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Event Recorders in Pediatric Cardiology: Improving Diagnosis in Symptomatic Patients

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What is known on this subject?

Arrhythmia related symptoms such as palpitations, chest pain, and syncope are common reasons for referral to pediatric cardiology clinics, yet establishing a symptom rhythm correlation in children remains challenging due to the intermittent nature of symptoms. Conventional 24-hour rhythm Holter monitoring is widely used in clinical practice; however, its limited recording duration often results in low diagnostic yield in pediatric patients with infrequent or transient symptoms. Patient-activated cardiac event recorders (ER) enable longer-term electrocardiographic monitoring and have been shown to improve the detection of paroxysmal arrhythmias compared with short-term Holter monitoring. Previous studies have primarily focused on the detection of pathological arrhythmias, while the clinical value of documenting benign rhythms during symptomatic episodes in pediatric patients has been less emphasized.

What this study adds?

This study demonstrates that patient-activated ERs significantly increase diagnostic yield in symptomatic pediatric patients, particularly in those with intermittent complaints and initially normal 24-hour Holter monitoring. Beyond the detection of pathological arrhythmias, the documentation of benign rhythm patterns especially sinus tachycardia during symptomatic episodes provides valuable symptom–rhythm correlation and supports clinical decision-making. Studies evaluating the use of ERs in pediatric populations are limited, and real-world single-center data with comparable patient numbers are scarce in the literature. In this context, our findings contribute meaningful evidence regarding the clinical utility of ERs in children. The results highlight the role of ERs not only as a diagnostic tool but also as an effective noninvasive method for excluding cardiac causes, reducing unnecessary investigations, and promoting the rational use of healthcare resources in pediatric practice.

ABSTRACT

Objective: To determine the diagnostic efficiency of using an event recorder (ER) in evaluating paroxysmal symptoms such as palpitations, syncope, and chest pain in children and to compare it with 24-hour rhythm Holter monitoring.

Material and Methods: The study included 61 pediatric patients who presented with paroxysmal symptoms and could not be diagnosed using standard tests. Patients' demographic data, clinical complaints, 24-hour Holter recordings, and ER records were analyzed retrospectively.

Results: The most common reason for admission was palpitations (57.4%). The most common rhythm finding detected by the ER was sinus tachycardia, identified in 28 patients (73.7%) during symptomatic episodes. Pathological arrhythmias were detected in 10 cases: ventricular extrasystoles (n=8), including uniform and bigeminal patterns and supraventricular tachycardia (n=2). Notably, while supraventricular extrasystoles were detected in two patients on 24-hour Holter monitoring, these findings were absent from the symptomatic recordings obtained with the ER. Gender, age, and the presence of structural heart disease had no statistically significant effect on the success of the ER (p>0.05).

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ABSTRACT

Conclusion: ERs offer significantly higher diagnostic success than 24-hour Holter monitoring in the diagnosis of infrequent rhythm disorders in children. Given their effectiveness in establishing symptom-rhythm correlation and promoting patient compliance, they should be considered a priority option for evaluating symptoms that cannot be explained by conventional methods.

Keywords: Child, arrhythmia, event recorder, Holter monitoring, palpitation

Introduction

Cardiac arrhythmias in children vary depending on the patients' ages and underlying cardiac events. They are observed in 1.5-2.5% of the general population (1,2). Various clinical situations are encountered, ranging from mild palpitations to syncope and sudden cardiac death (3). Palpitations are the most common reason for visits to pediatric cardiology outpatient clinics (4,5).

A detailed history and physical examination, in addition to electrocardiography (ECG) and echocardiography, constitute the gold-standard approach for diagnosing arrhythmias (6). Although ECG is a primary tool in diagnosing rhythm disorders, recordings obtained in the absence of symptoms are insufficient for diagnosis due to the paroxysmal nature of arrhythmias (7,8). For this reason, 24–48-hour Holter monitoring is routinely used to overcome this limitation and establish a symptom-rhythm relationship (9,10).

Nevertheless, 24-hour recordings are insufficient for definitive diagnosis in patients with less frequent symptoms (4,11). In patients with less frequent symptoms, event recorders (ERs) that can be activated at the time of symptom onset, have automatic detection capabilities, and offer recording for up to 30 days provide significant diagnostic advantages (12,13). While these devices have proven effective in adult patients, more data are needed on their effectiveness in pediatric patients and on their comparative effectiveness with other devices offering short-term recording capabilities (14).

The aim of our study is to determine the diagnostic value of ER use in children presenting to the pediatric cardiology outpatient clinic with complaints of palpitations, syncope, or chest pain, and to contribute to the literature by comparing ER data with other diagnostic tests.

