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Current case mix and results of catheter ablation of regular supraventricular tachycardia: are we giving unrealistic expectations to patients?

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Aims Catheter ablation (CA) has become the treatment of choice for regular supraventricular tachycardia (SVT). The purpose of this study was to investigate whether the current clinical results in a large single centre are as good as success rates quoted to patients from published trials and national cardiology society websites.
Methods and Results We recorded and analysed prospectively the acute and follow-up (FU) results of all CA procedures performed for SVT at our institution over a 2-year period. We compared our results with the success rates of 90–98% for CA quoted in the literature. We performed a total of 547 CA at our institution over 2 years, of which 389 (71%) were for regular SVT. Of these, 71 procedures (18%) were redo procedures. The overall acute procedural success rate was 96.1% (374/389). Follow-up data were available for 367 of 389 (94.3%) procedures. The overall 6-week success rate varied between 74.7 and 91.3% depending on the SVT type (average 83.9%). The FU success rates were lower for redo procedures (47/66, 71.2%) when compared with first ablation (*de novo*) procedures (261/301, 86.7%), $P = 0.003$.
Conclusion Published success rates are much better than current success rates in a large single centre. It is possible that the information regarding outcome given to patients during the consent process is not accurate.

Introduction

Catheter ablation (CA) has become the treatment of choice for regular supraventricular tachycardia (SVT). Surveys of CA practice are now several years old,[1–9] and it is likely that technology, case mix, and case selection criteria may have changed the results now achieved. Furthermore, the results presented by some studies may be misleading because the overall success rate per patient is highlighted rather than the success rate per procedure, even when multiple procedures are required. The purpose of this study was to compare the results of CA procedures currently performed for regular SVT in one institution with previously published results.

Methods

Patients referred to cardiac electrophysiologists at our institution for CA of regular SVT [atrioventricular nodal re-entry tachycardia (AVNRT), typical atrial flutter (AFL), accessory pathway, and atrial tachycardia] over a 2-year period were included in this study. We excluded those patients with congenital heart disease and atypical AFL. The details of all CA procedures were prospectively collected and entered into a database.

All patients were followed-up ~6 weeks after the procedure and evaluated particularly for symptoms, recurrence of arrhythmia, and complication. Patients who did not attend follow-up (FU) appointments were telephoned and if this failed, their family doctor was contacted in order to establish the patient's current level of symptoms and recurrence if any. Those who were lost to FU were excluded from the final results.

Diagnosis and ablation

All patients who underwent ablation for regular SVT were included, except those with atypical AFL and those with congenital heart disease. Patients were categorized into four groups: AVNRT, accessory pathways (manifest or concealed), isthmus-dependent AFL, and atrial tachycardia. Diagnoses were made using electrophysiological study (EPS) before proceeding to ablation, usually at the same sitting.

All CAs were performed or directly supervised by consultant (attending) electrophysiologists based at our

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institution. The EPS and ablation procedures were performed using standard techniques and a successful procedure was determined using standard endpoints, i.e. bidirectional isthmus conduction block for typical AFL, absence of conduction (anterograde or retrograde) over an accessory pathway, absence of inducibility of AVNRT, or atrial tachycardia. For patients with AVNRT, a jump in AV nodal conduction and a single echo beat without tachycardia induction was also accepted as a successful endpoint. Success was confirmed only after a 30 min waiting period, and if isoprenaline was required to initiate the tachycardia at original EPS, then this was also used during post-ablation testing.

We used X-ray, Ensite NavX (St Jude Medical, St Paul, MN, USA), or Carto (Biosense Webster, Diamond Bar, CA, USA) mapping systems to assist with ablation in a proportion of cases. We have described these techniques in detail previously and demonstrated that the catheter technology used does not influence the success rate of CA for regular SVT.[10] For this reason, we did not analyse the outcomes according to the technology used. We used radiofrequency (RF) ablation for most cases; however, cryoablation was used for all parahisian pathways and some AVNRT.

Outcome measures

Type of procedure: First attempt at ablation (*de novo* procedures) and redo procedures.

Procedure time: Time from entering to leaving the catheterization laboratory.

Acute success: CAs were considered successful at the completion of the procedure if standard end-points were reached as described earlier.

Six-week success: Success was defined as freedom from clinical arrhythmia at 6-week FU and was determined by patient symptoms and if necessary ECG Holter monitoring. In WPW syndrome, absence of symptoms, and pre-excitation in 12-lead ECG were considered as success.

Recurrence: Documented recurrence of index arrhythmia by 6-week FU in those patients who had a successful ablation.

