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ORIGINAL PAPER

Acute and long-term outcome of focal atrial tachycardia ablation in the real world: results of the german ablation registry

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Abstract

Introduction Catheter ablation of focal atrial tachycardia (FAT) can be a challenging procedure and results have been rarely described. The purpose of this study was to determine the characteristics and results of FAT ablation in the large cohort of the German Ablation Registry.

Methods The German Ablation Registry is a nationwide prospective multicenter database including 12566 patients who underwent an ablation procedure between 2007 and 2010. Among them 431 (3.4%) underwent an FAT ablation and 413 patients with documented locations were analyzed. Patients were divided into three groups according to the FAT location: biatrial (BiA, $n=31$, 7.5%), left atrial (LA, $n=110$, 26.5%), and right atrial (RA, $n=272$, 66%).

Results Acute success rate was 84% (68 vs. 85 vs. 85% in biA, LA, and RA, respectively, $p=0.038$). 4.8% of patients had an early recurrence during hospitalization, most in biatrial location ($p<0.001$). No major acute complication occurred. At 12 months, 81% were asymptomatic or improved. The incidence of major adverse cardiovascular and cerebrovascular events (MACCE) was 3.7%. Arrhythmia freedom without antiarrhythmic drugs was 58% and was lower in biA (34 vs. 56% in LA vs. 62% in RA, $p=0.019$). Early recurrence during hospitalization was an outstanding predictive factor for recurrence during follow-up.

Conclusion In this large patient population, FAT ablation had a relatively high acute success rate with a low complication rate. During follow-up, the recurrence rate was high, particularly in biatrial location. This was frequently predicted by an early recurrence during hospitalization.

Keywords Focal atrial tachycardia · Catheter ablation · Results

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Introduction

Focal atrial tachycardia (FAT) is a relative rare rhythm disorder, seen in less than 10% of electrophysiological studies [1]. It is due to an automatic, triggered, or microreentrant mechanism [2, 3]. Patients are often very symptomatic and the tachycardia refractory to medical treatment. Because FAT is reported to be difficult to treat medically, catheter ablation is recommended for symptomatic or incessant FAT [4]. In contrast with atrial fibrillation and atrial reentrant tachycardias, catheter ablation results in FAT have been rarely described. The reported success rates are high, but based on retrospective single-center studies and case series [5, 6].

The aim of this study was to determine the characteristics and results of FAT ablation in a large patient cohort.

Methods

The German Ablation Registry is a nationwide prospective multicenter database including a total of 52 German electrophysiology centers and conducted by the Institut für Herzinfarktforschung (IHF), Ludwigshafen, Germany. The IHF was responsible for project development, project management, clinical monitoring, patient follow-up, and data management. Additional support was provided by unrestricted grants from Medtronic, Biosense Webster, and Biotronik. The study was approved by the ethics committee of the Landesaerztekammer Rheinland-Pfalz in 2007.

Participating centers reported data from consenting patients in Internet-based electronic case report forms. All site information was confidential, and transmitted data were encrypted with a secure socket layer. Baseline characteristics were noted. Patients were treated according to the ablation center standards. The decision regarding the ablation method, imaging technologies, and energy source was left to the choice of the individual ablation center. Procedural data and complications were recorded [7, 8].

Patient population

Between 2007 and January 2010, 12,566 patients who underwent a catheter ablation procedure were enrolled in the registry. Among them, 448 FAT ablation procedures performed in 431 patients (3.4%) were documented. Patients with atrial fibrillation or other ablated arrhythmias during the same hospitalization were excluded ($n = 10$). 413 patients had documented location of the tachycardia and were included in our analysis. The first ablation for FAT during the index hospitalization was considered in the analysis. Patients were divided into three groups according to the location of the tachycardia: biatrial FAT (BiA, $n = 31$, 7.5%), left atrial FAT (LA, $n = 110$, 26.5%), and right atrial FAT (RA, $n = 272$, 66%).

All patients gave written informed consent before the ablation procedure and gave written consent for inclusion in the registry and processing of their anonymous data.

Definitions

Definition of focal atrial tachycardia

Focal atrial tachycardia was defined as a small site of earliest atrial activation from where it spreads centrifugally [9]. The range of activation during FAT was less than the tachycardia cycle length.

On the ECG, P wave configuration was different from that of sinus rhythm with an isoelectric baseline between P waves and frequency less than 250 bpm.

A tachycardia was defined as multifocal if more than one focus, with different P waves and different rates, was induced in the same patient.

Definition of success

Complete success was defined as elimination of all focal atrial tachycardias induced during the procedure.

Partial success was defined as elimination of one but not all atrial tachycardias.