Material and Methods

Sixty-one patients aged 0–18 years who presented to the pediatric cardiology clinic between March 2020 and March 2022 with various complaints, such as palpitations, chest pain, syncope, abdominal pain, and convulsions, were included.

Patients included in the study underwent routine history-taking, physical examination, 12-lead ECG, laboratory testing, echocardiography, and 24-hour Holter monitoring. An ER was used in patients without findings related to etiology. Patients over 18 years of age whose data and medical histories could not be accessed were not included in our study.

In this study, data from patients who presented with various complaints and had ER data were retrospectively reviewed.

The CardioMem® CM 100 XT (Getemed Medical and Information Technology) was used to record symptoms at onset. The patient initiated recordings by pressing the record button whenever they experienced symptoms. After the record button was pressed, the device recorded an electrocardiogram and stored it in memory along with the recording date and time. The recorded electrocardiograms were evaluated by the pediatric cardiology clinic. The study was approved by University of Health Sciences Türkiye, Çam and Sakura City Hospital Clinical Research Ethics Committee (decision number: 154, date: 11.05.2022). The study was conducted in accordance with the Declaration of Helsinki.

The rhythm findings obtained from the recordings were defined as follows: supraventricular tachycardia (SVT) –a rapid heart rhythm originating above the ventricles– was defined by three or more consecutive premature atrial beats at a rate exceeding age-specific normal limits. Supraventricular extrasystoles (SVE) are defined as premature beats originating from an ectopic atrial focus. Premature ventricular contractions (PVC) were defined as early ventricular beats characterized by a wide QRS complex and absence of a preceding P wave. Bigeminy is defined as a rhythm in which every normal beat is followed by a premature contraction. Uniform PVCs are ventricular premature beats originating from a single ectopic focus, resulting in identical QRS morphologies.

Statistical Analysis

Statistical analyses were performed using IBM SPSS Statistics for Windows, Version 21.0. Categorical variables were expressed as frequencies and percentages, while continuous variables were presented as mean ± standard deviation.

Descriptive statistics such as mean, standard deviation, and percentage distributions were provided. Chi-square analysis was used to assess associations between categorical variables, and the Mann-Whitney U test was used for comparisons between two groups.

Findings

Data from 61 patients were included in the study: 38 (62.3%) were female and 23 (37.7%) were male. The ages of the patients included in the study ranged from 10 to 215 months, with a mean of 146.3±51.8 months (12.2±4.3 years).

The most common presenting complaint was palpitations (35 of 61, 57.4%), followed by chest pain, syncope, abdominal pain, murmur, and cramping (Table 1).

In the initial ECG evaluation, sinus tachycardia was observed in four patients; however, no other pathological findings were identified during the baseline examination.

The 24-hour Holter rhythm analysis revealed findings in 8 of 61 patients (13.1%). Pathological arrhythmias and conduction abnormalities were identified in 6 patients: including ventricular extrasystoles (n=3), SVE (n=2), and a prolonged PR interval with wide QRS (n=1). Additionally, sinus tachycardia during symptomatic episodes was recorded in two patients (25%).

On echocardiographic evaluation, 48 (78.7%) had normal findings, whereas 13 (21.3%) had abnormal findings. Three (23.3%) of the patients with a pathology had mitral valve insufficiency; other pathologies identified are shown in Table 2.

It was recommended that ERs be activated when patients experienced symptoms. Patients recorded a mean of 67.1±73.6 events (range, 2–308 events). Upon review, 38 of the event recordings were found to be abnormal.

The most common rhythm finding detected by the ER was sinus tachycardia, identified in 28 patients (73.7%) during symptomatic episodes. Pathological arrhythmias were detected in 10 cases, consisting of ventricular extrasystoles (n=8, including uniform and bigeminal patterns) and SVT (n=2). Notably, 31 (81.6%) of these 38 patients had no pathology detected during their initial 24-hour rhythm Holter monitoring, while pathology was detected in only 7 (18.4%). Conversely, among the 23 patients with normal ER results, sinus tachycardia was identified in the Holter recording of one patient (4.3%). This discrepancy was attributed to the initiation of beta-blocker therapy following the Holter diagnosis; the therapy subsequently suppressed the arrhythmia during ER monitoring.

When comparing patients' 24-hour Holter and ER results, sinus tachycardia was detected in two patients by the 24-hour Holter and in 28 patients by the ER. The comparison of 24-hour Holter rhythm and ER data is summarized in Table 3.

