Initial outcome following invasive cardiac electrophysiologic studies and radiofrequency ablation of atrial fibrillation

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ABSTRACT

Background: Cardiac electrophysiologic study and radiofrequency ablation (RFA) have become an established mode of treatment for patients with refractory arrhythmias. These procedures are carried out regularly at the cardiac catheterization laboratory of Madras Medical Mission India. Objective: The purpose of this study was to evaluate our experience with cardiac electrophysiologic studies (EPS) and RFA catheter of atrial fibrillation (AF). Materials and Methods: This was a retrospective study carried out in the Cardiac Electrophysiology Department of the Institute of Cardiovascular Diseases, Madras Medical Mission, India. All cases diagnosed to have AF following cardiac EPS between January 2010 and April 2014 was selected for the study. The records, which were obtained from the Cardiac Electrophysiology Clinical Research Office of Madras Medical Mission, were reviewed. Forty-nine cases were chosen for analysis, using SPSS statistical software version 15. Results: There were 49 patients, 23 males and 26 females. The mean age was 57.53 years. Commonly associated diseases were diabetes mellitus 8 (16.3%), hypertension 18 (36.7%), and coronary heart disease 14 (28.5%). The ventricular rate was rapid most cases (91.2%). AF was diagnosed as being paroxysmal in 40 (81.6%), persistent in 5 (10.2%), chronic in 3 (6.1%), and lone in 1 (2.0%). Ablation was carried out in 28 (57.1%), the success rate being 90% for pulmonary vein isolation, and 90.9% for atrioventricular node ablation. Complication rate was 2.04%. Conclusions: Treatment of AF by RFA is highly effective and safe.

Key words: Atrial fibrillation, initial outcome, invasive cardiac electrophysiologic studies, radiofrequency ablation

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INTRODUCTION

Atrial fibrillation (AF) is characterized by irregular, disorganized, and chaotic electrical activity of the atrium.¹ Some characteristics aid recognition on electrocardiography.²⁻³

There are no P waves and the rhythm is irregularly irregular, with a variable ventricular rate between 110 and 160 bpm. The QRS complexes are usually <120 ms unless there are preexisting bundle branch block, accessory pathway, or rate-related aberrant conduction. Fibrillatory waves, small, irregular waves seen as a rapid-cycle baseline fluctuation, may be seen. AF can be distinguished from atrial flutter (AFL) by the presence of both saw-tooth wave configuration
and slower atrial rates and from atrial tachycardia (AT) with variable atrioventricular (AV) block, which usually presents with an atrial rate of approximately 150 beats/min because the atrial rate in AT is regular though the conduction to the ventricles is not.

Various types of AFs have been described. Paroxysmal AF is self-terminating with episodes lasting <7 days. Persistent AF is nonself terminating and last more than 7 days, and permanent AF last for more than 1 year. Many possible mechanisms are implicated in the pathophysiology, but it is thought to arise as a result of ectopic activity from tissues surrounding pulmonary veins (PVs) and other specialized tissues. The prevalence of AF has been estimated at 0.4% in the general population. They may occur at any age although it has been more in males, and the elderly and adults with valvular heart disease, especially with mitral valve (MV) lesions.

Standard treatment methods include the control of ventricular rate, the control of rhythm with antiarrhythmic and prevention of thromboembolism. Surgery can also be used as a method of ablation, radiofrequency ablation (RFA) has however become accepted as the treatment of choice for drug-refractory cases, comprising mainly of ablations of peripulmonary areas as well as ablation of the AV node (AVN) with subsequent insertion of a permanent pacemaker. RFA for AF in South-East Asia is under-reported, as most systematic have come from developed nations. In this report, we reviewed cases of AF in patients treated at the Cardiac Electrophysiology Department of Madras Medical Mission, India, between the years January 2010 and March 2014, with view to describing the burden of AF, electrophysiologic characteristics, associations, lines of management, as well as the initial outcome following radiofrequency catheter ablations (RFA).

**Materials and Methods**

The study was carried out at the Cardiac Electrophysiology Department of the Institute of Cardiovascular Diseases, Madras Medical Mission, India. Ethical approval was obtained. We retrospectively studied records of cases of AF that underwent cardiac electrophysiologic studies (EPS) carried out from January 2000 to March 2014. AF was diagnosed based on standard criteria.

