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ORIGINAL ARTICLE

Evaluation of pediatric patients with palpitations via cardiac event recorder, Holter monitoring and transesophageal electrophysiologic study in detecting arrhythmia*

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ABSTRACT

Objective: Palpitations are a common reason for referral to pediatric cardiologists, the diagnostic workup involves ambulatory, non-invasive recording devices and invasive procedures. We aimed to evaluate arrhythmic symptoms of pediatric patients with a cardiac event recorder, Holter monitoring and transesophageal electrophysiologic study (TEEPS) results.

Materials and Methods: Retrospective evaluation of pediatric patients who fitted an event recorder at tertiary University Hospital between January 2002 and August 2012. The data obtained from the same patients' as cardiac event recorder, Holter monitoring and TEEPS results were studied for comparison.

Results: During the study period, 40 patients who had all data of cardiac event recorder, Holter monitoring and TEEPS were included. The median age of the patients included in the study was 12 [interquartile range, 7-15] years. Using the Holter monitoring, supraventricular extrasystoles (SVEs) were detected in six (15%) patients and ventricular extrasystoles (VESs) in three (7.5%). According to the event recorder data of the 40 patients, there was sinus tachycardia in 20 (50%), supraventricular tachycardia (SVT) in three (7.5%), and SVEs in two (5%) patients. The event recorder data of the remaining 15 patients were assessed as normal. The analysis of the TEEPS results revealed atrioventricular nodal reentrant tachycardia in four (10%), atrioventricular reentry tachycardia in three (7.5%), and normal results in the remaining 33 (82.5%) patients.

Conclusions: This study demonstrated that a cardiac event recorder may also be considered as an important diagnostic tool in the diagnosis and ruling out of SVT in pediatric patients for whom the cause of arrhythmia cannot be identified with the Holter monitor, in patients who do not accept the use of TEEPS method following the use of Holter monitor, and in patients in whom SVT cannot be stimulated by TEEPS yet complaints persist.

Keywords: arrhythmia, cardiac event recorder, children, palpitation, supraventricular tachycardia.

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INTRODUCTION

Palpitation is one of the major reasons for pediatric cardiology admissions [1,2]. Differentiation of sinus tachycardia from the pathologic subtypes is one of the major challenges. Detection of tachycardia is also difficult in patients with short-term complaints. Recording systems such as 24-hour Holter monitoring, event recorders or provocation tests such as electrophysiologic studies (transesophageal or intracardiac) are some of the methods for diagnosis and differentiation [1,3]. Supraventricular tachycardia (SVT) is the most common symptomatic arrhythmia in childhood [4]. The diagnosis of SVT and the frequency of recurrence are not easy to determine due to the difficulties experienced with children in describing their complaints, short duration of SVT attacks, and the fact that these attacks end before an electrocardiogram (ECG) recording can be taken [5]. Various non-invasive (ECG, 24-hour Holter monitoring, event recorder, and exercise stress ECG test), semi-invasive [transesophageal electrophysiologic study (TEEPS)], and interventional (implantable loop recorder, intracardiac electrophysiologic study/intracardiac electrophysiologic study (IEPS)] methods are currently utilized to detect SVT [5].

In the event of symptoms that suggest the presence of SVT in children, the first choice is ECG recording, which is known as the gold standard method for diagnosing arrhythmia given its practical nature and easy accessibility. However, it may be difficult to diagnose short-term transient tachycardia using ECG. Therefore, 24-hour Holter monitoring is widely used in patients that cannot be diagnosed by surface ECG [6]. In cases where the symptom frequency is low, and due to the fact that symptoms may not occur during 24-hour Holter monitoring, the symptom moment can be captured with an event recorder, which is designed to record such data over a longer time [1,3,7,8]. However, there are only a limited number of publications providing event recorder data in pediatric age group.

TEEPS is a semi-invasive, easy-to-use, low-risk, reliable, and inexpensive diagnosis and treatment method with no major complications [9,10]. The TEEPS method has been shown to be effective in stimulating tachycardia and determining its mechanisms, assisting in the differential diagnosis of SVT, and guiding medical or ablative treatment decisions [10,11].

