


# Long-term follow-up after radiofrequency ablation of ectopic atrial tachycardia in young patients

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## Abstract

**Aim:** Ectopic atrial tachycardia (EAT) is a common arrhythmia in children, adolescents, and young adults. Radiofrequency (RF) ablation is often considered the treatment of choice in this population. We sought to evaluate the long-term follow-up after RF ablation.

**Methods and Results:** We retrospectively analyzed 36 young patients (age range 8-29 years), with clinical signs and symptoms suspected for EAT who underwent an electrophysiological study in our center. We evaluated the safety and acute success rate of ablation and the long-term follow-up. Ectopic foci were more frequently localized in the right atrium along the crista terminalis (28%) and EAT was successfully terminated in 97% of patients. At median follow-up (38 months), the recurrence rate was 20% with mostly recurrences expressed within 6 months.

**Conclusions:** The study confirmed the safety and high acute success rate of EAT ablation in a population of children, adolescents, and young adults. Therefore, catheter ablation of EAT can be considered early in the course of treatment of these patients. The evidence of most recurrences within 6 months could be useful for advising patients on likely outcomes.

## KEYWORDS

ablation, children, ectopic atrial tachycardia, young adults

## 1 | INTRODUCTION

Ectopic atrial tachycardia (EAT) is a frequent arrhythmia in children and young adults with structurally normal hearts, due to a rapid discharge for an automatic atrial focus.<sup>1-4</sup> Although generally benign, one-third of patients present with very frequent episodes, sometimes with an incessant behavior, which may promote tachycardia-mediated cardiomyopathy.<sup>5,6</sup>

Compared to the poor efficacy of medical therapy, radiofrequency (RF) catheter ablation has shown high short-term success

rate in particular for EAT arising from a single focus with a low risk of significant complication. Most studies reported acute success rates over 85%-90% of patients with rare major complications.<sup>7,8</sup> Therefore, RF ablation has evolved as the treatment of choice in patients with recurrent symptoms or incessant EATs. However, no clear data regarding long-term follow-up after RF ablation in this subset of patients are available in the literature.

In this single center study, we retrospectively evaluated the acute success rate of EAT ablation and the long-term follow-up in children, adolescents, and young adults.

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## 2 | METHODS

We retrospectively analyzed consecutive patients with age < 30 years who underwent a transcatheter ablation of EAT in the Cardiac Electrophysiology Laboratory, Policlinico San Donato (Milan, Italy),

from September 2006 to February 2015. Demographic, clinical, and procedural data were obtained from electronic medical records and institutional databases. We collected patients demographics, medical history, laboratory data, echocardiographic principal parameters, (left ventricular [LV] end-diastolic volume, LV ejection fraction [EF], left

**TABLE 1** Baseline patient characteristics and procedural data for the entire cohort and based on the occurrence of EAT relapse during follow-up

