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Curative Therapy of Cardiac Tachyarrhythmias with Catheter Ablation – A Review of the Experience with the First 1000 Patients

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ABSTRACT

Introduction: Cardiac tachyarrhythmias present as supraventricular or ventricular tachycardia. Catheter ablation has completely revolutionised the treatment of patients with these arrhythmias.

Method: We reviewed the experience of radiofrequency catheter ablation in a single centre.

Results: A total of 1,022 patients underwent radiofrequency catheter ablation from October 1991 – December 1997. There were 480 patients who had AV nodal re-entrant tachycardia, 429 patients with accessory pathways, 7 patients with both AV nodal re-entrant tachycardia and accessory pathways, 4 patients with both AV nodal re-entrant tachycardia and atrial tachycardia. Twenty-seven patients had atrial tachycardia ablation, 28 had atrial flutter ablation and 11 patients had AV node ablation for atrial fibrillation. The mean age of the supraventricular tachycardia patients was 41 ± 15 years (10 – 80 years). The mean duration of procedure was 108 ± 60 minutes (15 to 480 minutes) and the mean fluoroscopy time was 19 ± 17 minutes (3 – 122 minutes). Another 14 patients had ablation for right ventricular outflow tract ventricular tachycardia and 22 patients had ablation for idiopathic left ventricular tachycardia. The mean age of the ventricular tachycardia patients was 35 ± 14 years (19 – 65 years). The mean duration of the ventricular tachycardia ablation procedure was 185 ± 63 minutes (110 – 285 minutes) and the duration of fluoroscopy was 33 ± 16 minutes (range 14 – 68 minutes). Of the 1,022 patients, 1,002 (98%) of the patients were successfully ablated. There were significant complications in less than 1% of the patients and no mortality associated with the procedure. The recurrence rate was 5% and could be successfully reablated when the procedure was repeated.

Conclusion: Radiofrequency catheter ablation is thus an extremely safe and successful procedure and has replaced drug therapy as the treatment of choice for patients with supraventricular tachycardia and non-ischaemic ventricular tachycardia. It provides curative therapy without the need for life-long drug therapy.

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INTRODUCTION

Cardiac arrhythmias may present as tachyarrhythmias which may be supraventricular or ventricular. Previously, the only therapy available for tachyarrhythmias was medical therapy with antiarrhythmic drugs, which was however, not curative and had significant side effects. Electrophysiological studies (EPS) allowed accurate assessment of cardiac arrhythmias and subsequently guided arrhythmia surgery which cured the patients with cardiac arrhythmias. Catheter ablation is however, performed percutaneously and requires no surgical incision.

Catheter ablation began initially in the 1980s with the use of DC energy but it had only limited clinical utility because of the risk of barotrauma and the need for general anaesthesia[1,2]. Radiofrequency (RF) catheter energy for ablation was first introduced in 1987[3] and the combination of RF energy as the energy source and new technology using deflectable large tip catheters enabled catheter ablation to be performed safely and successfully. The use of RF energy enabled safe and controlled energy delivery with no worry of barotrauma or the need for general anaesthesia. RF energy has now completely replaced DC energy as the main source of energy used in catheter ablation.

The use of RF catheter ablation in humans was first reported in 1987 by Borggrefe[4]. It was however only in the early 1990s that the first clinical series of RF catheter ablation was reported[5-7]. In Singapore, RF catheter ablation was first performed in the Singapore General Hospital on 10 October 1991. The first published report of the procedure in Singapore was only on the first 100 cases[8]. Since then, the procedure has been increasingly used and widely accepted by the patients. We report here the experience of a single centre in Singapore, of the first 1000 cases performed from October 1991 to December 1997 and review the experience with this technique and explore the success rate of the procedure, possible complications associated with it and long-term outcome of the procedure.

