

ВИПАДКИ З ПРАКТИКИ

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DAILY HOLTER ECG MONITORING IN THE DIAGNOSTIC ALGORITHM OF HEART RHYTHM AND CONDUCTION DISORDERS IN CHILDREN AND ADOLESCENTS

Summary

Recent years have seen an increase in the prevalence of cardiac arrhythmias and conduction disorders in children, which are not always diagnosed in time. In order to verify the nature of arrhythmias in pediatrics as well as in therapy, an accessible and informative method of daily Holter ECG monitoring (DHECGM) is widely used.

Aim of the study was to assess the practical value of DHECGM in the algorithm for diagnosing heart rhythm and conduction disorders in pediatric patients.

Materials and Methods: Analysis of DHECGM was performed in 48 children who were hospitalized in the pediatric department of the Specialized Pediatric Care Center (SPCC) of the Poltava Regional Clinical Hospital (PRCH) in 2022-2023.

Research results. Sinus tachyarrhythmia or bradyarrhythmia, wandering atrial pacemaker was detected in half of the patients studied. Supraventricular and/or ventricular extrasystoles were detected in 87.5 % of children. Bi-, tri- and quadrigeminy were observed in 14 (27.1 %) of the patients. First or second degree sinoatrial block was observed in 25 % of patients. Atrioventricular block of 1st or 2nd degree (Mobitz type) with Wenkenbach-Samoilov periods was observed in 8 patients (16.6 %). Combined rhythm and conduction disturbances were observed in 82.3 % of the children studied. The article is illustrated by clinical cases of cardiac rhythm and conduction disorders in children of different ages.

Conclusions: DHECGM has broad capabilities for diagnosing cardiac rhythm and conduction abnormalities, allowing early detection of arrhythmias in pediatric patients and providing personalized recommendations.

Key words: Arrhythmias; Conduction; Heart; Daily Holter monitoring; ECG; Children.

Introduction

Cardiac arrhythmias occupy a leading position in the structure of cardiac morbidity and mortality in children [1,3,12]. In recent years, there has been a clear trend toward an increase in the prevalence of arrhythmias in the pediatric population, a diversification of their forms, and the difficulty of timely diagnosis [2,4,5]. The greatest risk of arrhythmias occurs during the neonatal period. Therefore, it is necessary and important to study cardiac rhythm and conduction disorders in newborns, not only with the aim of reducing perinatal losses, but also to prevent the development of complications in older children [6,19,20].

Cardiac arrhythmias can occur as a separate pathology, complicating the course of other diseases of cardiac and non-cardiac genesis and acquiring the status of a leading syndrome [8,9,21]. The development of rhythm and conduction disorders is typical for newborns and children aged 6-8 years, as well as 12-16 year-old adolescents, which can be caused by disorders of the autonomic nervous system [15,22,24].

In contrast to adults [11,13], arrhythmias in children often develop without clinical manifestations and can occur even in healthy individuals [26]. Often, the child's well-being is not affected for a long time, which complicates the timely diagnosis of this pathology and does not allow to accurately determine the duration of the patient's arrhythmia [4,5]. In the absence of timely and adequate therapy for 4-6 years, most arrhythmias progress, while stable and irreversible disorders of myocardial function are formed, requiring surgical treatment. At the same time, more than 85 % of children can be cured with medication if treatment is started in time [7,27]. In addition to their own value, cardiac arrhythmias can complicate the course of other diseases and assume the role of a leading syndrome. It is extremely important to

diagnose cardiac arrhythmias in children and adolescents in time in order to prevent a more severe course and the development of complications. Therefore, it is appropriate to make electrocardiographic (ECG) screening mandatory for children of this age group within the framework of medical supervision, and in the presence of even minimal cardiologic complaints it is necessary to prescribe DHECGM [3,9,10].

DHECGM is a modern instrumental method of informative, non-invasive and accessible diagnosis of cardiac arrhythmias in pediatric practice, named in honor of the American researcher Norman Holter, who introduced radioelectrocardiography and performed the first long-term ECG registration [14].

