Analysis of 2017 Holter records in pediatric patients

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Holter monitoring (HM) is widely used in arrhythmic disorders of adult patients; however, studies in the pediatric age group are limited. This study aims to determine the value of HM in diagnosis and treatment of disorders related to arrhythmias in pediatric patients.

We examined 2,017 Holter records of 1,500 children who applied to our institution between November 1994 and October 1998. The age ranged from 0-24 years (52% male, 48% female). The indications for HM were screening for arrhythmic symptoms (palpitation, chest pain, syncope) in 67 percent, monitoring dysrhythmic therapy in 17 percent, postoperative control in five percent, and pacemaker control in four percent. Palpitation is the leading presenting symptom, with more frequent findings of supraventricular extrasystole (SVE), supraventricular tachycardia (SVT), ventricular extrasystole (VE) and complete heart block (CHB) whem compared to other symptoms. Only 5.3 percent of the patients had arrhythmic symptoms during monitoring and asymptomatic patients had more frequent arrhythmias. SVT, VE, and CHB are more frequent findings in the abnormal heart with previous cardiac operations.

The diagnostic yield is low with arrhythmic symptoms in the pediatric age group; however, HM enables cumulative evaluation of heart rhythm and rhythm variability, which is important in diagnosing silent arrhythmias in high risk groups (abnormal heart, postoperative heart).

Key words: childhood arrhythmia, Holter monitoring.

In 1961, Holter[1] used a portable electrocardiorecorder that could record electrocardiogram (ECG) continuously for 10 hours. Since then, ambulatory ECG monitoring has been widely used for many clinical purposes[2,3]. Improvement of the recording quality over the next 10 years, and the diminished size and weight of the recording devices rendered the technique feasible for the pediatric age group as well[3].

Holter monitoring (HM) is one of the most specific and sensitive tools in diagnosis and follow-up of arrhythmias[4]. There are numerous studies on HM concerning adult patients; however, studies in the pediatric age group are limited. Rhythm and conduction disturbances differ in quality and quantity in different age groups. Clinical utility of HM may differ in pediatric and adult patients. We examined the Holter data of our department to investigate the arrhythmia spectrum of the pediatric patients and to determine the value of HM in diagnosis and treatment of these dysrhythmic disorders.

Material and Methods

In this study, 1,500 consecutive pediatric patients with 24-hour Holter records who applied to our institution between November 1994 and October 1998 are included; 2,017 Holter records of these 1,500 patients are reviewed. Del-Mar Avionics™ "Model 459, 3 channel cardiocarder" was used for 24-hour ambulatory ECG recording. The results were interpreted by two experienced pediatric cardiologists, using a computerized analysis program developed by Del-Mar Avionics Holter Systems (Del-Mar Avionics™ Irvine, California, USA). The presenting complaint, physical examination, chest x-ray, ECG, and echocardiographic findings were also studied. Any cardiac catheterization or surgery was especially noted, if present. The patients were

classified into subgroups according to age (newborn-infant: < 2 years; preschool age: ≥ 2 and < 5 years; school age: ≥ 5 and < 10 years; adolescent: ≥ 10 years), and cardiac pathology (patients with normal heart; preoperative congenital heart defect; postoperative congenital heart defect).

The patients or the parents noted any symptoms during HM, specifying in a diary the time and the activity accompanying the symptom.

Computerized statistical analysis program, "SPSS for Windows, version 6" was used for the non-parametric frequency analysis and chi-square tests.

Results

Fifty-two percent of the patients were male, 48 percent female. The age ranged from 0-24 years (mean = 9.96 years, median = 10 years). Only 18 records belonged to patients older than 18 years old (0.09%). The distribution of the patients according to age groups is given in Figure 1. Holter recording time ranged from 8-24 hours (mean = 22.7 hours, standard deviation SD = 2.6).

