Journal of Arrhythmia 29 (2013) 221–227

Contents lists available at ScienceDirect

Journal of Arrhythmia

journal homepage: www.elsevier.com/locate/joa

Original Article

National survey of catheter ablation for atrial fibrillation: The Japanese catheter ablation registry of atrial fibrillation (J-CARAF)

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ARTICLE INFO

Article history:
Received 12 November 2012
Accepted 10 December 2012
Available online 17 July 2013

Keywords:
Atrial fibrillation
Catheter ablation
Oral anticoagulant
Complication
Pulmonary vein isolation

ABSTRACT

To assess the current status of atrial fibrillation (AF) ablation in Japan, the Japanese Heart Rhythm Society (JHRS) instituted a national registry, the Japanese Catheter Ablation Registry of AF (J-CARAF).

Methods: Using an online questionnaire, the JHRS invited electrophysiology centers in Japan to voluntarily and retrospectively register data regarding the AF ablation procedures performed in September, 2011.

Results: A total of 128 centers submitted data regarding AF ablation procedures in 932 patients (age 62.1 ± 10.4 years; male 76.8%; paroxysmal AF 65.7%, CHADS2 score 1.0 ± 1.0). The majority received oral anticoagulant therapy during and following the procedure (68.9% and 97.5%, respectively). Pulmonary vein isolation (PVI) was performed in 97.5% of the patients; ipsilateral encircling PVI was the preferred technique (79.7%). Three-dimensional (3D) mapping systems and irrigated-tip catheters were used in 94.8% and 87.7% of the procedures, respectively. Ablation methods other than PVI were performed in 78.8% of all the patients and 73.5% of the patients with paroxysmal AF. Acute complications were reported in 6.2% of the patients, but no early deaths were recorded.

Conclusions: Ipsilateral encircling PVI, using 3D mapping and irrigated-tip catheters, is the standard AF ablation method in Japan. However, adjunctive ablations were performed frequently, even in patients with paroxysmal AF.

1. Introduction

Catheter ablation procedures for arrhythmias such as supraventricular tachycardia and atrial flutter have become established with excellent results. The permanent cure of tachycardias using catheter ablation is possible. Pulmonary vein isolation (PVI) is a cornerstone of atrial fibrillation (AF) ablation [1–4]. Since its introduction, significant progress has been made in AF catheter ablation; left atrial (LA) linear ablation [5–8], complex fractionated atrial electrogram (CFAE) ablation [9] or defragmentation [10], non-pulmonary vein (non-PV) foci ablation [11], and cardiac ganglion plexus ablation [12,13] are effective adjunctive procedures of PVI for treating non-PV AF triggers and substrates. However, systematic indications for these adjunctive procedures have not yet been established, and their selection is at the discretion of the attending physician and institute. Reportedly, single-procedure AF ablation has an efficacy of 50–64% [14]. Therefore, AF ablation procedures still have some obstacles to overcome.

It has also been reported that the incidence of complications associated with AF ablation, such as pulmonary vein stenosis,

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http://dx.doi.org/10.1016/j.joa.2012.12.015

atrioesophageal fistula, gastric hypomotility, and phrenic nerve paralysis, differs from that associated with other catheter ablation procedures [15], and their incidence in Japan remains to be elucidated.

AF is the most common tachyarrhythmia in the Japanese population, and AF ablation is increasingly used, despite the poorly established indications for adjunctive ablation, a relatively high recurrence rate, and specific complications. Determining the current status of AF ablation in Japan is crucial. Therefore, the Japanese Heart Rhythm Society (JHRS) instituted a nationwide registry of AF-related catheter ablation: the Japanese Catheter Ablation Registry of Atrial Fibrillation (J-CARAF). This registry aimed to collect objective data to assess the performance and safety of catheter ablation of AF in Japan.