Table 1. Distribution of patients according to their presenting complaints

Complaint	n	%
Palpitations	35	57.4
Chest pain	13	21.3
Syncope	8	13.1
Abdominal pain	2	3.3
Rattling	2	3.3
Contraction	1	1.6
Total	61	100.0

Table 2. Distribution of echocardiographic findings

Finding	n	%
Mitral valve insufficiency	3	23.1
Ventricular septal defect	1	7.7
Coronary fistula	1	7.7
Left ventricular hypertrophy	1	7.7
Operated atrial septal defect	1	7.7
Cardiomyopathy and mitral valve insufficiency	1	7.7
Williams syndrome and supravalvular aortic stenosis	1	7.7
Tricuspid valve insufficiency mitral valve insufficiency	1	7.7
Mitral valve prolapse	1	7.7
Total	13	100.0

Table 3. **Comparison of pathological and symptom-related findings detected by 24-hour Holter and event recorder**

Findings	24-hour Holter (n)	Event recorder (n)
Pathological arrhythmias		
Supraventricular tachycardia	0	2
Ventricular extrasystoles	3	8
Supraventricular extrasystole	2	0
Long PR interval/Wide QRS	1	0
Symptom-related rhythms		
Sinus tachycardia	2	28
Total	8	38

Discussion

This study examined the diagnostic effectiveness of an ER for evaluating arrhythmia-associated symptoms in children, such as palpitations, chest pain, and syncope. The results showed that the ER system had a higher diagnostic rate compared with the 24-hour Holter monitor (62.3% vs. 13.1%), indicating its use was beneficial.

In the study by Wu et al. (15), patient-activated ER systems were shown to provide high sensitivity in the diagnosis of paroxysmal arrhythmia and to be effective in recording symptoms in real time. Furthermore, patient compliance was high because of the device's portable, user-friendly design (15). In another study, Makowska et al. (16) reported that patient-activated ER systems were highly effective in establishing symptom-rhythm correlation and diagnosing paroxysmal arrhythmia. Considering these findings, ERs appear to be a superior method for diagnosing intermittent and symptom-associated arrhythmias.

Similarly, the literature indicates that ERs offer an effective alternative in the diagnosis of rhythm disorders in pediatric patients when conventional methods are limited. In a large case series, Saygi et al. (8) reported that 73% of the 583 pediatric patients presented with palpitations, and pathology was detected in 39.4% of them. Similarly, in our study, the most common presenting symptom was palpitations at 57.4%. This parallelism indicates that palpitations are the most common symptom of arrhythmia during childhood.

While the 24-hour rhythm Holter is a widely used method for diagnosing arrhythmias, it often fails to capture arrhythmias during symptomatic episodes because the monitoring duration is limited. In our study, the diagnostic yield (defined as the detection of either pathological arrhythmias or a definitive symptom-rhythm correlation) was 13.1% for 24-hour Holter monitoring and 62.3% for the ER. The fact that the ER captured a rhythm in 62.3% of symptomatic episodes, even when the finding was a benign rhythm such as sinus tachycardia, demonstrates its superior clinical utility by providing a definitive clinical diagnosis and ruling out serious arrhythmias. This difference supports the findings of Park et al. (11), who reported that specific arrhythmias, such as atrioventricular reentrant tachycardia and atrioventricular nodal reentrant tachycardia, were identified in patients whose diagnoses were not confirmed by Holter monitoring but were detected with an ER (17).

In our study, the most frequently detected rhythm by the ER was sinus tachycardia (73.7%). A similar study by Ekşi et al. (18) also reported sinus tachycardia as the most common finding, with a prevalence of 50%. Although sinus tachycardia is a benign rhythm, confirming it during symptomatic episodes is clinically significant as it provides definitive symptom-rhythm correlation and rules out serious arrhythmias. In our study, pathological arrhythmias were detected in 26.3% of cases in which a rhythm was captured; these comprised ventricular extrasystoles (21%) and SVT (5.3%). In a study by Gass et al. (19) that used implantable loop recorders, serious arrhythmias such as SVT, ventricular tachycardia, and atrial fibrillation were detected. Similarly, Ergul et al. (17) diagnosed sinus bradycardia, AV block, and SVT in children with unexplained syncope, resulting in a change in clinical diagnosis in 29% of cases. Our findings, along with these studies, highlight that ERs are valuable tools for capturing both pathological arrhythmias and benign rhythms during symptomatic episodes, thereby facilitating a more accurate clinical assessment.

In a study by de Asmundis et al. (20) in an adult population, the detection rate was 1.8% with a 24-hour Holter monitor, whereas it reached 89% with an ER. Another study supporting this, conducted by Ekşi et al. (18), found that the diagnostic rate of the ER was 42.1%, whereas that of the 24-hour Holter monitor was 9.5%. These results are similar to the findings we obtained in pediatric patients and demonstrate that patient-triggered long-term recording systems significantly increase diagnostic success compared with conventional methods.

