Is transesophageal electrophysiologic study valuable in children with successful radiofrequency ablation of supraventricular tachycardia on follow-up for recurrence?

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Abstract

Objective: The aim of this study was to evaluate the efficacy of transesophageal electrophysiologic study (TEEPS) for the determination of supraventricular tachycardia (SVT) recurrences in symptomatic and asymptomatic children after successful radiofrequency ablation (RFA) for SVT.

Methods: A total of 66 patients who underwent TEEPS after successful RFA were included. The demographic features, symptoms of the patients, and the characteristics of the recurrences induced by TEEPS were evaluated. The arrhythmia types induced during RFA were compared with those induced by TEEPS in terms of the compatibility of the diagnosis.

Results: Forty-two (63.6%) girls and 24 (36.4%) boys with a mean age of 11.8±3.4 years were followed-up for 44.1±15.7 months. The average time between RFA and TEEPS was 5.2±5.9 months. The diagnoses during RFA were atrioventricular nodal reentrant tachycardia (AVNRT) in 47 of 66 patients, atrioventricular reentrant tachycardia (AVRT) in 18 of 66 patients, and ectopic atrial tachycardia in 1 of 66 patients. SVT was induced by TEEPS in 2 of 25 symptomatic and 5 of 41 asymptomatic patients. The SVT inducibility rate was 5.5% (1/18) and 12.7% (6/47) in patients with AVRT and AVNRT, respectively. In addition, 85.7% (6/7) of all recurrences occurred within 3.5 months. The recurrences as AVNRT in 2 of 25 symptomatic patients occurred in the first month after RFA. AVNRT in 4 of 41 and AVRT in 1 of 41 asymptomatic patients were induced within 3.5 months and 15 months, respectively.

Conclusion: TEEPS seems to be a valuable screening and diagnostic method for the determination of recurrence in symptomatic and asymptomatic children who underwent successful RFA. *(Anatolian J Cardiol 2016; 16: 126-30)*

Key words: transesophageal electrophysiology, ablation, child

Introduction

Radiofrequency ablation (RFA) is the first-line of therapy with a high success rate and a low recurrence and complication rate in some children with supraventricular tachycardia (SVT) since the early 1990s (1). Long-term follow-up is necessary to detect the recurrence and new types of arrhythmias, which are thought to occur because of a change in the electrophysiologic characteristics of the conductive system of the heart by RFA energy (2). There are some methods such as clinical history, electrocardiography, and Holter monitoring to determine the results of successful RFA.

Transesophageal electrophysiologic study (TEEPS) is a safe, effective, and semi-invasive procedure for evaluation and termination of SVT, drug testing in terms of effective treatment, and risk evaluation in Wolff-Parkinson-White syndrome (3-10). The purpose of this study was to demonstrate the efficacy of TEEPS for the determination of recurrence in symptomatic and asymptomatic children who underwent successful RFA of SVT. In addition, we evaluated the accuracy of the diagnoses obtained by TEEPS after the ablation by comparing them with the diagnoses of the initial intracardiac electrophysiologic study (IEPS) before the ablation.

Methods

This study was performed in Hacettepe Medical Faculty, Department of Pediatric Cardiology. A total of 66 patients who underwent TEEPS after successful RFA were included in the study. The features of patients including age, gender, body weight, time period between ablation and TEEPS, symptomatol-

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ogy and structural heart defect, and the characteristics of the recurrences induced by TEEPS such as type and ratio were evaluated. The arrhythmia substrates at the initial IEPS before the ablation and at TEEPS after the ablation where SVT could be induced were compared in terms of the accuracy of the diagnoses obtained by TEEPS. Patients with inducible SVT by TEEPS underwent the invasive electrophysiologic study and ablation again.

