Outcomes following catheter ablation of atrial fibrillation in the UK – a single-centre cohort analysis

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The outcome and complications of atrial fibrillation (AF) ablation in a UK patient cohort were investigated by offering symptomatic, drug-refractory patients ablation. Treatment goals were to disconnect all pulmonary veins electrically and improve symptoms using a state-of-the-art ablation method. Outcomes were defined as: 'success' (no symptoms or Holter AF); 'partial success' (substantially reduced AF symptoms); 'clinical success' ('success' and 'partial success'); 'failure' (no symptom improvement).

A total of 100 consecutive patients (age: 49 years [range 37–76]; females: n=17; persistent AF: n=30; $CHADS_2$ score >1: n=7) underwent a first ablation (between January 2004 and May 2007). Ultimately 167 procedures were performed until follow-up censure in May 2009. Complications occurred in 15 patients – acutely in 11, during follow-up in four. Cumulative 'success', 'partial success', 'failure' and 'clinical success' rates after 22 ± 14 months were 60%, 26%, 14% and 86%, respectively. 'Clinical success' rates for paroxysmal and persistent subgroups were 73% and 47% (first procedure) rising to 87% and 83% (all procedures). Numbers of patients needing anti-arrhythmic drugs reduced significantly (p<0.0001).

In conclusion, catheter ablation improves symptoms in 83–87% of patients, reduces objective AF burden and the need for anti-arrhythmic drug therapy. It should be recommended routinely to symptomatic patients with drug-refractory AF without demonstrable heart disease.

Introduction

Catheter-ablation is an established treatment for patients with uncontrolled symptoms of atrial fibrillation (AF).[1] However, many cardiologists remain sceptical about its efficacy, and clinicians in general cannot relate ablation to the majority of AF patients.[2-4] Although ablation techniques vary, there is general consensus that it is crucial to treat all pulmonary vein–left atrial junctions.[5,6] Outcomes have usually been reported in terms of absolute success or failure after a short time period – not easily reconcilable with patient experiences subsequently.[7] Recently, large amalgamated experiences have been published, which help explain some earlier inconsistencies, but these assume uniformity of patient selection, follow-up and ablation techniques.[8]

Unlike in other arrhythmias, AF presents 'a moving target' for ablation.[9-11] As arrhythmia burden increases, ever more extensive ablation may be required to control it.[12] In patients with persistent AF, ablation results remain tantalisingly unpredictable, even after extensive bi-atrial procedures.[13-18] Similarly, patients with paroxysmal AF can be at different stages of atrial remodelling and do not respond uniformly to pulmonary vein isolation alone.[19-21]

The aim of this analysis was to report the AF ablation patient journey, based on a detailed evaluation of the course and outcome of 100 consecutive patients, treated in a uniform way by experienced operators at a single UK tertiary referral hospital. The object is to help clinicians better understand the nuances of AF ablation outcomes, largely concealed in larger series.

Methods

Patient selection

Patients with symptomatic AF without demonstrable heart disease, who were inadequately controlled by drug therapy, were considered for ablation. Structural heart disease and myocardial ischaemia were excluded as previously described.[7] All were motivated to undergo ablation by intolerable symptoms or lack of acceptance of AF.

Figure 1. Example of CARTO (A and B) and NavX (C and D) computer maps of the left atrium showing lesion sets to isolate pulmonary veins