2. Materials and methods

The survey was performed retrospectively using an online questionnaire. JHRS members were notified by mail. To facilitate the calculation of the proportion of electrophysiological centers capable of AF ablation, the first questionnaire determined whether catheter ablation for AF was performed in September, 2011. If AF ablation procedures were performed within that period, precise data on the patient background, AF ablation procedures, and the strategies, results, and complications were collected. The patient data included the age, gender, AF ablation procedure history, AF type (paroxysmal, persistent, or long-standing persistent), frequency of AF attacks in paroxysmal AF, thromboembolism risk factors, structural heart disease, left ventricular ejection fraction, left atrial (LA) volume and dimension estimated by echocardiography, and history of antiarrhythmic drug use. The AF ablation procedure data included the procedural time, use of a three-dimensional (3D) mapping system or irrigation catheter, use of anticoagulant agents, anesthesia, and sedation, intraoperative monitoring methods, and results of a post-procedure burst pacing AF induction test. The AF ablation strategy data included the PVI method, use of linear ablation of the LA roof or other sites, CFAE ablation, ganglion plexus ablation, non-PV trigger foci ablation, or cavotricuspid isthmus (CTI) ablation.

Continuous variables with a normal distribution were expressed as mean ± SD, and the data were compared between the patient groups using an unpaired *t*-test. Variables that were not normally distributed were expressed as the median (lower quartile, upper quartile). The comparison of categorical variables was accomplished using Fisher's exact test. Analyses were conducted using the Stat View 5.0 software (SAS Institute; NC, USA).

3. Results

A total of 199 institutes voluntarily submitted data and 165 (83%) of those had an electrophysiological center capable of catheter ablation in September, 2011; the majority ($n=128$, 64%) performed AF ablation during that period. A total of 932 sessions were performed, with a median of 5 AF procedures (lower and upper quartiles 2 and 9) per center per month. The largest center performed 56 AF ablation procedures in the month.

Table 1 shows the patients' background data. The average age was 62.1 ± 10.4 years, and 76.8% were male. Of all sessions, 77.5% were first AF ablation sessions, 19.7% were second sessions, and 2.8% were subsequent sessions. Patients with paroxysmal AF constituted 65.7% of the patients; 89.6% of those suffered from AF attacks more than once per week. The average CHADS2 and CHA2DS2-VASc scores were 1.0 ± 1.0 and 1.5 ± 1.3, respectively.

Table 1
Background information of the patients who underwent atrial fibrillation ablation.

Number of cases	$n=932$
Age (y)	62.1 ± 10.4
Male, *n* (%)	716 (76.8)
Type of AF	
Paroxysmal AF, *n* (%)	612 (65.7)
Persistent AF, *n* (%)	180 (19.3)
Long-standing persistent AF, *n* (%)	140 (15.0)
Frequency of paroxysmal AF attacks	
< 1/month	70 (11.4%)
< 1/week	206 (33.7%)
< 1/day	206 (33.7%)
> 1/day	75 (12.3%)
Unknown	55 (9.0%)
Lone AF, *n* (%)	208 (22.3)
Congestive heart failure, *n* (%)	127 (13.6)
Age 65–74 years, *n* (%)	321 (34.4)
Age > 75 years, *n* (%)	77 (8.3)
Hypertension, *n* (%)	483 (51.8)
Diabetes, *n* (%)	110 (11.8)
Stroke or TIA, *n* (%)	78 (8.4)
Vascular disease, *n* (%)	52 (5.6)
Coronary artery disease, *n* (%)	57 (6.1)
Dilated cardiomyopathy, *n* (%)	16 (1.7)
Hypertrophic cardiomyopathy, *n* (%)	37 (4.0)
Other cardiomyopathies, *n* (%)	7 (0.8)
Sick sinus syndrome, *n* (%)	67 (7.2)
Hyperthyroidism, *n* (%)	23 (2.5)
COPD, *n* (%)	20 (2.1)
Congestive heart disease, *n* (%)	8 (0.9)
Valvulardisease, *n* (%)	19 (2.0)
Chronic kidney disease on HD, *n* (%)	15 (1.6)
Post-open heart surgery, *n* (%)	22 (2.3)
Echocardiographic data	
LVEF (%)	63.5 ± 9.5
LA dimension (mm)	40.7 ± 15.2
LA volume (mL)	70.4 ± 33.8
History of anti-arrhythmic drug use (*n*)	1.2 ± 0.9
Disopyramide, *n* (%)	81 (8.7)
Cibenzoline, *n* (%)	172 (18.5)
Aprindine, *n* (%)	47 (5.0)
Pilsicainide, *n* (%)	254 (27.3)
Flecainide, *n* (%)	141 (15.1)
Propafenone, *n* (%)	34 (3.6)
Bepridil, *n* (%)	218 (23.4)
Sotalol, *n* (%)	9 (1)
Amiodarone, *n* (%)	66 (7.1)
Others, *n* (%)	86 (9.2)
Average CHA2DS2-Vasc score	1.5 ± 1.3
Distribution of the CHA2D2-Vasc score	
0, *n* (%)	240 (25.8)
1, *n* (%)	276 (29.6)
2, *n* (%)	223 (23.9)
3, *n* (%)	119 (12.8)
4, *n* (%)	54 (5.8)
< 5, *n* (%)	20 (2.1)
Average CHADS2 score	1.0 ± 1.0
Distribution of the CHADS2 score	
0, *n* (%)	326 (35.0)
1, *n* (%)	364 (39.1)
2, *n* (%)	162 (17.4)
3, *n* (%)	60 (6.4)
4, *n* (%)	15 (1.6)
< 5, *n* (%)	5 (0.5)
Session of AF ablation	
First session, *n* (%)	722 (77.5)
Second session, *n* (%)	184 (19.7)
Third session, *n* (%)	22 (2.4)
> fourth session, *n* (%)	4 (0.4)

