JACC Vol. 26, No. 1
July 1995:159–63

Comparison of Transesophageal and Intracardiac Electrophysiologic Studies in Characterization of Supraventricular Tachycardia in Pediatric Patients

RICARDO A. SAMSON, MD,* BARBARA J. DEAL, MD, FACC, JANETTE F. STRASBURGER, MD, D. WOODROW BENSON, JR., MD, PHD

Chicago, Illinois

Objectives. **This study sought to determine the accuracy of transesophageal electrophysiologic studies in diagnosing and characterizing various mechanisms of supraventricular tachycardia in pediatric patients.**

Background. **Transesophageal electrophysiologic studies are a relatively noninvasive means of characterizing supraventricular tachycardia. Although widely used, to our knowledge no data exist that directly compare information obtained from transesophageal electrophysiologic studies with that from intracardiac electrophysiologic studies.**

Methods. **We reviewed the records of 57 pediatric patients undergoing both transesophageal and intracardiac electrophysiologic studies at our institution. The results of these studies were compared with respect to mechanism of tachycardia, localization of accessory atrioventricular (AV) connections (if present) and characterization of anterograde accessory connection conduction properties.**

Results. **Tachycardia mechanisms were concordant in 56 of 57 patients: orthodromic reciprocating tachycardia in 43, antidromic reciprocating tachycardia in 1, both orthodromic and antidromic tachycardia in 2, AV node reentrant tachycardia in 5, atrial reentrant tachycardia in 4 and ectopic atrial tachycardia in 2. Of 29 patients with orthodromic reciprocating tachycardia using a concealed accessory connection, transesophageal study predicted the accessory connection site through changes induced by transient bundle branch block in 12. By the Bland-Altman method in 14 patients with pre-excitation, the anterograde accessory connection effective refractory period determined by transesophageal study compared favorably with that determined by intracardiac study (mean difference 5.0 ms, limits of agreement −55 and 65 ms).**

Conclusions. **Transesophageal electrophysiologic studies are a highly accurate means of diagnosing and characterizing various mechanisms of supraventricular tachycardia in pediatric patients.**

(J Am Coll Cardiol 1995;26:159–63)

Supraventricular tachycardia is a frequently encountered rhythm disturbance among pediatric patients. In addition to characterizing the mechanism of supraventricular tachycardia, electrophysiologic studies provide functional characterization that may be useful in the long-term management of these patients. For example, different mechanisms of supraventricular tachycardia are associated with distinct natural histories (1–6), which in turn is of great import in selecting among available therapies for pediatric patients.

Transesophageal electrophysiologic studies are a relatively noninvasive and less costly means to diagnose and characterize various types of pediatric supraventricular tachycardia than intracardiac electrophysiologic studies. To determine the accuracy of transesophageal electrophysiologic study, we compared the data obtained from patients who underwent both transesophageal and intracardiac electrophysiologic studies with respect to the mechanism of tachycardia, localization of accessory atrioventricular (AV) connections (if present) and characterization of anterograde conduction properties of accessory connections in patients with pre-excitation.

Methods

Patients. The study group included all 57 patients (26 male, 31 female) at our institution who underwent both transesophageal and intracardiac electrophysiologic studies from July 1986 to June 1994. Findings in 13 patients have been reported elsewhere (7). In general, patients underwent transesophageal study as initial evaluation of palpitations or tachycardia documented on the electrocardiogram (ECG) (7,8). Intracardiac study was performed in anticipation of surgical or radiofrequency catheter ablation. Average age at the time of initial symptoms was 6.3 ± 5.4 years (mean ± SD, range 0 to 18). Average age at time of transesophageal study was 9.6 ± 5.4 years (range 0 to 19.4), and average age at time of intracardiac electrophysiologic study was 10.4 ± 5.2 years (range 0.5 to 18.6).

From the Division of Cardiology, Department of Pediatrics, Northwestern University, Children's Memorial Hospital, Chicago, Illinois.

Manuscript received October 6, 1994; revised manuscript received December 30, 1994, accepted February 27, 1995.

*Present address and address for correspondence: Dr. Richard A. Samson, Department of Pediatrics, University of Arizona Health Sciences Center, 1501 North Campbell Avenue, Tucson, Arizona 85724.