In our study, we described the demographic characteristics of the patients, the indication for the procedure and the prevalence of associated cardiovascular morbidity in the patients. We also observed the percentage of cases with recurrent AF following previous RFA and documented the frequency of the various early complications of RFA and the success rate of the procedure. Patients had been chosen for cardiac electrophysiologic assessment if they had recurrent, drug refractory palpitations, recurrent palpitations with preference for ablative therapy over pharmacological, recurrent palpitations in association with syncopal attacks or dyspnea, symptomatic bradycardia, tachycardiomypathy, and recurrent shocks for patients with automatic implantable cardioverter defibrillator device. Patients with significant basal bradycardia and AV nodal disease were not considered suitable for rate limiting drugs and were considered for PV isolation (PVI) with or without permanent pacemaker implantation (PPI). Two electrophysiologists carried out the RFA.

Access was obtained through the right femoral vein and right femoral artery. Catheters used were Quadripolar 6F for high right atrium, His and right ventricular apex, lasso 20 pole 7F or lasso spiral 7F for left atrial mapping, 20 pole Optima spiral 6F, reflex on 20 pole and IBI lasso 20 and 10 pole for PV mapping, decapolar 6F for coronary sinus and EPT BLAZER II 7F STD curve, J and J cords Webster medium curve 7F, cool flex (St. Jude), and cool path (St. Jude IBI) irrigation catheter for the ablator. Transeptal punctures was obtained for deploying 8F sheath for ablation, and preface (Johnson and Johnson) sheath for placement of Optima 20 pole catheters.

The tachycardia was induced on programed atrial stimulation or with isupril infusion and vigorous protocols. In 21 patients (42.9%), three-dimensional (3D) electroanatomical mapping system (St. Jude Navx and St. Jude Ensite Velocity) was employed creating a fusion with offline acquired computed tomography images to define the left atrium and PVs.

Oral anticoagulation was stopped at 2–3 days before the ablation procedure. Throughout the procedure, the activated clotting time was maintained between 250 and 300 S using intravenous heparin. A conscious sedation using intravenous fentanyl and propofol was also maintained throughout the procedure. Antiarrhythmic drug treatment was suspended for the day of the ablation procedure and restarted the following day.

**Ablation**

For cases where AVN ablation was indicated, radiofrequency (RF) energy were delivered at a site where the compact AVN signals were optimal (A: H: V = 1:2:3) to produce complete heart block (CHB). The patient was observed for more than ½ h to ensure CHB persisted. In patients with previous pacemaker implantation, the pacemaker was reprogrammed to VOO, AVN was mapped at a site where H:V was 1:4 before RF energy (50°C, 50V) was used to create CHB. At the end of 45 min post-RFA if patient remained in CHB, device was reprogrammed to VVI mode.
Where tricuspid valve (TV) – inferior vena cava (IVC) isthmus linear lesion was performed, a standard of 480 s, 50°C, 50W was used. For circumferential PV ablations (PVA), after identifying the PV potentials, ablation lesions were delivered during sinus rhythm around the left and right superior and inferior PVs, resulting in termination of AF followed by the absence of electrical potentials within the PV postablation a power of 30 W and a temperature of 45°C was achieved using 7F St. Jude medium curve cool flux ablation catheter. Electrical disconnections into PV were confirmed with spiral catheter recordings documenting the absence of electrical potentials within the PV postablation. In 11 patients (22.4%), RF energy by conventional catheter was inadequate, and cool path irrigation tip catheter was used. Where patient remained in AF post-RFA, under deep sedation and after confirming the absence of intracardiac clots and after giving intravenous amiodarone 150 mg bolus followed by 50 mg infusion, a single synchronized cardioversion (150 J, biphasic) was delivered using R2 pads to convert to stable sinus rhythm. The data were analyzed using SPSS statistical software version 15 (SPSS, Inc., Chicago, Illinois, USA).

