Available online at www.sciencedirect.com

SciVerse ScienceDirect

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

Original Article

“Through the looking glass: 10-year-single centre experience in cardiac electrophysiology and radiofrequency ablation”

Col Prashant Bharadwaj, vsm^{a,*}, Brig Rajat Datta, vsm^b, Col Sunil Sofat^a,
Gp Capt Hemant Madan^a, Ajit Kabde^c

^a Senior Adviser (Med & Cardio), Army Hospital (R&R), Delhi 110010, India

^b Consultant (Med & Cardio), Army Hospital (R&R), Delhi 110010, India

^c Senior Resident (Cardio), Army Hospital (R&R), Delhi, India

ARTICLE INFO

Article history:

Received 1 May 2012

Accepted 16 July 2012

Available online 16 September 2012

Keywords:

Cardiac electrophysiology

Radiofrequency ablation

Cardiac arrhythmias

ABSTRACT

Background: Radiofrequency catheter ablation is an emerging curative modality of treatment for several types of cardiac arrhythmias. The aim of our study was to evaluate our experience of electrophysiology procedures over a 10-year-period and compare it with the published literature.

Methods and result: All patients undergoing cardiac electrophysiology and radiofrequency ablation procedures during the period from 01 January 2003 to 30 April 2012 were included in this study. The study analyzed 892 patients of which atrioventricular nodal reentrant tachycardia (AVNRT) was $n = 513$ (57.5%), accessory pathways $n = 230$ (25.8%), atrial tachycardia $n = 26$ (2.9%), atrial flutter $n = 15$ (1.7%), atrial fibrillation $n = 9$ (1.0%), ventricular tachycardia $n = 37$ (4.2%) and diagnostic studies $n = 62$ (6.9%). Three-dimensional electro-anatomic mapping was performed in $n = 17$ (1.9%). The success rate was 99% with AVNRT, 94% with accessory pathway, 81% with atrial tachycardia, 64% with ventricular tachycardia and 34% with atrial fibrillation. The major and serious complications rate was 0.45%.

Conclusions: The procedural success rate and the complication rate in this real-world study of the Armed Forces were comparable/superior to the reported literature.

© 2012, Armed Forces Medical Services (AFMS). All rights reserved.

Introduction

The management of cardiac arrhythmias has undergone a significant change with the advent of invasive cardiac electrophysiology. Cardiac arrhythmias most commonly result from the development of a reentry circuit caused by a myocardial scar or a developmental anomaly. Wolf–Parkinson–White syndrome is a classic example where the reentry current is due to the presence of a congenital accessory pathway. Destruction of this and any other abnormal

electrical circuits with radiofrequency (RF) current is termed radiofrequency ablation. RF ablation came into clinical practice at the end of the 1980s and revolutionized the way patients with arrhythmias could be cured and is in many cases the first-choice therapy.

RF ablation has been shown to be effective and safe, with a success rate exceeding 90–95% in patients with atrioventricular nodal reentrant tachycardia (AVNRT) or atrioventricular reentrant tachycardia (AVRT) due to accessory pathways (AP) and ranging from 80% to 100% in patients with atrial

* Corresponding author. Tel.: +91 11 23338126 (O), +91 11 23338238 (R), +91 9650833737 (mobile).

E-mail address: prashantbharadwaj@gmail.com (P. Bharadwaj).

0377-1237/\$ – see front matter © 2012, Armed Forces Medical Services (AFMS). All rights reserved.

<http://dx.doi.org/10.1016/j.mjafi.2012.07.013>

flutter.^{1–5} As techniques have been increasingly refined, more types of arrhythmias have become amenable to specific curative ablation procedures. For instance, RF ablation has recently been proposed as an effective procedure for the treatment of atrial fibrillation, whose therapy was limited to antiarrhythmic drugs until a few years ago, and the favorable results reported in several studies have led to a considerable increase in the number of ablation procedures. Similarly, new techniques, such as electro-anatomic three-dimensional (3D) mapping, have made it possible to successfully ablate more complex rhythm disorders, such as atypical atrial flutter or atrial tachycardia, atrial fibrillation and ventricular tachycardia. Available data on RF catheter ablation in literature has mainly been provided by observational studies carried out in dedicated specialized centers performing large numbers of procedures and there is paucity of data on catheter ablation in everyday practice in the “real world”. Complications associated with these ablative procedures occur at a low incidence of 2–5%.^{6,7}

The current observational study analyzed retrospectively the acute success and complication rates from an apex tertiary care center of the Armed Forces of patients undergoing electrophysiology and RF catheter ablation.