In this study, we aimed to report our experience using cardiac event recorder in pediatric patients since studies in the pediatric population are limited. Also, we aimed to assess arrhythmic symptoms in these pediatric patients using a cardiac event recorder, Holter monitoring, and findings from TEEPS.

MATERIALS and METHODS

Pediatric patients aged between 0-18 years, who fitted an event recorder at the Department of Pediatric Cardiology of Hacettepe University Faculty of Medicine between January 2002 and August 2012 were retrospectively evaluated. 24-hour Holter monitoring (Rozinn® Digital Holter Recorder Model No. RZ153PM) and TEEPS results of the event recorder patients were also included.

The patients' age, gender, reasons for admission, diagnoses, 12-lead ECG data, echocardiographic examinations were also recorded. The records were evaluated by the pediatric cardiologists of our department. Approval for the study was obtained from the Non-interventional Clinical Research Ethics Committee of University Faculty of Medicine (approval date/number: 19.10.2012/LUT 12/112).

An event recorder device which has a small phone size (Rozinn® "King of Hearts") was used for recording data for a predetermined time (looping memory) starting from the moment that the patient feels symptoms and presses the record button and ending with a warning sound. Two electrodes are attached to the chest wall, and the patient carries the monitor constantly, but the patient's rhythm is only recorded when the patient or his/her caregiver presses the record button. The recording system is equipped with a receiver/transmitter device that converts the patient's ECG to sound waves, a standard telephone line, and a central computer unit. After the patient's ECG is converted to sound waves, they are sent to the center via the telephone line and converted back into ECG waves and recorded there.

The patients were instructed how to use the event recorder by their doctors, and the first ECG recordings were created together. In addition, the patients and/or their parents were asked to record

data during symptoms, take at least one recording every day even if they had no symptoms, and send these records from a corded landline telephone to the corded landline telephone of the cardiology department. For the patients aged below three years, the parents were asked to take at least one recording every day (in the event of asymptomatic attacks) and record the times when they thought their children had symptoms (restlessness, constant crying, etc.). The ECG recordings received by the telephone were transferred to the computer. All the ECG recordings were evaluated by a pediatric cardiologist. An event recorder was applied to the patients that rarely had symptoms, couldn't be diagnosed with ECG or Holter monitoring and didn't prefer to undergo TEEPS as the first method or had persistent complaints after TEEPS.

TEEPS indications were defined as the presence of symptoms suggestive of arrhythmia, such as tachycardia and syncope, determination of SVT mechanisms, and evaluation of treatment after ablation. Consent was obtained from the parents of the patients in terms of TEEPS indications. IEPS was performed before ablation in the patients with recurrent arrhythmias who did not respond to anti-arrhythmic therapy.

Statistical analysis

Measurable variables were expressed as medians with interquartile ranges (IQR) and the percentages of all values relative to the total were given. Statistical Package for the Social Sciences (SPSS) v.18.0 for Windows XP software package was used to analyze the data.

RESULTS

During the study period, 40 patients who had all data of cardiac event recorder, Holter and TEEPS were included. Females consist the majority of patients (n=26 females; 65%). Median age was 12 [7-15] years. Three (7.5%) patients were under three and 37 (92.5%) were between 4-18 years old. Complaints of the patients during admission were palpitation in 37 (92.5%), chest pain in 12 (30%), syncope in 10 (25%), fatigue in 4 (10%). Three of the remaining patients, who did not encounter palpitations, disclosed incidents of syncope. Also, some patients had more than one complaint. The diagnoses made as a result of the examinations performed based on the patient complaints are shown in Table 1.

