Clinical Factors Associated with a Successful Catheter Ablation Outcome in Elderly Patients with Atrial Fibrillation

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Summary

Catheter ablation is currently an established treatment for symptomatic paroxysmal atrial fibrillation (AF). We focused on elderly patients with a high prevalence of AF and attempted to identify the clinical factors associated with unsuccessful ablation outcomes.

Among 735 consecutive patients who underwent AF ablation procedures, 108 (14.7%, 66 men) aged ≥ 75 years were included. Of them, 80 had paroxysmal AF, and the remaining 28 non-paroxysmal AF. All patients underwent pulmonary vein (PV) isolation and occasionally additional ablation. When AF recurred, redo ablation procedures were performed if the patient so desired.

The mean number of ablation procedures was 1.1 ± 0.4 times per patient. During a mean follow-up of 38.7 ± 21.7 months, sinus rhythm was maintained in 100 patients (92.6%) without any antiarrhythmic drugs, but not in the remaining 8 (7.4%). Left atrial diameter (LAD, \(P < 0.001\)), left ventricular (LV) systolic diameter (\(P < 0.001\)), LV diastolic diameter (\(P = 0.001\)), non-PV AF foci (\(P = 0.036\)), and diabetes (GAD = 0.045) were associated with unsuccessful ablation procedures. Multivariate logistic regression analysis revealed a large LAD and non-PV AF foci were significant independent predictors of AF recurrences, with odds ratios of 0.76 (\(P = 0.019\)) and 0.04 (\(P = 0.023\)), respectively. In a total of 124 procedures, one major (0.8%) and 11 minor (8.9%) complications occurred.

In elderly AF patients, catheter ablation of AF is effective and safe. Non-PV AF foci and a large LAD were independent clinical predictors of unsuccessful AF ablation outcomes.

Key words: Origin of AF

Over the past 20 years, there have been many reports of high success rates and few complications associated with catheter ablation in symptomatic patients with drug-refractory atrial fibrillation (AF).1-10 The guidelines recommend catheter ablation as an alternative approach to antiarrhythmic drug (AAD) therapy in patients with symptomatic AF.1-10 These data are derived from the general population with AF. As is well known, AF increases as one grows old. Therefore, most clinical data relevant to AF are derived from this elderly population.

Some literature has already reported that AF ablation is also effective and safe in elderly patients.9,12 However, the independent predictors of AF recurrences after ablation procedures in elderly AF patients remain unclear.

The purpose of this study was to evaluate the characteristics and clinical factors of an unsuccessful ablation outcome in symptomatic elderly AF patients who generally have a higher risk during AF ablation procedures.

Methods

Study population: Among 735 consecutive patients who underwent a catheter ablation procedure to eliminate symptomatic AF at our institutes between June 2011 and December 2017, 108 patients (14.7%) who were ≥ 75 years old (77 ± 2 years, 66 men) were included in this study. Eighty of these patients (74%) had paroxysmal AF and 28 persistent AF (26%). Of the patients with persistent AF, 7 (6.4%) had long-standing persistent AF. The definitions of paroxysmal, persistent, and long-standing persistent AF followed the practice guidelines for the management of AF, which were according to the European Heart Rhythm Association and American College of Cardiology.
Cardiology Foundation/American Heart Association/Heart Rhythm Society. All patients provided written informed consent for the study protocol, which was approved by the institutional review boards.

**Preparation for catheter ablation:** All AADs were discontinued 7 days before the ablation session and the patients were effectively anticoagulated for > 1 month. Warfarin was discontinued one day before the AF ablation session, and heparin bridging was not performed. Eighty-eight (81%) of the study patients took direct oral anticoagulants (DOACs) and those drugs were interrupted only on the day of the AF ablation.

Transesophageal echocardiography (TEE) was performed to exclude any atrial thrombi one day before the procedure in all patients regardless of the CHADS2 score. Fundamentally, we did not use multidetector computed tomography (CT) before the ablation procedure.

When the patients were in sustained AF before the procedure, we always performed a pharmacological or electrical cardioversion more than one month before the AF ablation. However, when AF recurred after the cardioversion, we performed a pulmonary vein (PV) isolation (PVI) during AF.