Results

Forty-nine cases of AF documented following cardiac EPS were reviewed, comprised 23 males and 26 females. The mean age was 57.53 years. The frequency of associated cardiovascular diseases in the patients studied were diabetes mellitus 8 (16.3%), hypertension 18 (36.7%), coronary heart disease 14 (28.5%), hypertrophic cardiomyopathy 1 (2.0%), tachycardia-induced cardiomyopathy 1 (2.0%), MV prolapsed 1 (2.0%), dilated cardiomyopathy 1 (2.0%), degenerative aortic valve disease 1 (2.0%), atrial septal defect 1 (2.0%), congenital bicuspid aortic valve 1 (2.0%), rheumatic heart disease 1 (2.0%), myxomatous MV 1 (2.0%), and hypothyroidism 1 (2.0%).

Over the study period, 968 cases of EPS were carried out of which 842 underwent RFA. A total of 28 (3.3%) of these RFA were for patients with AF. The distribution of indications for cardiac electrophysiologic assessment in the patients were recurrent, drug refractory palpitations 16 (32.6%), drug-refractory paroxysmal AF 7 (14.3%), sick-sinus syndrome (SSS) 3 (6.1%), persistent AF 3 (6.1%), palpitations with syncope/presyncope 5 (10.2%), resuscitated cardiac arrest 1 (2.0%), syncopal attacks 3 (6.1%), AF with FVR 4 (8.2%), palpitations with dyspnea 4 (8.2%), tachy-brady SSS 2 (4.1%), and suspected SSS with AVB 1 (2.0%).

There were three cases of previous RFA, one for typical AVN reentry tachycardia (AVNRT), and two for AF. Documented arrhythmias at baseline are as follows: AF 22 (44.9%), AT/AF/AFL/Sinus pauses 5 (10.2%), AFL/AF 3 (6.1%), regular narrow QRS tachycardia in 4 (8.2%), regular narrow QRS tachycardia with AF 3 (6.1%), regular wide QRS tachycardia 2 (4.1%), irregular narrow QRS tachycardia 2 (4.1%), AT/AF 2 (4.1%), irregular narrow 2 (4.1%), combinations of regular and irregular narrow QRS tachycardia 1 (2.0%), AFL/sinus bradycardia 1 (2.0%), AF/atrial ectopics/sinus bradycardia 1 (2.0%), and AFL/AF/PVC 1 (2.0%). No arrhythmia was documented at baseline in 2 (4.1%). The basic electrophysiologic characteristics of the study group are shown in Table 1 with sample surface and intracardiac electrograms in Figures 1 and 2.

Echocardiographic findings were documented in 36 (73.5%) of patients. These include dilated left atrium 6 (16.7%), global hypokinesia 4 (11.1%), concentric left ventricular (LV) hypertrophy 3 (8.3%), and mild LV dysfunction 2 (5.6%). Asymmetrical septal hypertrophy, left atrial clot with global hypokinesia, severe LV dysfunction, atrial septal defect, and moderate LV dysfunction were all present at frequency of 1 (2.8%) while 17 patients (47.2%) had a normal echo study.

The ventricular rate was documented in 34 (69.4%) patients. It was rapid (above 100/min) in 31 (91.2%), controlled on medication in 2 (5.9%), and normal in 1 (2.9%). The response to induction was documented in 24 (49.0%) cases. Fourteen (58.3%) of these did not have any sustained inducible tachycardia, 9 (37.5%) had inducible AF while AF was persistent in 1 (4.2%) without induction. The ventriculoatrial activation pattern was documented in 22 (43.1%), being concentric decremental in 13 (59.1%), and absent in 9 (40.9%).

AF was paroxysmal in 40 (81.6%), persistent in 5 (10.2%), chronic in 3 (6.1%), whereas a diagnosis of lone AF was made in 1 (2.0%). AF was preexcited in only 1 (2.0%). Dual arrhythmias were present in 26 cases (53.1%). The frequency of associated arrhythmias is as follows: Tachy-brady SSS 6 (12.2%), AT 5 (10.2%), AFL 3 (6.1%), SSS 3 (6.1%), and ventricular tachycardia (VT) 2 (4.1%) while there was one patient (2.0%) for each of the following: Typical AVNRT, SSS/AT, AT/AFL, typical AVNRT/AT, and atrioventricular nodal disease.