Transthoracic echocardiography, 12-lead ECG, Holter monitoring, event recorder, and TEEPS methods were applied to all the patients. The data obtained by the surface ECG, echocardiography, Holter monitoring, exercise ECG stress test, event recorder, and TEEPS methods are summarized in Table 2. Surface ECGs were taken during pediatric cardiology outpatient clinic admissions and found normal in 95% of the patients. However, one patient was diagnosed with sick sinus syndrome and needed a permanent pacemaker. The ECG showed a first-degree AV block. SVE was also found in Holter, but the event recorder and TEEPS results were normal. Additionally, left ventricular hypertrophy was detected in one patient's ECG. Although SVE was found in Holter and sinus tachycardia in the event recorder, TEEPS result was normal for this patient.

Table 1. Tests performed and diagnoses according to the presentation complaints

Complaints*	Holter monitoring		Event recorder		TEEPS	
	SVE (n = 6)	VES (n = 3)	SVT (n = 3)	ST (n = 20)	AVRT (n = 3)	AVNRT (n = 4)
Palpitation (n = 37)	5	3	3	16	3	4
Chest pain (n = 12)	3	1	3	6	1	1
Syncope (n = 10)	2	1	-	4	-	-
Fatigue (n = 4)	2	-	1	2	-	-

TEEPS: Transesophageal electrophysiologic study, SVE: Supraventricular extrasystole, VES: Ventricular extrasystole, SVT: Supraventricular tachycardia, ST: Sinus tachycardia, AVRT: Atrioventricular reentry tachycardia, AVNRT: Atrioventricular nodal reentrant tachycardia
*Some patients had more than one complaint.

Table 2. Surface ECG, echocardiography, Holter, event recorder and TEEPS results

n (%)	Surface ECG	Echocardiography	Holter monitoring	Event Recorder	TEEPS
Normal	38 (95.0)	31 (77.5)	31 (77.5)	15 (37.5)	33 (82.5)
1' A.V block	1 (2.5)	-	-	-	-
SVH	1 (2.5)	-	-	-	-
MVP	-	6 (15.0)	-	-	-
MVI	-	3 (7.5)	-	-	-
SVE	-	-	6 (15.0)	2 (5.0)	-
VES	-	-	3 (7.5)	-	-
ST	-	-	-	20 (50.0)	-
SVT	-	-	-	3 (7.5)	-
AVRT	-	-	-	-	3 (7.5)
AVNRT	-	-	-	-	4 (10.0)

TEEPS: Transesophageal electrophysiologic study, A.V: Atrioventricular, SVH: Left ventricular hypertrophy, MVP: Mitral valve prolapse, MVI: Mitral valve insufficiency, SVE: Supraventricular extrasystole, VES: Ventricular extrasystole, ST: Sinus tachycardia, SVT: Supraventricular tachycardia, AVRT: Atrioventricular reentry tachycardia, AVNRT: Atrioventricular nodal reentrant tachycardia

Twenty patients whose Holter results did not show palpitation and who did not want to undergo TEEPS fitted an event recorder device. Additionally, for the patients whose tachycardia could not be stimulated by TEEPS, they fitted an event recorder due to persisting complaints. Accordingly, 20 patients first wore the event recorder and then underwent TEEPS, whereas the remaining 20 patients first underwent TEEPS and then wore the event recorder.

1)*The patients who fitted an event recorder before TEEPS* (n=20)

Analysis of the data obtained by Holter monitoring revealed supraventricular extrasystoles (SVEs) in five and ventricular extrasystoles (VESs) in three patients. Event recorder revealed sinus tachycardia (ST) in ten, SVT in one, SVEs in two, and normal results in the remaining seven patients. The etiological examinations (anemia, hyperthyroidism, and fever) of the patients with ST were normal. For successful identification and discrimination of tachycardia, TEEPS was used following the event recorder and tachycardia was induced in six patients [atrioventricular reentry tachycardia (AVRT) in three and atrioventricular nodal reentrant tachycardia (AVNRT) in three]. Two of these patients were found to have SVT and SVE patterns based on the event recorder data (Figure 1). Radiofrequency ablation was successfully applied to these patients after IEPS, and their complaints did not recur during the follow-up.