DHECGM is a long-term recording of the patient's ECG during daily activities and is widely used in both clinical and outpatient settings [12,18,21]. The advantages of this method, given its non-invasiveness and physiological nature, can be considered the absence of age restrictions and contraindications for its use [6,9,19].

DHECGM recording time is 24-48 hours or longer, and the patient leads a normal lifestyle and exercise regime. During the procedure, the patient or his parents keep a diary in which they record all types of activities (sleep, physical activity, stress), the time of beginning and end of subjective sensations experienced by the patient (heart pain, palpitations, shortness of breath, etc.), and also indicate the time of taking medications. Later, the doctor gets acquainted with the results of automatic analysis presented by the program and carefully reviews the events selected by the computer, such as deviations of rhythm and repolarization processes, comparing the obtained changes with the marks in the patient's diary [8,26].

DHECGM is also recommended to evaluate the efficacy of antiarrhythmic therapy in children [3,21,27]. When re-examined after long-term therapy, it is mandatory to

compare it with the first recording of DHECGM before the start of medication [2,10,28].

According to the literature, the absolute indications for performing DHECGM in children are as follows [1,2].

1. Syncope/pre-syncope or dizziness in children with established heart disease, previously documented arrhythmia, implanted pacemaker.
2. Cause of syncope/pre-syncope associated with physical exertion not determined by other investigational methods.
3. Hypertrophic and dilated cardiomyopathy.
4. Probable or documented long QT interval syndrome.
5. Palpitations in patients who have undergone surgery for congenital heart disease and have significant residual hemodynamic abnormalities.
6. Children closely related to those who died of sudden infant death syndrome and Brugada syndrome.
7. Evaluation of the effectiveness of antiarrhythmic therapy during the period of rapid somatic growth of the patient.
8. Asymptomatic congenital total AV block in patients without pacemakers.

As for relative indications, they include:

1. Assessment of pacemaker response to changes in heart rate in patients with clinical symptoms of arrhythmia.
2. Assessment of the condition of an asymptomatic patient after surgical intervention for congenital heart disease, especially in the case of hemodynamic disorders, high risk of developing late postoperative arrhythmias.
3. Detection of recurrence of arrhythmias in children in the first 3 years of life with a history of tachyarrhythmia.
4. Suspicion of persistent atrial tachycardia.
5. Detection of ectopic ventricular complexes during ECG or exercise testing.

A major advantage of DHECGM is the ability to quantitatively assess cardiac rhythm and conduction abnormalities and their distribution during the day [15,29]. The nocturnal circadian type of arrhythmia indicates its dependence on the vagus nerve, and the daytime type indicates its sympathetic nature. Patients with mixed circadian type of arrhythmia and frequent extrasystoles (more than 1000 extrasystoles per day) have the highest risk of developing arrhythmogenic ventricular dilatation [10].

In order to evaluate the diagnostic value of 24-hour Holter ECG monitoring in the detection of cardiac rhythm and conduction disorders, we performed a DHECGM analysis of 48 children who were hospitalized in the pediatric department of the Specialized Pediatric Care Center (SPCC) of the Poltava Regional Clinical Hospital (PRCH) in 2022-2023.

The majority of patients (62.5 %) complained of pain, a feeling of arrhythmia and palpitations. In addition, syncope was observed in 4 children (8.3 %), more often provoked by physical or emotional stress. At the same time, every third child (37.5 %) had no complaints. Sinus rhythm was observed in most patients, but atrial rhythm was detected in 25 % of children. Automaticity disorders in the form of sinus tachyarrhythmia or bradyarrhythmia, wandering atrial pacemaker were detected in half of the patients. The most frequent supraventricular and/or ventricular extrasystoles with different quantitative characteristics were registered by DHECGM in 87.5 % of children, and allorhythmic polytopic extrasystoles of bi-, tri-, and quadrigeminal type were observed in 14 (27.1 %) patients. Cardiac conduction disorders were detected in 12 (25 %) patients in the form of