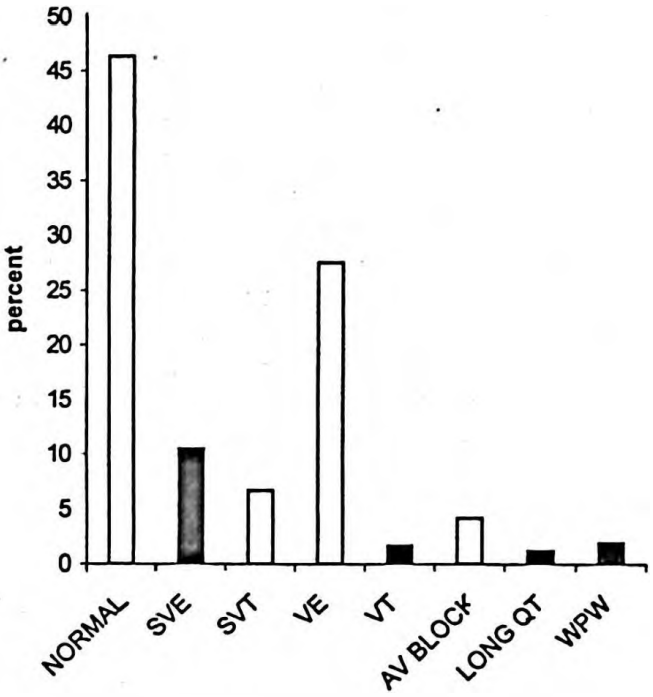

Fig. 2. Results of Holter records.
SVE: supraventricular extrasystole; SVT: supraventricular tachycardia; VE: ventricular extrasystole; VT: ventricular tachycardia; WPW: Wolff-Parkinson-White syndrome.

