Original Research

Ablation of Atrial Tachycardias with Radiofrequency Current After Surgical Repair of Complex Congenital Heart Defects

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Key words:
Atrial flutter, transposition of the great arteries, tetralogy of Fallot, single ventricle.

Introduction: Atrial tachycardias are a common problem following the surgical repair of complex congenital heart defects (CHD) and have a poor response to medication. The aim of this study was to describe the results of the treatment of such tachycardias with radiofrequency ablation in our hospital.

Methods: A retrospective study was performed of the medical records and electronically stored data from electrophysiological studies (EPS) and ablation procedures in patients with atrial tachycardias following the surgical repair of CHD. Established electrophysiological techniques were used in all patients, while newer three-dimensional imaging methods were also employed in some cases. Ablation was carried out using a radiofrequency generator and catheters with a 4-10 mm terminal electrode.

Results: Twenty-two patients aged 11-45 years (30.6 ± 10.8), including 9 women, underwent an EPS and ablation of atrial tachycardias after the surgical repair of CHD. All had recurrent tachycardias refractory to antiarrhythmic medication. The anatomical diagnoses were tetralogy of Fallot (8), transposition of the great arteries (6), single ventricle (3), and other (5). Most patients had typical atrial flutter and/or incisional atrial reentrant tachycardia. The initial success rate of ablation for all arrhythmias was 88% in patients with tetralogy of Fallot, 83% for transposition of the great arteries, 66% for single ventricle, and 80% for the other diagnoses. Three-dimensional imaging was of significant assistance in mapping and ablation and in reducing the duration of fluoroscopy. Two vascular complications (femoral arteriovenous fistulae) were observed. The tachycardia recurrence rate was 54%. After repeated procedures, 59% of patients were free of arrhythmias and antiarrhythmic medications. No patient with a single ventricle remained free of arrhythmias during follow up, while in the other groups the arrhythmia/drug-free rate was 66-75%. Two patients with unsuccessful ablation died, one from heart failure and the other because of the tachycardia.

Conclusions: Atrial tachycardias in patients with surgically treated CHD are associated with increased morbidity and mortality. Radiofrequency ablation has satisfactory results. In spite of the high relapse rate, a significant number of patients can become free of arrhythmias after repeat procedures.

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Atrial tachycardias are a common and potentially dangerous problem following the surgical repair of congenital heart defects (CHD).[1] Even patients with simple CHD, such as an atrial septal defect, can exhibit atrial tachycardias postoperatively, especially if the surgical repair is performed at an advanced age.[2,3] However, the conditions that mostly give rise to atrial tachycardias are the complex defects, mainly tetralogy of Fallot,[4,5] transposition of the great arteries after atrial surgery of the Mustard or Senning type,[6,7] and a single ventricle, with or without the Fontan operation.[8,9] The appearance of these tachycardias is

associated with a deterioration of cardiac function,[9] the occurrence of thromboembolic complications,[10] and sometimes sudden death.[1,8] Management with medication is problematic, firstly because many patients have an unsatisfactory response to therapy, and secondly because of the frequent side effects of antiarrhythmic drugs. In addition, apart from the tachycardias, many patients also exhibit severe dysfunction of the sinus or atrioventricular node that can be exacerbated by pharmaceutical treatment, necessitating the implantation of a permanent pacemaker.

The successful treatment of other forms of tachycardia with radiofrequency (RF) current has led to the application of the same method in patients with postoperative atrial tachycardias. The results in many cases have been very encouraging, although a number of problems still remain to be solved. This study presents a retrospective analysis of the treatment of atrial tachycardias in postoperative CHD patients using RF ablation in our hospital.

Material and methods

The study included 22 patients aged 11-45 years (mean 30.6 ± 10.8 years) who underwent an electrophysiological study (EPS) and ablation of atrial tachycardias following surgery for CHD in our hospital between 1998 and 2005. The procedures complied with ethical guidelines and the Declaration of Helsinki as revised in 2000. Demographic data, diagnoses and the surgical procedures the patients underwent are shown in Table 1. Most patients were operated on for either tetralogy of Fallot (8) or transposition of the great arteries (6), while the remainder had various other congenital anomalies. Two patients were children aged 11 and 14 years but the majority were adults. All patients were symptomatic and had been taking antiarrhythmic medication with one or more drugs, which were unsuccessful in treating their arrhythmias. After a detailed explanation of the invasive procedure, possible complications and success rates, the patients or their guardians gave written consent. Antiarrhythmic medication was discontinued 48 hours prior to the EPS. Sixteen patients were sedated with intravenous midazolam and pethidine or morphine, while 6 received general anaesthesia with tracheal intubation and administration of propofol and inhaled anaesthetic. General anaesthesia was used because of young age in two patients (11 and 14 years), because of Williams syndrome in one patient, and by patient choice in three adult patients.