©1995 by the American College of Cardiology

0735-1097/95/$9.50
0735-1097(95)00128-Q

Definition and diagnosis. Definitions of the mechanisms of supraventricular tachycardia utilized in transesophageal and intracardiac study have previously been described (3,5–12). In the present study, supraventricular tachycardia using accessory AV connections consisted of orthodromic and antidromic reciprocating tachycardia. In *orthodromic reciprocating tachycardia*, anterograde conduction proceeds over the AV node, and retrograde conduction proceeds through an accessory AV connection. In the transesophageal study, ventriculoatrial (VA) intervals measured from the onset of the surface lead QRS complex to the rapid deflection of the atrial component of the transesophageal ECG are >70 ms (13,14). During intracardiac study, orthodromic tachycardia is characterized by eccentric atrial activation and advancement of atrial electrograms by ventricular extrastimuli at a time when the His bundle is refractory (15). The permanent form of junctional reciprocating tachycardia is a special type of orthodromic reciprocating tachycardia in which anterograde conduction occurs over the AV node, and retrograde conduction occurs over an accessory connection with decremental conduction properties (16); the resultant VA intervals are characteristically prolonged. *Antidromic reciprocating tachycardia*, in which anterograde conduction occurs through an accessory connection and retrograde conduction through the AV node or a different accessory connection, shows a prolonged QRS duration with a configuration similar to that occurring with pre-excitation and that can be reproduced by atrial pacing at a comparable cycle length.

Two basic forms of primary atrial tachycardia (12) in which the primary electrophysiologic abnormality is contained completely within the atria are ectopic atrial tachycardia and atrial reentrant tachycardia. In *ectopic atrial tachycardia*, a nonsinus atrial focus displays enhanced automaticity, resulting in an inappropriately rapid atrial rate. Depending on the site of the focus, the surface P wave configuration may differ from that in sinus rhythm. Because of its abnormal automaticity, ectopic atrial tachycardia cannot be induced or terminated by pacing, although overdrive suppression may be evident. *Atrial reentrant tachycardia*, as the term implies, involves a reentrant mechanism that is confined to the atrium. Because both of these forms are independent of AV conduction, either tachycardia will persist in the setting of second-degree AV block.

AV node reentrant tachycardia is diagnosed by excluding supraventricular tachycardia utilizing accessory connections and primary atrial tachycardia. Two forms of AV node reentrant tachycardia have been described: 1) the typical, or common type, in which anterograde conduction proceeds down the slow pathway, and retrograde conduction proceeds through the fast pathway; and 2) the atypical, or uncommon form, in which anterograde conduction occurs by way of the fast pathway and retrograde conduction through the slow pathway. The common form is characterized by short VA intervals measured either by intracardiac (13) or transesophageal study (14).

Electrophysiologic study. All studies were performed in the postabsorptive state, and antiarrhythmic medications had been discontinued for at least 5 half-lives. Parental consent was obtained before each study. Sedation was obtained using either meperidine (1 mg/kg body weight), promethazine (1 mg/kg), morphine (0.1 mg/kg), midazolam (0.1 mg/kg) or fentanyl/droperidol solution (2 μg/kg and 0.01 mg/kg, respectively) as needed. In some patients undergoing intracardiac electrophysiologic study, general anesthesia, using propafol or inhalational agents, such as halothane or flurane, was employed.

The techniques for transesophageal and intracardiac electrophysiologic studies in our laboratory have been previously described (7,8). In transesophageal studies, a bipolar electrode was positioned within the esophagus for ECG recording. Anterograde conduction and refractory characteristics were determined during atrial pacing. To induce tachycardia, premature atrial extrastimuli were introduced into sinus rhythm or atrial paced rhythm, or incremental atrial pacing to second-degree AV block or burst atrial pacing was performed. If tachycardia was not inducible under baseline conditions, isoproterenol (0.02 to 0.1 μg/kg per min up to a maximum of 4 μg/min) was infused and the pacing protocol repeated. If tachycardia remained noninducible, the pacing protocol was repeated after infusion of atropine (0.04 mg/kg). During tachycardia, the VA interval was measured from the onset of the QRS complex to the rapid deflection of the atrial component of the esophageal ECG. For intracardiac studies, three or four quadripolar electrode catheters were inserted percutaneously and positioned to record electrograms from the high right atrium, His bundle, right ventricular apex and coronary sinus. Anterograde conduction and refractory characteristics were determined using premature extrastimuli, and atrial mapping within the right atrium and coronary sinus during tachycardia was performed. In patients with pre-excitation, the anterograde effective refractory period of an accessory connection was defined as the longest atrial coupling interval at which the accessory connection failed to conduct to the ventricle.