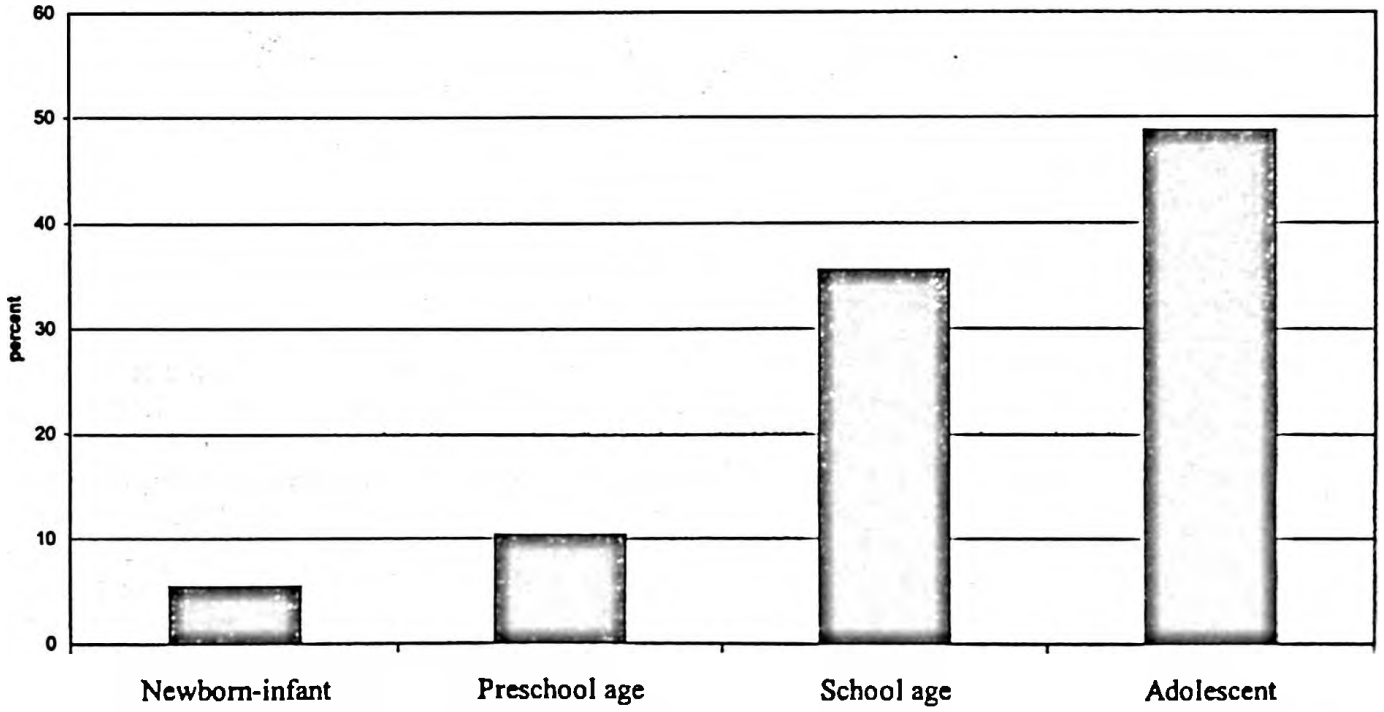

Fig. 1. Distribution of patients according to age groups.

Nearly half of the records were normal (45%). Ventricular extrasystole (VE) was the most frequent arrhythmia (28%), followed by supraventricular extrasystole (SVE) (11%), supraventricular tachycardia (SVT) (7%), and complete heart block (CHB) (4%) in decreasing frequency (Fig. 2).

Presenting Complaint/Clinical Indication for Holter Monitoring

Palpitation, chest pain, and syncope were the symptoms considered as major clinical indications for HM. Other indications included follow-up for pacemaker (PM) functions, known arrhythmias, or cardiac operation. Palpitation

was the leading single presenting complaint in our study group (22%), followed by syncope (10%) and chest pain (9%) (Fig. 3). Girls (50.1%) complained of palpitation more than boys (41.9%) ($p < 0.01$). Frequencies of other complaints were similar in both sexes ($p > 0.05$). More than one complaint refers to having at least two of three main complaints, namely chest pain, palpitation, and syncope. Palpitation was the most frequent postoperative symptom as well (22.1%). Among the postoperative patients, 33.3 percent were asymptomatic after cardiac operation.

Table I. Holter Findings and Associated Presenting Symptom

Holter findings	Associated presenting symptom
SVE	Palpitation
SVT	Palpitation
VE	Palpitation
Complete Heart Block	Palpitation
Long QT Syndrome	Syncope
WPW Syndrome	Not associated
VT	Not associated

SVE : supraventricular extrasystole.
SVT : supraventricular tachycardia.
VE : ventricular extrasystole.
WPW : Wolff-Parkinson-White syndrome.
VT : ventricular tachycardia.