METHODS

EPS is performed in the cardiac catheterisation laboratory. Informed consent was obtained from all the patients. The risk of EPS procedure is estimated to be about 1 – 2 per 1000 and for RF catheter ablation, it is estimated to be less than 1 per 100. Antiarrhythmic drugs were discontinued for at least 5 half-lives prior to the procedure. EPS involves the use of intracardiac electrode catheters which are inserted via the venous or arterial route by the percutaneous Seldinger technique to specific sites in the heart in order to monitor the sequence of electrical activation or to pace the heart. Usually, 4 electrode catheters are used. The catheters used are quadripolar catheters with 1 cm or 5 mm interelectrode spacing. The patients are fasted for at least 6 hours and are usually given light sedation with midazolam and fentanyl. An octapolar electrode catheter with 1 cm spacing between each pair of electrodes and 1 mm interelectrode spacing between each electrode in the pair, is then inserted into the left subclavian vein or the right internal jugular vein. The catheter is positioned in the coronary sinus, to map the left atrial and ventricular activity. Catheters are then also inserted via the right femoral vein usually and rarely in the left femoral vein as well and positioned in the right ventricular apex, high right atrium and His bundle. Special mapping catheters such as the Cordis-Webster Halo catheter are sometimes used to map the right atrium. The positioning of the catheter is aided by fluoroscopic guidance, using biplane fluoroscopy. When the catheters are inserted in the arterial system, heparin is administered 1000 – 2000 units bolus, with 1000 units/hour thereafter if necessary. The catheters are then connected to the Electrophysiological recorder which was initially the Gould Amplifier and subsequently the ART/Prucka system. The signals are filtered between 30 – 500 Hz.

The technique of radiofrequency catheter ablation of accessory pathways has been previously described[8]. We used the Radionics RFG or Medtronic Atakr electrosurgical unit for generating the radiofrequency energy. The catheters used were either the Mansfield-Webster Polaris, United States Catheter and Instruments (USCI) or Medtronic Atakr steerable catheters with a 4 mm large tip deflectable electrode catheter. This was connected to a junction box to allow for easy switching from recording mode to the electrophysiological amplifier and recorder or to ablating mode to the Radionics electrosurgical unit. A back plate was attached to the patient's left scapular region.

For patients with left sided accessory pathways, RF ablation was performed using a deflectable 7 French 4 mm tip electrode catheter positioned at the mitral annulus either by the retrograde transaortic approach or via the transeptal approach either above or below the mitral annulus, via the right femoral artery. Only one patient had ablation for a left sided accessory pathway via the transeptal approach. The catheter tip was positioned either below or above the valve leaflet. For right sided pathways, the tricuspid annulus was approached usually from the right femoral vein and rarely from the right subclavian vein or internal jugular vein. The site of the accessory pathway was localised by standard electrophysiological studies and accessory pathway potentials when present were also looked for. Electrogram fusion, the earliest ventricular activation, with activation preceding the delta wave and the earliest atrial activation during AV re-entrant tachycardia was mapped. Once the