Ectopics: The incidence of ectopics was recorded for patients who had symptoms, but did not have recurrence of their index arrhythmia either by ECG or by Holter monitoring.

Statistics

This was an observational study aimed to describe clinical outcomes of CA in a single large volume centre. Normally distributed continuous data are presented as mean $\pm$ standard deviation and all other data are presented as median (range). We compared the success rates between *de novo* and redo procedures using a χ^2 test, where $P = 0.05$ was considered to be the level of significance.

Results

We performed a total of 547 CA procedures at our institution over a period of 2 years (August 2003 to August 2005). This included ablation of all types of SVT, atrial fibrillation (44), ventricular tachycardia (32), and the compact AV node (26). Three hundred and eighty-nine procedures for regular SVT were included in our study and the baseline characteristics of those patients are given in *Table 1*. Twenty-two patients (5.7%) were lost to FU (five AVNRT, seven accessory pathways, eight typical AFL, and two atrial tachycardia), and they were excluded from the final result.

The overall acute success rate for all ablation procedures for regular SVT in the study period was 96.1% (374 of 389 procedures). The 6-week recurrence rate of all successful procedures was 12% (44 of 352), giving an overall success rate of 83.9% (308 of 367, excluding 22 patients who were lost to FU). Details of the success and recurrence rate at 6 weeks for each arrhythmia are listed in *Table 2*.

We also compared the results of patients undergoing their first procedure (*de novo*) with those who had previous attempt at ablation at our institution or other institution (redo procedure). We demonstrated a significant difference in the 6-week success rate for total ablation (261/301 *de novo* 87%, 47/66 redo 71%, $P = 0.003$), but not in individual types of arrhythmia (AVNRT: 105/115, 91%, 11/12, 91%, $P = 0.619$; typical AFL: 89/102, 87%, 15/20, 75%, $P = 0.285$; pathways: 56/70, 80%, 18/29, 62%, $P = 0.106$; atrial tachycardia: 11/14, 79%, 3/5, 60%, $P = 0.827$ for *de novo* and redo, respectively). The difference between *de novo* ablation recurrence and redo ablation recurrence for those who had successful ablation was most marked in patients with accessory pathways (12.5 vs. 30%) and atrial tachycardia (8.3 vs. 25%) (*Table 3*).

Symptoms of ectopic beats were common in all patients who had undergone successful ablation (20/352, 6%), ranging from 4 to 12% depending on the type of arrhythmia (*Table 2*).

Table 1 Baseline characteristics and complication rate of patients who had catheter ablation procedures for regular supraventricular tachycardia

	AVNRT	Accessory pathway	Typical AFL	Atrial tachycardia	Total
Total no. of procedures	132	106	130	21	389
Redo procedures, *n* (%)	12 (9)	32 (30)	22 (17)	5 (23)	71 (18)
Age (mean $\pm$ SD)	49 $\pm$ 17	40 $\pm$ 15	60 $\pm$ 10	49 $\pm$ 15	49.5 $\pm$ 16
Median procedure time in min (range)	90 (45–300)	120 (25–240)	90 (15–540)	120 (60–420)	90 (15–540)
Major complication[a], *n*	2	1	0	0	3

AVNRT, atrioventricular nodal re-entrant tachycardia; AFL, atrial flutter.
[a]Three patients had complete heart block, two of whom required permanent pacemaker.

Table 2 Success rate, recurrence rate, and incidence of symptomatic ectopics at 6-week follow-up

	AVNRT	Accessory pathway	Typical AFL	Atrial tachycardia	Total
Procedural success rate, *n* (%)	130 (98)	97 (91)	129 (99)	18 (86)	374 (96)
Number of patients lost to follow-up	5	7	8	2	22
Recurrence, *n* (%)	9 (7.2)	16 (17.8)	17 (14.0)	2 (12.5)	44 (12.5)
Ectopics, *n* (%)	8 (6)	4 (4)	6 (5)	2 (12)	20 (6)
Overall success rate at 6 weeks, *n* (%)	116 (91.3)	74 (74.7)	104 (85.2)	14 (73.7)	308 (83.9)