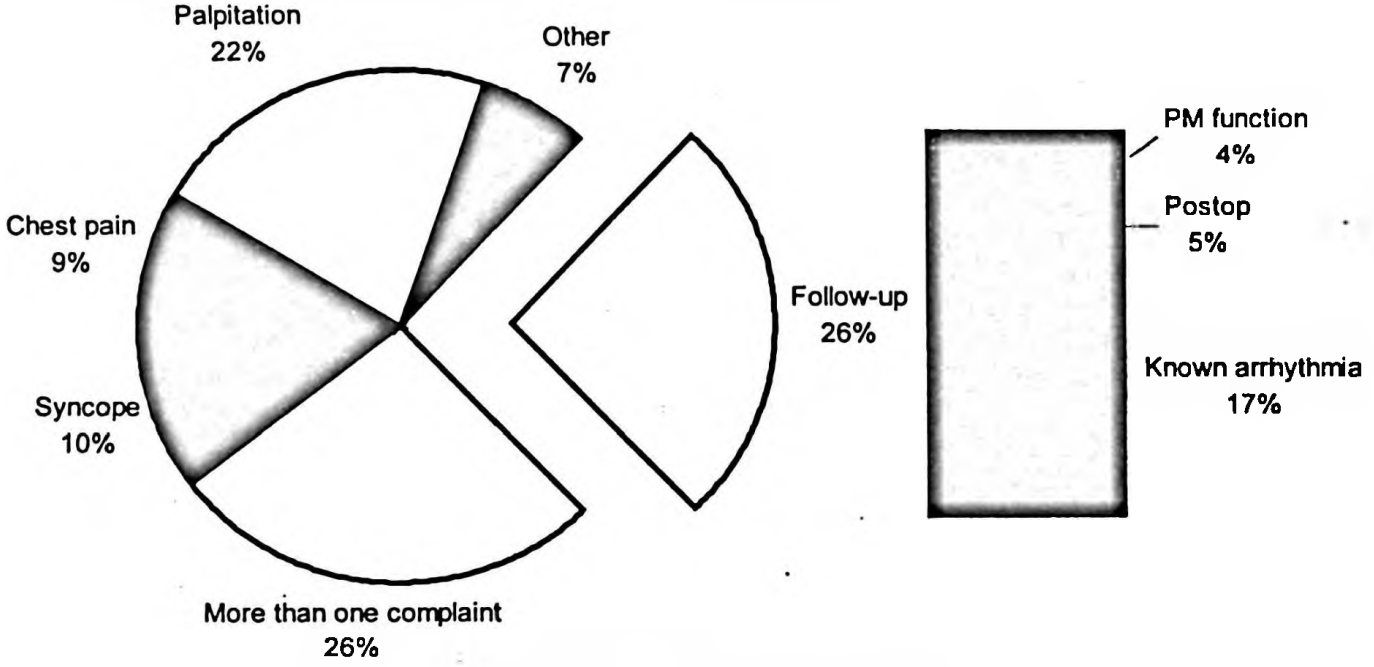

Fig. 3. Presenting complaints. Pm: pacemaker.

Among the patients presenting with palpitation, 71 percent had arrhythmia in their Holter records, whereas the frequencies of arrhythmia in Holter records of patients with syncope and chest pain were 601 and 51.5 percent, respectively. Patients having palpitation had significantly more dysrhythmic findings in their Holter record ($p = 0.012$). The least frequent dysrhythmic findings were noted in Holter records of those with chest pain ($p < 0.01$). SVE, SVT, VE, and CHB were significantly associated with palpitation ($p < 0.019$). Frequencies of these arrhythmias increased when palpitation was associated with syncope ($p < 0.01$). Long QT syndrome (LQTS) was significantly associated with syncope ($p < 0.01$). Wolff-Parkinson-White (WPW) syndrome had ventricular tachycardia (VT) were not significantly associated with any presenting complaint ($p > 0.05$) (Table I).

Patients presenting with symptoms like palpitation, chest pain and/or palpitation, but who did not have known arrhythmia or postoperative heart disease comprised 67 percent of the whole group (1,105 patients). Only 5.3 percent of these had similar complaints during HM, and only 34.8 percent of the 5.3 percent had arrhythmia in their Holter records. The majority of dysrhythmic patients in our study group were asymptomatic (54%) compared to the ones presenting with symptoms (46%). Ninety-one percent of the patients who had symptoms during HM were over eight years old.

Twenty-six percent of our patients (390 patients) did not have any complaint before having a Holter monitoring. HM was done to follow-up known arrhythmias, pm functions, or postoperative patients.

Age Groups

Supraventricular extrasystole (SVE), SVT, VT and CHB were observed most frequently in the newborn-infant age group. The frequencies of these arrhythmias significantly decreased with age ($p < 0.01$). VE was most frequently observed in adolescents. Its frequency increased with age; however, the difference was statistically non-significant ($p = 0.33$) (Fig. 4).

The newborn-infant age group was unique in terms of presenting complaint because this group was comprised of children who were unable to talk or express their complaints; therefore, this group had to be considered separately. Figure 5 summarizes the presenting complaints in newborn-infant group. Children < 2 years old represented only 5.2 percent of the whole group.