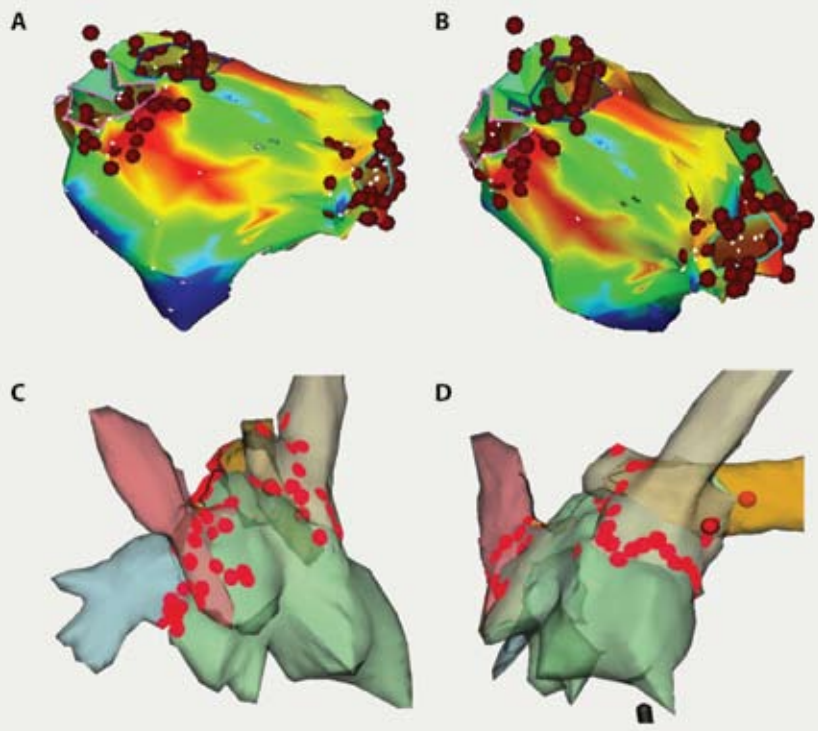
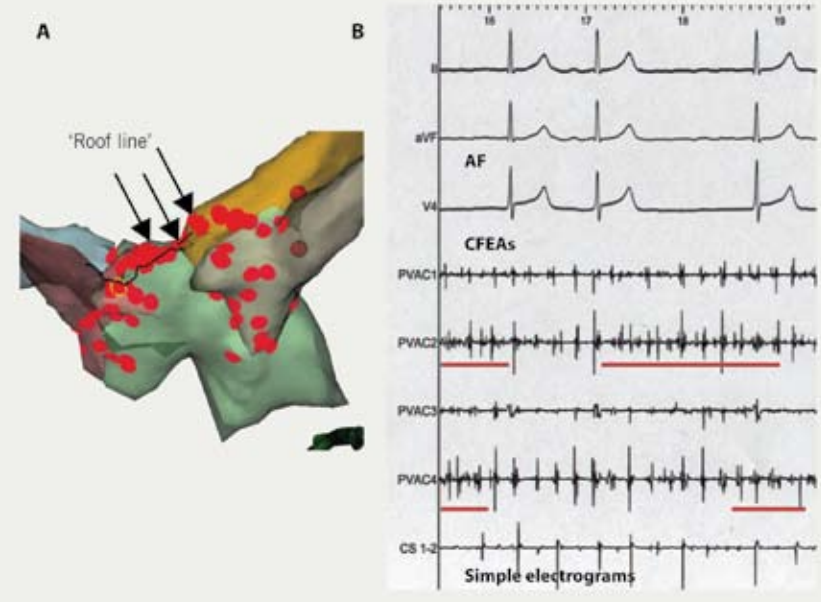


Figure 2. A NavX computer map of the left atrium (A), showing a 'roof-line' ablation linking right and left upper pulmonary vein ostia; and examples of focal complex fractionated electrogram ablation (CFEAs; underlined) and simple atrial electrograms during atrial fibrillation (AF) (B)