Table 3 Comparing the success of *de novo* and redo catheter ablation procedures

	n	Successful procedure, *n* (%)	Recurrence rate in successful procedure, *n* (%)[a]	Overall success at 6 week, *n* (%)[a]
De novo procedures				
AVNRT	120	118 (98.3)	8 (7.1)	105 (91.4)
Accessory pathways	74	68 (91.9)	8 (12.5)	56 (80.0)
Typical AFL	108	107 (99.0)	12 (12.0)	89 (87.2)
Atrial tachycardia	16	14 (87.5)	1 (8.3)	11 (78.5)
Total	318	307 (96.5)	29 (10.0)	261 (86.7)
Redo procedures				
AVNRT	12	12 (100.0)	1 (8.0)	11 (91.7)
Accessory pathways	32	29 (90.6)	8 (30.0)	18 (62.0)
Typical AFL	22	22 (100.0)	5 (25.0)	15 (75.0)
Atrial tachycardia	5	4 (80.0)	1 (25.0)	3 (60.0)
Total	71	67 (94.4)	15 (24.1)	47 (71.2)
Total procedures	389	374 (96.1)	44 (12.5)	308 (83.9)

[a]Twenty-two patients were lost to follow-up and they were excluded from the final result.

Accessory pathway

The different types of pathways ablated are given in *Figure 1*. Out of the three patients who had multiple pathways, two of them had two pathways and one patient had three pathways. Analysis of the success rates for all accessory pathway location revealed that the success rate was lowest for patients with multiple (0/3, $P = 0.005$) and posteroseptal (23/35, 65.7% $P = 0.079$) compared with pathways at other locations (51/61, 83.6%).

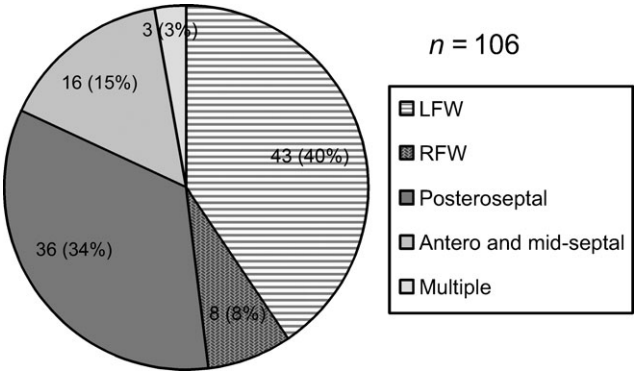

Figure 1 A pie chart illustrating the location of accessory pathways of the 106 patients who underwent catheter ablation of an accessory pathway in this study. LFW, left free wall; RFW, right free wall.

Major complications

Major complications occurred in three patients (0.8%), two of whom required permanent pacemaker for complete heart block. Both were redo procedures. One was a mid-septal accessory pathway ablation and the other was a slow pathway ablation for AVNRT. A further patient with AVNRT had transient complete heart block that lasted <24 h.

Discussion

Main findings

We have demonstrated that the overall patient single procedure success rate (84%) for CA of all regular SVT at 6 weeks is lower than previously described and we have shown for the first time that patients undergoing redo procedures have a significantly lower chance of success when compared with their first procedure. The success rate is higher for AVNRT (116/127, 91.3%) and typical AFL (104/122, 85.2%) but lower for accessory pathways (74/99, 74.7%) and atrial tachycardia (14/19, 73.7%). Six per cent of the patients who had successful ablation of their arrhythmia continue to have symptoms and documented ectopics without recurrence of their index arrhythmia.

Published results, clinical guidelines, and patient information

The ACC/AHA/ESC practice guidelines (2003)[11] and NASPE policy statement on CA (2003)[12] describe success rates for ablation of AVNRT as greater than 95–97%,[1,2,13] accessory pathway as 95%,[1,3,14,15] focal atrial tachycardia as 78%,[4–6] and isthmus-dependent AFL as 90–100%.[7–9]

Patient information provided on national websites also quote high success rates, although none presents complication rates. The American Heart Association patient information states a success rate of over 90% for RF ablation with a low risk of complication.[16] The Heart Rhythm Society website tells patients that in many types of arrhythmia the success rate for ablation procedures are between 90–98%, with no mention of complication rate.[17] The British Heart Foundation website says 'nine out of ten catheter (90%) ablation therapy procedures were successful'.[18]

Possible reasons for discrepancy between published data and this study

Procedural vs. patient outcomes

The results of regular SVT ablation in our institution are not as good as those presented on national guidelines and websites. One reason for this is that the latter are derived from studies presenting patient outcomes rather than procedure outcomes. This means that patients may have undergone multiple procedures (with the concomitant increase in risk) to achieve the success rate quoted. This may be misleading to patients who may be more interested in the likely outcome of their forthcoming procedure.

De novo vs. redo procedures

We are not aware of any study that examined the difference in success rate between *de novo* and redo procedures in various forms of SVT. This study showed a difference in the success rate between these two groups. Patients should be aware of this difference, particularly when making decisions about having another procedure. If a patient has their symptoms successfully controlled on medication, they may feel very differently about having a repeat CA if they know that the chance of success is much less than their first procedure.