2) *The patients who fitted an event recorder following TEEPS* (n=20)

SVEs was detected based on the Holter monitoring results in one patient. Additionally, among the 19 cases who were performed TEEPS due to the persistence of symptoms however in whom SVT could not be detected, ST was detected in 10 patients and SVT was detected in one (5.2%) patient based on the event recorder data. A patient with AVNRT detected by TEEPS had recurrent symptoms after RF ablation. SVT was detected in this patient based on the event recorder data, and therefore ablation was performed again (Figure 2).

DISCUSSION

This research highlighted the significance of a cardiac event recorder as a valuable diagnostic instrument for identifying SVT in pediatric patients when the cause of arrhythmia remains elusive through Holter monitoring analysis. This is particularly relevant when comparing it to the TEEPS method, where SVT cannot be induced despite persistent complaints.

Palpitation complaints in childhood may be ambiguous, and diagnosis may be challenging in this patient population due to difficulties in documentation [2]. Hence, non-invasive methods are preferred for diagnosis in the pediatric patient group in particular. Nevertheless, palpitations

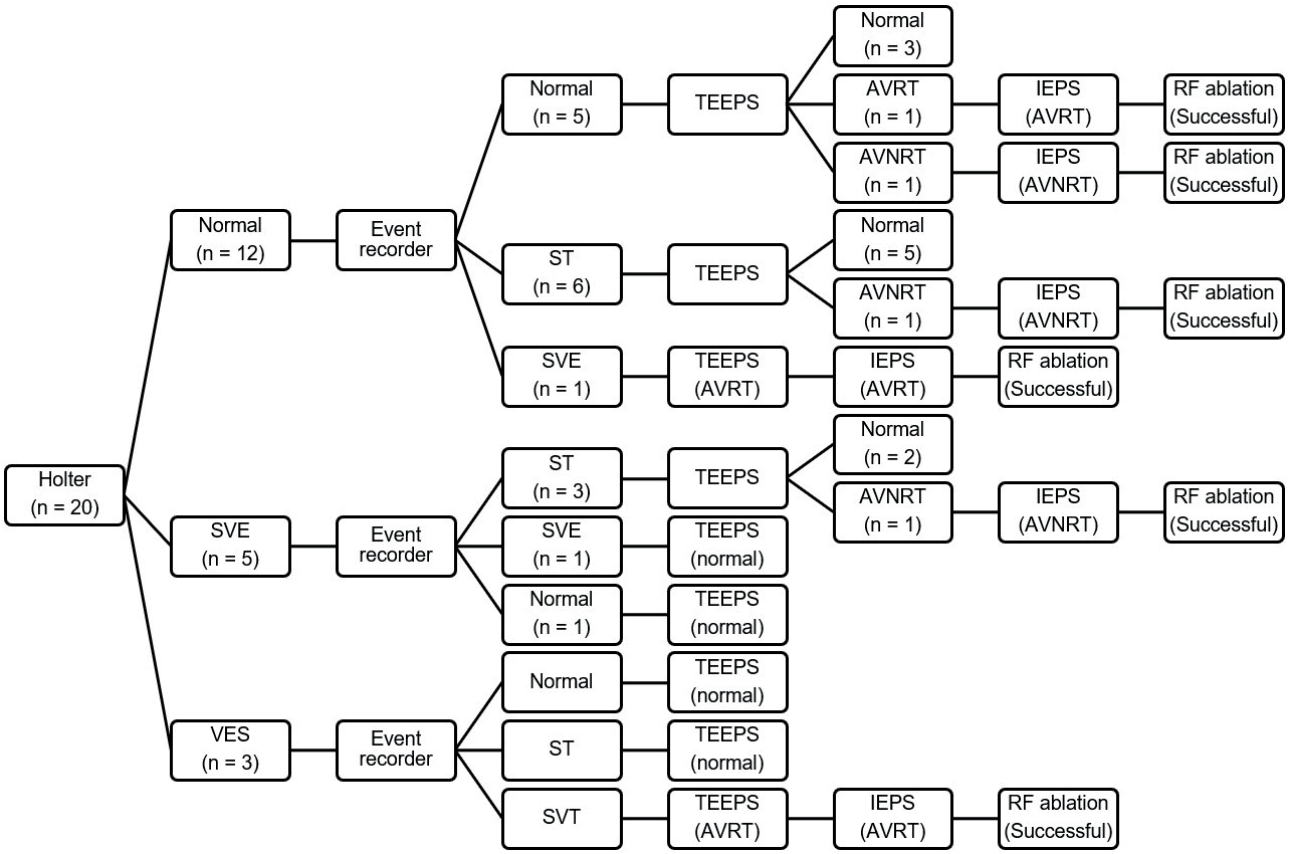

Figure 1. Data of the patients who fitted event recorder after Holter monitoring

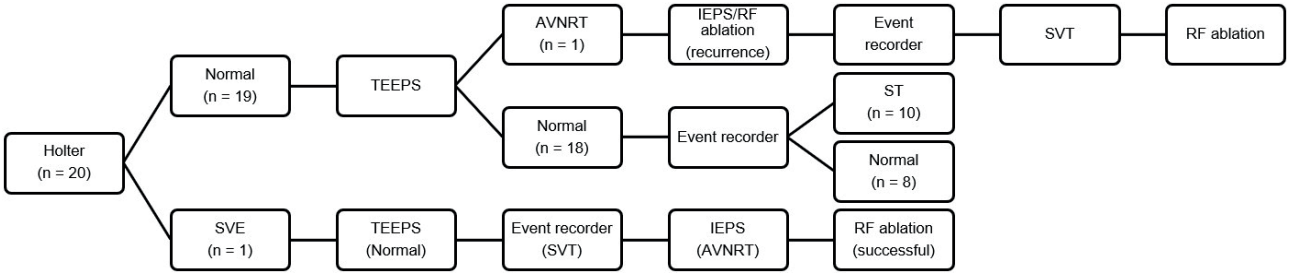

Figure 2. Data of the patients who fitted an event recorder after TEEPS

may not be detected using short-term recordings, such as ECG and Holter monitoring. In such cases, methods that allow long-term recordings, such as an event recorder or semi-invasive methods are used [1,3]. Since the event recorder device produce long-term recordings and the record button can be pressed whenever the patient begins to feel symptoms, it can detect SVT more accurately than a Holter monitoring.