During transesophageal study, to define therapeutic alternatives tachycardia was induced multiple times if possible to assess the effects of the following maneuvers or intravenous medications on tachycardia termination or induction, or both: Valsalva maneuver, ice to the face, adenosine (50 to 300 μg/kg), verapamil (0.15 mg/kg), procainamide (15 mg/kg over 15 min), propranolol (0.2 mg/kg) and edrophonium (0.15 mg/kg).

In patients with orthodromic reciprocating tachycardia, the occurrence of transient bundle branch block during tachycardia allowed localization of the accessory connection. Prolongation of tachycardia cycle length or VA interval during bundle branch block signified an ipsilateral location of the accessory connection. Conversely, if no change in VA interval occurred during bundle branch block, the accessory connection location was then determined to be on the contralateral side or septal (17). Bundle branch block typically occurred during the onset of tachycardia.

The presence of multiple accessory connections was suggested by one of the following criteria: changes in delta wave polarity, multiple routes of retrograde atrial activation or

evidence of mismatch of anterograde pre-excitation and the site of retrograde atrial activation during orthodromic reciprocating tachycardia.

Statistics. Results are expressed as mean value ± SD. Comparisons among groups were performed using the Student paired *t* test; $p < 0.05$ was considered significant. The method of Bland and Altman (18) was used to determine limits of agreement between anterograde accessory connection effective refractory periods as measured during transesophageal and intracardiac studies. Limits of agreement were defined as the mean difference in refractory periods ±2 SD.

Results

Mechanisms of supraventricular tachycardia. During transesophageal study, 59 mechanisms of supraventricular tachycardia were found in 57 patients: orthodromic reciprocating tachycardia (43 patients), antidromic reciprocating tachycardia (1 patient), both orthodromic and antidromic reciprocating tachycardia (2 patients), typical AV node reentrant tachycardia (4 patients), atypical AV node reentrant tachycardia (1 patient), atrial reentrant tachycardia (4 patients), and ectopic atrial tachycardia (2 patients). During intracardiac study, 59 mechanisms of supraventricular tachycardia were found and were identical to those determined by transesophageal study in all but one patient. This patient was diagnosed by transesophageal study as having atypical AV node reentrant tachycardia on the basis of VA interval, cycle length dependence on isoproterenol and the absence of second-degree AV block during tachycardia. During intracardiac study, an atrial reentrant tachycardia was diagnosed. Thus, determination of the supraventricular tachycardia mechanism was highly concordant between transesophageal and intracardiac studies, with agreement in 98% of patients undergoing both methods of study.

Accessory connection localization. Of 43 patients with orthodromic reciprocating tachycardia, concealed accessory connections were utilized in 29. During transesophageal study, transient bundle branch block occurred during tachycardia in 12 (41%) of 29 patients and allowed determination of the location of the accessory connection by changes (or absence of changes) observed in tachycardia cycle length or VA interval. A left-sided accessory connection was present in nine patients, and three were determined to have right-sided accessory connections. As determined by intracardiac study, 21 patients had concealed left-sided accessory connections, and 8 had right-sided accessory connections. Accessory connection locations were identical in all 12 patients in whom they were localized during transesophageal study. Therefore, when accessory connections were able to be localized during transesophageal study, location was identical to the results of intracardiac studies.

Anterograde accessory connection properties. Using the premature atrial extrastimulus technique, the anterograde accessory connection effective refractory period was determined by both transesophageal and intracardiac studies in 14 patients with pre-excitation. Anterograde accessory connection effective refractory period averaged 287 ± 49 ms as measured during transesophageal study versus 282 ± 46 ms during intracardiac study (p = NS). By the method of Bland and Altman, the mean difference in effective refractory period as determined by the two methods was 5.0 ms. The limits of agreement were −55 and 65 ms.

Multiple accessory connections. Of 46 patients with supraventricular tachycardia utilizing accessory connections, multiple accessory connections were diagnosed in two during transesophageal study. During intracardiac study, multiple accessory connections were found in 13 patients, including those 2 who had multiple connections on the basis of the transesophageal study. Multiple accessory connections were left-sided in five patients and right-sided in seven patients, and one patient had right anterior and left lateral connections. However, during intracardiac study, in 11 of the 13 patients, multiple connections were not evident until after an initial accessory connection had been ablated. In these patients, after radiofrequency catheter ablation of an existing accessory connection, initiation of supraventricular tachycardia displaying a different pattern of retrograde atrial activation was observed, leading to the diagnosis of a concealed accessory connection. Therefore, purely "diagnostic" intracardiac studies were as sensitive as transesophageal studies in detecting the presence of more than one accessory connection. Both "diagnostic" intracardiac and transesophageal studies had high specificities and positive predictive values for multiple accessory connections (100% for both), but their sensitivities and negative predictive values were low (15% and 25%, respectively).