Multipolar catheters were initially introduced to various endocardial sites, depending on the patient's anatomy. Quadripolar catheters were usually placed on the lateral wall of the right atrium, in the His bundle region and at the right ventricular apex. When possible, a catheter was also placed within the coronary sinus. In some patients decapolar or duo-decapolar catheters were used for simultaneous recording from multiple sites in the right atrium in order to depict the atrial activation sequence. If the patient was in sinus rhythm an EPS was performed to check the function of the sinus and atrioventricular nodes and programmed atrial stimulation was used to induce tachycardia. After the induction of stable tachycardia, or if there was spontaneous tachycardia at the start of the procedure, placement of the diagnostic catheters was followed by the introduction of a mapping-ablation catheter with a terminal electrode 4-10 mm in length. This catheter was used to record endocardial electrograms. An attempt was made to record fragmented or early electrograms (Figure 1a), or double potentials indicating the existence of a central anatomic obstacle and recording of potentials on either side of it (Figure 1b). An attempt was also made to demonstrate concealed entrainment during the tachycardia using rapid pacing from the catheter tip. Ablation was attempted at points where early or double potentials were recorded or where there was concealed entrainment (Figure 2). If the flutter was typical – i.e. arising from the cavotricuspid isthmus – anatomical ablation was performed under fluoroscopic guidance. Ablation was achieved by creating a continuous linear lesion in order to isolate the isthmus, either cavotricuspid or between other anatomical or surgical obstructions. In cases where the typical flutter had been documented on the ECG but could not be induced during the procedure, isthmus ablation was performed in an attempt to create a bidirectional block. In patients who had transposition of the great arteries and had undergone a Mustard or Senning operation, the approach to the isthmus or other points in the anatomically right atrium was retrograde via the aorta and the right ventricle (Figure 3). The RF current delivery was between the terminal electrode of the catheter and a plate electrode applied to the patient's back or thigh. The generator supplied up to 50 W if the lead tip was 4 mm long and up to 150 W if the tip was 8 or 10 mm long.

After 2002 three-dimensional imaging with a non-contact mapping system was used (Ensite®, Endocardial Solutions Inc., St Paul, MN, USA). This system

Table 1. Demographic and clinical data.

Patient	Age	Sex	Diagnosis	Previous surgery	Symptoms	Medication
1	44	F	Tetralogy of Fallot	Complete repair Homograft	Palpitations Presyncope	Verapamil
2	33	F	Tetralogy of Fallot	Complete repair Homograft	Palpitations	Digoxin Sotalol
3	25	F	Tetralogy of Fallot	Complete repair Homograft	Palpitations Heart failure	Digoxin
4	39	F	Tetralogy of Fallot	Repair Single pulmonary artery	Palpitations Heart failure	Digoxin Amiodarone
5	25	F	Tetralogy of Fallot	Complete repair	Palpitations	No
6	35	F	Tetralogy of Fallot	Complete repair	Palpitations	No
7	45	M	Tetralogy of Fallot	Complete repair Homograft	Palpitations	Sotalol
8	40	M	Tetralogy of Fallot	Complete repair	Palpitations	Atenolol Sotalol
9	14	M	D-transposition	Senning	Palpitations Presyncope Heart failure	Digoxin Sotalol
10	11	F	D-transposition	Mustard	Palpitations	Digoxin Sotalol
11	18	F	D-transposition	Senning Pacemaker	Palpitations	Digoxin Sotalol
12	33	M	D-transposition	Mustard	Palpitations Heart failure	Digoxin Amiodarone
13	35	M	D-transposition	Mustard	Palpitations Heart failure	Digoxin Amiodarone
14	23	M	D-transposition	Senning	Palpitations Syncope	Amiodarone
15	39	M	L-transposition	Closure of atrial and ventricular septal defects Excision of subvalvular stenosis	Palpitations	Verapamil
16	54	M	L-transposition		Palpitations	Amiodarone
17	45	F	Atrial septal defect	Closure with pericardium	Palpitations	Digoxin Propranolol
18	22	M	Supravalvular aortic stenosis	Replacement of aortic valve and ascending aorta	Palpitations	Digoxin Amiodarone Sotalol
19	24	M	Common atrioventricular canal Atrial septal defect	Closure of atrial septal defect Tricuspid valve replacement	Palpitations, Heart failure Thrombosis	Digoxin Amiodarone Sotalol
20	28	M	Double-inlet left ventricle Pulmonary stenosis	Waterston shunt	Palpitations Heart failure	Digoxin Amiodarone Sotalol
21	24	F	Single ventricle Atresia of left atrioventricular valve	Atrial septectomy Pulmonary ligation	Palpitations Heart failure	Amiodarone
22	30	M	Tricuspid atresia	Atriopulmonary anastomosis (Fontan)	Palpitations Presyncope	Amiodarone