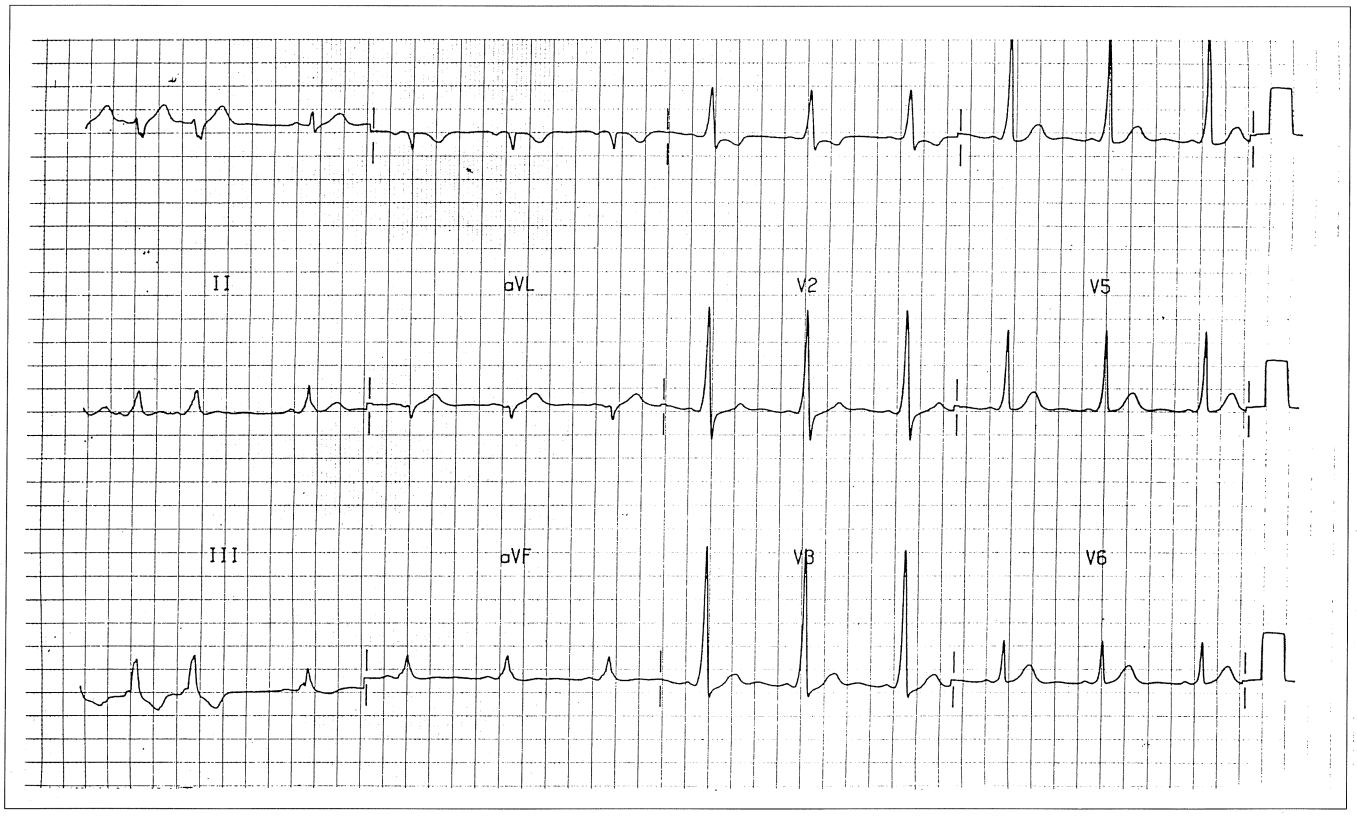

Fig 1 – 12-lead ECG showing pre-excitation from the Wolff-Parkinson-White syndrome.

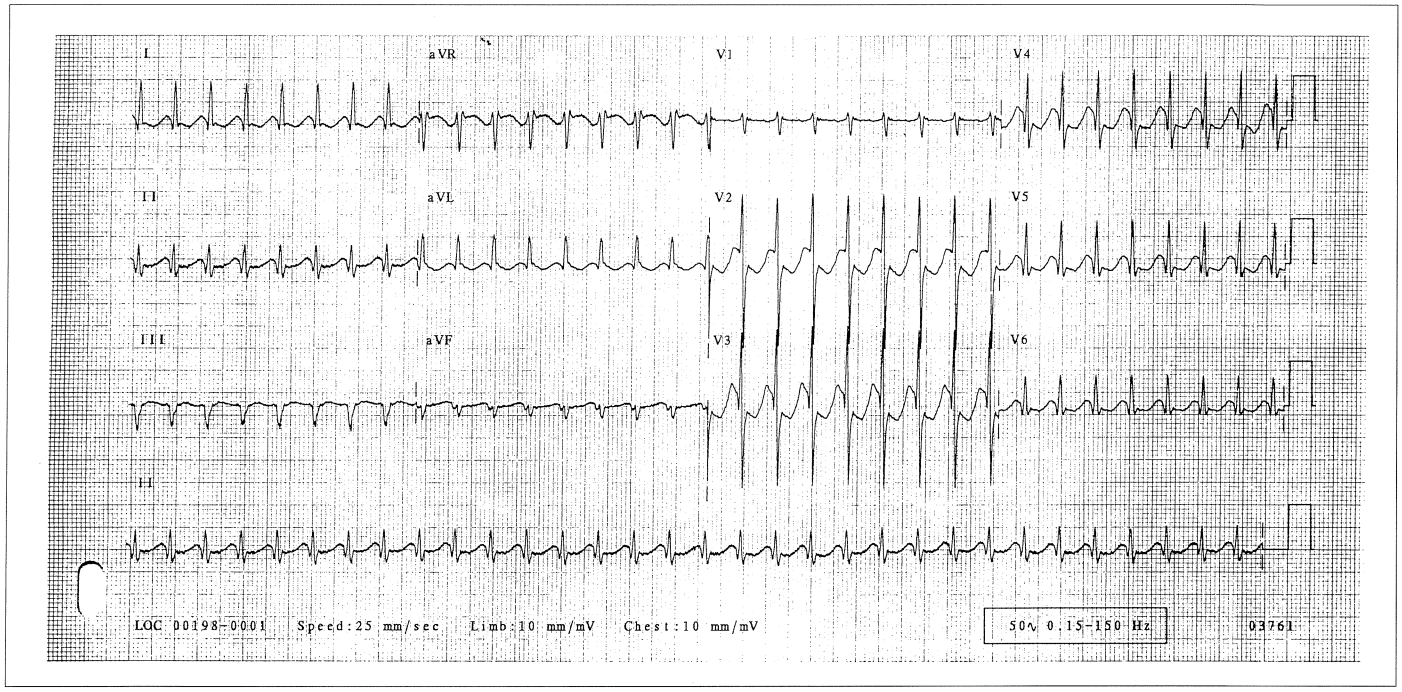

Fig 2 – 12-lead ECG showing a supraventricular tachycardia due to an atrioventricular re-entrant tachycardia.