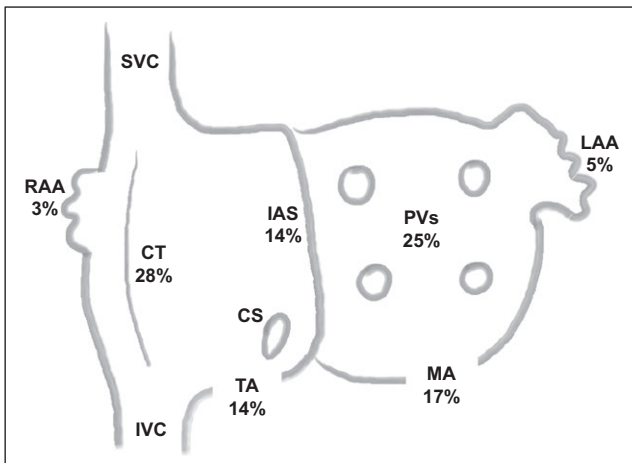
	Overall cohort (n = 36)	No EAT relapse during follow-up (n = 29)	EAT relapse during follow-up (n = 7)	P-value
Age at the time of RFA, y	16 (13.5-21.5)	18 (13-24)	15 (13-21)	0.45
Gender (Male), n (%)	23 (62%)	18 (62%)	5 (71%)	0.68
Weight at the time of RFA, kg	60 (51-72)	60 (51-73)	53 (50-70)	0.47
History of high level competitive sport activity, n (%)	13 (38%)	9 (31%)	4 (57%)	0.39
Age at the time of first ECG diagnosis of EAT, y	15 (12.5-19)	15 (13-20)	15 (10-16)	0.55
Symptoms leading to AT diagnosis, n (%)				0.25
Palpitations	30 (83%)	25 (86%)	5 (71%)	
Syncope	2 (6%)	2 (7%)	0 (0%)	
Heart failure symptoms	1 (3%)	1 (4%)	0 (0%)	
Other	3 (8%)	1 (4%)	2 (29%)	
Left ventricular ejection fraction at the time of RFA, %	60 (60-70)	60 (60-70)	61 (60-70)	0.74
Medical therapy before RFA, n (%)				0.76
Beta-blocker	5 (14%)	4 (15%)	0 (0%)	
Verapamil/diltiazem	3 (8%)	2 (7%)	1 (14%)	
VW IC class	3 (8%)	3 (11%)	0 (0%)	
VW III class	1 (3%)	1 (4%)	0 (0%)	
Beta-blocker and VW IC class	6 (17%)	5 (19%)	1 (14%)	
Verapamil/diltiazem and VW IC class	2 (6%)	1 (4%)	1 (14%)	
Number of ECG-documented AT episodes before RFA, n	3 (2-5)	3 (2-6)	3 (2-3)	0.91
Number of symptoms-suspected AT episodes before RFA, n	6 (3-10)	6 (3-10)	6 (3-15)	0.96
Relapsing on medical therapy before RFA, n (%)				0.92
No relapsing	8 (22%)	5 (18%)	2 (28%)	
Partial reduction of episode frequency and intensity	9 (25%)	8 (30%)	1 (14%)	
Reduction of episode frequency and intensity	5 (14%)	4 (15%)	1 (14%)	
No medical therapy before RFA	14 (38%)	10 (37%)	3 (43%)	
Sedation				0.25
Conscious sedation	27 (75%)	23 (78%)	4 (57%)	
General anesthesia with endotracheal intubation	9 (25%)	6 (22%)	3 (43%)	
Total fluoroscopic time, minutes	30 (20-49)	29.5 (20-38)	45 (22-61)	0.29
AT cycle length, ms	400 (355-450)	400 (350-450)	400 (380-400)	0.71
EAT interruption during RF delivery, n (%)	35 (97%)	29 (100%)	6 (85%)	0.21
EAT re-inducibility after RFA, n (%)				0.22
Yes, same AT	1 (3%)	0 (0%)	1 (14%)	
Multiple AT location	3 (8%)	3 (11%)	0 (0%)	1.0
Number of delivered RF pulses, n	8.5 (5-10.5)	9 (5-15)	8 (5-10)	0.63
Maximum delivered RF energy, W	25 (20-30)	25 (20-30)	25 (20-25)	0.47
Maximum ablation temperature, Celsius grade	52 (50-52.5)	52 (50-52)	52 (50-55)	0.41
Maximum duration of RF pulse, s	60 (60-90)	60 (60-90)	60 (60-90)	0.64

Values are n (%), median (first-third quartile range).

EAT, ectopic atrial tachycardia; BSA, body surface area; RFA, radio frequency ablation; VW, Vaughan Williams.

atrial area), medications before the procedure, time of first ECG diagnosis of EAT, procedural data from our electronic database. During follow-up, patients were seen by their referring pediatric cardiologist or at our institution on a regular basis. We collected all long-term follow-up data by reviewing clinical medical records and institutional databases.

All procedures performed in the study were in accordance with the ethical standards of the institutional and national research committee and with the 1964 Helsinki declaration.