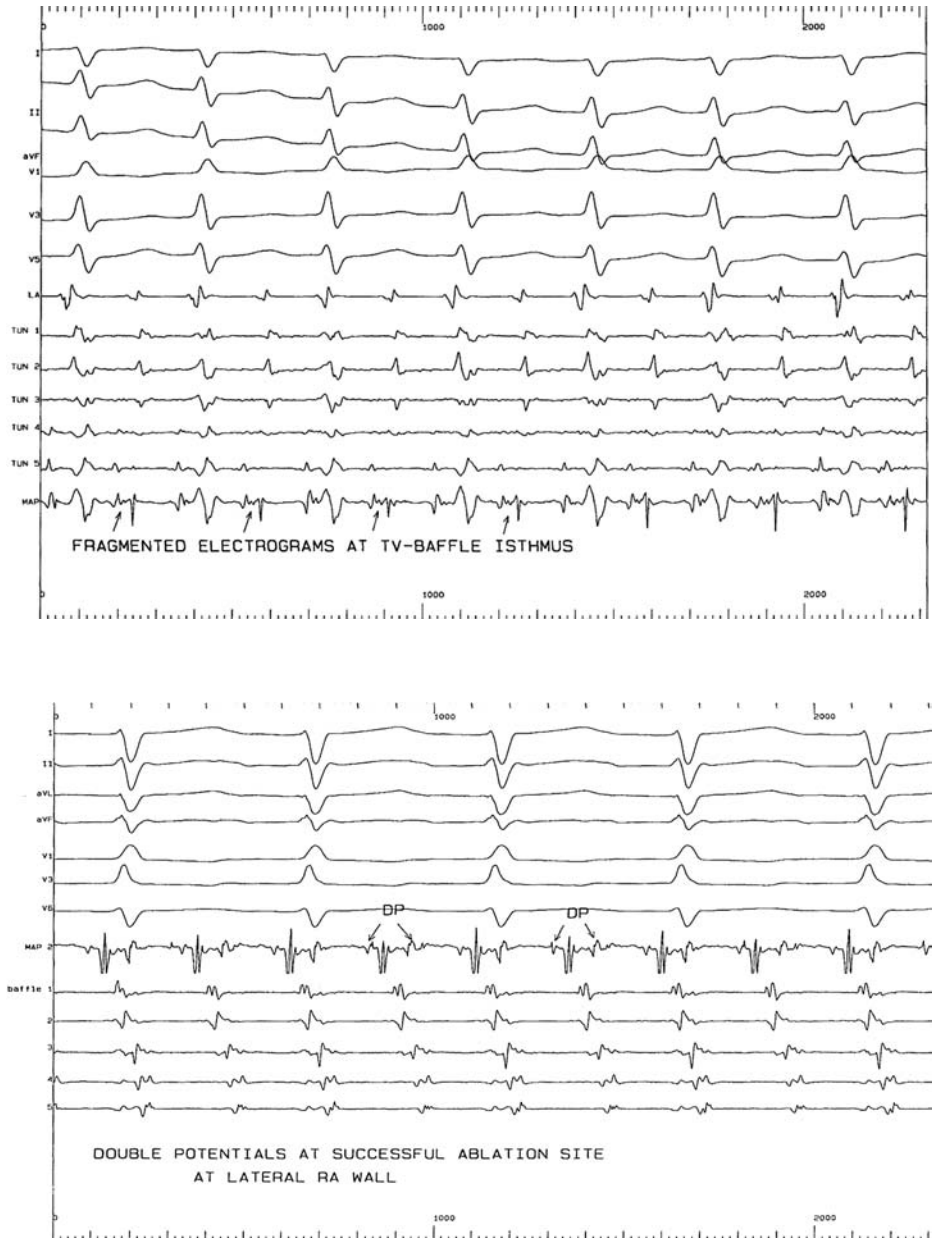

Figure 1. a) Patient with transposition of the great arteries after a Senning operation. Recording of fragmented early electrograms from the ablation catheter, which is placed in the region of the isthmus between the tricuspid valve and the surgical baffle separating the systemic from the pulmonary venous channel. b) A patient with transposition of the great arteries after a Mustard operation. Recording of double potentials from the ablation catheter, which is placed on the lateral wall of the right atrium in the region of the atrial incision.