Abbreviations: AF; atrial fibrillation, TIA; transient ischemic attack, COPD; chronic obstructive pulmonary disease, HD; hemodialysis, LVEF; left ventricular ejection fraction, LA; left atrium.

Table 2
Atrial fibrillation ablation procedures.

Number of cases	$n=932$
Pre-operative inspection	
Transesophageal echocardiography, *n* (%)	745 (79.9)
Magnetic resonance imaging, *n* (%)	10 (1.1)
Computed tomography, *n* (%)	753 (80.8)
Procedure time (h)	3.6 ± 1.3
Fluoroscopic time (min)	72.9 ± 52.7
Diagnostic and therapeutic instruments used	
CARTO system, *n* (%)	676 (72.5)
EnSite system, *n* (%)	208 (22.3)
Irrigation catheter, *n* (%)	817 (87.7)
OAC use during the procedure, *n* (%)	643 (68.9)
Vitamin-K antagonist, *n* (%)	553 (59.3)
Direct thrombin inhibitor, *n* (%)	87 (9.3)
Factor Xa inhibitor, *n* (%)	3 (0.3)
Anesthesia	
Local anesthesia, *n* (%)	30 (3.2)
Local anesthesia and light sedation, *n* (%)	405 (43.5)
Local anesthesia and deep sedation, *n* (%)	494 (53.0)
General anesthesia, *n* (%)	3 (0.3)
Intraoperative monitoring	
Arterial pressure monitoring, *n* (%)	741 (79.5)
Oxygen saturation monitoring (SpO_2), *n* (%)	932 (100)
End-tidal CO_2 monitoring (ETCO2), *n* (%)	19 (2.0)
Bispectral Index (BIS), *n* (%)	106 (11.4)
Postoperative administration of steroid, *n* (%)	66 (7.1)
For treatment of pericarditis, *n* (%)	26 (2.8)
For recurrence prevention, *n* (%)	40 (4.3)

Patients with AF alone were a minority (22.3%); 51.8% patients had a history of hypertension. The average left ventricular ejection fraction and LA volume (dimension) were $63.5 \pm 9.5\%$ and 70.4 ± 33.8 mL (40.7 ± 15.2 mm), respectively. The average number of antiarrhythmic drugs used was 1.2 ± 0.9, and the 3 most common drugs were pilsicainide (27.3%), bepridil (23.4%), and cibenzoline (18.5%). However, 189 patients (20.2%) had no history of antiarrhythmic drug use.

Table 2 shows the AF ablation procedure data. The preoperative inspection consisted of transesophageal echocardiography and cardiac computed tomography (CT) in 79.9% and 80.8%, respectively; cardiac magnetic resonance imaging (MRI) was performed in only 1.1% of the patients. Two 3D mapping systems were used during PVI [16] in 94.8% of the patients: the CARTO system (Biosense-Webster Inc., CA, USA) in 72.5% and EnSite system (St. Jude Medical, MN, USA) in 22.3% of the patients. Irrigated catheters were used in 87.7% of the patients. The procedure time was 3.6 ± 1.3 h, and fluoroscopy time 72.9 ± 52.7 min.