Patient selection

A total of 265 RFAs were performed for SVT between June 2007 and September 2012. In total, 261 of 265 ablations were considered successful and 4 of 265 were unsuccessful (SVT was still inducible at the end of the procedure). All patients had inducible sustained SVT in IEPS before the ablation. We reached 103 records of TEEPS that were performed after the successful ablation. Patients (n=37) who had preexcitation in the surface electrocardiogram during TEEPS were excluded from the study. Patients were accepted as symptomatic if they had palpitation, chest pain, or syncope after the ablation treatment. The patient population in this study was completely different from the study population that was investigated in our hospital (5, 11).

In our hospital protocol, TEEPS has been suggested for all patients who underwent successful RFA to check them approximately 3 months later in terms of recurrence, regardless of symptomatology because of our previous experience (11). We performed clinical evaluation, 24 h Holter monitoring, or exercise testing, and TEEPS in a routine evaluation of recurrence. Patients with sustained tachycardia by clinical evaluation, 24 h Holter monitoring, or exercise testing did not undergo TEEPS. If SVT cannot be induced by TEEPS after the ablation, the patients were evaluated by classical methods such as exercise testing and Holter monitoring on follow-up, even if they presented with symptoms again. All costs of the medical procedures of our patients were supported by The Republic of Turkey Ministry of Health. The study protocol and the patient information were approved by ethics committee of Hacettepe University.

Transesophageal electrophysiologic study procedure

The procedure for all patients was performed using the method previously defined (3, 6). The antiarrhythmic drugs at least 5 half-lives prior to TEEPS were stopped. IEPS and TEEPS were performed in the catheterization laboratory. After at least 4-h fasting, midazolam (0.1 mg/kg) was administered for sedation. In addition, 6 or 7 French catheters were inserted through the nose for patients weighing <15 kg or >15 kg, respectively. A 5-45 mA current was transmitted by a Fiab Programmable Cardiac Stimulator 8817 (FIAB SpA, Vicchio, Italy) for 5-20 ms. Electrocardiography was obtained by an EP Med by an EP Med System (EP MedSystems, Inc./St.Jude Medical, St. Paul, MN, USA). We usually did not use fluoroscopy in the procedure. If we were not able to detect adequate signals from the TEEPS catheter, we rarely used very short time fluoroscopy for catheter placement.

Table 1. Types of supraventricular tachycardia during the radiofrequency ablation in patients who were symptomatic and asymptomatic after ablation

Types of tachyarrhythmia	Symptomatic (n)	Asymptomatic (n)	Total
AVNRT	20 (30.3%)	27 (40.9%)	47
AVRT	5 (7.5%)	13 (19.6%)	18
EAT	-	1 (1.5%)	1
Total	25 (37.9%)	41 (62.1%)	66

AVNRT - atrioventricular nodal reentrant tachycardia; AVRT - atrioventricular reentrant tachycardia; EAT - ectopic atrial tachycardia

Stimulation was usually started by 10 mA for 10 ms with a heart rate faster than the baseline and was adjusted according to the stimulus threshold. The algorithm of the procedure consisted of single and double extrastimuli and rapid atrial pacing in the baseline state. If tachycardia could not be triggered, the protocol was performed again with isoproterenol [0.02-0.1 µg/kg/min (up to 4 µg/min)] and atropine intravenously (0.04 mg/kg) for all patients.

Tachycardia that did not disappear by itself was terminated using overdrive pacing, adenosine, or verapamil. The ventriculo-atrial interval was described as a period of time between the beginning of the QRS complex and the initial rapid deflection of the atrial signals on esophageal electrocardiography records. SVT was defined as atrioventricular nodal reentry tachycardia (AVNRT) if a ventricle-atrium interval was less than 70 ms in the presence of 1:1 ventricular-atrial relationship and no preexcitation. SVT was described as atrioventricular reentry tachycardia (AVRT) if a ventriculo-atrial interval was ≥70 ms during no atrium-ventricle dissociation and a ventricle-of ≥70 ms (10).