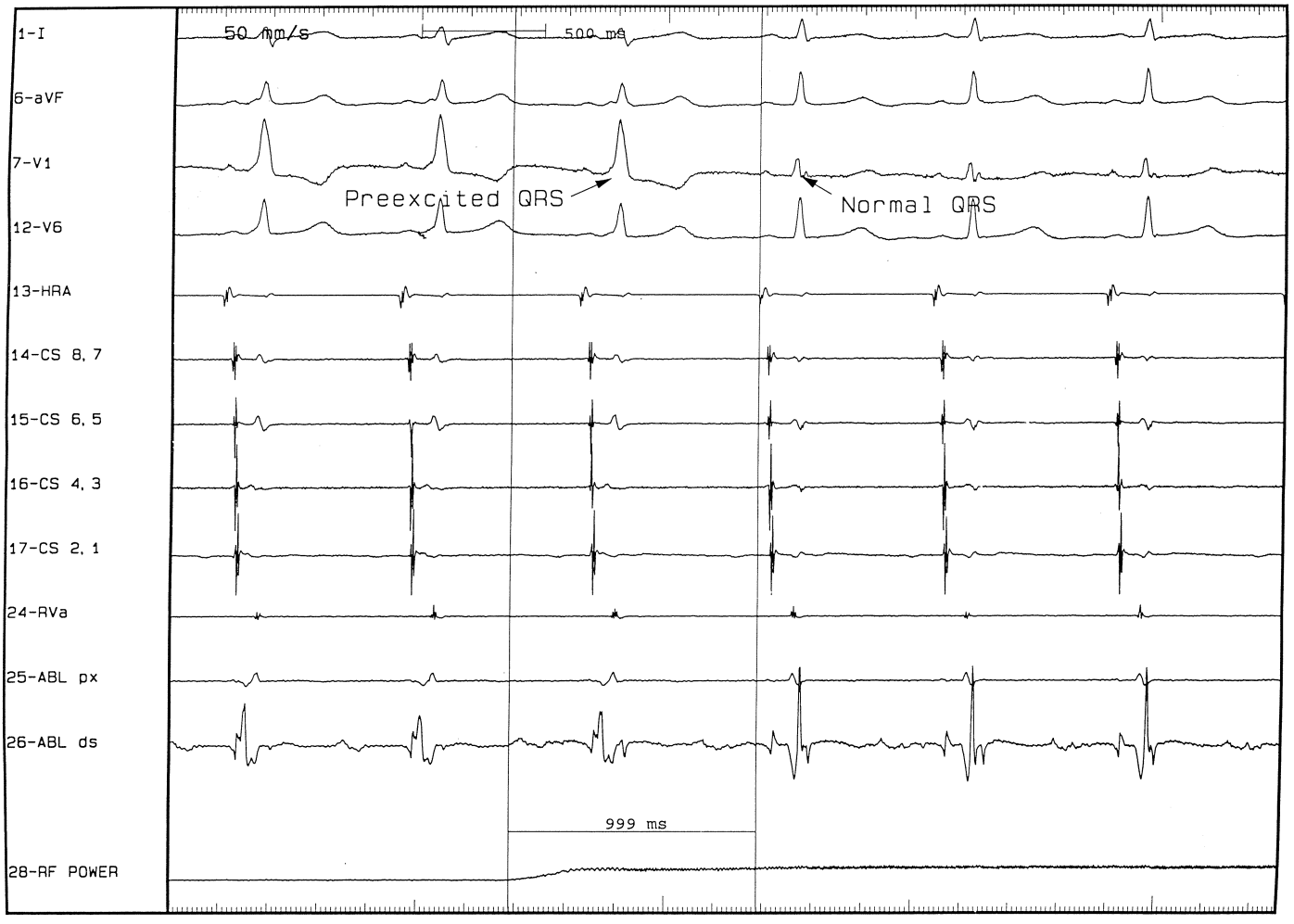

Fig 3 – Loss of pre-excitation during radiofrequency application (I, aVF, V1 and V6 represents surface ECG leads, HRA - high right atrium, CS - coronary sinus, RVa - right ventricular apex, ABL - ablation, px - proximal, ds - distal, RF - radiofrequency).