The comparison of Holter recordings with TEEPS results in this study indicated that arrhythmia recordings could not be obtained with Holter monitoring in most patients. TEEPS provided more accurate results than Holter monitoring and the event recorder in diagnosing SVT and determining the type of tachycardia. Similarly, in a study, it was stated that Holter monitoring was insufficient in showing the tachycardia mechanism in 140 patients with SVT detected by surface ECG [10]. In that study, it was reported that SVT and ST were definitively demonstrated only in 9.3% and 15.7% of the patients, respectively, with using Holter monitoring. Tachycardia was detected in the remaining 33 (23.5%) patients, but the onset and end times of tachycardia could not be recorded, and thus ST and SVT could not be differentiated. Since Holter recordings could not distinguish between ST and SVT in a significant number of patients, the authors of the study emphasized the effectiveness of the TEEPS method in elucidating the mechanisms of SVT that develop without pre-excitation in children. In another study, it was reported that the positive predictive value of TEEPS

in detecting SVT mechanisms was 91%, and stated that transesophageal atrial stimulation was effective in the evaluation of patients with arrhythmia [11]. A study reported that surface ECG, Holter monitoring, and exercise stress ECG methods frequently yielded negative results in patients with suspected SVT and suggested the use of TEEPS in these patients [12]. In the same study, AVNRT was induced in 45.1% of the 82 patients included in the study, AVRT in 23.1%, Wolff-Parkinson-White syndrome in 6%, and ventricular tachycardia (VT) in 1.2%, while the remaining 30.4% had normal findings. The tachycardia was induced at a rate of 69.5% based on TEEPS. The authors emphasized that TEEPS was a fast and low-cost method that could be used to detect SVT as an alternative method.