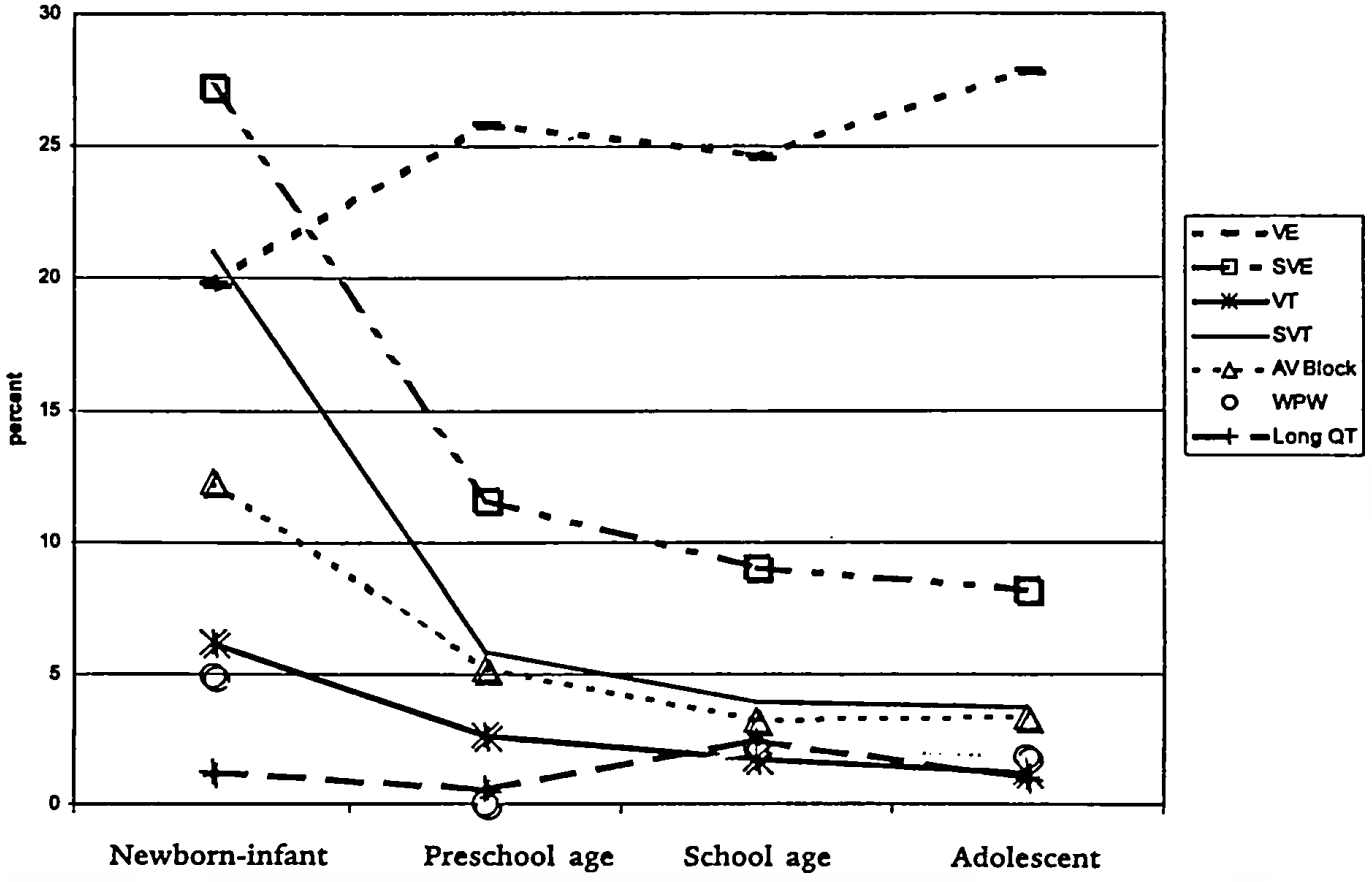

Fig. 4. Holter findings according to age groups.
VE: ventricular extrasystole; SVE: supraventricular extrasystole; VT: ventricular tachycardia; SVT: supraventricular tachycardia; WPW: Wolff-Parkinson-White syndrome.