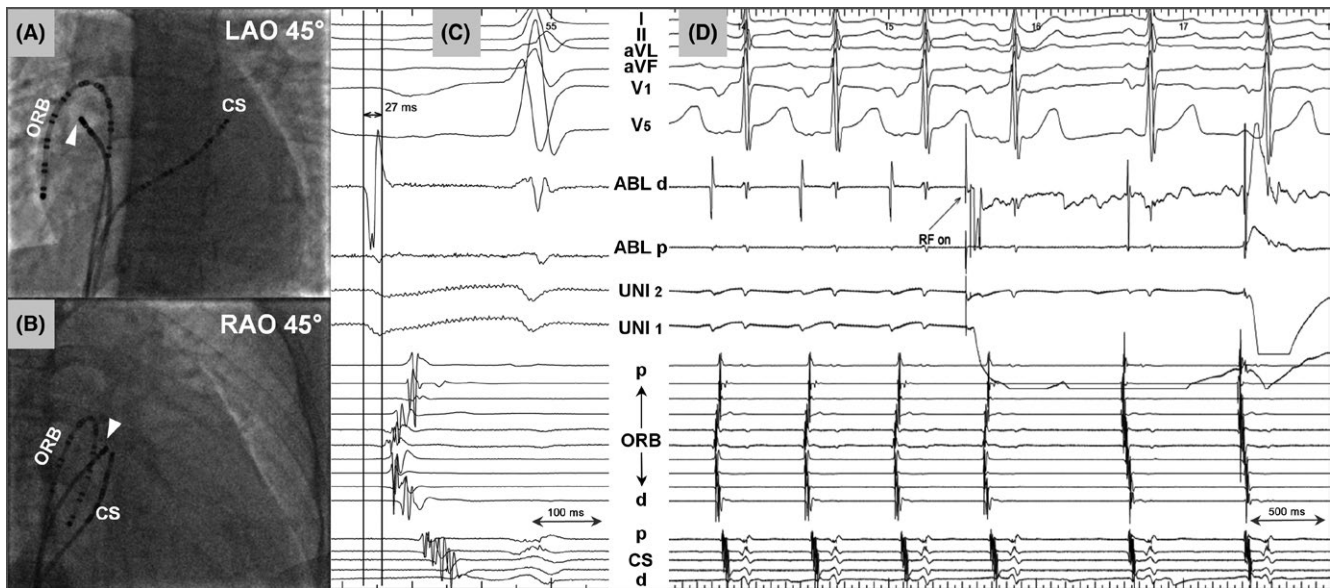


**FIGURE 1** Anatomic location: a schematic representation of atrial ectopic foci distribution in the study population. (RAA right atrial appendage, IAS, interatrial septum, CT, crista terminalis, TA tricuspid annulus, CS coronary sinus, PVs pulmonary veins, LAA left atrial appendage, MA mitral annulus)

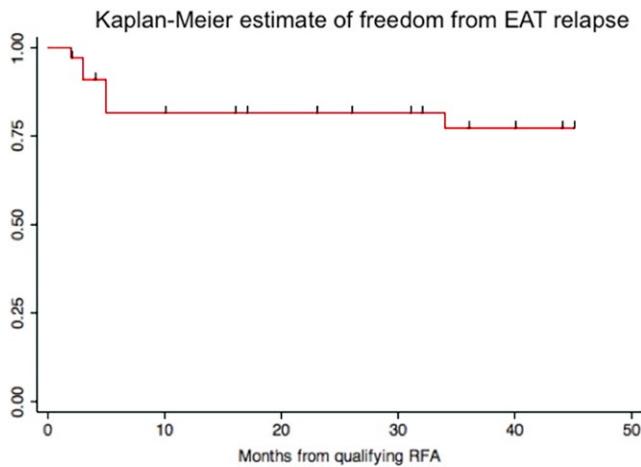
The procedure was performed under general anesthesia or conscious sedation. Twelve-lead ECG and intracardiac signals were recorded on a computerized acquisition system (LabSystem™ PRO EP-Recording System, Bard inc, Lowell, MA, USA). No 3D mapping was used. If atrial tachycardia was not present at baseline, isoproterenol at a dose of 1-5 µg/min was infused. Diagnosis of EAT was established using standard EP criteria.<sup>9</sup> Anatomic location of the atrial focus was identified during atrial tachycardia/ectopy by analyzing the P-wave morphology, atrial activation sequence, and conventional point-by-point mapping. A target area for ablation was identified when the local atrial activation preceded the onset of the surface P-wave by  $\geq 20$  ms, and ablation was performed at the site of earliest atrial activity and with the unipolar recording showing a QS morphology. Acute procedure success was defined as absence of any tachycardia despite infusion of isoproterenol and burst atrial pacing 30 minutes after the last RF pulse. No cryotherapy was used for ablation.