accessory pathway was localised, radiofrequency energy of 25 – 40 watts was delivered via the tip of the ablation catheter for 30 – 60 seconds (Figs 1 – 3). For patients with AV nodal re-entrant tachycardia, RF ablation was performed using the technique of slow pathway ablation in all except 1 patient who had inadvertently traumatised fast pathway and hence went on to have fast pathway ablation. Patients with atrial tachycardia were mapped to detect the earliest site of atrial activation endocardially. RF energy delivery was similarly at 25 – 35 Watts. Atrial flutter ablation was performed by ablation in the tricuspid-inferior vena cava isthmus. Ventricular tachycardia ablation was performed by mapping the earliest endocardial activation and pace-mapping techniques. For the idiopathic left ventricular tachycardia, mapping for Purkinje potentials also helped to guide the ablation site (Figs 4 – 5). When temperature-monitored ablation became available, RF ablation was performed with pre-set temperatures of 50 – 70°C. Post-ablation, the patients were observed for another 24 – 48 hours before they were discharged. The patients were then reviewed usually within 2 – 8 weeks after the procedure and continually followed up for at least 1 year after the procedure. Initially, routine repeat electrophysiological studies were performed at 12 – 24 weeks after the ablation to look for recurrence but as the incidence of recurrence was extremely low, repeat electrophysiological study was performed only for patients with clinical recurrence.

RESULTS

A total of 1,022 patients underwent RF catheter ablations from October 1991 to December 1997. All except 2 patients were symptomatic. The 2 asymptomatic patients were patients with pre-excitation on the ECG (Wolff-Parkinson-White syndrome) and had inducible rapid supraventricular tachycardia. Initially the procedure was done only for patients with Wolff-Parkinson-White syndrome but AV nodal re-entrant tachycardia, atrial tachycardia and atrial flutter are now routinely curable with RF catheter ablation. In patients with poorly controlled atrial fibrillation or had sustained proarrhythmic effect (eg. torsade de pointes), AV nodal ablation, followed by pacemaker implantation were performed to control the ventricular rate. There were 480 patients who had AV nodal re-entrant tachycardia, 429 patients with accessory pathways, 7 patients with both AV nodal re-entrant and accessory pathways, 4 patients with both AV nodal re-entrant tachycardia and atrial tachycardia. Twenty-seven patients had atrial tachycardia ablation, 28 had atrial flutter ablation and 11 patients had AV node ablation for atrial fibrillation. The mean age of the supraventricular tachycardia patients was 41 ± 15 years (10 – 80 years). The mean duration of procedure was 108 ± 60 minutes (15 to 480 minutes) and the mean fluoroscopy time was 19 ± 17 minutes (3 – 122 minutes). Another 14 patients had ablation for right ventricular outflow tract ventricular tachycardia and