RFA was carried out in 28 patients (57.1%). Twelve (24.5%) had AVN ablation, 10 (20.4%) had circumferential PVA [Figure 3]. Isthmus lesions were applied in 3 (6.1%), 2 (4.1%) had ablations of the focus of the initiating AT. AVN ablation with isthmus lesions, as well as PVA with isthmus lesions was both applied in 1 (2.0%). AVN ablation with PPI was done in 2 (2.7%) cases, one with associated AF with fast ventricular rate, the other a case of tachycardia-bradycardia SSS.

RFA was not applied in 21 (42.9%) patients, reasons including: Associated VT, considered for RFA of VT with 3D electroanatomical mapping and artificial implantable cardioverter-defibrillator implantation (1), deferment for PVI with 3D electroanatomical mapping (1), deferment for AVN
to consider RFA if AF persisted (3), medical therapy was recommended (6), recommendation for continued monitoring and later review (5), recommendation for PVI and PPI (1).

AF with FVR developed in one patient who had a previous PPI for past indication of symptomatic AFL with fast ventricular rate and intermittent prolonged CHB. The pacemaker (Axios S – Biotronik) was first reprogramed to VOO and after mapping the AVN, RFA was used to created CHB, after which the device was reprogramed to VVI mode at a rate of 40/min. Of the 28 patients who had RFA, 11 (40.7%) had his bundle ablation on account of associated fast ventricular rate, 10 (20.4%) had ablations around the PVs (5 all PV ostia, 4 left common trunk, and right upper and lower pulmonary ostia, and 1 left superior and inferior PVs), 3 (6.0%) had ablations involving the TV–IVC isthmus/coronary sinus-IVC isthmus on account of associated AFL, 3 had ablations of ectopic atrial sites: Superior crista region (1), para-Hisian (1) and left right atrial free (1) sites for associated inciting AT and one had ablation around the following: Left superior PV, left atrial appendage, mitral isthmus, and TV-IVC isthmus.

PVA was successful in 9 (90%) cases. In one patient, AF persisted after electrical isolation. The patient was direct current-cardioverted and placed on medical therapy pending later review. AVN ablation was successful in 10 (90.9%) cases. In one patient (9.1%), it was only modified with resulting intermittent CHB and complete right bundle branch block post-RFA. These all received permanent pacemakers. RFA was successful in only 1 of the 3 that had associated AFL. For the three that had inciting AT, RFA was successful in 1, unsuccessful in 1, and empirical in another. Of the 21 (42.9%) patients not treated with RFA, 8 (38.1%) had normal EPs, 4 (19.0%) needed to optimize medication before considering RFA, and 2 (9.5%) needed preparation for PPI. The following indications were all obtained in only 1 (4.8%) patient: Asymptomatic, though

### Table 1: Basic electrophysiologic characteristics of the study group

| Characteristic                        | Value                      |
|---------------------------------------|----------------------------|
| Basal sinus cycle length (ms, n=33)   | 914.21±160.93              |
| Basal PR interval (ms, n=33)          | 168.94±25.95               |
| Basal QRS interval (ms, n=36)         | 95.00±16.67                |
| Basal AH interval (ms, n=35)          | 74.91±11.54                |
| Basal HV interval (ms, n=39)          | 49.23±8.18                 |
| Antegrade AV node ERP (ms, n=21)      | 290.95±89.49               |
| Antegrade WP (ms, n=24)               | 306.67±79.05               |
| Retrograde AV node ERP (ms, n=15)     | 319.33±73.84               |
| Retrograde WP (ms, n=17)              | 324.71±74.84               |
| Basal QT interval (ms, n=21)          | 414.10±29.55               |
| Procedure time (ms)                   | 110.25±75.61               |
| Fluoroscopy duration (min)            | 19.58±21.02                |

AH-HV: Atrial potential–His potential interval; AV: Atrioventricular; ERP: Effective refractory period; HV: His potential–ventricular potential interval; ms: Millisecond; SD: Standard deviation; WP: Wenckebach point.

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**Figure 1:** Variable P waves and ventricular rate in surface electrocardiogram.

**Figure 2:** Irregular potentials from the high right atrium in atrial fibrillation.

**Figure 3:** Circumferential ablation of pulmonary veins.
persistent AF; multiple atrial trigger sites in elderly with dilated left atrium, significant bradycardia in combination with AV disease, chronic AF; need for 3D electroanatomical study for PVI, underlying hypertrophic cardiomyopathy, and underlying dilated cardiomyopathy.