Our study clearly demonstrates the diagnostic power of ERs in providing a definitive clinical diagnosis for 31 patients for whom 24-hour Holter monitoring was insufficient. Zimetbaum et al. (7) also emphasized that ER systems contribute significantly to clinical practice by providing symptom–rhythm correlation. Furthermore, Gutgesell and Lindsey (14) stated that portable rhythm recording technologies increase diagnostic accuracy in pediatric cardiology; Galli et al. (12) emphasized that longer-term, patient-activated systems, such as ERs, are rapidly being integrated into clinical practice to address these limitations. Satou et al. (13), on behalf of the American Heart Association, emphasized in a scientific report that mobile health technologies, such as ERs, contribute to early diagnosis and follow-up, while potentially reducing clinical visits. Although Holter monitoring has been widely used in pediatric cardiology for many years, it remains limited by its short recording time and its frequent inability to capture data simultaneously with symptoms.

The most important advantage of ERs is that they can provide an ECG recording during symptomatic events (e.g., palpitations) and offer high patient comfort because of their size, mobility, and the absence of external electrodes attached to the patient's chest (21). Usadel et al. (22) reported that, in a study of 226 patients aged 0–17 years, the ER had a sensitivity of 92% for diagnosing SVT, 77% for detecting abnormal ECGs, and a specificity of 92%. Furthermore, the Pediatric and Congenital Electrophysiology Society/Heart Rhythm Society consensus report by Kusumoto et al. (23) emphasized that delays in diagnosing arrhythmia-related symptoms in childhood can lead to consequences, including cardiomyopathy, sudden cardiac events, and substantial deterioration in quality of life. It was noted that pediatric patients exhibit distinct characteristics relevant to arrhythmia diagnosis: symptoms are typically transient, irregular, and short-lived, and common misrepresentation of symptoms in younger age groups limits the effectiveness of other diagnostic methods (23). These findings emphasize that mobile diagnostic devices, such as ERs that patients can activate when symptoms develop, offer advantages over ECG and Holter monitoring for early diagnosis, particularly in the pediatric population. Furthermore, ERs yielded the same findings in most patients in whom Holter monitoring detected pathology, demonstrating that ERs also have high diagnostic accuracy. In this respect, they constitute a reliable alternative for diagnosis and follow-up.

Rossano et al. (24) found that in almost half of children presenting with syncope and palpitations, the symptoms were psychogenic rather than cardiac. This situation demonstrates that, especially in children with unexplained but recurrent symptoms, the diagnostic process is not limited to identifying pathology but also includes differentiating psychogenic causes and detecting normal rhythm (24). In this context, the ER is a valuable tool for excluding noncardiac causes in the differential diagnosis.

Study Limitations

Considering the limitations of this study, its retrospective and single-center design and the relatively limited number of patients restrict the applicability of the findings to other patient groups. Furthermore, the coincidence of the treatment process with the recording period in some patients is a potential limitation that may affect diagnostic accuracy. The lack of long-term follow-up data also prevented an assessment of the clinical course of arrhythmias. Therefore, larger, prospective, and multicenter studies are needed to evaluate the diagnostic efficacy of ER systems. Furthermore, advanced studies comparing new-generation mobile ECG technologies, wearable devices, and remote monitoring systems in the pediatric population will contribute to the personalization of diagnostic algorithms based on patient characteristics.

Conclusion

In conclusion, the data obtained in this study demonstrate that the use of ERs in patients presenting with suspected arrhythmia during childhood significantly contributes to the diagnostic process. In children with transient, recurrent symptoms such as palpitations, syncope, and chest pain, conventional diagnostic methods are often inadequate; however, the ER significantly increases diagnostic yield because it can record during symptomatic episodes. In our study, the diagnostic rate increased from 13.1% with 24-hour Holter monitoring to 62.3% with the ER, demonstrating that this method should be used more effectively in pediatric cardiology practice. Considering diagnostic accuracy, patient comfort, and ease of use, ER systems should be considered a priority option, especially for evaluating symptoms that cannot be explained by conventional tests.

Ethics

Ethics Committee Approval: The study was approved by University of Health Sciences Türkiye, Çam and Sakura City Hospital Clinical Research Ethics Committee (decision number: 154, date: 11.05.2022).

Informed Consent: Because of the retrospective design of the study, individual informed consent was waived.

Footnotes

Authorship Contributions

Surgical and Medical Practices: E.Ö., M.H.H.T., İ.C.T., Concept: M.Ö., İ.C.T., Design: E.Ö., İ.C.T., Data Collection or Processing: M.Ö., E.Ö., M.H.H.T., İ.C.T., Analysis or Interpretation: M.Ö., E.Ö., M.H.H.T., Literature Search: M.Ö., İ.C.T., Writing: M.Ö.

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