Safety

Major adverse cardiovascular and cerebrovascular event (MACCE) were defined as a combination of death, myocardial infarction, or stroke.

Complications were categorized in acute (occurring during ablation or hospitalization) and long-term complications (occurring during the follow-up period).

Follow-up

Follow-up was performed according to each ablation center's protocols, including scheduled visits in the outpatient clinic. Furthermore, 12 months after the index ablation procedure, telephone interviews were performed by the IHF. Patients were interrogated for complications, medication, symptoms, and 12-lead ECG documentation. During follow-up, the use of antiarrhythmic drugs (AAD) was left to the treating physician.

Statistical analysis

Continuous variables are presented as mean and standard deviation or median with quartiles, and categorical variables as percentages. Comparison of continuous variables was performed using the Mann–Whitney–Wilcoxon test. For comparison of categorical variables, the Pearson χ^2 test and for hospital events Fisher's exact test was used. These statistics are based on the available cases. The CHADS2 and CHA2DS2-VASc risk scores were calculated from the documented patients' characteristics according to the ESC guideline [10].

To combine the incidence of MACCE (death, myocardial infarction, or stroke) during the 1-year follow-up, methods of survival analysis (log-rank test) were used to analyze 1-year survival free from MACCE after the ablation procedure. Predictors of recurrence or need of antiarrhythmic drugs at follow-up were analyzed by logistic regression. A stepwise variable selection procedure was applied requiring $p \leq 0.1$ for entry and $p \leq 0.2$ for stay in the model, including the following potential predictors: age (linear), sex, structural heart disease, location of arrhythmia (BiA/LA/RA), first ablation, multifocal ablation, irrigated tip, tip size 4 mm, cryoenergy, procedure duration, procedural success (no/partial/complete), and early recurrence.

All statistical tests were two-tailed, and $p < 0.05$ was considered significant. Statistical computations were performed at the biometrics department of the IHF using the SAS 9.3 software package (SAS Institute, Cary, NC).

Results

Patient characteristics and severity of symptoms

Table 1 shows the baseline characteristics of the patient population. The right atrial location was more frequent in female (62%) and less frequent in case of valvular heart disease (7%).

Most of the patients were symptomatic, with 96% having palpitations and 7% a presyncope or syncope. The tachycardia occurred at least once per month in 88% of patients and was documented in 90%. Resistance to antiarrhythmic drugs (AAD) was reported in 70% of patients.

Procedural parameters

Ablation procedures were performed under analgo-sedation (72%) or in a conscious state. Vascular access was obtained through a femoral vein in all patients. FAT was mapped conventionally (54%) or using a 3D Mapping system (46%, CARTO or Navx), more frequently in biatrial or left atrial tachycardia. In 26% of patients, a transseptal puncture was performed to access the left atrium. Radiofrequency energy was used in 96% of patients and cryoenergy in 4%. In 84% of patients a 4 mm-tip catheter was used. Catheter irrigation was used in 44% of patients, mostly in the left atrial or biatrial location. The procedural parameters (procedure, fluoroscopy, and radiofrequency duration) were all significantly shorter in case of right atrial tachycardia (Table 2).

Table 1 Baseline characteristics and differences between atrial locations

	Patients ($n=413$)	Biatrial (BiA, 31)	Left atrial (LA, 110)	Right atrial (RA, 272)	p
Age (years), mean	60 ± 15	65 ± 11	59 ± 16	60 ± 16	0.10
Female	56	48	44	62	0.004
CHADS2 risk score, mean	0.9 ± 0.9	0.8 ± 0.5	1.1 ± 0.8	0.8 ± 1.0	0.32
CHA2DS2-VASc risk score, mean	2.0 ± 1.4	1.8 ± 0.5	2.5 ± 1.4	2.1 ± 1.5	0.26
Diabetes	10	19	7	10	0.14
Chronic kidney disease	7	25	0	7	0.11
Hypertension	59	75	75	49	0.09
Prior stroke	1.4	0	4	0	0.37
COPD	3	0	4	2	0.85
Implanted cardiac device	8.5	26	4	8.5	< 0.001
Structural heart disease	37	52	38	35	0.20
Coronary artery disease	18	10	20	18	0.41
Valvular heart disease	10	32	14	7	< 0,001
Cardiomyopathy (dilated, hypertrophic)	3	0	2	4	0.31
LV dysfunction (EF < 40%)	7	0	9	7	0.26

Data are percentages of patients or means ± standard deviation

COPD chronic obstructive pulmonary disease, *LV* left ventricular, *EF* ejection fraction