sinoatrial block (SA block) of the 1st or 2nd degree (8.3 %), and in 8 (16.6 %) children atrioventricular block (AV block) of the 1st or 2nd degree (Mobitz type) with Samoilo-Wenckenbach periods was detected. In 6 children (12.5 %) the ECG showed a shortening of the PQ interval and in 3 (6.2 %) of the examined children a prolongation of the QT interval above the age norms. It should be noted that almost all patients had combined cardiac dysfunction and autonomic nervous system dysfunction, which explains the frequency of rhythm disturbances, especially in adolescents [2,3,15].

The diagnostic value of the DHECGM method in the detection of cardiac rhythm and conduction disorders is beyond doubt. Even in patients in our study who had no symptoms and minimal changes on the ECG at rest, DHECGM revealed significant cardiac conduction abnormalities that required not only further monitoring, but also recommendations for daily routine and further treatment.

Therefore, it is necessary to remember the possibilities and practical significance of the DHECGM method in detecting heart rhythm and conduction disorders in pediatric patients, which is clearly demonstrated by the following clinical cases.

A 16-year-old boy was hospitalized in the department with complaints of periodic pain in the heart area and behind the sternum, shortness of breath during physical activity, and rapid fatigue. From the medical history it is known that the child has been attending the freestyle wrestling section for more than two years. During another training session, the boy lost consciousness. He was taken by ambulance to the pediatric unit of the SPCC at PRCH. The boy underwent a complete clinical, laboratory (complete blood count, biochemical blood markers) and instrumental examination (ECG, rhythmogram (RG), orthostatic test (OT), echocardiogram) with the aim of differential diagnosis of the type of myocardial damage.

The patient's ECG showed pronounced sinus bradyarrhythmia, first-degree AV block, episodes of isometric AV dissociation. Echocardiography revealed a first-degree prolapse of the anterior leaflet of the mitral valve, an additional chord of the left ventricle. Taking into account the anamnesis and ECG data, the boy underwent DHECGM, which revealed the following changes: sinus rhythm was registered during the day, pronounced bradyarrhythmia with heart rate of 56 in 1 minute, episodes of wandering atrial pacemaker. First-degree atrioventricular block was detected, as well as 71 episodes of atrioventricular block progression to the second degree of the second type (Mobitz II) with frequent Samoilo-Wenckenbach periods. Supraventricular and ventricular ectopic activity was not recorded. Circadian index increased to 1.72. Tolerance to physical activity is below average. Moderate signs of autonomic dysregulation due to the parasympathetic component.

The diagnosis was made: II degree AV block (Mobitz type II) with Samoilo-Wenckenbach periods. 1st degree mitral valve prolapse.

Taking into account the complaints of syncope and the detection of significant disturbances of conduction function on the DHECGM (2nd degree AV block) in order to exclude Morgagni-Adams-Stokes attacks, the patient was sent for consultation to the arthrologist of the National M. M. Amosov Institute of Cardiovascular Surgery of NAMS of Ukraine to clarify the diagnosis and recommendations for further observation and treatment.

After the consultation, the diagnosis made in the pediatric department was confirmed. Recommendations were given

regarding the exclusion of sports, therapy according to the treatment protocol, dynamic monitoring of the young man with a mandatory repeat of DHECGM in 6 months.