uses a metallic mesh with multiple electrodes that is applied to a balloon on the tip of a catheter. After being introduced to the right atrium, the mesh is opened and the balloon is filled with a radiopaque solution. The mapping catheter is then moved so as to come into contact with as many points as possible on the right atrium. In this way a three-dimensional geometric model is created on which the depolarisation sequence is projected with the aid of virtual electrograms recorded from the electrode mesh. Using this three-dimensional model, the ablation catheter can be guided to the isthmus of the circuit, where a continuous linear lesion is created to block conduction and stop the tachycardia (Figure 4).

After completion of the ablation, a 30-minute waiting period followed, before a re-examination for inducible tachycardia or the existence of a two-way block.

Heparin was administered throughout the procedure to maintain an activated clotting time >200 s. Preventive antibiotics were also given.

The patients were monitored for 24 hours in hospital; on the day after the intervention they underwent an ECG, echocardiographic examination and

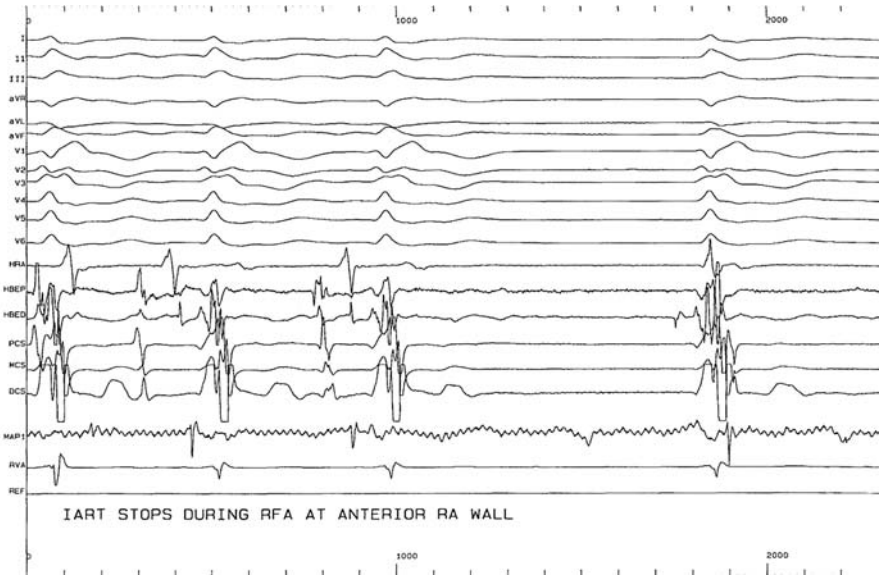

Figure 2. Patient with tetralogy of Fallot after surgical repair and implantation of a homograft from the right ventricle to the pulmonary artery. The patient had three forms of tachycardia. The figure shows cessation of the tachycardia during ablation of the lateral wall of the right atrium, between the atrial incision and the tricuspid valve.

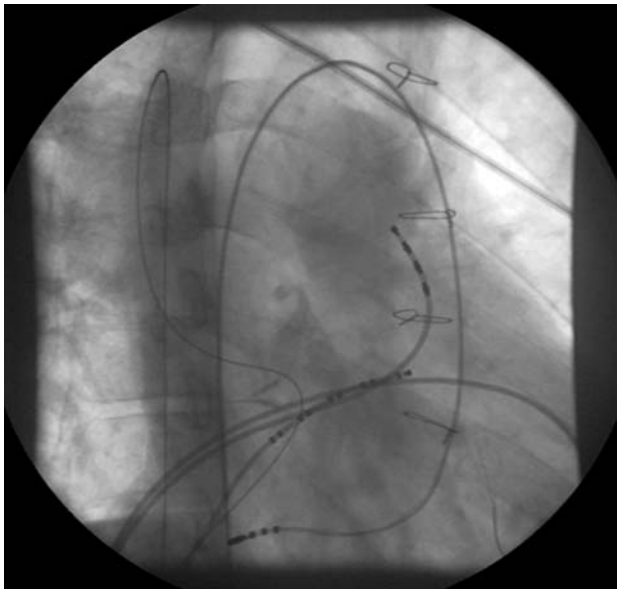

Figure 3. Patient with transposition of the great arteries after a Mustard operation. The ablation catheter has been placed at the isthmus between the tricuspid valve and the surgical baffle, having passed through the aortic valve and the right ventricle.