Statistical analyses

The Statistical Package for the Social Sciences program (SPSS Inc., version 15.0, Chicago, USA) was used for statistical analyses. Normality of distribution was analyzed with the Shapiro-Wilk test. Comparisons of categorical variables were performed by Fisher's exact test. Two-group comparisons were made with the Mann-Whitney U test for numerical variables. The numerical variables were shown as mean±standard deviation. Categorical variables were demonstrated as number and percentage (%). A p value of less than 0.05 was considered statistically significant.

Results

A total of 66 patients [24 (36.4%) boys and 42 (63.6%) girls; 41 asymptomatic and 25 symptomatic] who underwent TEEPS after the ablation were included in the study. The mean age at the time of TEEPS was 11.8±3.4 years, and the mean weight was 43.3±13.8 kg. Mitral valve prolapse was present in 5 of 66 patients (7.5%).

IEPS of the patients indicated the presence of tachycardia as AVRT because of a concealed pathway in 18 patients (27.2%),

Table 2. Types of induced tachycardia in patients during the intracardiac electrophysiologic study before the ablation and transesophageal electrophysiologic study after the ablation

Initials of patients	Type of tachycardia during IEPS before RFA	Type of tachycardia during TEEPS	Type of tachycardia during the second RFA	Symptoms	Time interval between RFA and TEEPS (months)	Characteristics of induced sustained tachycardia
1. S.O.	AVNRT	AVNRT	AVNRT	Asymptomatic	3.5	Recurrence
2. U.K.	AVNRT	AVNRT	AVNRT	Asymptomatic	2.5	Recurrence
3. G.H.	AVNRT	AVNRT	AVNRT	Asymptomatic	2.5	Recurrence
4. K.B.	AVNRT	AVNRT	AVNRT	Asymptomatic	2	Recurrence
5. M.G.	AVNRT	AVNRT	AVNRT	Palpitation	1	Recurrence
6. M.M.	AVNRT	AVNRT	AVNRT	Palpitation	0.5	Recurrence
7. S.Y.	AVRT	AVRT	AVRT	Asymptomatic	15	Recurrence

AVNRT - atrioventricular nodal reentrant tachycardia; AVRT - atrioventricular reentrant tachycardia; IEPS - intracardiac electrophysiologic study; RFA - radiofrequency ablation; TEEPS - transesophageal electrophysiologic study

AVNRT in 47 patients (71.2%), and ectopic atrial tachycardia in 1 patient (1.5%) (Table 1).

SVT was induced by TEEPS in 5 of 41 (12.1%) asymptomatic and 2 of 25 (8.0%) symptomatic patients. Total recurrence in our study group was 10.6% (7/66). No new type of arrhythmia was found in the patients having recurrence compared with those diagnosed during IEPS. All types of recurrent SVT induced by TEEPS were identical with those recorded during IEPS (Table 2). The tachycardia inducibility rate was 5.5% (1/18) and 12.7% (6/47) in patients with AVRT and AVNRT, respectively.

A total of 25 patients (37.8%) were symptomatic after the ablation. Symptoms included palpitations in 22 patients and chest pain in 3. All symptomatic patients with inducible SVT by TEEPS had only palpitation. Sustained tachycardia was induced in 2 of 25 (8.0%) patients from the symptomatic group in the first month after the ablation, and they were both diagnosed with AVNRT. The average follow-up duration for the symptomatic patients was 51.4 months and no recurrence, except for these 2 patients, was noted during this time period.

Five of 41 (12.1%) asymptomatic patients had recurrence by TEEPS as AVNRT in 4 patients who were diagnosed within 3.5 months and AVRT in 1 patient who was diagnosed on the 15th month after the ablation. The average follow-up duration for the asymptomatic patients was 39.4 months, and no recurrence, except for these 5 patients, was noted during this time period.

The average duration between the ablation and TEEPS on follow-up was 5.2±5.9 months. The average follow-up duration after TEEPS was 44.1±15.7 months. TEEPS was performed in 3.5 months in 51.5% (34/66) of all patients, and 85.7% (6/7) of all recurrences also occurred in 3.5 months (Table 2).