**Catheter ablation procedure:** The surface electrocardiograms (ECGs) and bipolar intracardiac electrograms were continuously monitored and stored on a computer-based digital recording system (LabSystem PRO [Bard Electrophysiology, Lowell, MA, USA]). The bipolar electrograms were filtered from 30 to 500 Hz. A 6-Fr 8-pole or 4-pole 3-site mapping catheter (BeeAT; Japan Lifeline Co. Ltd., Tokyo) was inserted through the right jugular vein and positioned in the coronary sinus for pacing, recording, and internal cardioversion. Two 5-Fr circular mapping catheters (Libero; Japan Lifeline Co. Ltd. or AFocus II; Abbott [St. Jude Medical], Minneapolis, MN) through 2 long sheaths were placed in the PVs, respectively. The electrophysiological study (EPS) and ablation were performed under unconscious sedation with propofol and dexmedetomidine.

All patients underwent a PVI. The PVI approach performed at our institutes has been previously described in detail. Briefly, after a single transseptal puncture, 3 long 8-Fr sheaths (SL0; AF Division, St. Jude Medical, St. Paul, MN, USA) were introduced into the LA. A 5,000 IU intravenous bolus of heparin was administered immediately following the venous access, with a continuous infusion of 1,000 IU/h to maintain an activated clotting time of 350–400 seconds. Two 5-Fr circular mapping catheters through 2 long sheaths were placed in the superior and inferior PVs, respectively.

The left- and right-sided ipsilateral PVs were circumferentially and extensively ablated under fluoroscopic and electrophysiologic guidance. Radiofrequency current was delivered with an 8-mm-tip non-irrigated ablation catheter (Ablaze Fantasista, Japan Lifeline Co. Ltd.) or irrigated-tip ablation catheter (FlexAbility TMD, Abbott [St. Jude Medical], Minneapolis, MN or Thermocool9, Biosense Webster, Inc., Diamond Bar, CA, USA) through another long sheath under the guidance of a 3-dimensional (3D) cardiac mapping system (EnSite PrecisionTM, Abbott [St. Jude Medical] or CARTO3, Biosense Webster) without multidetector CT images.

After completing the PVI, a cavitricuspid isthmus (CTI) ablation was also performed to create a bidirectional conduction block. However, we did not perform a CTI ablation in patients undergoing a prolonged procedure time. We always delivered intravenous injections of 40 mg of adenosine triphosphate (ATP) in all cases more than 30 minutes after the PVI, with the exception of patients with bronchial asthma.

Further, as a feature of our institute, an incremental isoproterenol infusion (starting at 5 μg, and increasing it up to 10 μg, and 20 μg/minute for 2 minutes) was also given twice before and after the PVI, and was limited only by patient intolerance, hypotension, or the onset of AF. If frequent atrial premature contractions not generated from the PVs were present, focal ablation targeting non-PV foci was added. When AF recurred, a re-do PVI and linear ablation (the left atrial roof, inferior line) were performed. However, a mitral isthmus line and continuous fractionated atrial electrogram (CFAE) ablation were not performed if they were not necessary.

**Postablation follow-up:** Patients were followed up in the outpatient clinic at 2 weeks, and 1, 3, 6, 12, 24, and 36 months after the procedure, and then further followed up either in the outpatient clinic or contacted by telephone every year. AF recurrence was assessed on the basis of the symptoms in conjunction with serial 12-lead ECGs performed during each outpatient clinic visit, and 24-hour Holter ECGs were performed at 1, 2, 3, 4, 6, and 12 months. Patients who had symptoms were provided a portable ECG monitor (Omron, Kyoto, Japan) to monitor events for the duration of our study.

Discovery of paroxysmal or persistent episodes of AF/atrial tachycardia (AT) continuous for ≥ 30 seconds after the 2-month blanking period on the ECGs or Holter ECGs were considered a recurrence of AF and a repeat procedure was performed if the patient so desired. Freedom from AF was defined as no detectable AF/AT episodes on ECG modalities after the final procedure.

After 3 to 6 months, in the absence of any AF, antiocoagulant treatment was discontinued unless a past history of a stroke or severe arteriosclerosis was present. AADs were not prescribed in patients with paroxysmal AF but were prescribed for 1 to 3 months following the ablation in patients with non-paroxysmal AF.