Discussion

The main finding of this study is that compared with intracardiac electrophysiologic studies, transesophageal electrophysiologic studies are highly accurate in diagnosing and characterizing various types of supraventricular tachycardia in pediatric patients. Tachycardia mechanisms, as diagnosed by the two techniques, were concordant in 56 of 57 patients. In patients with tachycardia utilizing concealed accessory connections, transesophageal study correctly localized accessory connections in 12 patients in whom transient bundle branch block occurred during supraventricular tachycardia. Finally, assessment of anterograde accessory connection conduction and refractory properties as determined during transesophageal study correlated highly with those determined during intracardiac study.

Mechanisms of supraventricular tachycardia. Transesophageal electrophysiologic study proved to be accurate in identifying several different mechanisms of supraventricular tachycardia. Specifically, the diagnoses of orthodromic reciprocating tachycardia, antidromic reciprocating tachycardia, typical AV node reentrant tachycardia, atrial reentrant tachycardia and ectopic atrial tachycardia were made using transesophageal pacing and recording techniques. This is consistent with the study by Gallagher et al. (14) in which the utility of the

esophageal ECG to distinguish orthodromic reciprocating tachycardia from AV node reentrant tachycardia was demonstrated in older patients. This distinction was based on a VA interval in the esophageal ECG in which 16 of 16 patients with orthodromic reciprocating tachycardia had VA intervals >70 ms in the esophageal lead, whereas 11 of 12 patients with AV node reentrant tachycardia had VA intervals <70 ms. One criticism of transesophageal electrophysiologic studies is that if a cutoff of 70 ms is utilized, patients with atypical AV node reentrant tachycardia may be misdiagnosed as having orthodromic reciprocating tachycardia. However, the prevalence of atypical AV node reentry within the pediatric population is sufficiently low that in our study, none of the 43 patients with orthodromic reciprocating tachycardia determined during transesophageal electrophysiologic study was found to have atypical AV node reentrant tachycardia during intracardiac electrophysiologic study.

Accessory connection localization. Of 29 patients with concealed accessory connections, transesophageal electrophysiologic study was useful in predicting the site of the accessory connection in 12. Compared with intracardiac studies, these predictions were correct in all 12 patients. An obvious limitation of the ability of transesophageal studies to predict the side of accessory connection is the dependence on the occurrence of bundle branch block. In 17 patients, bundle branch block during tachycardia did not occur, and the site of accessory connection could not be predicted. However, in those electrophysiologic studies in which bundle branch block is observed, the site of the accessory connection can be predicted with accuracy approaching 100%. Knowledge of the accessory connection location may be useful information to provide to pediatric patients and their families if radiofrequency catheter ablation is being contemplated so that they can provide informed consent. For example, if an accessory connection is known to be left-sided, then the physician can provide more details about the procedure, such as retrograde or transseptal approach and estimated likelihood for successful ablation or potential complications.

Anterograde accessory connection properties. Assessment of anterograde conduction and refractory properties of accessory connections in patients with pre-excitation may be useful in stratifying the risk for ventricular fibrillation and sudden death in the setting of atrial fibrillation. Patients with longer anterograde accessory connection effective refractory periods are thought to be at lower risk than those with accessory connections capable of rapid anterograde conduction (19). Prediction of anterograde accessory connection effective refractory period during transesophageal electrophysiologic study compared favorably with that determined during intracardiac electrophysiologic study. During transesophageal pacing, assessment of the anterograde accessory connection effective refractory period may be limited by atrial muscle refractoriness and the ability to capture the atrium. Although use of a wider pulse width (10 vs. 2 ms in intracardiac studies), higher current (up to 20 vs. 4 mA) and wider interelectrode distance (29 vs. 5 mm) may overcome technical difficulties related to capture of the atrium (20), these measures may be less effective when pacing is at premature intervals close to the refractory period.