A 17-year-old boy is hospitalized in the pediatric department of the SPCC with no complaints. It is known from the medical history that during a routine examination the adolescent had ECG changes in the form of frequent ventricular extrasystoles. A complete clinical and laboratory examination was performed, which allowed to exclude inflammatory changes in the patient. During instrumental examination of ECG and RG, ventricular extrasystoles of trigeminal type were observed, which persisted during RG and OT. Considering the pronounced changes in the ECG, the boy underwent DHECGM, which revealed more significant changes: during the day, sinus rhythm was recorded with episodes of wandering atrial pacemaker, non-persistent AV block of the first degree was detected, as well as episodes of progression of AV block to the second degree of type I (Mobitz I) with Samoilov-Wenkenbach periods. Polytopic ectopic activity was registered – 163 isolated supraventricular extrasystoles, as well as ventricular ectopic activity in pathological amounts with signs of parasympathetic activity: a total of 5636 isolated ventricular extrasystoles, mainly during the day. The circadian index is within the age-related norm of 1.37. Exercise tolerance is below average. Signs of autonomic nervous system dysfunction were noted.

In the presented case, at the time of registration of DHECGM, the patient had progression of rhythm and conduction disturbances in the form of increase in pathological number of ventricular extrasystoles, development of supraventricular extrasystoles and conduction disturbances in the form of second-degree AV block (Mobitz type I) with Samoilov-Wenkenbach periods. Diagnosis: Frequent polytopic extrasystoles (supraventricular, ventricular). Second degree AV block (Mobitz type I) with Samoilov-Wenkenbach periods.

Given the progression of changes in the DHECGM, the patient must exclude physical activity, appropriate treatment according to the protocol and consultation of an arrhythmologist in a specialized medical institution.

A 10-year-old boy was hospitalized in the pediatric department with complaints of compressive pain in the heart, palpitations, syncope, and severe weakness. From the medical history it is known that he had ARVI two weeks ago, after which he developed syncope and general weakness.

The inpatient examination revealed inflammatory changes in the general blood count: leukocytosis up to 11.2×10^9 , an increase in band neutrophils up to 8 %, a decrease in hemoglobin to 106 mm/h, an increase in ESR to 18 mm/h. A biochemical blood test showed an increase in C-reactive protein (> 6 mg/L). The ECG showed sinus tachycardia, WPW syndrome, prolongation of the QT interval, and impaired repolarization processes in the left ventricle. The WPW syndrome was preserved on the ECG during OT. Echocardiography revealed the following changes: EDD 6.1 cm, EDV 188 mm, ESD 4.5 cm, ESV 92 mm, enlarged left ventricular cavity, paradoxical movement of IVS, hypokinesis up to 3 mm. Ejection fraction (EF) and contractile function (CF) were reduced (51 % and 26 %, respectively) and left ventricular trabecularity was increased.

A pronounced sinus tachycardia (heart rate up to 125 per 1 minute) was noted on the DHECGM, and the WPW syndrome was noted during the day. Circadian index was increased to 1.65. The tolerance to physical activity is low.

On the basis of detected inflammatory changes, according to the results of laboratory and instrumental methods of examination, the diagnosis was made: non-rheumatic carditis with cardiac dysrhythmia, acute course. WPW syndrome. Cardiomyopathy?

Taking into account the clinical laboratory data and the results of ECG, ECHO, DHECGM, the patient was referred for consultation with a cardiac surgeon at the Heart Institute of the Ministry of Health of Ukraine to clarify the diagnosis and further treatment. At the Heart Institute, the child underwent an ECHO, which also revealed an increase in the left ventricular cavity and a decrease in myocardial contractility (EF 49 %), typical of congenital pathology.

At the Scientific and Practical Center of Pediatric Cardiology and Cardiac Surgery, the boy underwent cardiac MRI with intravenous contrast for diagnostic purposes, which allowed to confirm the diagnosis of dilated cardiomyopathy.

The cardiac surgeon made a consultative conclusion: dilated cardiomyopathy. Paradoxical motion of the interventricular septum. Decreased contractile function of the left ventricle. Moderate physical activity was recommended to the patient, and a geneticist's consultation with the patient and his parents was mandatory to identify the hereditary form of this myocardial pathology.

This case demonstrates the complexity of clinical diagnosis of this disease and confirms the conclusion that cardiac rhythm and conduction disorders can occur not only randomly and in the absence of cardiac complaints, but can also be organic and even congenital.