Pathway location

Posteroseptal ($n = 36$, 34%) and other septal ($n = 16$, 15%) pathways form nearly half of the single pathway ablation procedures in our study, which is much higher than ATAKR[1] trial group (20 and 8%, respectively). This may explain why the success rates are lower for accessory pathway ablation in our study. It has been demonstrated in previous studies that the location of pathway has an influence in the success of CA procedures with left free wall pathway showing slightly higher success rate than accessory pathways in other locations.[1,3] Left free wall pathway accounts for 42% ($n = 43$) of all single accessory pathway in our study and 54% in the ATAKR trial group.

Change in case mix

The mean age of this study population was 49.5 years, whereas in the ATAKR trial population, the mean age was 37 years and 31% of them were under 20 years of age. The mean age for those who underwent accessory pathway ablation was 40 and 27 years, respectively. On further analysis of accessory pathway ablation, we found that patients under the age of 40 years have higher success rate than patients who are 40 years and above (45/54, 83.3%, 29/45, 64.4% $P = 0.05$). This difference is not demonstrated in the other groups.

Arrhythmia mix

This study is a typical representation of the arrhythmia mix in any high volume centre performing CA, whereas some of the published data were derived from separate trials looking into individual arrhythmia in single or multiple centres.

Ablation energy type

We recently showed that the failure rate and recurrence rate are higher with cryoablation when compared with RF ablation for AVNRT.[19] We compared the acute and FU results of 71 cases, each of cryo and RF ablation for AVNRT. Patients in the cryo group had higher primary failure rate than RF (15.4 vs. 2.8%) and significantly higher recurrence rate (19.8 vs. 5.6%). Therefore, as our study included some patients who had cryo [AVNRT: 39 (29.5%), pathways: 18 (16.9%)], the overall results may be inferior when compared with other studies that exclusively used RF ablation, such as the ATAKR trial.

Complication rates

The major complication rate in our study is much lower than the ATAKR trial (0.8 vs. 3.0%). According to the NASPE Prospective Cardiac ablation registry, there was 1% incidence of second or third degree AV block in patients who underwent AV-nodal modification for AVNRT and 1.2% for AFL ablation.[20]

Experience of the operators

The primary operators of all cases were fully trained cardiac electrophysiologists who had completed training in cardiac electrophysiology. The primary operator was present throughout all cases. There was no significant relationship between the length of time out of training and the outcome of ablation.

Incidence of ectopics

The incidence of symptomatic ectopics after CA is common with a significant proportion of patients continuing to experience palpitations and documented ectopics without documented SVT recurrence. We are not aware of any study examining the incidence of symptomatic ectopics after CA. It is helpful to warn patients about this when discussing the outcome of these procedures.

Limitations of the study

We only present the first FU data, which is between 6 and 8 weeks, as all patients are routinely followed-up in our institution at this interval. Even though the planned FU time was 6 weeks, this was variable for practical reasons. Some patients missed their initial appointments and have to rebook their appointments and sometimes it was not possible for them to get 6-week appointments. This resulted in the mean and median FU time as 8.7 and 6.8 weeks, respectively. We can make no comment on late (>6–8 week)

recurrences. We recognize that 22 patients (5.7%) were lost to FU. We did not include these patients in the final result; however, it is reasonable to speculate that these patients were likely to have been asymptomatic. It is also possible that patients with asymptomatic recurrences of their arrhythmia may not have been recognized.

Conclusion

Catheter ablation is rightly the current treatment of choice for regular SVT. Patients and their physicians have high expectations as a result of previously published observational studies and information available from cardiology society websites. The results of this study, however, shows that the 'real world' success rates are lower than expected because of the reasons discussed earlier. It is reassuring, however, that the procedures remain very safe with 0.8% major complication rate. It is important for institutions to audit their own success rates and should be careful in giving patients accurate information about the outcome of these procedures.

Conflict of interest: R.J.S. is a member of the Speakers Bureau for St Jude Medical and the scientific advisory board of Biosense Webster.