Materials and methods

The acute outcomes and complications of all electrophysiology and RF catheter ablation procedures performed at an apex tertiary care center of the Armed Forces during a 10-year period from January 1, 2003, to 30 April, 2012, were retrospectively assessed. The ablation procedures were classified according to the arrhythmias induced using standard electrophysiological techniques and definitions. The arrhythmia

Fig. 1 – RF ablation of typical AVNRT-decatheter coronary sinus catheter, quadripolar bundle of his catheter and RF ablation catheter at the slow pathway region.

Fig. 2 – RF ablation of accessory pathway-decatheter coronary sinus catheter, quadripolar right ventricular catheter and RF ablation catheter in at the mitral annulus via a retro-aortic approach.

types included AVNRT (both typical and atypical); AV reentrant tachycardia involving an AP, either concealed or manifest; atrial flutter, including clockwise or counter-clockwise right or left atrial flutter; atrial tachycardia, including focal or macro-reentrant atrial tachycardia; atrial fibrillation with pulmonary vein isolation (PVI) and ventricular tachycardia (VT) ablation in patients with and without structural heart disease.

Ablation procedures were performed using standard mapping and ablative techniques. In greater than 99% of cases, radiofrequency was the energy source applied through a 4 mm tip ablation catheter. For atrial flutter, an 8 mm tip catheter was used for most procedures. For PVI, an irrigated

Fig. 3 – CARTO map for left atrial tachycardia.

Fig. 4 – Map for LVOT ventricular tachycardia using the Array Balloon.

catheter was used. Radiofrequency energy was typically delivered at a power required to achieve a set temperature of 50 °C–65 °C. Radiofrequency energy was applied for 30 s to 2 min during continuous electrocardiography, intracardiac electrogram monitoring and intermittent fluoroscopic monitoring. In complex cases electro-anatomic three-dimensional (3D) mapping catheter navigation systems (CARTO, Biosense Webster Inc, USA, NavX, St Jude Medical, USA and Array Balloon, St Jude Medical, USA) was used (PVI, VT or atrial tachycardia).

Patients were brought to the electrophysiology laboratory in a fasting state. Coronary sinus access was routinely performed with a non-deflectable decapolar catheter from the right internal jugular vein. His and right ventricular catheters were advanced from the femoral vein. Detailed electrophysiological evaluation was performed using standard stimulation and recording techniques to establish the correct diagnosis and identify the appropriate ablation site. The study was labeled as a diagnostic study when there was no inducible tachycardia and RF ablation was not performed. Slow pathway ablation was performed in patients with AVNRT, usually in the left anterior oblique view (Fig. 1). The retrograde aortic approach via the femoral artery was routinely used for left-sided AP's (Fig. 2). Right-sided APs were approached via the femoral veins using the antero-posterior or left anterior oblique view. For complex arrhythmias like atrial tachycardia and ventricular tachycardia 3D electro-anatomic mapping was used by CARTO and NavX systems (Figs. 3 and 4). Patients were routinely monitored for 24 h after the procedure. A 12-lead electrocardiogram was obtained before discharge.

Acute ablation success was defined based on arrhythmia type as follows:

- AVNRT – inability to initiate more than single AV node echo beat with and without isoproterenol challenge;
- Atrial tachycardia – inability to reinitiate the tachycardia;
- AV reentry – absence of antegrade and/or retrograde AP conduction;
- Atrial flutter – bidirectional isthmus block demonstrated following ablation with a multipolar electrode catheter;
- Ventricular tachycardia – termination and non-inducibility on extra-stimulation in patients with structural heart disease and during isoproterenol infusion in patients without structural heart disease.