Genetic testing at the Center for Medical Genetics revealed the presence of a pathogenic gene for hemochromatosis in the boy and his mother (the father is healthy).

Hemochromatosis is a hereditary genetic disease with variable clinical manifestations in which the human body begins to accumulate iron from food. The disease is transmitted in an autosomal recessive manner and is associated with the homozygous C2832Y gene. Iron overload in hemochromatosis significantly affects the cardiovascular system, which can lead to heart failure and mortality. Literature data indicate cardiovascular manifestations of hemochromatosis such as dilated cardiomyopathy, conduction disorders, heart failure, cardiac fibrosis, myocardial infarction, and valvular heart disease [17,25].

Considering the presence of a hereditary form of this genetic pathology, the patient was tested for iron and ferritin levels in blood serum: iron was 53.0 mmol/L; ferritin 73.10 ng/ml (within normal limits). According to the literature, iron and ferritin levels correlate with the severity of myocardial damage and may be markers of heart failure [23]. Early detection of this pathology in a patient may prevent complications and improve the prognosis of the disease.

Conclusions

The above clinical examples demonstrate the complexity of the algorithm for diagnosing cardiac rhythm and conduction disorders in pediatric patients, who sometimes have no cardiovascular complaints and do not seek medical care from cardiovascular specialists. At the same time, the problem of arrhythmias and their causes is characterized by a significant prevalence and the need for timely diagnosis and individualized correction. The management of such patients requires an integrated approach involving various

specialists and a reasonable expansion of the laboratory and instrumental examination panel.

Conflict of Interests. The authors have no conflicts of interest to declare.

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ДОБОВЕ ХОЛТЕРІВСЬКЕ МОНИТОРУВАННЯ ЕКГ В АЛГОРИТМІ ДІАГНОСТИКИ ПОРУШЕНЬ СЕРЦЕВОГО РИТМУ ТА ПРОВІДНОСТІ У ДІТЕЙ ТА ПІДЛІТКІВ

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Резюме.

Останні роки характеризуються зростанням поширеності порушень серцевого ритму та провідності серед дитячого населення, які не завжди своєчасно діагностуються. З метою верифікації характеру аритмій в педіатрії, як і в терапії, широко використовуються доступний та інформативний метод добового холтер-моніторингу ЕКГ (ДХМ ЕКГ).

Метою роботи була оцінка практичного значення добового холтерівського моніторингу ЕКГ в алгоритмі діагностики порушень серцевого ритму та провідності у педіатричних хворих.

Матеріали і методи дослідження: Проведено аналіз ДХМ ЕКГ 48 дітям, які знаходились на стаціонарному лікуванні у педіатричному відділенні центру спеціалізованої педіатричної допомоги (ЦСПД) Полтавської обласної клінічної лікарні (ПОКЛ) в період 2022-2023 років.

Результати дослідження. Синусна тахі- або брадиаритмія, міграція водія ритму по передсердям визначалась у половини обстежених. Суправентрикулярна і/або шлуночкова екстрасистоля реєструвалась у 87,5 % дітей. У 14 (27,1 %) обстежених спостерігалась екстрасистоля по типу бі-, три- та квадригемінії. У 25 % хворих виявлена синоатріальна блокада I або II ступеня. Атріовентрикулярна блокада I або II ступеня (тип Мобітз) з періодами Самойлова-Венкенбаха зареєстрована у 8 (16,6 %). Поєднані порушення серцевого ритму та провідності спостерігались у 82,3 % обстежених.

Стаття проілюстрована клінічними випадками порушень ритму серця та провідності у дітей різного віку.

Висновки. ДХМ ЕКГ має широкі можливості в діагностиці порушень ритму та провідної функції серця, що дозволяє своєчасно виявляти аритмії у педіатричних пацієнтів та надавати персоналізовані рекомендації.

Ключові слова: аритмії; провідність; серце; добовий холтер-моніторинг; ЕКГ; діти.

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