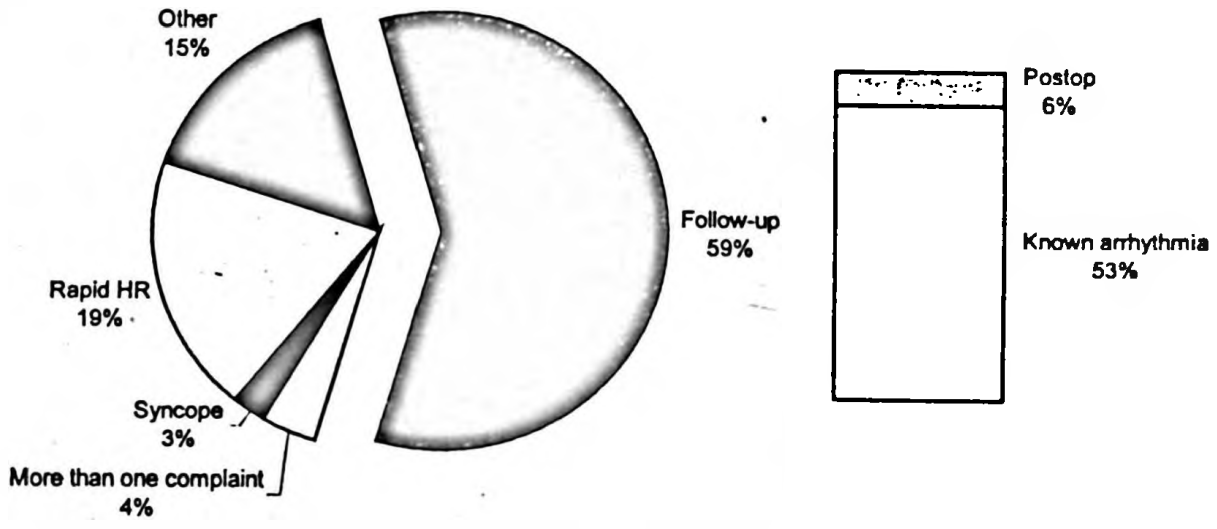

Fig. 5. Presenting complaints in newborn-infant group. HR: heart rate.

Cardiac Pathology

Table II summarizes the Holter finding of our study group in relation to cardiac pathology. VE was the most frequent arrhythmia in all three groups regarding cardiac pathology (normal heart-24.5%, preoperative abnormal heart-31.7%, or postoperative abnormal heart-34.3%). Its frequency was not significantly different in any of the groups. SVT was the most frequent arrhythmia requiring treatment in the normal heart (4.4%). It was observed more frequently in the preoperative abnormal heart (11.6%) than in the normal heart. It was most frequently seen in the postoperative abnormal heart (16.8%) ($p < 0.05$) among all the groups. SVT, VE, and CHB were statistically more frequent findings in the abnormal heart with previous cardiac operations ($p < 0.05$). Although VT was expected to be more frequent in the postoperative abnormal heart, the difference was not significant in any of these groups.

Table II. Holter Findings in Relation to Cardiac Pathology

	Frequency (%)		
Holter findings	Normal heart	Preoperative abnormal heart	Postoperative abnormal heart
SVE	9.6	10.9	13.3
SVT	4.4	11.6	16.8
VE	24.5	31.7	34.3
VT	1.7	3.4	1.5
AV Block	2.9	5.5	8.8
WPW Syndrome	2.1	2.4	0.2
LQT Syndrome	1.5	1.7	0
PM Rhythm	1.5	6.1	25.2
PM Dysfunction	0.1	0.3	8.0

SVE: supraventricular extrasystole; SVT: supraventricular tachycardia; VE: ventricular extrasystole; VT: ventricular tachycardia; AV: atrioventricular; WPW: Wolff-Parkinson-White; LQT: Long-QT; PM: pacemaker.

Postoperative Patients

In our study group, 231 of 1,500 patients had a cardiac operation before a HM. These patients had more frequent SVE, SVT, VE and CHB in Holter records than the ones without cardiac operations ($p < 0.05$) (Table II). On the other hand, WPW syndrome and LQTS were less frequent in this group ($p < 0.05$), and the frequency of VT was similar in both groups ($p > 0.05$). The frequency of arrhythmias was similar between the types of operation, namely atriotomy, ventriculotomy, atrioventriculotomy, aortotomy, and pulmonary arteriotomy, with the exception of the left ventriculotomy, which as more frequently associated with VT (statistically insignificant; $p = 0.23$).