Complications and follow-up

The patients were followed for 4–24 weeks after ablation on outpatient visits and on telephone. Complications were grouped into the following three categories according to the seriousness or permanence of the event:

1. Major or life-threatening complications: death, myocardial infarction, embolic stroke involving transient or permanent neurological alteration, persistent unintentional heart block (second- or third-degree), valve disruption and pulmonary embolism;
2. Serious complications: deep venous thrombosis, pericardial effusion requiring drainage, pseudoaneurysm and transient heart block; and
3. Minor complications: hematoma, pericarditis and pericardial effusion without tamponade.

Statistical analysis

Results are presented as the number of procedures performed and mean $\pm$ SD where appropriate.

Results

From January 1, 2003, to 30 April, 2012, 892 electrophysiology and RF ablations were performed at an apex tertiary care center of the Armed Forces. Patients' characteristics are

Table 1 – Characteristics of patients undergoing electrophysiology and RF ablation (n = 892).

	Patients, n (%)	Men (%)	Age, years ^a	Age, range
AVNRT	513 (57.5)	305 (57.1)	49 $\pm$ 17	11–74
Accessory pathway (AP)	230 (25.8)	137 (59.6)	37 $\pm$ 18	10–68
Atrial tachycardia	26 (2.9)	17 (65.3)	42 $\pm$ 11	11–62
Atrial flutter	15 (1.7)	11 (73.3)	52 $\pm$ 19	21–71
Atrial fibrillation	9 (1.0)	7 (77.7)	41 $\pm$ 12	25–54
Diagnostic	62 (6.9)	40 (64.5)	45 $\pm$ 15	10–75
Ventricular tachycardia	37 (4.2)	29 (78.3)	45 $\pm$ 21	23–66

^a Mean $\pm$ SD.

Fig. 5 – Characteristics of procedures performed as per the arrhythmia.

presented in Table 1. The mean ($\pm$ SD) age of patients was 52 ± 18 years (range 10–75 years), and 546 patients (61%) were males. The indications for ablation were AVNRT ($n = 513$), accessory pathways ($n = 230$), ventricular tachycardia ($n = 37$), atrial tachycardia focal/macro-reentrant ($n = 26$), isthmus dependent atrial flutter ($n = 9$) and atrial fibrillation ($n = 9$) as shown in Fig. 5. There were 62 diagnostic studies. Table 2 shows the short-term success rates and the procedural parameters according to ablation type. The management of complex arrhythmias with 3D electro-anatomic mapping was embarked upon 4 years ago and these were used in atrial tachycardias, atrial flutter, atrial fibrillation and ventricular tachycardias. The characteristics of patients who underwent 3D electro-anatomic mapping are given in Table 3. The overall success rates varied between 34% (atrial fibrillation) and 99% (AVNRT). There was no difference in the success rates between the younger and older patients. The incidence of complications as per the type of procedure done is given in Table 4. Fifteen patients (1.6%) had complications, including four major, four serious and seven minor complications. Among patients undergoing AVNRT ablation, three had a permanent pacemaker implanted for inadvertent persistent complete AV block during ablation and all patients had their pacemakers implanted immediately after ablation. One patient had a stroke during ablation of the left free wall pathway via the retro-aortic approach that recovered completely over the next 2 days. Four patients had pseudoaneurysms of the femoral artery access site that were treated by ultrasound guided local compression. None of the patients with hematomas required a blood transfusion.

Discussion

During the past decade, several studies have reported results of RF ablation for cardiac arrhythmias. The present study confirms the safety and efficacy of radiofrequency catheter ablation (RFA) for cardiac arrhythmias. We found a high acute success rate (from 81% to 99%) using conventional electrophysiology techniques and a success rate of 34–64% using 3D electro-anatomic mapping. Our success rates with AVNRT were 99% vs 95% (p value 2.275), AP's were 94% vs 93% (p value 30.8), atrial flutter 91% vs 88% (p value 6.69) and for atrial tachycardia 81% vs 82% (p value 30.85) in published reports.^{6–13} We had a relatively low complication rate (1.6%) vs 2–5% (p value 4.45) with no mortality related to the procedure. Our success rates with 3D anatomic mapping were not assessed on account of their recent introduction and low numbers. The major complications we had were in 4 (0.45%) patients that included the need for unexpected, permanent cardiac pacing in 3 (0.58%) patients and spontaneously recovering stroke in one patient (0.45%). The success rate and incidence of major complications reported in the present study are similar/superior to the results from published reports.^{6–13}