In comparison, in a study conducted with an event recorder, it was stated that ST was recorded in 87% of the patients and SVT in 13%, and invasive diagnostic methods could be avoided in patients with ST detected at the time of symptoms [8]. The authors also noted that the event recorder provided more information compared to 24-hour Holter monitoring, given its longer recording duration and the fact that it can be activated by the patient in the event of symptoms. In a study conducted with 495 patients, they have obtained the event recorder data for a mean duration of 103 ± 97 days and reported that the event recorder detected SVT in 15% of the patients with a sensitivity of 83% and negative predictive value of 99% [13]. Due to our small sample size and retrospective study design, we were unable to provide results for the event recorder sensitivity and specificity. They also stated that the event recorder detected SVT especially in children with palpitation complaints, and no SVT was detected in the presence of chest pain, syncope, and pre-syncope. Furthermore, the authors reported in the light of other studies that the event recorder recording durations longer than 16 weeks did not increase its sensitivity, and the most cost-effective recording duration for SVT detection was four weeks.

In a study conducted with 460 patients, ectopic beats were detected only in 5% of the patients in whom Holter monitoring was used, whereas the event recorder recorded ST in 25%, SVT in 8%, 198 VES in 4%, SVEs in 2%, and VT in 0.04% of the patients, indicating a diagnostic success rate of 40% [7]. Based on these results, the efficacy of stand-alone use of the event recorder in detecting SVT remains uncertain, but it may be useful in the non-invasive evaluation of patients with intermittent symptoms before or after TEEPS. Although SVT was not detected with the event recorder in most of our cases when SVT was not stimulated by TEEPS, we think that it can be applied to selected patients with persisting symptoms before repeated use of invasive methods. In patients presenting with palpitations or syncope, an event recorder can provide data which can be useful in differentiating between benign and malignant arrhythmias.

In our study, it was observed that SVT could be induced when TEEPS was applied to the patients whose tachycardia could not be detected with the event recorder or who had ST. Therefore, we concluded that further measurements are needed in patients where no tachycardia is detected with the event recorder, and that the data obtained from the event recorder alone would not be sufficient for the follow up of such patients. In addition, patients diagnosed with SVT with the event recorder may need to undergo TEEPS, which is a semi invasive and reliable method, in order to detect the mechanism of SVT. The fact that chest pain was a frequent symptom in our patients with ST might be associated with the anxiety levels of the patients at the time of recording. Although ST is usually a benign arrhythmia, it may be associated with conditions such as hyperthyroidism, fever, anemia, drugs, and hypoxia. No etiological cause was determined in our patients.

The main limitations of our study were its retrospective nature and the relatively small size of the study sample. Hence, further prospective randomized studies with larger series are needed to corroborate the findings of this study.

Therefore, we suggest that in cases where no tachycardia is detected with the event recorder, it is not appropriate to only follow up patients considering that this result would be sufficient. In addition, patients diagnosed with SVT with the event recorder may need to undergo TEEPS, which is a semi-invasive and reliable method, to detect the mechanism of SVT.

CONCLUSION

This study revealed that cardiac event recorder can be used as an important diagnostic tool for the follow-up of patients with intermittent symptoms, those who do not accept the TEEPS procedure, and cases in which SVT cannot be stimulated by TEEPS but complaints persist. However, the use of an event recorder may be limited in patients who cannot activate the monitor during recording, who are asymptomatic, or who have arrhythmias accompanied by loss of consciousness. Furthermore, ensuring patient compliance may be difficult since the event recorder needs to be left attached for a long time.

Author contribution

Study conception and design: SÖ, NE, and İE; data collection: NE and İE; analysis and interpretation of results: NE, SÖ and İE; draft manuscript preparation: NE, SÖ and İE. All authors reviewed the results and approved the final version of the manuscript.

Ethical approval

The study was approved by the Non-interventional Clinical Research Ethics Committee of Hacettepe University Faculty of Medicine (Approval No: 12/112; 19.10.2012).

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Conflict of interest

The authors declare that there is no conflict of interest.

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