24-hour Holter monitoring. Aspirin in an antiplatelet dosage was given for two months, after which time the patient was re-examined in the outpatients' department. The subsequent follow up depended on the clinical picture and included clinical examination, ECG, ultrasound, and occasionally 24-hour Holter. In cases with recurrence of the tachycardia most patients underwent a repeat EPS.

Results

The EPS findings are given in Table 2. Most patients had typical flutter arising from the cavotricuspid isthmus, while the second most common form of tachycardia was a right atrial incisional re-entrant type. Two patients also had typical AV nodal re-entrant tachycardia that was ablated during the procedure together with the atrial tachycardia. Eighteen patients had one form of tachycardia, three had two forms and one had three forms of tachycardia. In 15 patients three-dimensional imaging was used, mainly with the Ensite system. The duration of the procedures was 150-495 (303 ± 99) minutes and the fluoroscopy time was 15-110 (36 ± 26) minutes. The latter duration was significantly shorter when three-dimensional imaging was used (26 ± 17 versus 51 ± 32 minutes). The initial ablation was successful in 18 of 22 patients (81%). In one patient the typical flutter was ablated, but the re-entrant tachycardia in the right atrial free wall remained. In three patients (one with complete transposition, one with congenitally repaired transposition and one with tricuspid atresia after a Fontan operation) ablation was unsuccessful. Complications were observed in two patients and involved femoral arteriovenous fistula. Surgical repair was carried out in both cases with no further problems.

Follow-up duration was 1-9 years (3.8 ± 2.8). Results from follow up, relapses and repeat procedures are detailed in Table 4. As the table shows, recurrence of the tachycardia was frequent, occurring in 12/22 patients

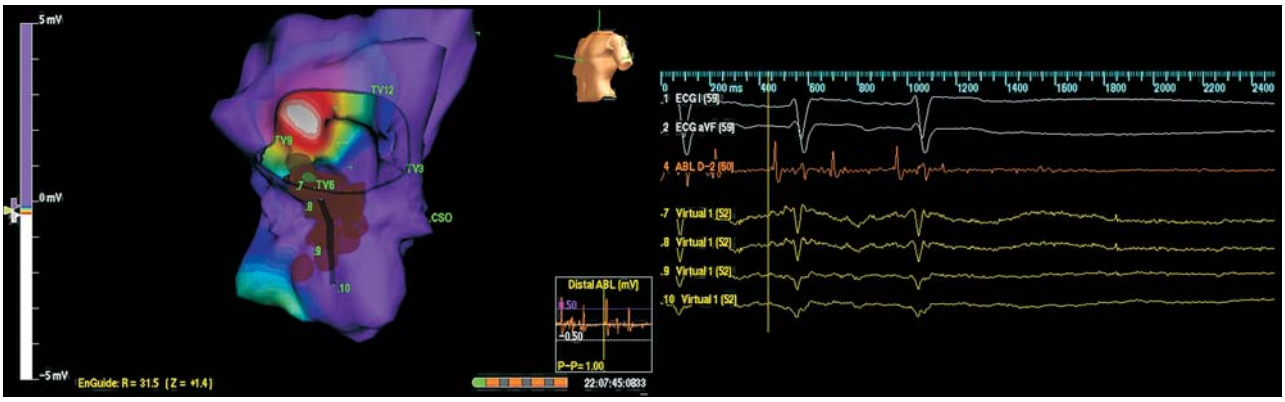

Figure 4. Patient with tetralogy of Fallot after surgical repair. Ablation of typical atrial flutter by creation of a linear lesion at the isthmus with the aid of the Ensite system. Interruption of the flutter can be seen, followed by a long pause due to sinus node disease.

Table 2. Findings from electrophysiological study.