During TEEPS, isoproterenol or isoproterenol plus atropine was used in 3 and 62 patients, respectively. No drug was required in 1 patient for tachycardia induction. The sustained tachycardia was inducible without drug in 1 patient, with isoproterenol in 3 patients, and with isoproterenol plus atropine in 3 patients during TEEPS.

No complications such as atrial fibrillation and the need of cardioversion occurred during or after TEEPS.

Patients having induced tachycardia by TEEPS underwent the RFA again, and the types of tachycardia recorded during the second IEPS in the patients having induced tachycardia by TEEPS were identical with those obtained by TEEPS.

There was no statistically significance between patients with recurrence and the others in terms of age (p=0.134), sex (p=0.615), body weight (p=0.937), time period between RFA and TEEPS (p=0.216), symptomatology (p=0.649), and structural heart disease (p=0.107).

Discussion

In this study, we determined inducible tachycardia by TEEPS in asymptomatic and symptomatic patients after successful RFA. All types of recurrent SVT were the same as those diagnosed during IEPS. No significant relationship was determined between the patients having recurrence and the others in terms of age, gender, weight, drugs for induction, symptomatology, and structural heart disease. We also stated probability of recurrence in patients without symptoms using TEEPS.

Assessment of recurrence after successful ablation is usually performed using noninvasive methods such as clinical evaluation, exercise testing, or Holter monitoring (11). However, although these methods are the first step to assess the recurrence of tachycardia in practice, they are not always effective in children to assess the recurrence of tachycardia. Children cannot usually accurately describe their symptoms, and it is very difficult to acquire electrocardiography during symptom or clinical tachycardia. Children, especially younger ones, usually cannot complete the entire exercise stages. Holter monitoring is useful only for patients having symptoms very often. Moreover, the differential diagnosis between the various tachycardias is not always easy, even if SVT is recorded in these methods (9, 11, 12). However, transesophageal stimulation has several advantages compared with IEPS. Hospitalization is not needed after TEEPS, and it can be performed at any time whenever parents or children choose to undergo it. Procedure time is short, and the

cost of the procedure is not as high as catheterization. Patients do not face with risks related to catheterization and general anesthesia. There is extremely low or no X-ray exposure. Data collected during TEEPS can be compared with data obtained from IEPS (12).

Erdoğan et al. (13) determined the TEEPS data in 147 patients, and SVT was triggered in 72 patients. They speculated that TEEPS is a useful method for the evaluation and management of symptomatic patients probably because of arrhythmia (14). A study by Pehrson et al. (4) showed the inducibility rate of tachycardia by TEEPS in patients (aged 13-73 years) with electrocardiography-documented SVT to be 90%. In 2 separate studies, the positive predictive value of TEEPS was determined as 98.2% and 91% (10, 14). In our study group, the total recurrence ratio was 10.6%, and 7.5% of the recurrences was from the asymptomatic group. Probably, we could not have determined recurrence earlier in the asymptomatic patients by standard methods if TEEPS was not used. We think that TEEPS is beneficial, highly accurate, and easy to perform to uncover recurrence after the successful ablation in the asymptomatic and symptomatic children.

Erdoğan et al. (11) determined a higher recurrence rate (16%) by TEEPS compared with the results of study by Çeliker et al. (15) who observed a total recurrence rate of 4% in 73 patients after RFA of SVT within 2 months using clinical and electrocardiographic data. This difference could be related to the higher accuracy and sensitivity of TEEPS in defining the recurrence after RFA compared with clinical and electrocardiographic data. Similarly, studies performed by Van Hare et al. (16) and Nielsen et al. (17) reported an overall recurrence rate of 7% in 154 patients and 10.7% in 517 patients, respectively, using classical methods. Our study showed that classical techniques, such as exercise testing and Holter monitoring, were not enough to detect the recurrence more accurately after successful ablation and that patients with successful ablation should be checked in terms of recurrence especially in the first 4 months.