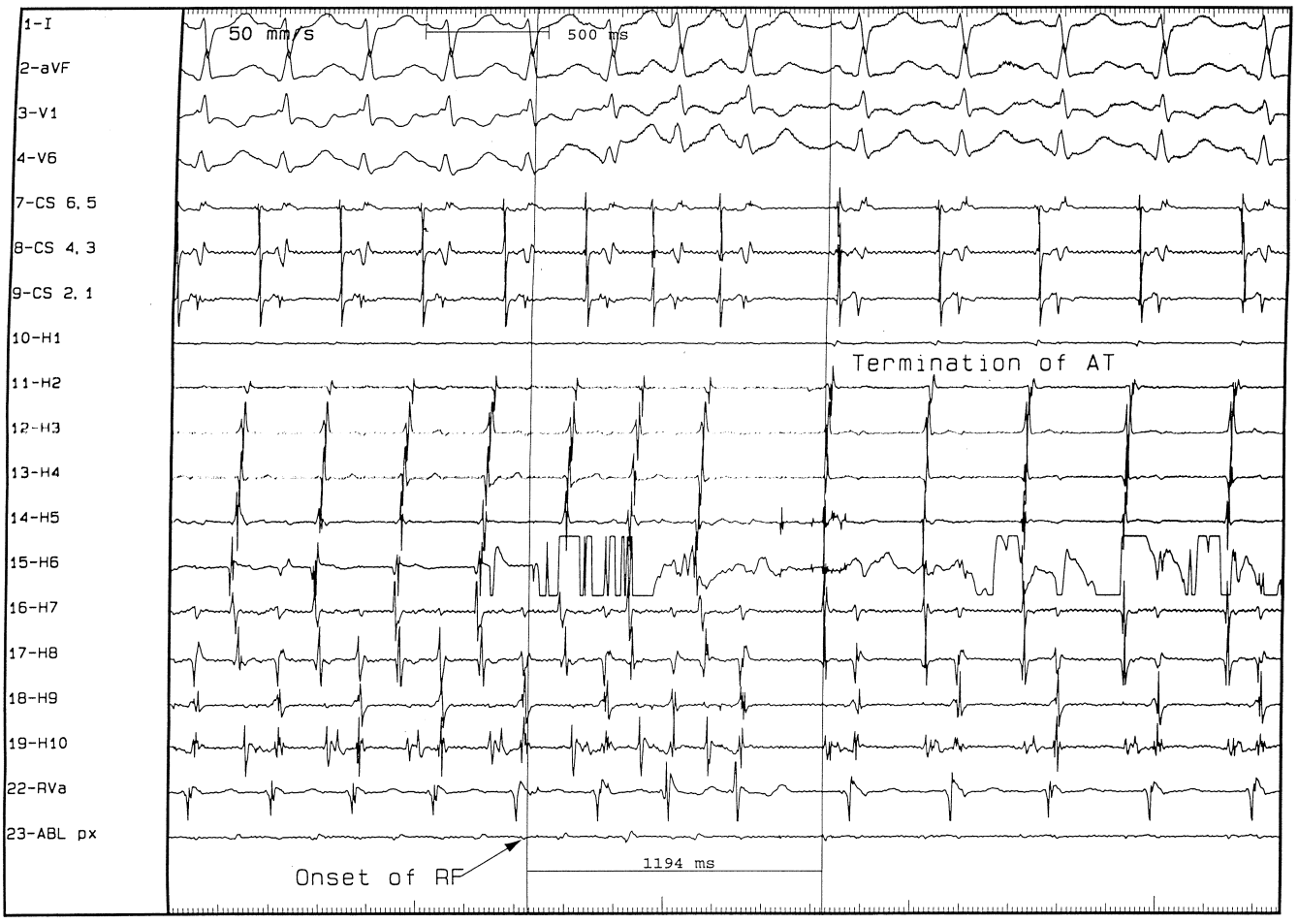

Fig 4 – Termination and ablation of atrial tachycardia (I, aVF, V1 and V6 represents surface ECG leads, HRA - high right atrium, CS - coronary sinus, H - Halo Catheter, RVa - right ventricular apex, ABL - ablation, px -proximal.