Patient	Diagnosis	Induced tachycardias	Cycle length of main tachycardia (ms)	Other findings
1	TOF	AFL, IART lat RA wall	250	AVNRT
2	TOF	AFL, IART lat RA wall	310	
3	TOF	AFL	240	SND
4	TOF	AFL	320	
5	TOF	IART lat RA wall	230	
6	TOF	AFL	330	SND
7	TOF	IART lat RA wall	370	
8	TOF	AFL, IART lat RA wall	320	
9	D-TGA	AFL, IART SVC	250	
10	D-TGA	IART lat RA wall	250	
11	D-TGA	AFL	260	AVNRT
12	D-TGA	IART lat RA wall	288	
13	D-TGA	AFL	410	
14	D-TGA	AFL	280	
15	L-TGA	AFL, IART lat wall	310	
16	L-TGA	IART (LA)	360	Monomorphic VT
17	ASD	AFL	280	
18	Supravalvular AS	AFL	240	
19	CAVC, SV ASD	IART lat RA wall	280	
20	DILV, PS	AFL	330	
21	DILV, PHT	AFL	480	
22	Tricuspid atresia	IART lat RA wall	250	

AFL – atrial flutter; ASD – atrial septal defect; AVNRT – AV nodal re-entrant tachycardia; CAVC – common atrioventricular canal; D-TGA – dextro-transposition of the great arteries; DILV – double-inlet left ventricle; IART – incisional atrial re-entrant tachycardia; LA – left atrium; lat – lateral; L-TGA – levo-transposition of the great arteries; PHT – pulmonary hypertension; PS – pulmonary stenosis; RA – right atrial; Supravalvular AS – supravalvular aortic stenosis; SND – sinus node disease; SV ASD – *sinus venosus* ASD; SVC – superior *vena cava;* VT – ventricular tachycardia.

(54%). The ablated tachycardia reappeared in six patients, whereas in four a new tachycardia was observed (atrial fibrillation in three and AV nodal reentrant tachycardia in one). The remaining two patients did not undergo a second EPS and so the precise nature of the tachycardia could not be determined. Of the nine patients who underwent a second EPS, ablation of the tachycardia was attempted in those without atrial fibrillation. The ablation was successful in five of the seven (one with AV nodal tachycardia and four with atrial flutter or atrial re-entry tachycardia). The results of the re-ablation procedures and the long-term outcomes in relation to the type of CHD are given in Table 5. Patients with tetralogy of Fallot had the best outcomes, fol-

Table 3. Ablation.

Patient	3-D imaging	Lesions	Fluoroscopy time (min)	Procedure duration (min)	Success	Complications
1	No	50	71	420	Yes	No
2	No	106	110	420	Partial[1]	No
3	No	15	23	150	Yes	No
4	Yes	38	30	300	Yes	Yes[2]
5	Yes	6	16	150	Yes	No
6	Yes	22	19	180	Yes	No
7	Yes	22	20	300	Yes	Yes[2]
8	Yes	81	27	300	Yes	No
9	No	60	53	495	Yes	No
10	No	4	35	240	Yes	No
11	No	10	14	300	Yes	No
12	No	105	53	420	No	No
13	Yes	58	71	300	Yes	No
14	Yes	15	13	180	Yes	No
15	Yes	81	60	480	Yes	No
16	Yes	18	30	300	No	No
17	Yes	50	22	300	Yes	No
18	Yes	15	15	210	Yes	No
19	Yes	27	19	210	Yes	No
20	Yes	53	23	270	Yes	No
21	Yes	29	25	290	Yes	No
22	Yes	57	20	360	No	No

[1]Successful ablation of typical flutter, unsuccessful ablation of incisional atrial re-entrant tachycardia.
[2]Arteriovenous femoral fistula.

Table 4. Follow up, relapse rate, and final results.

Patient	Relapse	Repeat procedure	Findings of new EPS, clinical arrhythmia	Results of new ablation	Other procedures	Final result
1	No	-	-	-	No	Free
2	No	-	-	-	VVI pacemaker	Drugs
3	No	-	-	-	No	Free
4	Yes	No	-	-	No	Drugs
5	No	-	-	-	No	Drugs
6	No	-	-	-	DDD pacemaker	Free
7	Yes	Yes	IART	Successful	No	Free
8	No	-	-	-	No	Free
9	Yes	Yes	AVNRT	Successful	No	Drugs
10	No	-	-	-	DDD pacemaker	Free
11	Yes	Yes	AFL	Successful	DDD pacemaker	Free
12	Yes	No	-	-	No	Death (CHF)
13	No	-	-	-	SVC stent	Free
14	No	-	-	-	No	Free
15	Yes	Yes	AFL	Successful	No	Free
16	Yes	Yes	Left IART	Failed	No	Drugs
17	No	-	-	-	No	Free
18	Yes	Yes	AFL	Successful	Maze procedure	Drugs
19	Yes	No	A.Fib	-	No	Drugs
20	Yes	No	A.Fib	-	No	Drugs
21	Yes	Yes	IART, A.Fib	Failed	No	Drugs
22	Yes	No	IART	-	No	Death (CHF)

A.Fib – atrial fibrillation; CHF – congestive heart failure; Drugs – antiarrhythmic drugs; Free – free of arrhythmia; Other abbreviations as in Table 2.