**Statistical analysis:** Continuous variables are expressed as the mean ± standard deviation or median (25-75%) for non-normally distributed variables. Comparisons between patients with successful and unsuccessful ablation outcomes were performed using an unpaired t test, Fisher’s exact test, or Mann-Whitney test. Categorical variables were compared using the chi-square test. A multivariate logistic regression analysis was constructed to assess the most significant indices as clinical factors for an unsuccessful ablation outcome in elderly AF patients. Kaplan-Meier analysis was used to determine the percentage of patients free from AF after the initial and final procedure, and any differences were evaluated using the log-rank test. Parameters which had a correlation (P < 0.2) with unsuccessful ablation outcomes in the univariate analysis were included in the multivariate analysis. We assessed whether
we achieved a successful ablation in these patients by the final session.

A *P* value of < 0.05 (2-tailed) was considered to indicate statistical significance. All statistical analyses were performed using EZR on R-commander version 1.24 software (Saitama Medical Center, Jichi Medical University, Saitama, Japan).

**Results**

**Patient characteristics:** The characteristics of the elderly AF patients in this study are shown in Table I. Seventy-six (70%) patients had hypertension, 28 (29%) chronic kidney disease, and 20 (19%) sick sinus syndrome without implanting an emergent pacemaker. The mean body mass index (BMI) and body surface area were 23.1 ± 3.1 kg/m² and 1.6 ± 0.2 m², respectively. The duration of AF was 4.5 ± 4.9 years, including for both paroxysmal and non-paroxysmal AF.

The mean left ventricular ejection fraction determined by echocardiography was 69.1 ± 9.6%. The mean LA diameter and length on admission were 40.1 ± 6.6 and 54.1 ± 8.0 mm, respectively. The average LA appendage flow velocity determined by TEE was 48.1 ± 19.3 cm/sec in all patients; it was 50.3 ± 18.6 cm/sec during sinus rhythm in 92 (85%) and 36.2 ± 19.7 cm/sec during AF in 16 (15%).

The CHADS₂ score was high, with an average score of 2.2 ± 1.0 points. The median (25-75% value) brain natriuretic peptide (BNP) level was 106.1 [8.8-2185.4] pg/mL.

**AF ablation outcomes and procedural complications:** The AF ablation outcomes are shown in Table II. During the first session, a PVI with bidirectional conduction block of the CTI was successfully performed in all 99 patients (92%). As a result, 68 patients (63%) received only a PVI and CTI. The remaining 40 patients (37%) needed additional ablation. Additional focal ablation, superior vena cava (SVC) ablation, and LA linear ablation were performed in 21 (19%), 17 (16%), and 10 (9.2%) patients, respectively. However, no mitral isthmus ablations or CFAE ablations were performed in our study.

After the first session, 20 (19%; paroxysmal 14 and non-paroxysmal 6) patients had an AF recurrence and 15 (14%) underwent a repeat ablation. The remaining 5 patients did not receive additional ablation. Among the 5 patients who did not receive ablation, 4 were satisfied with the lower number of AF attacks after the ablation. In the remaining patient (non-paroxysmal, 83 years), his family did not want him to undergo another session after considering the success rate and risk due to the ablation.

In the end, we performed a total of 127 sessions to eliminate AF. We mainly used an irrigated-tip ablation catheter and it was used in 67 (62%) sessions and alternatively an 8-mm-tip non-irrigated ablation catheter was used in 41 sessions (38%). The successful outcomes of ablation did not differ between the two ablation catheters (*P* = 0.475).

During the mean follow-up of 38.7 ± 21.7 months, sinus rhythm was maintained in 100 patients (93%) without any AADs (paroxysmal AF, 93%; non-paroxysmal AF, 93%), but not in the remaining 8 patients (7.4%). Furthermore, 3 of 8 patients progressed to permanent AF. Kaplan-Meier curve estimates for the freedom from AF without AADs after the initial and final ablation sessions.

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### Table I. Characteristics of the Elderly AF Patients