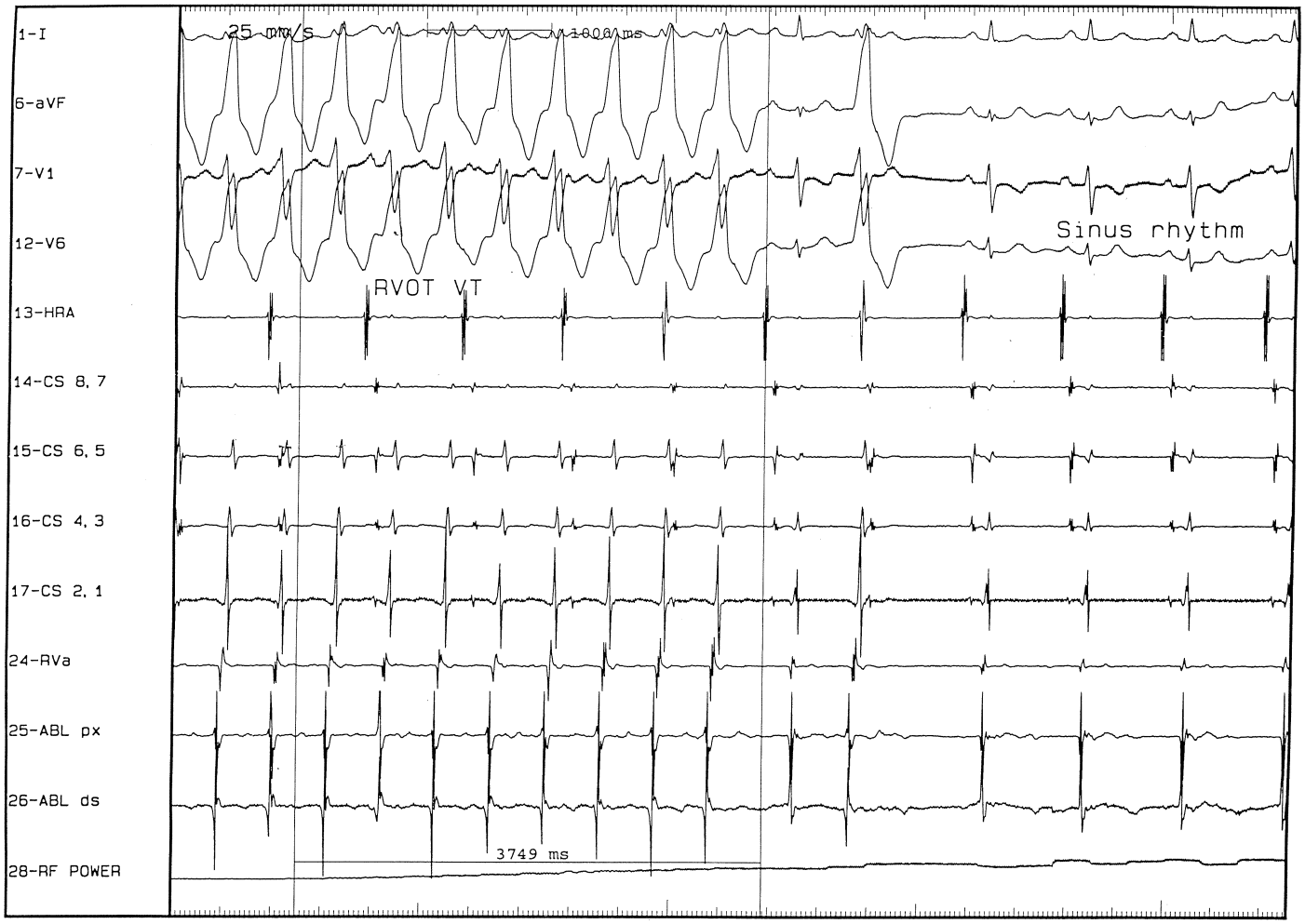

Fig 5 – Termination and ablation of right ventricular outflow tract ventricular tachycardia by radiofrequency application (I, aVF, V1 and V6 represents surface ECG leads, HRA - high right atrium, CS -coronary sinus, RVa -right ventricular apex, ABL - ablation, px -proximal, ds -distal, RF - radiofrequency).

22 patients had ablation for idiopathic left ventricular tachycardia. For the ventricular tachycardia ablation patients, the mean age was 35 ± 14 years (19 – 65 years) and the mean duration of the procedure was 185 ± 63 minutes (110 – 285 minutes) and the duration of fluoroscopy was 33 ± 16 minutes (range 14 – 68 minutes). Overall, 1,002 (98%) of the patients were successfully ablated. Ten patients however required a second ablation procedure for the arrhythmia to be successfully ablated.

There were significant complications in < 1% of the patients and no mortality was associated with RF ablation procedure. Major complications developed in 8 patients. One patient developed cardiac tamponade, secondary to insertion of the coronary sinus catheter rather than the ablation itself, and which required immediate surgical drainage. One patient developed thromboemboli to the toe. Two patients had AV fistula, one of which required surgical repair. Three patients had high grade AV block which was asymptomatic and 1 patient had right bundle branch block. Minor complications included small pneumothorax secondary to subclavian puncture for insertion of the coronary sinus catheter and hematomas at the site of insertion of the catheter in the femoral region. All these resolved spontaneously without the need for any specific therapy. Recurrence of the tachycardia occurred in 45 patients (4.5%), and were successfully reablated when the patients had a repeat RF ablation.

DISCUSSION

Our review indicates that radiofrequency catheter ablation is extremely successful with 98% of the patients with supraventricular tachycardia and non-ischaemic ventricular tachycardia completely cured. Initial reports by Jackman[5] reported a 99% success rate in 177 accessory pathways present in 166 patients. Similarly, Calkins[6] reported a success rate of 93% in 56 patients, while Lesh[9] reported a success rate of 89% in 100 patients who underwent radiofrequency ablation of the accessory pathways. Our initial report on accessory pathway ablation reported a success rate of 98%[8]. This review reports on our further experience since then, with more than 1000 cases. It has shown that although more complex tachycardias including atrial tachycardia and atrial flutter are now ablated, the success rate remains extremely high. This is comparable to other published series with larger number of cases of ablation such as that reported by Kay et al, on their initial 760 cases[10]. RF catheter ablation was successful in 346 of 363 patients (95.3%) with accessory pathways, with a complication rate of 1.1% and a recurrence rate of 5.5%. For AV nodal

re-entry, RF ablation was successful in 244 of 245 patients (99.6%) by selective ablation of the slow pathway in 234 patients and the fast pathway in 10 patients. The other patients had ablation for atrial tachycardia, atrial flutter or AV nodal ablation. Similarly, Manolis et al[11] reviewed the published literature on radiofrequency catheter ablation and reported their own experience in 214 patients with cardiac arrhythmias. For supraventricular arrhythmias, the success rates of RF ablation of > 90% was reported.