To the best of our knowledge, the present study is the first and largest observational, single-center study ever reported in the Armed Forces. The fluctuation in the number of procedures is related to the mobile population of the cardiac electrophysiologists at our institute and the arduous learning curve for these procedures.

Interestingly, our results showed that notwithstanding the changing population of the cardiac electrophysiologists at our institute the learning curve rates were rapidly achieved (within 2 years) with the overall success rates remaining stable over time. Of note, our electrophysiology procedures are performed in the real world where the cardiac catheterization laboratory time is shared amongst other invasive cardiology work. However, this factor did not result in an increase in the complication rate or in ablation failure compared with other published studies emanating from dedicated electrophysiology centers in the world.

Over the last couple of years we have made forays into 3D electro-anatomic mapping for complex arrhythmias. However the stumbling block remains the steeper learning curve and long procedure time further clustering the cardiac catheterization laboratory time and staff. RFA improves health-related quality of life to a greater extent than medical treatments^{14,15} and is less expensive than medical therapy over time among patients who have frequent symptomatic episodes of tachycardia.

Table 2 – Short-term success rates and procedural parameters according to ablation type.

	AVNRT	Accessory pathway (AP)	Atrial tachycardia	Atrial flutter	Atrial fibrillation	Ventricular tachycardia
Patients	513	230	26	15	9	37
RF lesions	6 ± 4	11 ± 10	20 ± 14	18 ± 10	36 ± 12	21 ± 11
Fluoroscopy time (in minutes)	12 ± 9	26 ± 18	31 ± 15	28 ± 12	42 ± 18	39 ± 13
Success rate (%)	99	94	81	91	34	64

Table 3 – Characteristics of 3D electro-anatomic mapping patients.

	CARTO Biosense Webster Inc, USA (n)	NavX, St Jude Medical, USA (n)	Array Balloon, St Jude Medical, USA (n)
Atrial tachycardia	10	1	0
Atrial flutter	2	0	0
Atrial fibrillation	9	0	0
Ventricular tachycardia-structurally normal heart	2	0	1
Ventricular tachycardia-scar related	6	0	0

Table 4 – Complications as per the procedure done.

	Major (%)	Serious (%)	Minor (%)
AVNRT	3 (0.58)	0	0
Accessory pathway (AP)	1 (0.43)	1 (0.43)	4 (1.73)
Atrial tachycardia	0	0	1 (3.84)
Atrial flutter	0	1 (6.7)	1 (6.7)
Atrial fibrillation	0	1 (11.1)	0
Diagnostic	0	0	0
Ventricular tachycardia	0	1 (2.7)	1 (2.7)
Total	4 (0.45)	4 (0.45)	7 (0.78)

Study limitations

The present study was a database analysis. All procedures were prospectively included from 01 January 2003 to 30 April 2012. Complications were collected in the database during each hospitalization and also at the time of follow-up (4–24 weeks post ablation). Some complications may not have been reported for a minority of patients who were not seen for post ablation follow-up.

Conclusions

The results of this large single apex tertiary care center of the Armed Forces highlight the experience with cardiac electrophysiology over the last decade. The study is the largest of its kind of a real world assessment in an institution which performs a spectrum of cardiac interventions. Our experience showed results similar or superior to those of previous studies performed in dedicated institutions undertaking cardiac electrophysiology. Our results confirm that RFA is safe and effective, supporting ablation therapy as a first-line therapy for the majority of patients with recurrent symptomatic or disabling cardiac arrhythmias.

Conflicts of interest

All authors have none to declare.