Although RFA is the preferable first-line of therapy in children with SVT, there is a doubt on the long-term effects of RFA, which may have proarrhythmic effects. Kimman et al. (18) showed new types of recurrence of SVT after successful RFA in children. Similarly, Mujovic et al. (19) reported new types of arrhythmia in 16% of 124 adult patients who underwent RFA for accessory pathways. The study from our center with a similar methodology also described the possibility of new types of tachycardia after RFA using TEEPS (11). In contrast to previous studies, the types of recurrences determined by TEEPS were identical to those determined during IEPS in our patients. However, this can be because of the small number of patients, characteristics of the population, or short-term follow-up in this present study.

During long-term follow-up, there is a common perception among clinicians that patients with symptoms related to arrhythmia usually must be investigated more aggressively than those without symptoms. The TEEPS results in our study were normal in 92.0% of patients who were symptomatic after the ablation. This is significant knowledge for parents and children, who are worried about the recurrence of their disease, showing that every symptom related to arrhythmias may not be indicative of the kind of recurrence after the ablation. On the other hand, the tachycardia by TEEPS was induced in 12.1% of the asymptomatic patients. This information points out the possibility of recurrence after the ablation in patients having no clinical tachycardia. Children can tell no symptoms even if they have palpitation. In addition, SVT can be felt as a normal heart beat by children. It seems that symptomatology can sometimes mislead us in the management of tachycardia in children and that TEEPS as an objective method is useful for patients in terms of earlier diagnosis and treatment.

Our study also stated that the results of TEEPS were not affected by different operators or physicians. The staff of the electrophysiology laboratory in our hospital was almost totally changed in our study period compared with those in the previous similar study performed by Erdoğan et al. (11), and we found similar results in our investigation compared with the previous one. This finding shows that TEEPS and the interpretation of its results can be learned and used easily in clinical practice by physicians. The authors assert that all procedures contributing to the work comply with the ethical standards of the the Declaration of Helsinki (20).

Study limitations

There are some limitations of our study. First, we could not include all patients who underwent successful RFA in our hospital because of inability of reaching all data. Our hospital is a reference center in our region, and most of the patients are referred from other districts for ablation treatment, and some of them have left the follow-up after the ablation because their symptoms were checked by different cardiologists in their district. Second, this study determined the mid-term effectiveness of TEEPS and not the long-term effectiveness.

Conclusion

TEEPS seems to be an easy-to-learn, safe, and effective technique on follow-up to evaluate the recurrence of SVT in patients after successful RFA. In addition to clinical evaluation, Holter monitoring, and exercise testing, TEEPS can be suggested as an alternate method for the determination of recurrence in patients who underwent RFA in terms of early diagnosis and treatment regardless of symptomatology. Patients with successful RFA should be considered in terms of the recurrence especially in the first 4 months.