Many centers performed AF ablation while the patients were under anticoagulation therapy, which consisted of vitamin K antagonists in 59.3%, direct thrombin inhibitors in 9.3%, and factor Xa inhibitors in 0.3% of the patients.

Table 3 shows the AF ablation strategies. Because PVI is considered the cornerstone of AF ablation, 97.6% of the patients underwent PVI. Ipsilateral encircling PVI [17,18] (79.7%) was the standard method; however, individual PVI (10.3%) [19] and box isolation (5.8%) [20] were also performed at some centers. Ablation adjunctive to PVI was performed in 78.5% of the patients. The CTI and superior vena cava were ablated in 56.5% and 16.6% of the patients, respectively. Adjunctive ablation other than CTI ablation was performed in 453 patients (48.6%). The execution rate depended on the AF persistence: 38.3% in paroxysmal AF, 57.2% in persistent AF, and 82.1% in long-standing persistent AF ($p < 0.0001$). LA linear ablation was performed in 25.5% of the patients; of those, the ablation was on the LA roof in 22.4% and at other sites in 17.6%. The rate of CFAE ablation was 13.1%, and consisted of LA CFAE ablation in 12.8% and right atrial CFAE ablation in 4.8% of the patients. LA linear ablation was performed more frequently than CFAE ablation ($p < 0.0001$). Seventy-four patients (7.9%) underwent both LA linear ablation and CFAE ablation. Finally, 98.7% of the AF ablation sessions resulted in sinus rhythm.

Table 3
Ablation strategies and acute results.

Number of cases	$n=932$
PVI, *n* (%)	910 (97.6)
Ipsilateral encircling PVI, *n* (%)	743 (79.7)
Box isolation, *n* (%)	54 (5.8)
Individual PVI, *n* (%)	96 (10.3)
Other PVI, *n* (%)	17 (1.8)
Adjunctive ablation, *n* (%)	731 (78.8)
In paroxysmal AF cases ($n=612$), *n* (%)	450 (73.5)
In persistent AF cases ($n=180$), *n* (%)	148 (82.2)
In long-standing persistent AF cases ($n=140$), *n* (%)	131 (93.6)
Cavotricuspid isthmus ablation (CTI), *n* (%)	527 (56.5)
Adjunctive ablation other than CTI, *n* (%)	453 (48.6)
In paroxysmal AF cases ($n=612$), *n* (%)	235 (38.3)
In persistent AF cases ($n=180$), *n* (%)	103 (57.2)
In long-standing persistent AF cases ($n=140$), *n* (%)	115 (82.1)
Ablation of CFAEs, *n* (%)	123 (13.1)
CFAEs in the LA, *n* (%)	119 (12.8)
CFAEs in the RA, *n* (%)	45 (4.8)
Focal ablation, *n* (%)	70 (7.5)
Focal ablation in the LA, *n* (%)	30 (3.2)
Focal ablation in the RA, *n* (%)	44 (4.7)
LA linear ablation, *n* (%)	238 (25.5)
LA roofline ablation, *n* (%)	209 (22.4)
LA linear ablation other than a roofline, *n* (%)	164 (17.6)
Superior vena cava (SVC) ablation, *n* (%)	155 (16.6)
Coronary sinus (CS) ablation, *n* (%)	44 (4.7)
Ganglion plexus (GP) ablation, *n* (%)	25 (2.7)
Electrical cardioversionduring the procedure	419 (40.3)
1 time, *n* (%)	228 (26.4)
2 times, *n* (%)	78 (9)
3 times, *n* (%)	16 (1.8)
>4 times, *n* (%)	27 (3.1)
AF induction testing with burst pacing after ablation, *n* (%)	484 (55.4)
Induced and persisted for ≥5 min, *n* (%)	72 (8.2)
Induced and persisted for <5 min, *n* (%)	408 (43.8)
Cardiac rhythm at the end of the procedure	
Sinus rhythm, *n* (%)	920 (98.7)
AF, *n* (%)	6 (0.6)
Other, *n* (%)	5 (0.5)

Adjunctive ablation was defined as an ablation procedure other than PVI.
Abbreviations: PVI; pulmonary vein isolation, CFAE; complex fractionated electrogram, LA; left atrium, RA; right atrium, and AF; atrial fibrillation.

Table 4
Comparison of ablation procedures in relation to atrial fibrillation type.