| Characteristic                  | Value          |
|--------------------------------|----------------|
| Age (years)                    | 77.2 ± 2.2     |
| Gender, male/female            | 66 / 42        |
| Body mass index (kg/m²)        | 23.1 ± 3.1     |
| Body surface area (m²)         | 1.61 ± 0.2     |
| Types of AF; paroxysmal/non-paroxysmal | 80 / 28     |
| Duration of AF (months)        | 53.4 ± 58.7    |
| CHADS₂ score (points)          | 2.2 ± 1.0      |
| Congestive heart failure (%)   | 18 (17)        |
| Hypertension (%)               | 76 (70)        |
| Diabetes mellitus (%)          | 21 (19)        |
| Stroke (%)                     | 9 (8.3)        |
| Presence of organic cardiac disease (%) | 21 (19)     |
| Chronic kidney disease (%)     | 28 (26)        |
| Sick sinus syndrome (%)        | 20 (19)        |
| LA diameter (mm)               | 40.1 ± 6.6     |
| LA length (mm)                 | 54.1 ± 8.0     |
| LV ejection fraction (%)       | 69.1 ± 9.6     |
| LV diastolic diameter (mm)     | 47.9 ± 6.3     |
| LV systolic diameter (mm)      | 29.1 ± 5.3     |
| LAA flow velocity (cm/s)       | 48.1 ± 19.3    |
| No. of ineffective antiarrhythmic drugs | 1.3 ± 1.1   |
| Electrical cardioversion (%)   | 25 (23)        |
| BNP (pg/mL)                    | 106.1 [8.8-2185.4] |

Continuous data are expressed as the mean ± standard deviation or median [25%-75% value]. AF indicates atrial fibrillation; LA, left atrium; LV, left ventricular; LAA, left atrium appendage; and BNP, brain natriuretic peptide.

### Table II. Outcome of the AF Ablation Procedure

| Outcome                        | Value          |
|--------------------------------|----------------|
| PV isolation (%)               | 108 (100)      |
| CTI ablation (%)               | 99 (92)        |
| SVC isolation (%)              | 17 (16)        |
| Focal ablation (%)             | 21 (19)        |
| LA posterior ablation (%)      | 10 (9.2)       |
| Mitral isthmus ablation (%)    | 0              |
| CFAE ablation (%)              | 0              |
| Non-PV AF foci (%)             | 30 (28)        |
| Procedure time (minutes)       | 168.1 ± 32.3   |
| Fluoroscopy time (minutes)     | 62.3 ± 18.9    |
| Complications (%)              | 11 (10)        |
| Systemic thromboembolism       | 0              |
| TIA                            | 0              |
| Tamponade                      | 1              |
| Pericardial effusion (without drainage) | 3            |
| Major bleeding                 | 0              |
| Permanent phrenic nerve injury | 0              |
| Transient phrenic nerve injury | 4              |
| Peri-esophageal vagal plexus injury | 0               |
| Femoral vascular complications | 4              |

Continuous data are expressed as the mean ± standard deviation. PV indicates pulmonary vein; CTI, cavitricuspid isthmus; SVC, superior vena cava; LA, left atrium; CFAE, continuous fractionated atrial electrogram; and TIA, transient ischemic attack.
are shown in Figure 1A and B, respectively.

Major complications occurred in only one patient (0.9%). Cardiac tamponade was observed in that patient and it was treated uneventfully with percutaneous pericardiocentesis. In addition, 11 minor (10.2%) complications occurred. Three patients had slight pericardial effusions without drainage and another 4 developed transient phrenic nerve injury during the SVC isolation, which recovered within a month. The remaining 4 patients suffered from femoral vascular complications such as hematomas, arteriovenous fistulae, and pseudoaneurysms after the ablation procedures.

**Origin of AF in our study:** The origins of AF are shown in Figure 2. In 88 (88%) of the 100 patients, AF was induced spontaneously or by using a high dose isoproterenol infusion. In the remaining 8 patients, the AF foci could not be identified for various reasons.

As shown in Figure 2, the main focus was the PVs, especially both superior PVs. Thirty of 100 (30%) patients had non-PV foci. The most common origins of the non-PV foci were the atrial septum, SVC, and posterior LA. There were no significant differences between paroxysmal and non-paroxysmal AF regarding non-PV foci (26/80 versus 4/28, \( P = 0.086 \)). Overall, we were not able to identify the AF origin in a total of 20 patients (19%). Ablation was successful in 17 (85%) of the 20 patients and additional ablation was not required. Therefore, we concluded that they had only PV foci and that the remaining 3 patients had non-PV AF foci.

**Comparison between successful and unsuccessful elderly AF patients:** Table III shows a comparison between the patients with successful and unsuccessful ablation outcomes. There were significant differences in the LA diameter (LAD), left ventricular (LV) systolic diameter, LV diastolic diameter, non-PV AF foci, and diabetes mellitus (DM) and these were significant predictors of an AF recurrence after a final ablation procedure (\( P < 0.001 \), \( P < 0.001 \), \( P = 0.001 \), \( P = 0.036 \), \( P = 0.045 \), respectively; Table III).