We have also demonstrated that the procedure is extremely safe. Our complication rate has remained at less than 1%. We have not had any mortality but cardiac tamponade which required surgical drainage occurred in 1 case. It is thus important that we remain vigilant during our ablation procedures and RF ablation should be done only by electrophysiologists with adequate training and experience. Chen et al[12], in a large series of 2,593 patients, showed that radiofrequency catheter ablation was associated with a 3.1% incidence of complications and multiple logistic analysis found that older age and systemic disease in elderly patients were the independent predictors of complications.

Our study also demonstrated that the procedure can be rapidly performed. The whole procedure could be performed in about 100 min for supraventricular tachycardia and 180 mins for ventricular tachycardia. This includes the time for catheter insertion and waiting for another 30 – 60 min after the ablation procedure to look for immediate recurrence after ablation. Recurrence after discharge from hospital has remained extremely low at less than 5% and these were usually less symptomatic than before the ablation. The procedure could be easily repeated and ablation successfully performed.

Drug treatment has been the mainstay of therapy and is still very important in acute therapy when non-pharmacological maneuvers such as the Valsalva maneuver or carotid sinus massage fail to convert the supraventricular tachycardia to sinus rhythm. Long-term therapy with drugs is however not reliable, having been associated with significant side effects and with most patients having problems with compliance, as these patients are often completely well in-between attacks. In the young patient, especially young women of child-bearing age, long-term drug therapy is also not advisable. Curative therapy was initially possible only via surgical ablation of the accessory pathway or AV nodal modification, but this was not a popular technique as it involved major open heart surgery and had significant morbidity and even possibly mortality and hence was applicable only to a very small group of patients with extremely symptomatic arrhythmias not controlled by drug therapy. Catheter ablation has completely revolutionised the treatment of patients with cardiac arrhythmias. There are few medical therapies that can claim a complete cure of the patient. Unlike other modalities of therapy, there can be no randomised trial between catheter ablation and drug therapy. One offers complete cure while the other is only palliative and needs life-long drug therapy. The advice by doctors for long-term drug therapy is thus no longer tenable. Furthermore, paroxysmal supraventricular tachycardia and non-ischaemic ventricular tachycardia is often quite symptomatic, with paroxysmal palpitation which comes on suddenly, and may be associated with syncope or near syncope. When prolonged, it can also result in significant complications including heart failure, tachycardia cardiomyopathy and aggravation of underlying heart disease, especially ischaemic heart disease. Patients should no longer be asked to bear recurrent symptomatic attacks on the argument that it will not kill the patient. Even this argument is not fool proof because there are reports of sudden death even in patients with supraventricular tachycardia, albeit rare[13,14]. Patients with severe disabling symptoms or have complications, should definitely have catheter ablation. In less symptomatic patients with infrequent symptoms, the guiding principle should be informed choice. The patients should be counselled regarding the pros and cons of both medical treatment and catheter ablation, including complications, of each approach. The ultimate decision and responsibility for treatment lies with the patient. At the National Heart Centre, all patients are informed that medical therapy is an acceptable alternative if the patient has only mildly symptomatic and infrequent attacks occurring only once every few years. However, they are advised that curative therapy with radiofrequency catheter ablation is available and that we have performed the procedure in more than 1,000 cases, with 98% of the patients completely cured. The recurrence rate is < 5% and the risk of any complication is < 1%. The procedure is performed under sedation and local anaesthesia and the whole procedure is usually completed within 1 – 2 hours. The patients are required to stay only one night and are usually discharged the next day after the procedure. Having been informed of these alternatives, the patient then makes the choice of therapy. In our experience, most patients who have more than a few attacks will eventually prefer curative therapy.

In conclusion, RF catheter ablation is an extremely safe and successful procedure providing definitive cure for all patients with supraventricular tachycardia and idiopathic ventricular tachycardia. At present, the only supraventricular arrhythmia not directly curable by catheter ablation is atrial fibrillation. AV node ablation and AV node modification by ablation can however be used to control those patients with poorly controlled atrial fibrillation. Newer techniques using perhaps electroanatomical mapping will probably help us to improve our success in ablating atrial fibrillation and ischaemic ventricular tachycardia. Thus in experienced centres, RF catheter ablation is the treatment of choice for all patients with symptomatic

cardiac arrhythmias, rather than drug therapy which is not curative. It has truly revolutionised the treatment of patients with cardiac tachyarrhythmias.

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