Ablation procedure

Ablation was performed in a uniform way. The left atrium was accessed by double-wiring of a single trans-septal puncture. An internal cardioversion/pacing catheter was positioned in the coronary sinus and a Lasso catheter (Biosense Webster Inc., CA, USA) used to guide ablation and confirm electrical isolation of veins. Ablation was performed using irrigation-tipped Webster 4 mm (Celsius 'Thermocool', Biosense Webster) or Navistar 4 mm catheters (Biosense Webster Inc., CA, USA). Patients were anticoagulated with unfractionated heparin, to maintain an activated clotting time longer than 250 seconds. Navigation and ablation were guided by either NavX-ESI (St Jude Medical Inc., St Paul, USA) or CARTO-XP (Biosense Webster Inc., CA, USA) mapping systems. Ablation lesions were sited around each pulmonary vein separately (**figure 1**). The acute procedural goal was to isolate all identified pulmonary veins (PVI). Ablation energy was power limited to 30 W, temperature to 50 °C with irrigation flow rate of 17–30 ml/min. Additional linear lesions (**figure 2A**) were performed in patients with persistent AF or in any who continued in AF despite PVI. Focal sites at which complex fractionated electrograms were consistently recorded during AF – possible perpetuators of the arrhythmia – were also targeted for specific ablation at repeat procedures[17,18,22] (**figure 2B**). Afterwards, patients with a history of long paroxysms or persistent AF continued their anti-arrhythmic drugs. All were on either warfarin or aspirin.

Follow-up

Patients were reviewed regularly out to 12 months following each procedure, their rhythm status determined on the basis of symptoms and a 12-lead electrocardiogram (ECG) at each visit. Only arrhythmias continuing beyond a two-month 'blanking period' are reported. All patients, free of AF symptoms, also had 48-hour to seven-day Holter ECG recordings. Anti-arrhythmic therapy was withdrawn three months after ablation. However, if symptoms returned later, therapy was restarted and the patient offered repeat ablation. Most patients who continued to experience symptoms despite anti-arrhythmic therapy opted for repeat ablation(s). Three outcome categories were

defined: 'success' (i.e. no symptoms, ECG or Holter evidence of AF lasting >30 seconds; no class 1C or III anti-arrhythmic therapy); 'partial success' (i.e. AF symptoms and objective AF burden substantially reduced on or off previously ineffective, anti-arrhythmic therapy); 'failure' (i.e. no clinically relevant change in symptoms or AF burden). Follow-up was censured on 31st May 2009.

Patients' own assessment of ablation outcome

An anonymised questionnaire was distributed by the hospital's Clinical Governance Department in spring 2008 to assess:

- symptom impact on quality of life pre-ablation
- effect of ablation outcome on symptoms and quality of life
- whether they would undergo ablation treatment again, or recommend it to others.

Results were correlated with objective arrhythmia outcomes to derive the fourth outcome category – 'clinical success' (i.e. the sum of 'success' and 'partial success' categories (clinician assessed) combined with patients' own evaluation).

Statistical methods

All values are expressed as mean and one standard deviation. Comparisons between groups were made using Student's *t* and Fishers' exact testing. Subgroup comparisons were made using analysis of variance. Differences were considered significant at the 5% level.

Results

By 31st May 2009, over 1,000 AF ablation procedures had been performed at this hospital, using a variety of techniques.[7] The 100 consecutive patients reported in detail here were those without demonstrable heart disease, who had a first procedure for AF in the period between June 2004 and June 2007 using a uniform, 'state-of-the-art' ablation method. Mean age was 55 ± 11 years (range 22–74), length of AF history was 66.5 months (range 3–240), 83 were male and 30 (30%) had persistent AF. In only seven was $CHADS_2$ risk score greater than one ($CHADS_2$ scores: 0 n=69; 1 n=24; 2 n=3; 3 n=3; 4 n=1). Scores were contributed to by the following: heart failure at presentation due to tachycardia myopathy (n=4), treated hypertension (n=25), age over 75 years (n=1), diabetes mellitus (n=5) and stroke (n=4). No patient had prior infarction, active myocardial ischaemia or idiopathic cardiomyopathy. AF symptoms had not been controlled by potent anti-arrhythmic drugs. Fifty-six had failed flecainide or propafenone and 13 had failed amiodarone or sotalol in high dose. Most patients were also taking beta-blocking agents, calcium channel blockers or digoxin prior to their first ablation.