Multivariate logistic regression analysis was performed to test which predictor was the most associated with unsuccessful ablation outcomes. The results showed that a large LAD and non-PV AF foci were significant independent predictors of AF recurrences, with odds ratios of 0.76 (95% CI, 0.60-0.95; \( P = 0.019 \)) and 0.04 (95% confidence interval [95% CI], 0.00-0.65; \( P = 0.023 \)), respectively (Table IV).

**Discussion**

**Main findings:** The findings of the present study were as follows. First, catheter ablation achieved a successful outcome in 92.6% without any AADs in symptomatic elderly AF patients (defined as ≥ 75 years old). Second, multivariate logistic regression analysis showed that non-PV AF foci and a large LAD were associated with an unsuccessful ablation outcome. Third, in a total of 124 procedures, one major (0.9%) and 11 minor (10.2%) complications occurred.

**Rate of elderly patients among all patients undergoing catheter ablation:** The prevalence of AF steadily increases with aging. In general, as expected, the AF prevalence was 3.67% of Japanese people aged ≥ 75 years.\(^{15}\) Our 108 study patients might be very low in number in
Figure 2. A: Diagram representing the sites of the 169 AF foci in 88 patients (PA view). B: Table digitizing the sites of the 169 AF foci in 88 patients. The large 5 pointed asterisks indicate 10 cases and the small 5 pointed asterisks indicate 1 case. Furthermore, the blue 5 pointed asterisks indicate the PV sites and red 5 pointed asterisks indicate non-PV sites. PV indicates pulmonary vein; LSPV, left superior PV; LIPV, left inferior PV; RSPV, right superior PV; RIPV, right inferior PV; PA, posterior-anterior; LA, left atrium; RA, right atrium; LAA, left atrial appendage; RAA, right atrial appendage; SVC, superior vena cava; IVC, inferior vena cava; CS, coronary sinus; CT, crista terminalis; and LLRA, low lateral right atrium.

Table III. Comparison of the Patient Characteristics Between the Successful and Unsuccessful Groups After the Final Session

|                        | Successful (n = 100) | Unsuccessful (n = 8) | P value |
|------------------------|----------------------|----------------------|---------|
| Age (years)            | 77.2 ± 2.2           | 77.1 ± 2.6           | 0.927*  |
| Gender, male           | 60                   | 6                    | 0.479†  |
| Body mass index (kg/m²)| 23.1 ± 3.1           | 23.8 ± 3.6           | 0.488*  |
| Paroxysmal AF/ non-paroxysmal AF| 74 / 26 | 6 / 2 | 1.000†  |
| Duration of AF (months)| 35.1 [1-360]         | 79.0 [8-132]         | 0.091‡  |
| CHADS2 score (0 / 1 / > 2 points) | 0 / 26 / 74 | 0 / 0 / 8 | 0.090‡  |
| Congestive heart failure| 15                   | 3                    | 0.127†  |
| Hypertension           | 70                   | 6                    | 1.000†  |
| Diabetes mellitus      | 17                   | 4                    | 0.045‡  |
| Stroke                 | 9                    | 0                    | 1.000†  |
| Presence of organic cardiac disease | 20 | 1 | 1.000†  |
| Chronic kidney disease | 25                   | 3                    | 0.425‡  |
| Sick sinus syndrome    | 17                   | 3                    | 0.164‡  |
| LA diameter (mm)       | 39.5 ± 6.5           | 47.8 ± 3.7           | < 0.001* |
| LV ejection fraction (%)| 69.6 ± 8.9           | 63.8 ± 15.4          | 0.096*  |
| LV diastolic diameter (mm)| 47.3 ± 6.0         | 54.6 ± 7.2           | 0.001*  |
| LV systolic diameter (mm)| 28.6 ± 6.0           | 35.1 ± 9.5           | < 0.001* |
| LAA flow velocity (cm/second) | 48.5 ± 19.4 | 43.0 ± 18.4 | 0.470*  |
| No. of ineffective antiarrhythmic drugs | 1.2 ± 1.1 | 2.0 ± 1.3 | 0.057*  |
| BNP (pg/mL)            | 106.1 [8.8-2185.4]   | 106.0 [64.9-609.0]   | 0.622‡  |
| Non-PV AF foci (%)     | 25 (25.0)            | 5 (62.5)             | 0.036†  |
| Procedure time (minutes)| 166.9 ± 31.9        | 183.4 ± 35.0         | 0.166*  |
| Fluoroscopy time (minutes)| 63.4 ± 18.9        | 62.2 ± 20.2          | 0.869*  |