## 2.1 | Statistical analysis

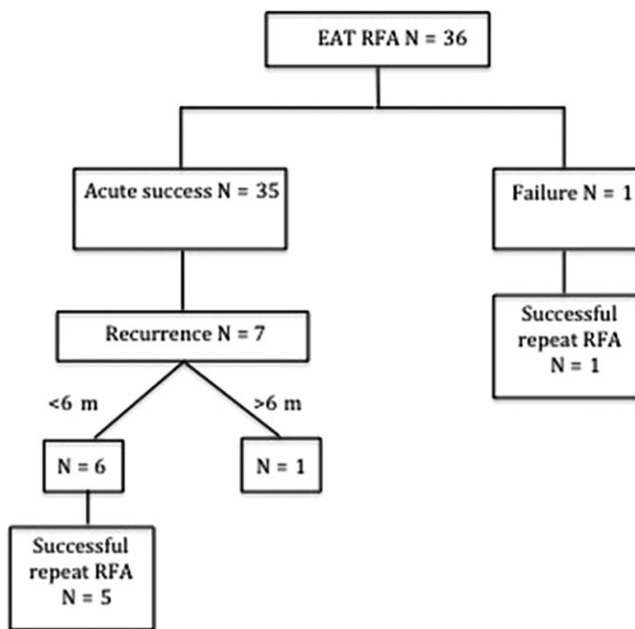
Data are reported as mean  $\pm$  standard deviation, median (first and third quartile), or frequency (%). Between-group comparison for clinical and outcome variables were performed using independent samples *t* test, Wilcoxon rank sum test, chi-square analysis, or Fisher's exact test using appropriate variable-specific denominators. Relapsing of EAT during follow-up was defined as the primary outcome. Univariable Cox regression model was used to identify factors associated with the primary outcome, which are presented with the hazard ratio (HR) and 95% confidence intervals (CI). Due to the small number of events, multivariable analysis of outcomes



**FIGURE 2** Focal atrial tachycardia termination during radiofrequency ablation at the superior portion of the tricuspid annulus. (A) and (B) left and right anterior oblique radiograms, respectively, showing the successful ablation site (white arrows). C, surface ECG and intracardiac recordings showing early bipolar activation (ABL d) and QS unipolar morphology (UNI 1) at the successful ablation site. D, Immediate tachycardia termination and restoration of sinus rhythm after RF onset. ABL: ablation catheter; CS: coronary sinus; d: distal; LAO and RAO: left and right anterior oblique projections, respectively; ORB: ventipolar orbiter catheter at the tricuspid annulus; p: proximal; RF: radiofrequency; UNI 1 and UNI 2: unipolar recordings from the distal poles of the ablation catheter



**FIGURE 3** Rate of EAT recurrences at follow up: Kaplan-Meier curve of EAT recurrence after ablation



**FIGURE 4** Outcomes after ectopic atrial tachycardia (EAT) radiofrequency ablation (RFA)

was not performed. All tests were two-sided. A  $P < 0.05$  was considered significant. Given the exploratory nature of the study, no adjustment for multiple comparisons was performed. Analysis was performed using STATA data analysis software (StataCorp LP, College Station, Texas).

### 3 | RESULTS

Fifty consecutive patients (age  $< 30$  years) with clinical signs and symptoms suspected for EAT were considered for the study. All patients underwent an electrophysiological (EP) study. In 49 patients, the arrhythmia was spontaneously present or inducible: an EP diagnosis of EAT was confirmed in 36 patients and a transcatheter ablation was

performed. Twelve patients were excluded from the analysis because of the presence of congenital heart disease and an EP diagnosis of macroreentrant atrial tachycardia. The clinical characteristics of the cohort are summarized in Table 1. Ten patients (38%) were practicing high-level competitive sport activity at the time of the procedure. The most frequent symptom referred by the patients during tachycardia was palpitations. All patients had more than one ECG-documented episode of arrhythmia before ablation (median 3 I.Q. 2-5). In 62% of patients, medical therapy was attempted before ablation with variable efficacy (partial reduction of symptoms in 25% of patients and no reduction in 22%): beta-blockers alone or in association with IC antiarrhythmic drugs were used in most of the cases.

Persistent or incessant EAT was present in 33% of the patients at the time of the procedure.

Ectopic foci were anatomically distributed as follows: right atrial foci were more frequently mapped along the crista terminalis (28%) and the tricuspid annulus (14%). In the left atrium, they tended to cluster adjacent to the pulmonary veins (PVs) (25%) and in particular the right superior PV, or at the mitral annulus level (17%). The interatrial septum and the perinodal area were the sites of foci location in the 14% of EAT. In three patients, multiple ectopic foci were mapped and ablated to interrupt the arrhythmia. (Figure 1) Local presystolic atrial electrical activity at the ectopic focus preceded the onset of surface P-wave during AT by 20-60 ms (mean time:  $-34 \pm 9$  ms).

Arrhythmia interruption during RF application was achieved in 35 patients (97%). A representative case is shown in Figure 2. In one case, there was a transient EAT termination during mapping by local catheter pressure at the target site which correctly predicted the site for successful ablation.