Cardioactive medications recorded in our patients include warfarin 15 (30.6%), Pradaxa 1 (2.0%), antiplatelets 11 (22.4%), statins 7 (14.35), diltiazem 9 (18.4%), amiodarone 13 (26.5%), digoxin 5 (10.2%), beta-blockers 13 (26.5%), flecainide 1 (2.0%), and angiotensin-receptor blockers 6 (12.2%). Early complications were observed in only 1 (2.04%) patient. Pulmonary edema with accelerated hypertension and sinus tachycardia had developed in the observational period postprocedure, with respiratory acidosis, hypoxia, and hypotension postintubation, requiring elective intubation and inotropic supports. No mortality was seen.

**Discussion**

This study describes the results of cardiac electrophysiologic study and catheter ablation of cases of AF carried out in the Electrophysiology Department of Madras Medical Mission between January 2000 and March 2014. The sex distribution was roughly even 46.9% in males as against 53.1% in females. The mean age of 57.3 years in our sample is higher than the figure of 48 years reported by Nasser et al.\(^9\) and the 53 years reported by Oussama et al.\(^9\) This may be explained by late referrals in a center from a less developed nation.

The most frequently associated cardiac condition was hypertension, followed distantly by coronary heart disease and diabetes. Nasser et al.\(^5\) reporting from Iran found a much lower prevalence of hypertension though it was still the most common associated disease. However, Nielsen et al.\(^10\) reporting from Denmark, found a markedly higher association with hypertension, similar to our own study.

It is noteworthy that 3.3% of total ablations in Madras Medical Mission over the study period were for cases of AF. In comparison 1.25% of ablations reported by Awan et al.\(^11\) from Pakistan were for AF and 1.7% was reported by Iturralde-Torres et al.\(^12\) from Mexico.\(^12\) Madras Medical Mission being a quaternary-level referral Center for Interventional Cardiology in India, a higher hospital prevalence for conditions requiring complex cardiac interventions would be expected. Most cases of AF (81.6%) were diagnosed as paroxysmal. Majority (89.5%) of the cases reported by Williamson et al.\(^13\) were chronic. Their study was published in 1994. As EPS becomes more available and affordable, less severe cases are referred for investigation.

The initial success rate was 90% for PVI and 90.9% for AVN ablation. This compares with 94% initial success rate obtained for PVI by Oral et al.\(^14\) Sanders et al.\(^15\) had a lower initial success rate, 82%. They used a focal approach; the lower success rate is therefore not surprising. A much lower success rate, 45–60%, was recorded by Chevalier et al.\(^16\) but this was in the first 100 cases at their center. Higher rates would be expected in more experienced hands. A total of 81 (95%) of 85 PVs could be completely isolated in a single-balloon technique by Klein et al.\(^17\) This was all with cryoablation that is safer and better tolerated.

The complication rate was 2.04%, and there was no mortality in this study. In their worldwide survey, Cappato et al.\(^18\) reported a complication rate of 6–10%. Zado et al.\(^19\) in their report of ablation of AF in elderly patients reported a complication rate that ranged from 1.6% to 2.9%. The rates in our series are therefore comparable to that obtained in other reputable centers worldwide. It is noteworthy that this is the first systematic report, to the best of our knowledge, of relatively large number of cases of AF our center. The reported distribution in types of AF, the burden of AF, the success and complication rates of AF ablation from our center are thus new contributions to the medical literature.

This study had limitations. The nationality of patients was not included in the data collected and, the study being retrospective, gaps in the data recorded could not be filled. Important characteristics including family history of arrhythmias and sudden deaths, blood pressures, body mass index, electrolytes, echocardiographic function indices, renal function indices, details of pharmacological treatments, and serum lipid profile were also not part of the data retrieved during data acquisition. Follow-up data was also not collected to determine the intermediate-term success rate.

**Conclusion**

This study shows that RFA of AF had a high success rate and very low incidence of complication.