Continuous data are expressed as the mean ± standard deviation or median [25%-75% value]. *P values were determined by an unpaired t test, †Fisher’s exact test, or ‡Mann-Whitney test. AF indicates atrial fibrillation; LA, left atrium; LV, left ventricular; LAA, left atrial appendage; BNP, brain natriuretic peptide; and PV, pulmonary vein.

comparison to the general population over the age of 75. Catheter ablation in octogenarians accounts for 3.7-4.7% of all AF ablation procedures. Consequently, we believe that the number of patients whom we have ablated was not that small. However, AF ablation is not performed in all elderly AF patients. Based on the past results involving our data, it was necessary for the attending physician to determine which patients were suitable for AF ablation.
Furthermore, we should consider how much longer the patient has to live.

During the follow-up period, 4 study patients died even though this procedure was performed. The causes of death were cancer, a myocardial infarction, chronic obstructive pulmonary disease, and an unknown cause.

**Efficacy of AF ablation in elderly patients:** According to the literature, the success rate after the final procedure is 59-87% in elderly patients.9-12 The success rate of ablation in elderly AF patients is considered to be as good as that in non-elderly AF patients.6,8,12,14 However, to the best of our knowledge, these studies did not report the effect of AF ablation in elderly patients. In our series, the success rate after the 1st session was 81.4% (88 of 108). Although 5 patients did not receive additional ablation after the 1st session, they were satisfied with only one AF ablation in spite of a non-complete recovery. This may be one of the characteristics of performing ablation in elderly AF patients. Finally, sinus rhythm was highly maintained in 92.6% of the patients without any AADs during a mean follow-up of 38.7 ± 21.7 months (Figure 2).

There were several reasons for our high success rate. First, there were few obese patients, in whom recurrence is common. In fact, only 6 patients (5.6%) had a BMI > 28 kg/m² and two (1.9%) had a BMI > 30 kg/m². Several studies have described that AF recurrences are related to obesity and obstructive sleep apnea. However, the elderly population generally has few obese people. Therefore, obesity was not a significant independent predictor in our study.6,15-17 Second, the mean LAD by echocardiography was a normal size at 40.1 ± 6.6 mm. Generally, when the LA diameter/volume is increased, PV stretching occurs.18 As a result, it is easy for AF to occur. Many previous studies have demonstrated that a large LA was significantly related to an unsuccessful ablation.7,8,20-22 Indeed, only 24 patients (22.2%, maximum size 60.1 mm) had a large LAD of > 45.0 mm. Moreover, the mean LAD gradually deceased to 38.5 ± 5.8 mm by 3 months and 36.6 ± 5.5 mm by 1 year after the final ablation. Third, all non-paroxysmal AF patients received electrical cardioversion one month before the ablation and sinus rhythm was identified once in all 28 study patients. Fourth, the duration of AF in the non-paroxysmal patients (21 persistent and 7 long standing persistent AF) was relatively short at 13.8 ± 19.3 years (1-68 months). Finally, we performed exhaustive testing to determine if there were any non-PV AF foci multiple times using a high dose isoproterenol infusion. In particular, we thought the disappearance of the non-PV AF foci was the most important factor that increased the success rate of the AF ablation.

Based on the above, our AF ablation was also effective in elderly patients. To say nothing of anticoagulants, AF ablation is regarded as one of the choices for treating AF in elderly AF patients.

**Safety of AF ablation in elderly patients:** Although complications occurred in 4.5% in the world-wide survey due to AF ablation procedures,23 the major complication rate in the present study was similar at 2.9-5.8% to that in the elderly patients in previous studies.6,11,12. Our major complication rate was also very small, with one major (0.8%) and 11 minor (8.9%) complications out of a total of 124 procedures, which was similar to that in previous studies. All complications occurred during the 1st session.