At the end of the procedure, EAT was not inducible despite isoproterenol infusion and burst atrial pacing after 30 minutes of observation in 97% of the patients. No acute or long-term complications were reported in all patients.

A detailed description of the procedural data is summarized in Table 1.

Freedom from EAT during follow-up is described in Figure 2. At median follow-up (38 months), the recurrence rate was 20%. (Figure 3)

**TABLE 2** Risk factors for EAT relapsing after RFA

Predictor (Univariable analysis)	HR (95% CI)	P-value
Age at intervention, per year	0.94 (0.83, 1.07)	0.34
Sex (Female)	0.78 (0.15, 4.04)	0.77
History of high level competitive sport activity	1.95 (0.43, 8.75)	0.39
History of previous ablation	2.00 (0.39, 10.35)	0.41
Interruption of AT during RF delivery	0.16 (0.02, 1.44)	0.10
Re-Inducibility of AT after RFA	1.36 (0.53, 3.46)	0.52
Left AT	0.88 (0.19, 3.92)	0.87
Medical therapy after RFA	2.39 (0.46, 12.34)	0.30

EAT, ectopic atrial tachycardia; RFA, radio frequency ablation.

Seven patients had a recurrence during follow up and nearly all recurrences (six out of seven patients) were evident within 6 months. Two patients restarted antiarrhythmic medications after arrhythmia's recurrence. Five patients required a second AT ablation procedure to control symptoms. A different site of origin for the EAT was identified in three patients during the second procedure. (Figure 4)

Risk factor analysis for primary outcome is summarized in Table 2. None of the risk factors analyzed showed a statistical correlation with EAT recurrences. (Table 2)

## 4 | DISCUSSION

Our study describes the long-term follow-up of RF ablation for EAT in children, adolescents, and young adults without structural heart disease.

Although EAT can manifest at any age, the prevalence of this arrhythmia is significantly higher in children, adolescents, and young adults.<sup>5</sup> Radiofrequency transcatheter ablation has been demonstrated as a valuable option for the treatment of this arrhythmia.<sup>7-11</sup>

In our study, we confirmed the safety and acute success rate of EAT ablation in young patients highlighting the long-term efficacy of the procedure in this population. No major complications were encountered in any of the patients.

Previous literature showed better outcomes of the procedure when performed with electroanatomical mapping compared to conventional strategy, in terms of acute success rate and recurrences.<sup>12-14</sup> However, a recent study showed similar acute success rate in patients who underwent catheter ablation with both strategies.<sup>14</sup> In our cohort, EAT was successfully terminated in 97% of the patients, using conventional mapping.

Recurrence rates after acute success were previously shown less likely with the use of electroanatomical mapping.<sup>12-14</sup> Kang et al showed 16% recurrence rate with electroanatomical mapping compared to 35% with conventional procedure with a median age at the time of first ablation of 12.8 years.<sup>14</sup> In our cohort, we had recurrences in seven patients (20% of the population) using conventional mapping, a finding comparable to previous reports.<sup>12-14</sup> Five of them (14% of the population) needed a second procedure in order to achieve EAT control. Kang et al showed that nearly 20% of patients evaluated in the multicenter study needed at least a second procedure because of EAT recurrences or initial ablation failure.<sup>14</sup> Therefore, our results are comparable to previous reports in terms of acute success rate and long-term efficacy.

In our study, nearly all recurrences were evident within 6 months from the procedure. These findings were not shown previously and it could be a very useful advice for physicians and patients in terms of follow-up and possible outcomes of the procedure.

In this cohort of patients, ectopic foci mainly followed the atrial anatomical distribution described in the adults population,<sup>15</sup> while Toyohara et al demonstrated that in children with age < 7 years, ectopic foci were mostly localized in the left and right appendage, because of the presence of residual embryonic tissue.<sup>16</sup> This feature

disappears with older age, as confirmed in our study that involved older children, adolescents, and young adults.

In our study, we could not identify a risk predictor of recurrence after EAT ablation probably due to the small cohort of patients.

## 5 | CONCLUSIONS

This study confirmed the safety and high acute success rate of transcatheter ablation of EAT in a population of children, adolescents, and young adults and it demonstrates the long-term efficacy of this procedure. The evidence of mostly recurrences within 6 months may be a useful finding in order to give better information to physicians and patients regarding follow up and likely outcomes.

## CONFLICT OF INTEREST

Authors declare no conflict of interests for this article.

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