Table 2 Procedural data

	Patients ($n=413$)	Biatrial (BiA, 31)	Left atrial (LA, 110)	Right atrial (RA, 272)	p
Use of 3D—mapping systems	46	65	73	33	<0.001
Radiofrequency energy	96	90	98	96	0.14
Ablation catheter					
4 mm	84	84	85	84	0.99
Irrigated tip	44	74	65	32	<0.001
Radiofrequency time (s), median (IQR)	329 (162; 861)	1202 (240; 1800)	840 (353; 1573)	268 (139; 600)	<0.001
Procedure duration (min), median (IQR)	135 (90; 190)	195 (170; 300)	159 (120; 218)	115 (71; 160)	<0.001
Fluoroscopy time (min), median (IQR)	17 (9; 29)	24 (17; 47)	23 (13; 33)	14 (8; 26)	<0.001
Fluoroscopy dose (cGy/cm^2), median (IQR)	1682 (742; 3600)	3317 (1116; 4967)	2335 (1256; 4541)	1301 (568; 2970)	<0.001
Acute results					
Complete success	84	68	85	85	0.038
Partial success	8	16	4	8	0.054
Failure	9	16	11	7	0.12

Data are percentages of patients or medians with quartiles

Table 3 Location of ablated focal atrial tachycardias

FAT locations	Number of foci
Right atrium	($n=303$ patients)
Crista terminalis	75
Septum	98
Multifocal	28
Sinus node	18
Other	97
Left atrium	($n=141$ patients)
Pulmonary veins	51
Septum	29
Multifocal	40
Other	60

Table 3 shows the location of ablated FAT. The most common site of origin of left focal atrial tachycardias was the pulmonary veins. In the right atrium, FAT arose most frequently from the crista terminalis and the septum. A multifocal location was more frequently in the left atrium.

Efficacy

Acute success

Acute success rate was 84% (68 vs. 85 vs. 85% in biatrial, left and right atrial location, respectively, $p=0.038$). A partial success was reported in 8% of patients.

4.8% of patients had an early recurrence during the hospital stay (22.6% in biatrial location, 3.6% in LA and 3.3% in RA location, $p<0.001$). 23% were discharged with an AAD class I, III, or IV and 59% with a betablocker (Table 4).

Long-term success

81% of patients had no symptoms or symptoms improvement during follow-up. Arrhythmia freedom without AAD was 58% and was lower in biatrial tachycardia (34 vs. 56% in LA tachycardia vs. 62% in RA tachycardia, $p=0.019$). 20% of patients were under AAD I or III (45 vs. 23% vs. 17%, $p=0.009$). Arrhythmia freedom with AAD was 68% without significant difference between groups. A repeat ablation within the 12 months was performed in 12% of patients (Table 5).

Table 6 shows the predictive factors associated with recurrence or need of AAD in the multivariable analysis. Early recurrence during hospitalization was the most predictive factor (OR 8.26, 95% CI 1.78–38.38, $p=0.007$). Other variables including age, gender, FAT locations, type of ablation catheter, and other procedural parameters were not significantly associated with recurrence during follow-up.

Safety

Acute complications

No MACCE and no major bleeding occurred. The incidence of minor bleeding was 1.5% (6.5% in BiA, 1.8% in LA and 0.7% in RA group, $p=0.04$). Other complications occurred in < 1% (Table 5).

Complications during follow-up

Information on 1-year follow-up was obtained from 410 (99.3%) patients at a median time of 607 days (quartiles 527, 714) after index discharge. At follow-up, 393 (96%)

Table 4 Procedural complications and hospital events

	Patients ($n=413$)	Biatrial (BiA, 31)	Left atrial (LA, 110)	Right atrial (RA, 272)	p*
Complications, *n* (%)					
Major bleeding	0 (0)	0 (0)	0 (0)	0 (0)	–
MACCE (death, stroke or MI)	0 (0)	0 (0)	0 (0)	0 (0)	–
Aneurysm/arteriovenous fistula	4 (1.0)	0 (0)	2 (1.8)	2 (0.7)	0.51
Pericardial effusion	4 (1.0)	1 (3.3)	2 (1.9)	1 (0.4)	0.083
AV-block II or III (intermittent/not requiring pacemaker implantation)	5 (1.3)	0	2 (2)	3 (1.2)	n.s
Minor bleeding (%)	6 (1.5)	2 (6.5)	2 (1.8)	2 (0.7)	0.040
Early recurrence during hospitalization	20 (4.8)	7 (22.6)	4 (3.6)	9 (3.3)	< 0.001
Early recurrence or repeat ablation during hospitalization	30 (7.3)	7 (22.6)	9 (8.2)	14 (5.1)	0.005
AAD I or III at discharge (%)	22	52	34	14	< 0.001
Amiodarone (%)	7	23	13	3	< 0.001
Betablockers (%)	59	48	61	60	0.44

