recurrence–free survival probabilities at 5 years were 59.4% after the initial CA and 81.1% after the final CA; in addition, during a median follow-up period of 47.9 (range, 5.3–123.3) months after the initial CA, AF progressed from paroxysmal to persistent in 15 (1.2%) patients (0.3%/y). The present study investigated the clinical predictors and elucidated that the duration of AF history, number of ineffective antiarrhythmics used, and left atrial diameter indexed to the body surface area were significant predictors of AF recurrence and that patient age and left atrial diameter indexed to the body surface area were predictors of AF progression. In conclusion, this study underscores the effect of CA on preventing AF recurrence and AF progression for a long period, although repeat CA sessions might be required.