Multiple accessory connections. Detection of multiple accessory connections was identical using transesophageal electrophysiologic study and the baseline diagnostic intracardiac study; however, 11 patients were found to have an additional accessory connection after radiofrequency ablation of one accessory connection. In general, eight regions have been used to describe accessory connection location (e.g., right lateral, posteroseptal). Multiple accessory connection locations were in different regions in 9 of these 11 patients. In the other two patients, multiple accessory connections were located within the same region, and therefore, the possibility of spatial mismatch caused by an angled orientation of a single connection cannot be excluded. Therefore, purely "diagnostic" intracardiac electrophysiologic studies did not uncover other accessory connections until a primary accessory connection had first been abolished and were as sensitive as transesophageal studies in detecting multiple connections.

The presence of multiple accessory connections in 23% of our patients after ablation of one accessory connection might suggest that the prevalence of multiple connections has been underestimated in the past using intracardiac electrophysiologic studies (21,22). However, the fact that the patients in our study subsequently underwent surgical or radiofrequency catheter ablation also suggests that our patients were a highly select group because their arrhythmias were difficult to control with medications. It would not be surprising to find a higher prevalence of multiple connections in this group. The true incidence of multiple accessory connections is not known, and, as discussed by Wellens et al. (23), reliable detection of multiple accessory connections using noninvasive means may not be readily accomplished.

Conclusions. In recent years, radiofrequency catheter ablation has emerged as an important and definitive therapy for many forms of supraventricular tachycardia in pediatric patients (24–28). A consensus is emerging that diagnostic intracardiac electrophysiologic studies for supraventricular tachycardia should include therapeutic radiofrequency catheter ablation (29). However, a generally agreed upon set of guidelines for use of radiofrequency catheter ablation in patients of all ages has not been established. Specifically, in the pediatric population, based on the natural history of a specific mechanism of supraventricular tachycardia, small patient size and potential complications of the ablation procedure, radiofrequency catheter ablation may not be indicated (30). The utility of transesophageal electrophysiologic studies has been demonstrated in the evaluation of palpitations (8) and antiarrhythmic medications (31,32) and in the definition of the natural history of supraventricular tachycardia (3) in the pediatric population. In our experience, transesophageal electrophysiologic studies are useful as an initial evaluation in defining treatment options in pediatric patients with supraventricular tachycardia. As demonstrated in the present study,

transesophageal electrophysiologic studies are a highly accurate technique for evaluating supraventricular tachycardia.