	PaAF $n=612$	PeAF $n=180$	LSPeAF $n=140$	*p*-value
CTI ablation, *n* (%)	330 (53.9)	99 (55)	98 (70)	0.0022
SVC ablation, *n* (%)	105 (17.1)	24 (13.3)	26 (18.6)	0.38
Focal ablation, *n* (%)	40 (6.5)	16 (8.9)	14 (10)	0.28
CFAE ablation, *n* (%)	32 (5.2)	40 (22.2)	45 (32.1)	<0.0001
Linear ablation, *n* (%)	92 (15)	57 (31.7)	89 (63.6)	<0.0001

Abbreviations: PaAF; paroxysmal atrial fibrillation, PeAF; persistent atrial fibrillation, LSPeAF; long-standing persistent atrial fibrillation, CTI; cavotricuspid isthmus, SVC; superior vena cava, CFAE; complex fractionated atrial electrogram.

Table 5
Complications of atrial fibrillation ablation.

Number of cases	$n=932$
Total, *n* (%)	58 (6.2)
Pericardial effusion requiring drainage, *n* (%)	10 (1.1)
Pericardial effusion not requiring drainage, *n* (%)	19 (2.0)
Valve injury, *n* (%)	0 (0)
Transient high degree atrioventricular block, *n* (%)	1 (0.1)
Sinus arrest, *n* (%)	2 (0.2)
Transient ischemic attack, *n* (%)	0 (0)
Symptomatic cerebral infarction, *n* (%)	2 (0.2)
Asymptomatic cerebral infarction, *n* (%)	2 (0.2)
Pneumothorax, *n* (%)	0 (0)
Hemothorax, *n* (%)	1 (0.1)
Prolonged phrenic nerve paralysis, *n* (%)	1 (0.1)
Air embolism, *n* (%)	1 (0.1)
Severe pulmonary vein stenosis, *n* (%)	0 (0)
Hematoma at the puncture site, *n* (%)	11 (1.2)
Pseudoaneurysm, *n* (%)	4 (0.4)
Gastric hypomotility, *n* (%)	4 (0.4)
Death, *n* (%)	0 (0)

Table 6
Discharge prescription.

Number of cases	$n=932$
OAC use, *n* (%)	908 (97.5)
Vitamin-K antagonist, *n* (%)	761 (81.7)
Direct Thrombin inhibitor, *n* (%)	147 (15.8)
Factor Xa inhibitor, *n* (%)	0 (0)
Anti-platelet agents, *n* (%)	43 (4.6)
Antiarrhythmic drugs, *n* (%)	492 (53.6)
Disopyramide, *n* (%)	14 (1.5)
Cibenzoline, *n* (%)	57 (6.1)
Aprindine, *n* (%)	26 (2.8)
Pilsicainide, *n* (%)	79 (8.5)
Flecainide, *n* (%)	99 (10.6)
Propafenone, *n* (%)	23 (2.5)
Bepridil, *n* (%)	172 (18.5)
Amiodarone, *n* (%)	50 (5.4)
Others, *n* (%)	18(1.9)
Verapamil, *n* (%)	64 (6.9)
Beta-blocker, *n* (%)	253 (25.7)
Digitalis, *n* (%)	13 (1.4)
Angiotensin converting enzyme inhibitor, *n* (%)	51 (5.5)
AngiotensinII receptor blocker, *n* (%)	233 (25.0)
Statin, *n* (%)	153 (16.4)

Table 4 lists a comparison of the rates of ablation procedures based on the types of AF. CTI ablation was performed in 53.9%, 55%, and 70% of paroxysmal, persistent, and long-standing persistent AF patients, respectively ($p=0.0022$). There were no differences in the frequencies of SVC ablation and focal ablation between the AF types ($p=0.38$ and $p=0.28$, respectively). On the other hand, the rates of CFAE ablation and linear ablation were highest in the longstanding-persistent AF patients (32.1% and 63.6%) and lowest in paroxysmal AF (5.2% and 15%).

Table 5 lists the complications of AF ablation. Pericardial effusions occurred in 29 sessions (3.1%), and emergency drainage of a cardiac tamponade was required in 10 sessions (1.1%). Symptomatic cerebral infarctions occurred in two patients (0.2%), and asymptomatic cerebral infarctions were diagnosed using CT or MRI in two patients (0.2%). Other major complications were a hemothorax in one patient; prolonged phrenic nerve palsy in one patient; gastric hypomotility in four patients; and an air embolism in one patient. No deaths were reported.