MACCE major adverse cardiovascular and cerebrovascular event, *AV-block* atrio-ventricular block, *AAD* antiarrhythmic drugs

*Fisher's exact test

Table 5 Long-term outcome in follow-up survivors

	Patients ($n=393$)	Biatrial (BiA, 30)	Left atrial (LA, 108)	Right atrial (RA, 255)	p
No symptoms or symptom improvement (%)	81	72	82	81	0.49
12-month success					
Arrhythmia freedom without AAD class I or III (%)	58	34	56	62	0.019
Arrhythmia freedom with or without AAD class I/III (%)	67	51	66	70	0.10
Arrhythmia freedom with use of AAD class I/III (%)	9	17	10	8	0.30
Arrhythmia recurrence despite AAD class I/III (%)	11	28	13	9	0.009
AAD class I, III use (%)	20	45	23	17	0.009
Reablation (%)	12	14	12	12	0.97
Patient perception of ablation therapy					
Successful (%)	71	50	72	74	0.11
Partly successful (%)	17	22	16	16	0.79
Patient would agree being treated at the same hospital again (%)	94	83	98	94	0.06

Table 6 Predictors of recurrence or need for AAD in the multivariate analysis

Variable	OR	95% CI	p
Early recurrence	8.26	1.78–38.38	0.007
Failure	4.22	1.78–10.01	0.001
Partial success	3.12	1.26–7.75	0.014
Structural heart disease	1.96	1.23–3.10	0.004
Multifocal ablation	1.88	1.10–3.21	0.020

patients were alive. The mortality rate was 4%, with 18% cardiac mortality and 53% undetermined cause. The cumulative incidence of MACCE at 366 days was 3.7%, without significant difference between groups. Major bleeding and minor bleedings occurred in 0.3 and 0.5%. The most frequent complications during follow-up were syncope (2%) and groin complications (2%). Two specific complications related to ablation were reported: one phrenicus palsy and one non-fatal atrio-esophageal fistula.

Discussion

This large analysis from the German ablation registry confirms the rarity of FAT, and corroborates some electrophysiological findings that were previously reported. The acute success rate is high and the complication rate low. however,

these real-world data emphasize the difficulties encountered during FAT ablation, reflected by the relatively high recurrence rate at a long-term follow-up.

Ablation efficacy

The acute success in this real-world population was high, but lower than previously reported [2]. FAT ablation can be a challenging procedure, because it often requires an extended and precise mapping. The use of 3-D mapping systems was relatively low in our study, so that we could speculate that, with the more widespread use of these systems more recently, ablation success could be higher. New technologies such as multipoint high-density mapping [11–13] and panoramic mapping [14] could be useful in difficult cases (such as in non sustained or instable tachycardia). Other recent techniques such as contact force could also improve ablation results [15–17].

Biatrial tachycardias, frequently septal, or multifocal had a lower success rate. The frequency of multifocal atrial tachycardia in our study is consistent with the study of Hu et al. [18], which showed a lower success rate in this type of FAT. For septal or biatrial tachycardias, the difficulty is due to the necessity of a precise mapping, including right and left atrial septum and the coronary cusps [6, 19]. Because an FAT is not always stable, such an extended mapping is not always possible, which could explain the lower success rate this group of patients. The other frequent FAT locations seen in our study confirm the data in the literature. The foci are not randomly distributed, but tend to cluster over certain zones (i.e., crista terminalis in the RA and pulmonary veins in the LA) [20, 21].

Safety

The incidence of acute complications in this population was low and confirms the safety of this procedure [4]. During follow-up, although one rare but severe ablation-related complication occurred (i.e. esophageal fistula), the incidence of MACCE was low, probably reflecting the relatively healthy population.

Limitations

The registry coverage was based on a voluntary participation, so that it is possible that some centers with better or worse results did not join the registry.

No data were available concerning the stimulation protocol or the use of orciprenaline, which could explain some failures. Assessment of procedural success (waiting period and stimulation protocol) and follow-up care were not entirely standardized, but performed according to the usual practice of each center. Finally, no data were given concerning the mechanism of the arrhythmia.

Conclusion

In this large patient population, FAT ablation had a relatively high acute success rate with a low complication rate. During long-term follow-up, most of the patients showed a symptom improvement and low incidence of MACCE. However, the recurrence rate was high, particularly in biatrial location. This was frequently predicted by an early recurrence during hospitalization.

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Compliance with ethical standards

Conflict of interest None declared.

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