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References

1. Joung B, Lee M, Sung JH, Kim JY, Ahn S, Kim S. Pediatric radiofrequency catheter ablation: sedation methods and success, complication and recurrence rates. Circ J 2006; 70: 278-84.
2. Sileikiene R, Baksiene D, Sileikis V, Kazakavicius T, Vaskelyte J, Kevalas R. Changes in electrophysiologic properties of the conductive system of the heart in children with atrioventricular nodal reentrant tachycardia after 2-8 years following radiofrequency catheter ablation of the slow pathway. Medicina (Kaunas) 2009; 45: 632-8.
3. Benson DW Jr, Dunnigan A, Benditt DG, Pritzker MR, Thompson TR. Transesophageal study of infant supraventricular tachycardia: Electrophysiologic characteristics. Am J Cardiol 1983; 52: 1002-6.
4. Pehrson SM, Blomström-Lundqvist C, Ljungström E, Blomström P. Clinical value of transesophageal atrial stimulation and recording in patients with arrhythmia-related symptoms or documented supraventricular tachycardia-correlation to clinical history and invasive studies. Clin Cardiol 1994; 17: 528-34.
5. Erdoğan I, Özer S, Karagöz T, Şahin M, Çeliker A. Clinical importance of transesophageal electrophysiologic study in the management of supraventricular tachycardia in children. Turk J Pediatr 2009; 51: 578-81.
6. Akın A, Özer S, Karagöz T, Aykan HH, Gülgün M, Özkutlu S, et al. Sensitivity of transesophageal electrophysiologic study in children with supraventricular tachycardia on electrocardiography. Pacing Clin Electrophysiol 2014; 37: 1002-8.
7. Toni L, Blaufox AD. Transesophageal evaluation of asymptomatic Wolff-Parkinson-White syndrome. Pacing Clin Electrophysiol 2012; 35: 519-23.
8. Blaufox AD, Warsy I, D'Souza M, Kanter R. Transesophageal electrophysiological evaluation of children with a history of supraventricular tachycardia in infancy. Pediatr Cardiol 2011; 32: 1110-4.
9. Özer S, Allen S, Schaffer MS. Adenosine- and verapamil-sensitive ventricular tachycardia in the newborn. Pacing Clin Electrophysiol 2001; 24: 898-901.
10. Samson RA, Deal BJ, Strasburger JF, Benson DW Jr. Comparison of transesophageal and intracardiac electrophysiologic studies in characterization of supraventricular tachycardia in pediatric patients. J Am Coll Cardiol 1995; 26: 159-63.
11. Erdoğan I, Özer S, Karagöz T, Çeliker A. Transesophageal electrophysiologic study to determine the inducibility after successful ablation of supraventricular tachycardia in children. Pacing Clin Electrophysiol 2009; 32: 1402-6.
12. Brembilla-Perrot B, Chometon F, Groben L, Ammar S, Bertrand J, Marcha C, et al. Interest of non-invasive and semi-invasive testings in asymptomatic children with pre-excitation syndrome. Europace 2007; 9: 837-43.
13. Erdoğan I, Özer S, Karagöz T, Şahin M, Çeliker A. Clinical importance of transesophageal electrophysiologic study in the management of supraventricular tachycardia in children. Turk J Pediatr 2009; 51: 578-81.
14. Lee PC, Hwang B, Chen SA, Hsieh MH, Tsai CF, Chiang CE, et al. The results of radiofrequency catheter ablation of supraventricular tachycardia in children. Pacing Clin Electrophysiol 2007; 30: 655-61.
15. Çeliker A, Kafalı G, Karagöz T, Ceviz N, Özer S. The results of electrophysiological study and radio-frequency catheter ablation in pediatric patients with tachyarrhythmia. Turk J Pediatr 2003; 45: 209-16.
16. Van Hare GF, Javitz H, Carmelli D, Saul JP, Tanel RE, Fischbach PS, et al.; Participating Members of the Pediatric Electrophysiology Society. Prospective assessment after pediatric cardiac ablation: recurrence at 1 year after initially successful ablation of supraventricular tachycardia. Heart Rhythm 2004; 1: 188-96.
17. Nielsen JC, Kottkamp H, Piorkowski C, Gerds-Li JH, Tanner H, Hindricks G. Radiofrequency ablation in children and adolescents: results in 154 consecutive patients. Europace 2006; 8: 323-9.
18. Kimman GP, Bogaard MD, van Hemel NM, van Dessel PF, Jessurun ER, Boersma LV et al. Ten year follow-up after radiofrequency catheter ablation for atrioventricular nodal reentrant tachycardia in the early days forever cured, or a source for new arrhythmias? Pacing Clin Electrophysiol 2005; 28: 1302-9.
19. Mujovic N, Grujic M, Mrdja S, Kocijancic A, Mujovic N. The occurrence of new arrhythmias after catheter-ablation of accessory pathway: delayed arrhythmic side-effect of curative radiofrequency lesion? Srp Arh Celok Lek 2011; 139: 458-64.
20. Williams JR. The Declaration of Helsinki and public health. Bulletin of the World Health Organization 2008; 86: 650-1.