Among the postoperative patients, those who were younger and without symptoms, and those who presented in the early postoperative period had more dysrhythmic findings in their Holter records ($p < 0.05$) (data not shown). CHB was observed mostly in the first 15 days postoperatively (before the patient was discharged from the hospital). Its frequency decreased as the follow-up period increased ($p < 0.05$). SVE was observed least frequently in the first 15 days postoperatively, and its frequency increased as the follow-up period increased ($p < 0.05$) (Table III).

Table III. Holter Findings in Postoperative Period

	Frequency (%)			
Holter findings	1st 15 days	1st 15 days-1st month	1st month-1st Year	>1 Year
SVE	4.5	9.7	18.9	22.5
SVT	8.1	3.2	14.7	20.7
VE	32	25.8	27.3	45.9
VT	0.9	0	4.2	0.9
AV Block	16.1	9.7	8.4	2.7
WPW Syndrome	0	0	0	0
LQT syndrome	0	0	0	0
PM Rhythm	57.5	25.8	33.3	7.2
PM Dysfunction	18.6	19.4	6.3	0

SVE: supraventricular extrasystole; SVT: supraventricular tachycardia; VE: ventricular extrasystole; VT: ventricular tachycardia; AV: atrioventricular; WPW: Wolff-Parkinson-White; LQT: Long-QT; PM: pacemaker.

Discussion

Clinical indications for Holter monitoring are different in pediatric and adult patients; however, the most frequent and common indication in both groups is the investigation of arrhythmic symptoms like palpitation, chest pain, and syncope[5]. In many clinical studies it is difficult to associate symptoms with arrhythmias, since serious arrhythmias are frequently observed in asymptomatic patients[6,7]. HM has a low diagnostic yield in explaining arrhythmic symptoms of adult patients[2,8-12]. If the symptoms occur every day, the possibility of recording arrhythmia during HM is very high; however, if they occur less frequently, transtelephonic ECG (TTECG) or electrophysiological study (EPS)

may be necessary. Especially TTECG has an advantage over HM since it selectively records the time of the event and therefore the overall recording time is longer than with HM. There are a few studies in literature comparing the results of HM and EPS; practically, the data obtained via these procedures are complementary[13,14].

Although patients with symptoms like palpitation, chest pain and/or syncope comprised the majority (67%) of our study group, only a small portion (5.3%) of these had similar complaints during HM. Less than half (34.8%) of the patients complaining of palpitation, chest pain, or syncope during HM had arrhythmia in Holter records. This suggests that the intervals of arrhythmic symptoms are widely set apart in pediatric patients. Therefore, HM has a low diagnostic yield in pediatric patients. Young children are usually unable to describe subjective symptoms like palpitation and chest pain. In our study group, patients having no arrhythmic symptoms before or during HM had more frequent arrhythmias than the ones with symptoms. HM enables cumulative evaluation of heart rhythm, which is important in diagnosing silent arrhythmias in high-risk groups like patients with abnormal heart or in postoperative patients.

The frequency and the type of rhythm and conduction disturbances vary with the age of the patient. Cardiac arrhythmias, especially VE, increases with age[3,15,16]. Although statistically insignificant, the frequency of VE increased with age in our group. On the other hand, SVE, SVT, VT, CHB are observed most frequently in the newborn-infant group and frequency of these arrhythmias significantly decreases with age. SVT and WPW syndrome are self-limited in the newborn period. The first dysrhythmic episode may be observed shortly after birth and even if left untreated, no further episodes may be observed at older age. WPW syndrome may be asymptomatic until the 6th decade, and asymptomatic WPW syndrome is frequent in family members of symptomatic patients[17,18]. Since the first symptom of WPW syndrome may be sudden death, it is appropriate to screen the asymptomatic members of the family whenever a patient with WPW syndrome is identified.