Acknowledgments

We acknowledge the contribution and are grateful to the following cardiac electrophysiologists who have played a role

in taking the plunge and sustaining the program at this institution over the years viz Col (retd) A. Dhall, SM, Col (retd) V. Jetley, VSM and Col S.K. Malani. We are also grateful to all our cardiac catheterization laboratory staff and technicians who stood by us and provided unstinted support for these procedures.

REFERENCES

1. Prystowsky EN. Atrioventricular node reentry: physiology and radiofrequency ablation. *Pacing Clin Electrophysiol.* 1997;20: 552–571.
2. Hindricks G. The Multicentre European Radiofrequency Survey (MERFS): complications of radiofrequency catheter ablation of arrhythmias. *Eur Heart J.* 1993;14:1644–1653.
3. Delise P, Sciarra L. Asymptomatic Wolff-Parkinson-White syndrome: what to do. Extensive ablation or not? *J Cardiovasc Med.* 2007;8:668–674.
4. Inama G, Pedrinazzi C, Durin O, Agricola P, Romagnoli P, Gazzanig P. Usefulness and limitations of the surface electrocardiogram in the classification of right and left atrial flutter. *J Cardiovasc Med.* 2006;7:381–387.
5. Pedrinazzi C, Durin O, Agricola P, Romagnoli P, Inama G. Efficacy and safety of radiofrequency catheter ablation in the elderly. *J Interv Card Electrophysiol.* 2007;19:179–185.
6. Chen SA, Chiang CE, Tai CT, et al. Complications of diagnostic electrophysiologic studies and radiofrequency catheter ablation in patients with tachyarrhythmias: an eight-year survey of 3,966 consecutive procedures in a tertiary referral center. *Am J Cardiol.* 1996;77:41–46.
7. Brugada J, Matas M, Mont L, Petit M, Navarro-Lopez F. One thousand consecutive radiofrequency ablation procedures. Indications, results, and complications. *Rev Esp Cardiol.* 1996;49:810–814.
8. Jackman WM, Beckman KJ, McClelland JH, et al. Treatment of supraventricular tachycardia due to atrioventricular nodal reentry, by radiofrequency catheter ablation of slow-pathway conduction. *N Engl J Med.* 1992;327:313–318.
9. Calkins H, Yong P, Miller JM, et al. Catheter ablation of accessory pathways, atrioventricular nodal reentrant tachycardia, and the atrioventricular junction: final results of a prospective, multicenter clinical trial. The Atakr Multicenter Investigators Group. *Circulation.* 1999;99:262–270.
10. Wu D, Yeh SJ, Wang CC, Wen MS, Lin FC. A simple technique for selective radiofrequency ablation of the slow pathway in atrioventricular node re-entrant tachycardia. *J Am Coll Cardiol.* 1993;21:1612–1621.
11. Belhassen B, Fish R, Glikson M, et al. Noninvasive diagnosis of dual AV node physiology in patients with AV nodal reentrant tachycardia by administration of adenosine-5'-triphosphate during sinus rhythm. *Circulation.* 1998;98:47–53.
12. Erdogan A, Schulte B, Carlsson J, et al. Clinical characteristics of patients with AV-nodal reentrant tachycardia (AVNRT):

- modification by high frequency catheter ablation. Study of 748 patients after high frequency catheter ablation. *Med Klin (Munich)*. 2001;96:708–712.
13. Delise P, Sitta N, Zoppo F, et al. Radiofrequency ablation of atrioventricular nodal reentrant tachycardia: the risk of intraprocedural, late and long-term atrioventricular block. The Veneto Region multicenter experience. *Ital Heart J*. 2002;3:715–720.
 14. Bathina MN, Mickelsen S, Brooks C, Jaramillo J, Hepton T, Kusumoto FM. Radiofrequency catheter ablation versus medical therapy for initial treatment of supraventricular tachycardia and its impact on quality of life and healthcare costs. *Am J Cardiol*. 1998;82:589–593.
 15. Cheng CH, Sanders GD, Hlatky MA, et al. Cost-effectiveness of radiofrequency ablation for supraventricular tachycardia. *Ann Intern Med*. 2000;133:864–876 (Erratum in 2001;135:933).