Table 5. Summary of results in relation to type of congenital heart disease.

Disease	Success		Relapse of same tachycardia		New arrhythmia	Successful repeat procedure	Patients free of arrhythmia	
TOF	7/8	(88%)	2/7	(27%)	0	1/1	6/8	(75%)
D-TGA	5/6	(83%)	1/5	(20%)	1	2/2	4/6	(66%)
L-TGA	1/2	(50%)	1/1	(100%)	0	1/2	1/2	(50%)
Single ventricle	2/3	(66%)	1/2	(50%)	2	0/1	0/3	(0%)
Other conditions	3/3	(100%)	1/3	(33%)	0	1/1	2/3	(66%)
Total	18/22	(82%)	6/18	(33%)	3	5/7	13/22	(59%)

Abbreviations as in Table 2.

lowed by those with transposition of the great arteries or other simpler forms of CHD. No patient with a single ventricle was free of arrhythmias on long-term follow up, mainly because of the appearance of atrial fibrillation in two patients. One patient with a single ventricle who had undergone a Fontan operation died as a result of the arrhythmia. This patient was admitted to a provincial hospital with cardiogenic shock, following a prolonged episode of atrial tachycardia with rapid ventricular response, and could not be resuscitated. Another patient with transposition of the great arteries who had undergone a Mustard operation died of heart failure due to severe dysfunction of the systemic right ventricle.

Four patients underwent permanent pacemaker implantation (three dual site, one single site) for sick sinus syndrome, while one patient had a Cox-Maze III operation and mitral valvuloplasty.

Discussion

In this study we present our long-term results from a series of surgical patients with CHD who underwent RF ablation for atrial arrhythmias. As far as we know, this is the first such series to be reported from a Greek centre.

The type of CHD followed the distributions reported in other similar series in the international literature, with the exception of patients with a single ventricle, who made up a rather small part of our patient population.[11-19] The three categories of CHD patient who most frequently exhibit postoperative atrial tachycardias are those with a single ventricle (usually after a Fontan operation), those with tetralogy of Fallot, and patients with transposition of the great arteries (after atrial switch procedures).

The three patients with a single ventricle were not representative of the general population of such patients, since only one had undergone a Fontan operation. The other two had undergone only palliative procedures and had pulmonary hypertension and extreme enlargement of the right atrium. The ablation attempt was a palliative measure, since there was no possibility of surgical improvement, and was undertaken with the knowledge that the chance of successfully treating all the arrhythmias was very small. Indeed, although both cases of atrial flutter were ablated successfully, atrial fibrillation subsequently appeared. The patient with a Fontan operation in whom ablation was unsuccessful was a candidate for surgical treatment and was referred to a cardiac surgery centre with experience of such procedures; unfortunately, he died suddenly because of a tachycardia episode that could not be treated in time. This case provides further confirmation of the severe morbidity associated with postoperative atrial tachycardias in patients with CHD and the need for their prompt and effective treatment. In general, patients with a single ventricle and atrial tachycardias, with or without a Fontan operation, have the lowest success rate of ablation following surgery. A significant number of those patients may benefit more from surgical treatment including a combination of the extra-cardiac Fontan and Maze operations.[20]

In patients with tetralogy of Fallot atrial tachycardias are more common than ventricular.[4,5] Although the latter have been correlated with sudden death and are a source of more anxiety, it appears that atrial arrhythmias cause greater morbidity. It is significant that patients with tetralogy of Fallot and atrial tachycardias have usually undergone surgical repair at an older age, while some of them have been reoperated because of severe pulmonary valve insufficiency. The long-term increase in right atrial pressures and the scar on the free wall from the atrial incision often create multiple substrates for tachycardia. Despite the

difficulty of the procedures, as evidenced by the long fluoroscopy time and overall duration, the final success rate (around 80%) is significant, if one takes into account that the success rate of medication is <50%. A large number of patients remain free of tachycardia and the need for drug treatment. There are, of course, patients who require long-term medication, either for ventricular arrhythmias or for atrial tachycardias refractory to ablation, such as atrial fibrillation or atypical atrial flutter. Finally, a percentage of patients need permanent pacing, usually because of sinus node disease.