Table 6 shows the prescriptions at discharge. Most patients (908, 97.5%) received oral anticoagulant (OAC) agents at discharge, such as warfarin in 761 patients (81.7%) and dabigatran in 147 patients (15.8%). Antiarrhythmic drugs were prescribed in 436 patients (53.6%); the three most frequently prescribed drugs were bepridil (18.5%), flecainide (10.6%), and pilsicainide (8.5%).

4. Discussion

The J-CARAF was created in order to assess the status of AF ablation in Japan today, as a supplement to the JHRS summary of the Japanese Catheter Ablation Registry (JCAR) [21,22]. This is the first report of the J-CARAF, which describes the current indications, procedures, strategies, and complications of AF ablation in Japan.

4.1. Electrophysiological centers performing atrial fibrillation ablation

Several years ago, the number of electrophysiological centers performing AF ablation was small; AF ablation was considered complicated and difficult to accomplish, while its efficacy and indications were controversial. It is impressive that 78% of electrophysiological centers performing catheter ablation in September 2011 also performed AF ablation in the same period. These data indicate that the use of this procedure is rapidly increasing in Japan, possibly because of technical developments, such as 3D mapping systems, and an increase in the number of skilled physicians. The guidelines of the Japanese Circulation Society and American Heart Association, Advances and Controversies in Atrial Fibrillation, and the Heart Rhythm Society (HRS) designate facilities as Class I ablation facilities for drug refractory, symptomatic AF at electrophysiological centers performing more than 50 procedures per year [23,24]. In 68 centers, more than five AF sessions were performed per month. Therefore, more than 50% of the centers participating in this registry and performing AF ablation might fulfill the criteria for a Class I designation.

4.2. Patients receiving atrial fibrillation ablation

The average age of the patients undergoing AF ablation was 62.1 ± 10.4 years, which is relatively young for patients with AF. Table 1 shows that lone AF was relatively uncommon, but indicates that typical patients undergoing AF ablation were middle-aged men with preserved LV function, mild LA remodeling, a relatively low risk of cardiogenic cerebral infarctions, and paroxysmal AF attacks occurring more than once a week. We can speculate that the purpose of AF ablation was to improve a compromised quality of life. The number of second AF ablation sessions was 25% of the total first sessions (184/722), indicating the current re-ablation rate in Japan. Twenty-two patients underwent a third AF ablation session, so the ratio of third sessions to first sessions was only 3%. Even though the efficacy of AF ablation over multiple procedures is estimated to be 73–81% [14], the majority of patients who underwent AF ablation twice but experienced recurrence declined a third session.

4.3. Ablation strategy

PVI was performed in 97.6% of the patients, constituting the minimum necessary intervention for AF ablation in Japan (Table 3). Of all the patients, 78.5% underwent adjunctive ablation other than PVI, which was also performed in 73.5% of the patients with paroxysmal AF. Interventions other than PVI and CTI ablation, such as linear, focal, or CFAE ablation, were performed in 48.6% patients. Although extensive ablation of non-PV AF substrates with linear or CFAE ablation was recommended in patients with long-standing persistent AF [4], those patients constituted only 15% of the total.

In fact, 38.3% of the patients with paroxysmal AF underwent ablation other than PVI and CTI ablation. These data could indicate that these extensive ablations are performed more often than necessary. The rate of linear ablation (roof/mitral valve isthmus) was significantly higher than that of CFAE ablation (25.5% versus 13.1%, $p < 0.0001$). Japanese physicians preferred linear to CFAE ablation for substrate modification. However, physicians must realize that creation of complete heart block, although difficult to accomplish, is recommended by the HRS, European Heart Rhythm Association, and European Cardiac Arrhythmia Society *Expert Consensus Statement* [4].