Table 1. Extent of ablations performed by session

RFA 1 Procedure time: 209 ± 46 min X-ray screening time: 41 ± 21 min X-ray dose: 1,184 mSv (61–5,389)	RFA 1 n=100	RFA 2 n=49	RFA 3 n=14	RFA 4 n=4
Pulmonary vein isolation	100	40	8	1
Additional linear lesions	45	12	8	1
- Left atrium	(25)	(9)	(2)	1
- Right atrium	(25)	(3)	(6)	(1)
Inter-atrial septal ablation	0	6	3	0
CFEAs ablation	7	2	5	2
Incomplete procedure/abandoned	5	0	0	1

Key: CFEAs = focal complex fractionated electrogram ablation; PVI = pulmonary vein isolation; RFA = radiofrequency ablation procedure

Note: numbers in brackets refer to the number of times the linear lesion was sited (i.e. lesion sets not mutually exclusive); numbers without brackets indicate the number of patients who had that component at that ablation procedure

Cumulative outcome results

In total, 167 separate ablation procedures were performed in these 100 patients and procedure-related complications occurred in 15 (15%) (**tables 1 and 2**). Acute complications included cardiac tamponade, requiring pericardiocentesis in five (3% of procedures), pericarditis with effusion treated conservatively in five (3% of procedures), significant discomfort at catheter access site in two (1%) and allergic iodine contrast reaction in one (0.6% of procedures). Late complications occurred in four (4%) patients – one (0.6% of procedures) each of – unexplained sudden death six months after ablation, minor stroke with normal brain imaging, pulmonary vein stenosis of more than 75% (treated conservatively), pulmonary embolus 10 days after ablation (managed conservatively). Left atrial flutter occurred in eight (8%) patients and was typically persistent and more symptomatic than AF. After a mean follow-up of 22 months (range 3–92 months) cumulative 'success', 'partial success' and 'failure', as defined, for the whole group were 60%, 26% and 14%, respectively. Outcomes for paroxysmal AF at time of first ablation were 61%, 26% and 13%, respectively, after 1.5 ± 0.7 procedures per patient and for persistent AF, 57%, 26% and 17%, respectively, after 2 ± 1 procedures ('success': p=0.66).

Patients' own assessment of ablation outcome

Of the 100 patient questionnaires circulated 12 months after ablation, 80 were returned and analysed. Sixty-five (81%) described symptoms as "bad" or "terrible" prior to ablation. Of these, 58 (89%) felt "much better" afterwards – symptoms having improved to "none" or "not bad at all" (p<0.0001). Seventy-four (92%) described AF as interfering with their life at least "modestly" prior to ablation. Afterwards, 40 (58%) felt symptoms did not affect their quality of life "at all" (p<0.001), 29 (42%) rated interference as "only a little" and 11 (14%) as "moderately interfering" with their life. Seventy-four (92%) indicated that ablation had improved symptoms sufficiently for them to undergo the procedure, if faced with the same choice again, four were unsure and two said that they would not have opted for ablation. These results support the clinical impression that the outcome 'partial (anti-arrhythmic) success', as defined, also indicates patients who, although not free of AF, have benefited substantially from the procedure. Therefore, defining 'clinical success' as the sum of objective clinician-defined 'success'