Patients with transposition of the great arteries in the modern era are usually treated surgically with anatomical correction (arterial switch) and rarely exhibit rhythm disturbances. Patients who have undergone older types of procedure (Mustard or Senning) have a significant incidence of atrial tachycardias. These patients usually have good atrioventricular node function and may show a rapid ventricular response (even 1:1 conduction) during tachycardia. In consequence, tachycardia may quickly lead to destabilisation of the patient's clinical condition, with deterioration of the already borderline function of the systemic right ventricle, or even to sudden death. Thus, atrial tachycardias should be treated promptly and effectively in these patients. Given the moderate efficacy of antiarrhythmic drugs and their possible complications, especially in patients with borderline cardiac function or sinus node disease, catheter ablation is clearly superior to medication. In these cases, the main arrhythmia is a typical flutter arising from the cavotricuspid isthmus, or a re-entrant tachycardia in the right atrial free wall. Since, however, the isthmus is divided by the baffle that is placed to divert the venous blood into the left atrium, ablation cannot be achieved via the venous route. Our own experience, as well as that of most other authors, has shown that ablation via arterial access is almost always essential in order to successfully block the isthmus or to gain access to the right atrial free wall.[21,22] It should also be remembered that apart from macro-re-entrant tachycardias, patients with transposition of the great arteries may also exhibit focal tachycardias (re-entrant or automatic), as well as typical AV nodal re-entrant tachycardia.[22] Even though in one of the two cases in our series ablation of the atrial tachycardia was achieved via the venous route, in most cases a trans-aortic approach is required because of the baffle that prevents direct access via the inferior *vena cava* to the tricuspid annulus.[22] Focal atrial tachycardias are also usually located close to the ostia of the pulmonary veins.[22] The overall success of ablation procedures in various series that included patients with transposition of the great arteries ranged from 73-80%,[15,21,22] rates that are comparable with our own results.

Patients with other, simpler heart conditions have a lower incidence of atrial arrhythmias than do those with the three forms of CHD discussed above. Nevertheless, even patients with simple diseases, such as atrial septal defect, also develop atrial arrhythmias with a frequency directly proportional to their age at the time of operation.[2,3] The treatment of tachycardia in these patients is based on the same general principles referred to above. Even if the chance of sudden death appears to be small, there are the risks of thromboembolic episodes and deterioration of the function of the sinus and/or atrioventricular nodes. Given the relatively high efficacy of ablation, these patients may benefit significantly from invasive treatment, provided they have repeated episodes of atrial tachycardia that are not controlled by safe antiarrhythmic drugs, or concomitant bradycardias that are exacerbated by medications.

An important problem that is seen in all types of CHD, although mainly in the more complex ones (transposition, tetralogy, single ventricle), is the frequent recurrence of tachycardias that have been ablated, and often the appearance of new forms of tachycardia. In the international literature, the recurrence rates range from 20-52%.[11,13,17,19] These percentages are high but a significant number of patients remain free of arrhythmias after a repeat ablation procedure. The use of newer mapping methods has allowed effective ablation in a larger number of patients, with the creation of fewer lesions (usually focal rather than linear),[12] and probably will reduce the rate of relapse. In addition, the use of catheters with an irrigated tip[18] or a long terminal electrode appears to improve both the immediate and the long-term result of ablation. In any case, relapses usually occur during the first year after ablation (88% of cases), whereas patients who remain free of relapse for one year have a 91% probability of a long-term cure.[19]

As regards radiation exposure, although this is high compared with simpler ablation procedures, it can be reduced significantly by the use of newer mapping techniques. Both our own series and the international experience show that the fluoroscopy time was reduced by 50% in procedures that employed non-fluoroscopic mapping methods.[17]

Finally, concerning complications, these were few considering that the procedures were long and includ-

ed the use of many catheters. Vascular complications are frequent, probably because multiple catheters are introduced through the femoral vessels in patients who have undergone repeated catheterisations in the past. In our series the only serious complications were vascular, at a rate similar to the 6% reported by Triedman et al.[18]

Limitations of the study

This study had all the limitations of any retrospective study encompassing a long period, during which the operators' experience improved progressively and new technology was introduced. In spite of that, even patients who underwent ablation at the start of the study period, without three-dimensional imaging methods, remained free of arrhythmias for many years. The small number of patients in each diagnosis group made a statistical analysis of the data impractical.

Conclusions

Patients who undergo surgery for CHD often exhibit atrial tachycardias that are refractory to medication. RF ablation can offer significant benefit to most patients with two functional ventricles, although more than one procedure may be required. The acquisition of experience and the use of new technology for mapping and ablation help to increase the efficacy of the procedure.

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