4.4. Ablation strategy based on AF types

CTI ablation and SVC ablation constituted a majority of the ablation procedures adjunctive to PVI in patients with paroxysmal AF. Although we did not collect data regarding the incidence of CTI-dependent atrial flutter and SVC firing in this registry, the procedure rates of CTI ablation (54%) and SVC ablation (17%) in paroxysmal AF patients were estimated to be higher than their incidence [4]. Moreover, the frequencies of CTI and SVC ablation for paroxysmal and persistent AF were almost the same. Therefore, we speculated that CTI and SVC ablation procedures were routinely performed in some centers regardless of their comorbid arrhythmias. Although routine ablation of CTI and SVC would possibly prevent future CTI-dependent atrial flutter and SVC firing, there is a risk of a reconnection of the block line that could create an arrhythmic substrate [25,26], leading to complications such as phrenic nerve palsy. The question of whether or when routine CTI or SVC ablation procedures might be appropriate is still controversial. The JHRS plans to collect data on AF ablation follow-up that will enable an evaluation of the efficacy of CTI and SVC ablation procedures in patients undergoing ablation for paroxysmal AF. Predictably, the frequencies of substrate modifications, such as CFAE ablation and linear ablation, increased with the duration of AF persistence. On the other hand, the frequencies of ablation targeting AF triggers, such as SVC ablation and focal ablation, were almost the same between the AF types, which would indicate that these triggers play important roles, even in patients with long-standing, persistent AF [27,28].

4.5. Periprocedural anticoagulation therapy

Data from this registry revealed 3 interesting points regarding OAC use during AF ablation. First, the majority of electrophysiological centers performed AF ablation while 68.9% of the patients were still receiving OAC agents, which is a greater proportion than previously reported [29]. OAC withdrawal prior to AF ablation has been the subject of debate because undertaking procedures with OAC agents could increase hemorrhagic complications. Recently, some authors reported that periprocedural OAC therapy prevented thromboembolic events without increasing fatal hemorrhagic events [30–34]. These reports must have impacted the continuous therapeutic anticoagulation during procedures. Second, the number of patients receiving OAC agents during the procedures seemed large (68.9%), considering their low risk of cerebral infarction. Although OAC indications are expanding, even the latest guidelines do not recommend OAC use in patients with CHADS2 or CHA2DS2-VASc scores of 0 [35], accounting for 35% and 25.8% of the patients in this registry, respectively. It is possible to speculate that physicians administer OAC agents to patients without indications prior to ablation procedures, to prevent periprocedural cerebral infarctions. Third, most patients (97.5%) received OAC agents at discharge. Systemic anticoagulation is recommended for all patients for at least 2 months following an AF ablation procedure [4], because the atria are often stunned after sinus conversion by ablation [36]. Physicians in Japan followed this recommendation appropriately.

4.6. Complications of atrial fibrillation ablation

AF ablation is a complex procedure and is consequently associated with a relatively high risk of complications. Major complications in the acute phase were evident in only 2.2% of the patients (21/932), and no early deaths were recorded. A previous worldwide survey of AF ablation complications reported a major complication rate of 6%; 0.05% (4/8745) of patients died following AF ablation [15]. Although the Japanese complication rate tends to be lower than that in worldwide surveys, the J-CARAF is a retrospective and voluntary survey and may underestimate the complication rate because physicians who encountered severe complications may hesitate to register their results. Therefore, this complication rate should be interpreted as the lowest estimate.

5. Conclusions

Ipsilateral encircling PVI, using 3D mapping and an irrigated-tip catheter, is the standard method of AF ablation in Japan. Ablation methods other than PVI were also performed frequently, even in patients with paroxysmal AF. Although the average CHADS2 score was low, periprocedural OAC therapy was often administered to prevent ablation-related thromboembolisms. Attending physicians must know the standard indications, methods, and risks of AF ablation in the real world, make their own interpretations and modifications, and use them based on the experiences and activity of individual electrophysiological centers.

Conflict of interest

None of the authors has any conflict of interest to declare.