Table 2. Summary of cumulative ablation procedures and their outcomes

	1st ablation n=100	2nd ablation n=49	3rd ablation n=14
Pulmonary vein isolation/repeat isolation	100 (100%)	40	8
Pulmonary vein isolated confirmed acutely	77 (77%)	---	---
Additional linear ablation lesions	45	12	8
- Right atrial isthmus	25	9	2
- Left atrial line(s)	25	3	6
Inter-atrial septal ablation	0	6	3
CFEAs (left ± right atria)	7	2	5
Overall outcome			
'Success'	37	19 (39%)	4 (28.5%)
'Partial success'	30	18 (37%)	6 (43%)
'Failure'	33	12 (24%)	4 (28.5%)
'Clinical success'	67	37 (76%)	10 (71%)
Outcome by AF behaviour	(*p=0.007;	(*p=NS;	(*p=NS;
Paroxysmal	**p=0.002)	**p=NS)	**p=NS)
Success*	32 (46%)	14 (47%)	2 (40%)
Partial success	22 (31%)	10 (33%)	1 (20%)
Failure	16 (23%)	6 (28%)	2 (40%)
'Clinical success' **	54 (77%)	24 (80%)	3 (60%)
Persistent			
Success*	5 (16%)	5 (26%)	2 (22%)
Partial success	8 (27%)	8 (42%)	5 (56%)
Failure	17 (57%)	6 (32%)	2 (22%)
'Clinical success'**	13 (43%)	13 (68%)	7 (78%)
Complications	(10 patients)	(4 patients)	(1 patient)
Acutely			
Cardiac tamponade	4	2	0
Pericarditis ± pericardial effusion	2	1	1
Iodine contrast allergy	1	0	0
Pain at vascular access site	1	1	0
During follow-up			
Sudden cardiac death at 6 months	1	0	0
Stroke (resolution ≤72 hours)	1	0	0
Pulmonary embolus at 14 days	1	0	0
LUPV stenosis (75%)	1	0	0
Persistent thigh numbness	1	0	0

Key: AF = atrial fibrillation; CFEAs = focal complex fractionated electrogram ablation; LUPV = left upper pulmonary vein; NS = not significant

and 'partial success' indicates those who have either no AF or are sufficiently improved, in their own estimation, not to need further intervention. 'Clinical success' was achieved in 86% of the 100 patients (paroxysmal AF 87%; persistent AF 83%; p=0.75).

Does 'failure' of first AF ablation indicate a non-responder or the need for a repeat procedure?

As indicated by the following analysis, cumulative benefits accrue from repeat ablation procedures (**table 2**).

First ablation procedure

Although all identified pulmonary vein–left atrial junctions were treated, complete electrical isolation could only be confirmed in 77 (77%). Complications occurred in 10 (10%) patients. Overall 'clinical success' rate was 67%, but 'success' and 'clinical success' rates were significantly better for paroxysmal than for persistent AF ('success': 46% versus 16%, p=0.007; 'clinical success': 77% versus 43%, p=0.002).

Second ablation procedure

All patients continuing to experience AF symptoms were recommended repeat ablation and 49 had a second procedure 12.7 ± 8.1 months after the first. Pulmonary vein reconnections were found in some or all veins in 40 (82%) patients and complications occurred acutely in four (8%). There were no late complications. Overall 'clinical success' for the second procedure was 76%. Differences in 'success' and 'clinical success' rates between initially paroxysmal and persistent AF were no longer significant ('success': 47% versus 26%, p=0.23; 'clinical success': 80% versus 68%, p=0.49).

Third ablation procedure

Fourteen patients (14%) underwent a third AF ablation 26.7 ± 19.0 months after their first procedure. Pulmonary vein reconnections were found in eight (57%). One patient developed pericarditis, treated conservatively, and four developed atypical atrial flutter. Overall 'clinical success' for the third procedure was 71%. 'Success' and 'clinical success' rates were the same for paroxysmal and persistent AF patients ('success': 40% versus 22%, p=0.55; 'clinical success': 60% versus 78%, p=1.0).

Fourth ablation procedure

Four patients (4%) underwent a fourth ablation 29 ± 13 months after their first procedure. The indication was left atypical atrial flutter in three. Flutters terminated with addition of a left atrial 'roof-line' in one, with focal ablation around right lower pulmonary vein in another and with ablation at sites of complex fractionated electrograms in a third. AF arose from the right atrial appendage in the fourth patient. There were no complications. 'Success' rate, therefore, was 100%.

Patients changing from rhythm to rate-control management

Eight (8%) patients changed to rate-control management – four after the first and four after the second ablation procedure. They tended to be older (64 ± 9 versus 55 ± 11 years, p≤0.01). Six required complete AV-junction ablation for symptom control.