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**Conflicts of interest**

There are no conflicts of interest.
References

1. Chowdhury P, Lewis WR, Schweikert RA, Cummings JE. Ablation of atrial fibrillation: What can we tell our patients? Cleve Clin J Med 2009;76:543-50.
2. Medi C, Hankey GJ, Freedman SB. Atrial fibrillation. Med J Aust 2007;186:197-202.
3. King DE, Dickerson LM, Sack JL. Acute management of atrial fibrillation: Part I. Rate and rhythm control. Am Fam Physician 2002;66:249-56.
4. Mathew ST, Patel J, Joseph S. Atrial fibrillation: Mechanistic insights and treatment options. Eur J Intern Med 2009;20:672-81.
5. Safaei N, Montazerghaem H, Azarfarin R, Alizadehasl A, Alikhah H. Radiofrequency ablation for treatment of atrial fibrillation. Bioimpacts 2011;1:171-7.
6. Chen MC, Chang JP, Chen YL. Surgical treatment of atrial fibrillation with concomitant mitral valve disease: An Asian review. Chang Gung Med J 2008;31:538-45.
7. Reynolds MR, Zimethaum P, Josephson ME, Ellis E, Danilov T, Cohen DJ. Cost-effectiveness of radiofrequency catheter ablation compared with antiarrhythmic drug therapy for paroxysmal atrial fibrillation. Circ Arrhythm Electrophysiol 2009;2:362-9.
8. European Heart Rhythm Association; European Association for Cardio-Thoracic Surgery, Camm AJ, Kirchhof P, Lip GY, Schotten U, Savelieva I, et al. Guidelines for the management of atrial fibrillation: The Task Force for the Management of Atrial Fibrillation of the European Society of Cardiology (ESC). Europace 2010;12:1360-420.
9. Wazni OM, Marrouche NF, Martin DO, Verma A, Bhargava M, Saliba W, et al. Radiofrequency ablation vs antiarrhythmic drugs as first-line treatment of symptomatic atrial fibrillation: A randomized trial. JAMA 2005;293:2634-40.
10. Cosedis Nielsen J, Johannessen A, Raatkainen P, Hindricks G, Walfriidsson H, Kongstad O, et al. Radiofrequency ablation as initial therapy in paroxysmal atrial fibrillation. N Engl J Med 2012;367:1587-95.
11. Awan ZA, Irfan M, Shah B, Noor L, Khan SB, Amin F. Radiofrequency catheter ablation for supraventricular tachycardias: Experience at Peshawar. J Ayub Med Coll Abbottabad 2009;21:98-101.
12. Iturralde-Torres P, Colin-Lizalde L, Kershenovich S, González-Hermosillo JA. Radiofrequency ablation in the treatment of tachyarrhythmias. Experience concerning 1,000 consecutive patients. Gac Med Mex 1999;135:559-75.
13. Williamson BD, Man KC, Daoud E, Niebauer M, Strickberger SA, Morady F. Radiofrequency catheter modification of atrioventricular conduction to control the ventricular rate during atrial fibrillation. N Engl J Med 1994;331:910-7.
14. Oral H, Knight BP, Tada H, Ozaydin M, Chugh A, Hassan S, et al. Pulmonary vein isolation for paroxysmal and persistent atrial fibrillation. Circulation 2002;105:1077-81.
15. Sanders P, Morton JB, Deen VR, Davidson NC, Sparks PB, Vohra JK, et al. Immediate and long-term results of radiofrequency ablation of pulmonary vein ectopy for cure of paroxysmal atrial fibrillation using a focal approach. Intern Med J 2002;32:202-7.
16. Chevalier P, Al Ghazzy M, Rivard L, Mestre C, De Breyne B, Pineau J, et al. Radiofrequency ablation of atrial fibrillation: The first 100 cases in Lyon. Int J Cardiol 2009;133:283-4.
17. Klein G, Oswald H, Gardiwal A, Lüsebrink U, Lissel C, Yu H, et al. Efficacy of pulmonary vein isolation by cryoballoon ablation in patients with paroxysmal atrial fibrillation. Heart Rhythm 2008;5:802-6.
18. Cappato R, Calkins H, Chen SA, Davies W, Iesaka Y, Kalman J, et al. Worldwide survey on the methods, efficacy, and safety of catheter ablation for human atrial fibrillation. Circulation 2005;111:1100-5.
19. Zado E, Callans DJ, Riley M, Hutchinson M, Garcia F, Bala R, et al. Long-term clinical efficacy and risk of catheter ablation for atrial fibrillation in the elderly. J Cardiovasc Electrophysiol 2008;19:621-6.