The diagnostic value of HM is not well known in asymptomatic arrhythmia[2]. The "premature ventricular contraction hypothesis" briefly proposes that certain frequencies and forms of VE, even if the patient is asymptomatic, predict the occurrence of sustained ventricular arrhythmias. The corollary to this hypothesis is that suppression of these VE's will protect patients from episodes of sustained arrhythmia, and prolong life[19]. Non-sustained VT and sinus pause may stay asymptomatic for a long time[20,21]. In a study concerning healthy middle aged adults, death within five years was more frequent in those having more than 10 VE per 1,000 beats; however, the reason of death was not stated in the study[15]. In another study of adults over 65 years old, patients having more than 100 VE per day, multifocal VE's, or more than 1.5 second sinus pause had higher risk of dying due to cardiac reasons[16]. These two studies seem to support the "premature ventricular contraction hypothesis". There is no randomized controlled study in the pediatric age group verifying this hypothesis. Furthermore, many other studies have shown that medical treatment of asymptomatic patients does not increase survival, and that cases of frequent or complex SVE or VE have a relatively good prognosis in the long-term follow-up if they are not associated with cardiac disorders[2,15]. The negative inotropic and proarrhythmic effects of many antiarrhythmic drugs are well known. In our study group, as VE increased with age, VT was most frequently observed in the newborn-infant age group and decreased with age. This finding conflicts with the "premature ventricular contraction hypothesis"; before, the asymptomatic arrhythmias must be treated in otherwise healthy people, considering the severity of arrhythmia, associated cardiac pathology, and frequency of similar arrhythmias[2].

In the pediatric age group, VT is not frequent and is usually associated with congenital cardiac anomalies, cardiac tumors, cardiomyopathy, or myocarditis. When VT is seen in an anatomically normal heart, it is referred to as "idiopathic VT"[22]. The most frequent arrhythmia requiring treatment in a normal heart is SVT[23,24]. This was true for the patients in our study group as well. SVT, VE and CHB are more frequent in structural heart disease compared to normal heart ($p < 0.01$). However, the frequency of VT is not different in the normal or abnormal heart ($p > 0.05$).

Early and late arrhythmias seen in patients undergoing cardiac surgery impose important

problems. During intracardiac repair cannulation, ventriculotomy/atriotomy incision and sutures may damage the conduction system, or the scar tissue may act as a focus of increased automaticity. Atrial switch operations like Senning and Mustard, total correction for tetralogy of Fallot and Fontan operations carry high-risk for postoperative arrhythmias. The frequency of arrhythmia and the risk of sudden death increase with older age at operation, residual hemodynamic disorder, symptoms suggesting arrhythmia, and in the late postoperative period[25,26].

Postoperatively, 33 percent of the patients are asymptomatic. Those having symptoms mostly presented in the late postoperative period with palpitation. In our patient group, those who were asymptomatic had more frequent abnormal Holter records ($p < 0.01$). In our institution, routine repeated HM is done after procedures like total correction of tetrology of Fallot, Senning and Mustard operations for transposition of the great arteries, or palliation for complex cardiac pathologies during follow-up of postoperative patients, even if the patient is asymptomatic. Therefore, the asymptomatic arrhythmias are recognized earlier and more frequently. CHB is more frequenct in the immediate postoperative period and its frequency decreases as the follow-up period increases. Most of the CHB seen after cardiac operations are transient; the permanent ones are treated with pacemakers. Therefore, the frequency of CHB decreases in the follow-up period. Postoperative syncope is most frequently associated with abnormal Holter findings (100%). The least frequent arrhythmia-associated symptom is chest pain (60%) ($p = 0.01$).

Holter monitoring has not been used for risk evaluation or to determine myocardial ischemia in children with arrhythmias. Our retrospective study was not informative in this field. On the other hand, HM is effective in investigating asymptomatic arrhythmias in high-risk pediatric patients (congenital heart disease and postoperative patients). It is useful in monitoring antiarrhythmic therapy and pacemaker functions. HM has a low diagnostic yield in associating symptoms like palpitation, syncope and chest pain with arrhythmia in children.

Holter monitoring (HM) is a non invasive technique with no complications, is a relatively cheap procedure compared to other procedures like EPS or TTECG, and it can be applied in out patient settings to patients of any age. Since HM enables cumulative analysis of heart rhythm and rhythm variability, it has advantages over other techniques. It should be the first line diagnostic tool in investigating known and suspected arrhythmias of children.

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