Anti-arrhythmic drug requirements before ablation and at most recent review

Prior to ablation 73 (73%) patients were taking Class 1C or III agents, alone or in combination therapy: flecainide 53 (53%), propafenone 3 (3%), disopyramide 4 (4%), high-dose sotalol 6 (6%) and amiodarone 7 (7%). At latest follow-up 22 ± 14.6 months later, only 20 (20%) still required these drugs: flecainide 14 (14%), propafenone 2 (2%) and amiodarone 4 (4%); and, in five, flecainide was only being used as a 'pill-in-the-pocket' regimen (p<0.0001).

Discussion

Although only a 100 consecutive patient cohort from a larger experience, this detailed analysis complements the perspective provided by larger, amalgamated AF-ablation series and specifically relates to a UK population.[7,8] Its step-by-step analysis shows that outcomes are more nuanced than conveyed by earlier series, which simply reported recurrence or complete absence of AF at some arbitrary time point.[23-25] The overall 'clinical success' rate of 86% confirms a role for ablation as a means of controlling medically refractory symptoms. The results, at mean follow-up of 22 ± 14.6 months, are consistent with those already reported previously by our group and by other authors from pioneering hospitals.[7,13,26-29] On this basis, therefore, catheter ablation should be offered routinely to symptomatic patients with AF, inadequately controlled by potent anti-arrhythmic drug therapy.

The results also show that – in addition to patients who either have no AF ('success') or those whose arrhythmia is unchanged ('failure') – there is another group ('partial success') who benefit sufficiently to also consider their ablation successful.[26] Ninety per cent of patients in this middle category reported 'significant improvement' after ablation – a figure similar to the 86% 'clinical success' rate identified by objective arrhythmia assessment. This 'partial success' group, inadequately discussed in most series, is readily recognisable to clinicians who, although not performing ablations themselves, routinely follow-up these patients.[25]

This report highlights the difficulty in achieving long-term electrical isolation of pulmonary veins with a 'state-of-the-art' ablation technique. Even when pulmonary vein isolation had been achieved acutely, almost all patients needing subsequent procedures had residual or re-established connections.[30] If catheter ablation of AF is to be cost-effective and be made available to the majority of patients who might benefit, pulmonary vein isolation needs to be permanent, once achieved acutely. This cannot be guaranteed currently.[19-21]

Although 'success' following a first ablation was significantly better (p<0.007) for patients with paroxysmal (46%) as compared to persistent (16%) AF, eventual outcome was similar (60% versus 57%, p=0.66). Although at odds with most reports, this observation is supported by similar results from a recent, much larger series.[8] It is probably explained by the fact that patients with paroxysmal or persistent AF behaviour are essentially the same, differing only in their stage of AF natural history.[8,30]

Complications occurred in 15 patients (9% of procedures).[31] However, most were self-limiting or resolved with treatment. There were no instances of oesophageal injury, phrenic nerve palsy or pulmonary vein stenosis needing intervention.[31,32] Atypical left atrial flutter – although not really a 'complication' – occurred in eight (8%) patients, was usually incessant, resistant to drugs and challenging to ablate.[13] It was the main indication for third and fourth procedures.

This analysis reports medium-term outcome in a consecutive cohort of patients who have undergone catheter ablation, performed in a standard way, for AF at a UK tertiary referral hospital. The results are presented in a novel way with the aim of helping clinicians not involved in the delivery of this treatment, and patients, better understand what can be offered and expected. The overall conclusion, based on the outcomes achieved, is that catheter ablation should be offered routinely to all patients with symptomatic, medically refractory AF ●

Conflict of interest

None declared.

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Key messages

- Over 80% of patients with structurally normal hearts respond to catheter ablation of atrial fibrillation (AF), having less symptoms and less arrhythmia burden than they would have had with optimum anti-arrhythmic drug therapy
- Catheter ablation allows withdrawal of anti-arrhythmic therapy in the majority of cases
- Catheter ablation of AF carries a small risk of acute complications, but most are readily treatable and do not have long-term sequelae
- Catheter ablation should be offered routinely to patients with symptomatic AF, inadequately controlled by trials of potent anti-arrhythmic drug therapy

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