References

1. Lundberg A. Paroxysmal atrial tachycardia in infancy: long term follow-up study of 49 subjects. Pediatrics 1982;70:638–42.
2. Deal BJ, Keane JF, Gillette PC, Garson A Jr. Wolff–Parkinson–White syndrome and supraventricular tachycardia during infancy: management and follow-up. J Am Coll Cardiol 1985;5:130–5.
3. Benson DW Jr, Dunnigan A, Benditt DG. Follow-up evaluation of infant paroxysmal supraventricular tachycardia: transesophageal study. Circulation 1987;75:542–9.
4. Perry JC, Garson A Jr. Supraventricular tachycardia due to Wolff–Parkinson–White syndrome: early disappearance and late recurrence. J Am Coll Cardiol 1990;16:1215–20.
5. Pongiglione G, Strasburger JF, Deal BJ, Benson DW Jr. Use of amiodarone for short-term and adjuvant therapy in young patients. Am J Cardiol 1991;68:603–8.
6. Dunnigan A, Benson DW Jr, Benditt DG. Atrial flutter in infancy: diagnosis, clinical features and treatment. Pediatrics 1985;75:725–9.
7. Ko JK, Deal BJ, Strasburger JF, Benson DW Jr. Supraventricular tachycardia mechanisms and their age distribution in pediatric patients. Am J Cardiol 1992;69:1028–32.
8. Pongiglione G, Saul JP, Dunnigan A, Strasburger JF, Benson DW Jr. Role of transesophageal pacing in evaluation of palpitations in children and adolescents. Am J Cardiol 1988;62:566–70.
9. Gillette PC. The mechanisms of supraventricular tachycardia in children. Circulation 1976;54:133–9.
10. Garson A Jr, Gillette PC. Electrophysiologic studies of supraventricular tachycardia in children. I. Clinical–electrophysiologic correlations. Am Heart J 1981;102:233–50.
11. Benditt DG, Benson DW Jr, Dunnigan A, Gornick CC, Anderson RW. Atrial flutter, atrial fibrillation, and other primary atrial tachycardias. Med Clin North Am 1984;68:895–918.
12. Josephson ME, Wellens HJJ. Differential diagnosis of supraventricular tachycardia. Cardiol Clin 1990;8:411–42.
13. Benditt DG, Pritchett ELC, Smith WM, Gallagher JJ. Ventriculoatrial intervals: diagnostic use in paroxysmal supraventricular tachycardia. Ann Intern Med 1979;91:161–6.
14. Gallagher JJ, Kasell J, Smith WM, Grant AO, Benson DW Jr. Use of the esophageal lead in the diagnosis of mechanisms of reciprocating supraventricular tachycardia. PACE 1980;3:440–51.
15. Benditt DG, Benson DW Jr, Dunnigan A, et al. Role of extrastimulus site and tachycardia cycle length in inducibility of atrial preexcitation by premature ventricular stimulation during reciprocating tachycardia. Am J Cardiol 1987;60:811–9.
16. Critelli G, Gallagher JJ, Thiene G, Rossi L. The permanent form of junctional reciprocating tachycardia. In: Benditt DG, Benson DW Jr, editors. Cardiac Preexcitation Syndromes: Origins, Evaluation and Treatment. Boston: Martinus Nijhoff, 1986:233–54.
17. Goldstein MA, Dunnigan A, Benson DW Jr. Bundle branch block during orthodromic reciprocating tachycardia onset in infants. Am J Cardiol 1989;63:301–6.
18. Bland JM, Altman DG. Statistical methods for assessing agreement between two methods of clinical measurement. Lancet 1986;1:307–10.
19. Klein GJ, Bashore TM, Sellers TD, Pritchett ELC, Smith WM, Gallagher JJ. Ventricular fibrillation in the Wolff–Parkinson–White syndrome. N Engl J Med 1979;301:1080–5.
20. Gallagher JJ, Smith WM, Kerr CR, et al. Esophageal pacing: a diagnostic and therapeutic tool. Circulation 1982;65:336–41.
21. Gallagher JJ, Sealy WC, Kasell J, Wallace AG. Multiple accessory pathways in patients with the pre-excitation syndrome. Circulation 1976;54:581–91.
22. Colavita PG, Packer DL, Pressley JC, et al. Frequency, diagnosis, and clinical characteristics of patients with multiple accessory atrioventricular pathways. Am J Cardiol 1987;59:601–6.
23. Wellens HJJ, Atie J, Smeets JLPRM, Cruz FES, Gorgels AP, Brugada P. The electrocardiogram in patients with multiple accessory atrioventricular pathways. J Am Coll Cardiol 1990;16:745–51.
24. Jackman WM, Beckman KJ, McClelland JH, et al. Treatment of supraventricular tachycardia due to atrioventricular nodal reentry by radiofrequency catheter ablation of slow-pathway conduction. N Engl J Med 1992;327:313–8.
25. Van Hare GF, Lesh MD, Scheinman M, Langberg JJ. Percutaneous radiofrequency catheter ablation for supraventricular arrhythmias in children. J Am Coll Cardiol 1991;17:1613–20.
26. Dick M II, O'Connor BK, Serwer GA, LeRoy S, Armstrong B. Use of radiofrequency current to ablate accessory connections in children. Circulation 1991;84:2318–24.
27. Walsh EP, Saul JP, Hulse JE, et al. Transcatheter ablation of ectopic atrial tachycardia in young patients using radiofrequency current. Circulation 1992;86:1138–46.
28. Goldberger J, Kall J, Ehlert F, et al. Effectiveness of radiofrequency catheter ablation for treatment of atrial tachycardia. Am J Cardiol 1993;72:787–93.
29. Calkins H, Sousa J, El-Atassi R, et al. Diagnosis and cure of the Wolff–Parkinson–White syndrome or paroxysmal supraventricular tachycardias during a single electrophysiologic test. N Engl J Med 1991;324:1612–8.
30. Saul JP, Hulse JE, Papagiannis J, Van Praagh R, Walsh EP. Late enlargement of radiofrequency lesions in infant lambs: implications for ablation procedures in small children. Circulation 1994;90:492–9.
31. Benson DW Jr, Dunnigan A, Benditt DG, Thompson TR, Narayan A, Boros S. Prediction of digoxin treatment failure in infants with supraventricular tachycardia: role of transesophageal pacing. Pediatrics 1985;75:288–93.
32. Rhodes LA, Walsh EP, Saul JP. Programmed atrial stimulation via the esophagus for management of supraventricular arrhythmias in infants and children. Am J Cardiol 1994;74:353–6.