Appendix

This survey was conducted with the voluntary support of the JHRS members. The following centers participated in the survey:

Akita Medical Center;
Anjo Kosei Hospital;
Asahikawa Medical University Hospital;
Edogawa Hospital;
Ehime University Hospital;
EP Expert Doctors-Team Tsuchiya;
Fujita Health University Hospital;
Fukuoka Sanno Hospital;
Gakkentoshi Hospital;
Gifu Prefectural General Medical Center;
Gunma Cardiovascular Center;
Gunma University Hospital;
Hamamatsu Medical Center;
Hayama Heart Center;
Hiratsuka Kyosai Hospital;
Hirosaki University School of Medicine and Hospital;
Hiroshima City Hospital;
Hiroshima Prefectural Hospital;
Hokkaido Medical Center;
Hokkaido University Hospital;
Hokko Memorial Hospital;
Hyogo Brain and Heart Center;
Hyogo College of Medicine Hospital;

Ichinomiyanishi Hospital;
IMS Katsushika Heart Center;
Ishikawa Prefectural Central Hospital;
Izuo Hospital;
Japanese Red Cross Kumamoto Hospital;
Japanese Red Cross Kyoto Daini Hospital;
Jikei University Hospital;
Kagawa Prefectural Shirotori Hospital;
Kagoshima Medical Center;
Kameda Medical Center;
Kanazawa Medical University Hospital;
Kanazawa University Hospital;
Kansai Rosai Hospital;
Keio University Hospital;
Kimitsu Chuo Hospital;
Kitano Hospital;
Kitasato University Hospital;
Kobe City Medical Center General Hospital;
Kobe University Hospital;
Kokura Memorial Hospital;
Komaki City Hospital;
Konan Kosei Hospital;
Kumamoto Hospital;
Kurashiki Central Hospital;
Kushiro Kojinkai Memorial Hospital;
Kyoto University Hospital;
Kyoto-Katsura Hospital;
Kyushu Medical Center;
Kyushu University Hospital;
Maizuru Kyosai Hospital;
Matsue Red Cross Hospital;
Mie Heart Center;
Mie University Hospital;
Nagano Chuo Hospital;
Nagoya City East Medical Center;
Nagoya Daini Red Cross Hospital;
Nagoya Ekisaikai Hospital;
Nagoya University Hospital;
Nara Hospital Kinki University Faculty of Medicine;
Nara Medical University Hospital;
National Cerebral and Cardiovascular Center;
Nihon University School of Medicine, Itabashi Hospital;
Niigata University Medical and Dental Hospital;
Nippon Medical School Hospital;
Ogaki Municipal Hospital;
Ohta Nishinouchi Hospital, Ohta General Hospital Foundation;
Oita Medical Hospital;
Oita University Hospital;
Ome Municipal General Hospital;
Osaka City General Hospital;
Osaka City University Hospital;
Osaka General Medical Center;
Osaka Medical College Hospital;
Osaka Police Hospital;
Osaka Red Cross Hospital;
Osaka Rosai Hospital;
Saitama Medical University International Medical Center;
Saitama Red Cross Hospital;
Sakurabashi Watanabe Hospital;
Sapporo Medical University Hospital;
Self-Defense Forces Central Hospital;
Sendai City Hospital;
Sendai Kousei Hospital;
Shiga Medical Center for Adults;
Shiga University of Medical Science Hospital;
Shinshu University Hospital;
Shiroyama Hospital;
Shizuoka General Hospital;
Shizuoka Medical Center;
Shizuoka Saiseikai General Hospital;
Shonan Hospital;
Showa University Fujigaoka Hospital;
Showa University Hospital;
Social Insurance Chukyo Hospital;
St. Marianna University School of Medicine Hospital;
Surugadai Nihon University Hospital;
Takai Hospital;
Takase Clinic;
Takeda Hospital;
The Cardiovascular Institute;
The Sakakibara Heart Institute of Okayama;
Toho University Ohashi Medical Center;
Toho University Omori Medical Center;
Tohoku University Hospital;
Tokushima Red Cross Hospital;
Tokuyama Central Hospital;
Tokyo Medical and Dental University, University Hospital of Medicine;
Tokyo Medical University Hospital;
Tokyo Metropolitan Hiroo Hospital;
Tokyo Women's Medical University Hospital;
Tominaga Hospital;
Tottori Prefectural Central Hospital;
Toyama Prefectural Central Hospital;
Toyama University Hospital;
Toyohashi Heart Center;
Toyota Kosei Hospital;
Tsuchiura Kyodo General Hospital;
University Hospital, Kyoto Prefectural University of Medicine;
Yamagata University Hospital;
Yamaguchi University Hospital;
Yamanashi Kosei Hospital;
Yamato Kashihara Hospital;
Yokohama General Hospital;
Yokohama Minami Kyousai Hospital;
Yokohama Rosai Hospital; and
Yokosuka Kyosai Hospital.

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