As one of the reasons for fewer complications, all 108 patients received a TEE just before the procedure. By performing TEE,24 we confirmed that there were no perioperative thromboembolic events. In addition, as described in the methods, we performed frequent follow-up visits at the outpatient clinic after the procedure. Thus, if we identified an AF recurrence, we could re-start the anticoagulants. In fact, we discontinued anticoagulants in 76.9% (83 of 108) of the patients after the ablation and did not detect any new onset of a stroke during the follow-up.

Regarding another factor for the fewer complications, we performed the AF ablation very carefully in the study patients because they could easily have complications. As a result, we had few major complications during the procedure. To reduce the complications further, we needed to reduce the procedure time to within at least 120 minutes and perform only a bilateral PVI without any additional ablation. Our mean procedure time was too long and was a mean of 168.1 ± 32.3 minutes (Table II). The only patient with a cardiac tamponade underwent only a PVI and it took 158 minutes.

**Factors related to AF recurrences in elderly AF patients:** The prevalence of AF is high among elderly people and it is important to cure them by AF ablation, which may reduce cerebral infarctions.25 We should identify challenging cases in order to perform effective ablation because elderly patients are essentially at high risk.

There were various independent predictors of an AF recurrence after the AF ablation. According to the guidelines, the stage of AF (i.e., paroxysmal, persistent, or long-standing persistent), size of the LA, and presence and severity of any underlying cardiac disease have been defined as clinical factors for a successful catheter ablation procedure in general AF patients.7,8 In particular, the size of the LA is considered to be the most significant predictor among all parameters.7,8,20-22 Similar to our results, a large LAD was a significant independent predictor of an AF recurrence in the multivariate logistic regression analysis, with an odds ratio of 0.76 (P = 0.019, Table IV). Overall, a large LA was correlated with an AF recurrence regardless of age.

On the other hand, as well as for other generations,13 many PV foci were identified in the elderly patients in the present study. However, there were a lot of non-PV AF foci as well, especially on the atrial septum, SVC, and

**Table IV. Clinical Factors Associated with an Unsuccessful AF Ablation Procedure Determined by Logistic Regression Analyses**

| Variables                | Odds Ratio | 95% CI     | P value |
|--------------------------|------------|------------|---------|
| LA diameter              | 0.76       | 0.60-0.95  | 0.019   |
| Non-PV AF foci           | 0.04       | 0.00-0.65  | 0.023   |
| Diabetes mellitus        | 0.15       | 0.02-1.23  | 0.077   |
| LV diastolic diameter    | 0.88       | 0.66-1.17  | 0.380   |
| LV systolic diameter     | 0.94       | 0.72-1.22  | 0.621   |
| Gender                   | 1.85       | 0.16-21.1  | 0.619   |

CI indicates confidence interval; PV, pulmonary vein; AF, atrial fibrillation; LA, left atrium; and LV, left ventricular.
posterior LA. In particular, the SVC and posterior LA were some of the main locations of the non-PV triggers of AF.10–14 Santangeli, et al. demonstrated that octogenarians present with a significantly higher rate of non-PV trigger sites than non-octogenarians (84% versus 69%, P = 0.001), which most commonly occur in the coronary sinus (54%), left atrial appendage (32%), SVC, and interatrial septum (14%).10–14

In fact, we used high dose isoproterenol to evaluate whether there were non-PV foci or not. The isoproterenol infusion can be used not only to identify non-PV triggers in paroxysmal and persistent AF, but also to confirm PV reconnections after the PVI. As a result, 88% (88 of 100) of the patients had a successful AF induction by high dose isoproterenol as well as 88% (67 of 76) in a previous study.20–22 Unfortunately, we did not evaluate all foci with atrial firing in the unsuccessful patients who underwent ablation procedures. Thus, their results may slightly differ from our data.

Study limitations: This study has some potential limitations. First, it was a retrospective and observational study that did not compare the results in detail of patients ≤ 74 years old. Second, this study had a small sample size and was a single center study, which might have caused a statistical bias. Nevertheless, the results were found to be clear and statistically significant. Third, the judgment of a successful or unsuccessful outcome of catheter ablation may depend on the patients’ own selection to a non-pharmacological therapeutic strategy because we performed the second or third sessions of ablation according to the patient’s desire.

Conclusions

In symptomatic elderly AF patients, catheter ablation of AF is effective and safe. Non-PV AF foci and a large LAD might be independent clinical predictors of unsuccessful AF ablation outcomes.

Disclosure

Conflicts of interest: The authors declare that there is no conflict of interest.

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