References

1. Calkins H, Yong P, Miller JM, Olshansky B, Carlson M, Saul P *et al.*, for the ATAKR Multicenter Investigators Group. Catheter ablation of accessory pathways, atrioventricular nodal reentrant tachycardia, and the atrioventricular junction: final results of a prospective, multicenter clinical trial. *Circulation* 1999;**99**:262–70.
2. Clague JR, Dagres N, Kottkamp H, Breithardt G, Borggrefe M. Targeting the slow pathway for atrioventricular nodal reentrant tachycardia: initial results and long-term follow-up in 379 consecutive patients. *Eur Heart J* 2001;**22**:82–8.
3. Lesh MD, Van Hare GF, Scheinman MM, Ports TA, Epstein LA. Comparison of the retrograde and transseptal methods for ablation of left free wall accessory pathways. *J Am Coll Cardiol* 1993;**22**:542–9.
4. Hsieh MH, Chen SA. Catheter ablation of focal AT. In: Zipes DP, Haissaguerre M, eds. *Catheter Ablation of Arrhythmias*. Armonk, NY: Futura Publishing Co., Inc; 2002. p185–204.
5. Goldberger J, Kall J, Ehlert F, Deal B, Olshansky B, Benson DW *et al*. Effectiveness of radiofrequency catheter ablation for treatment of atrial tachycardia. *Am J Cardiol* 1993;**72**:787–93.
6. Poty H, Saoudi N, Haissaguerre M, Daou A, Clementy J, Letac B. Radiofrequency catheter ablation of atrial tachycardias. *Am Heart J* 1996;**131**:481–9.
7. Willems S, Weiss C, Ventura R, Ruppell R, Risius T, Hoffmann M *et al*. Catheter ablation of atrial flutter guided by electroanatomic mapping (CARTO): a randomized comparison to the conventional approach. *J Cardiovasc Electrophysiol* 2000;**11**:1223–30.
8. Chen SA, Chiang CE, Wu TJ, Tai CT, Lee SH, Cheng CC *et al*. Radiofrequency catheter ablation of common atrial flutter: comparison of electrophysiologically guided focal ablation technique and linear ablation technique. *J Am Coll Cardiol* 1996;**27**:860–8.
9. Kottkamp H, Hugl B, Krauss B, Wetzel U, Fleck A, Schuler G *et al*. Electromagnetic versus fluoroscopic mapping of the inferior isthmus for ablation of typical atrial flutter: a prospective randomized study. *Circulation* 2000;**102**:2082–6.
10. Earley MJ, Showkathali R, Alzetani M, Kistler PM, Gupta D, Abrams DJ *et al*. Radio frequency ablation of arrhythmias guided by non-fluoroscopic catheter location: a prospective randomized trial. *Eur Heart J* 2006;**27**:1223–9.
11. Blomstrom-Lundqvist C, Scheinman MM, Aliot EM, Alpert JS, Calkins H, Camm AJ *et al*. ACC/AHA/ESC Guidelines for the management of patients with supraventricular arrhythmias—executive summary. *J Am Coll Cardiol* 2003;**42**:1493–531.
12. Scheinman M, Calkins H, Gillette P, Klein R, Lerman BB, Morady F *et al*. NASPE policy statement on catheter ablation. *Pacing Clin Electrophysiol* 2003;**26**:789–99.
13. Jackman WM, Beckman KJ, McCleeland JH, Wang X, Friday KJ, Roman CA *et al*. Treatment of supraventricular tachycardia due to atrio-ventricular nodal reentry by radiofrequency catheter ablation of slow pathway conduction. *N Engl J Med* 1992;**327**:313–8.
14. Kuck KH, Schulter M, Geiger M, Siebels J, Duckeck W. Radiofrequency current catheter ablation of accessory arioventricular pathways. *Lancet* 1991;**337**:1557–61.
15. Calkins H, Sousa J, El-Atassi R, Rosenheck S, deBuitleir BM, Kou WH *et al*. Diagnosis and cure of the Wolff–Parkinson–White syndrome or paroxysmal supraventricular tachycardias during a single electrophysiologic test. *N Engl J Med* 1991;**324**:1612–8.
16. American Heart Association Website. http://www.americanheart.org/presenter.jhtml?identifier=6 (3 January 2007).
17. Heart Rhythm Society Website: Patient and Public Page.http://www.hrspatients.org/patients/treatments/cardiac_ablation.asp (3 January 2007).
18. British Heart foundation Website. Heart health. http://www.bhf.org.uk/hearthealth/index.asp?secID=1&secondlevel=77&thirdlevel=474&artID=1624 (3 January 2007).
19. Gupta D, Al-Lamee RK, Earley MJ, Kistler P, Harris SJ, Nathan AW *et al*. Cryoablation compared with radiofrequency ablation for atrioventricular nodal re-entrant tachycardia: analysis of factors contributing to acute and follow-up outcome. *Europace* 2006;**8**:1022–6.
20. Scheinman MM, Huang S. The 1998 NASPE prospective catheter ablation registry. *Pacing Clin Electrophysiol* 2000;**23**:1020–8.