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Modern Methods of Functional Diagnostics in Pediatric Practice

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Abstract: The study of the functional ability of a particular organ is important when examining both an adult patient and a child. Functional methods allow you to answer a number of questions. Firstly, the results of the study are used to judge how the disease affects the function of an organ or system. Secondly, based on certain parameters, we can judge the compensatory capabilities of the body. Thirdly, by testing with medications or some other influences (physiotherapy, physical activity, etc.), we help the patient select an adequate treatment and regimen. And finally, by conducting dynamic monitoring of the patient with repeated functional examination, the doctor can judge the effectiveness of treatment, carry out timely correction of treatment and rehabilitation measures, and often predict the course of the disease.

Key points: modern methods of functional diagnostics, children.

Methods for diagnosing respiratory function disorders (ERF) have become widely used in pediatric practice only in the last decade. In Russia, as throughout the world, there is an increase in allergic diseases, and primarily bronchial asthma (BA). According to a number of authors, 5–7% of the population or more suffer from asthma [1, 2]. In our country, not only is there a quantitative increase in the incidence of asthma among children, but also the number of severe asthma is increasing, and the mortality rate from this disease is also increasing. In 1997, the National Program "Bronchial Asthma in Children. Treatment Strategy and Prevention" was adopted. According to this program, along with the data of a clinical examination, an important role is given to the results of the study of respiratory function in diagnosing the disease, determining the severity of asthma and its exacerbation [3]. Among the methods for studying the lungs, spirometry and pneumotachometry are the most common. Both methods are used in numerous instruments that record the forced expiratory flow-volume curve of the vital capacity of the lungs. Work on any of the devices must necessarily begin with its calibration (daily and in the case of replacing the pneumotachographic grid or the entire sensor).

FVD studies are carried out under conditions of relative rest, 1.5 - 2 hours after eating. It is possible to objectively assess the parameters of respiratory function in children over 6 years of age, since younger patients are not able to methodically correctly perform deep forced exhalation. To achieve cooperation with the child, you can invite several children into the office at the same time and start the study with a patient who is familiar with this procedure. Often the presence of a parent helps to conduct an examination of the child.

Among the disorders of the ventilation function of the lungs, obstructive and restrictive disorders, as well as their combination, are distinguished. Obstructive disorders are caused by changes in bronchial patency, and restrictive disorders are caused by changes in pulmonary compliance. The diagnostic criteria for respiratory function disorders are described in detail in many works [4,5,6]. Most often (about 70%) obstructive disorders are detected and tests with dosed inhaled bronchodilators are used to determine their reversibility. When conducting them, it is important to observe the following conditions: 1) it is necessary to stop taking bronchodilators 12 hours before

the study; 2) inhalation is carried out through a spacer; 3) children under 7 years of age should be given one inhalation; those over this age should be given two inhalations with an interval of 15 seconds.

It is better to assess the bronchodilator response by the dynamics of the forced expiratory volume in 1 s (FEV1), since this indicator has the highest reproducibility. According to our data, a test should be considered positive if the FEV1 value has increased by 150 ml, or by 12% or more relative to the initial value. The ideal is to conduct a bronchodilator test, taking into account reproducibility in a particular patient, but this doubles the time for examining the child and is not acceptable in everyday practice**.** The study of bronchial hyperreactivity with bronchoconstrictors (acetylcholine, methacholine, histamine) should be carried out only if there are specially trained personnel and the room is equipped with everything necessary to eliminate induced bronchospasm. In asthma, exercise testing is often performed to detect post-exertional bronchospasm (PEB). However, it is possible to judge PNB only in cases where physical activity is precisely dosed (using a bicycle ergometer or treadmill).

Peak flowmetry is another method of functional diagnostics, widely used for monitoring BA, and is described in detail in the National Program [3]. Assessment of maximum expiratory flow (MEF) should be carried out individually. The best MPV result with good respiratory function indicators, according to the flow-volume curve obtained outside of an exacerbation of the disease, is considered as a normal MPV value for a particular patient.

Diagnosis of restrictive ventilation disorders is possible only by determining the structure of the total lung capacity (TLC) using the method of general plethysmography or the method of diluting an inert gas (usually helium) in a closed system. Large diagnostic centers and pulmonology hospitals should be equipped with these devices. Restrictive disorders are diagnosed in 17% of patients with chronic bronchopulmonary diseases (CBPD), such as idiopathic pulmonary fibrosis (IPF), chronic exogenous allergic pulmonary alveolitis (EAP), and lung damage in children with congenital immunodeficiency conditions.

In contrast to adults, approximately 13% of children with chronic pulmonary disease have no disturbances in the ventilation function of the lungs during the study of respiratory function. This is explained by the high compensatory abilities of the child's body, the continuing development of the bronchopulmonary system during the period of life up to 8 years, while the formation of chronic pulmonary disease occurs mainly in the first 3 - 4 years of life. However, in these patients, it is possible to detect, using mass spectrometry, capno- and oxigraphy, disturbances in the distribution of ventilation and perfusion and uneven ventilation-perfusion relationships in the lungs.

Great diagnostic capabilities are offered by a new method - the pulse oscillometry method (IOS) [7,8], which characterizes the mechanical properties of the ventilation apparatus as a whole in response to external vibrations during quiet breathing of the patient. According to research data [9] and our observations, the IOS method allows us to diagnose the nature of ventilation disorders, establish obstruction of the central, peripheral airways and airways located outside the chest.

In chronic and recurrent lung diseases in children, the circulatory system, which is functionally closely connected with the respiratory system, is often involved in the pathological process. Early recognition of disturbances in the activity of the heart in chronic lung pathology in children (IPF, EAA, cystic fibrosis, etc.) is of great importance for the timely diagnosis of pulmonary hypertension, appropriate and successful treatment of cardiovascular disorders. That is why such patients should undergo an ECG examination and cardiac echocardiography (EchoCG) at least once a year.

Functional diagnostic methods in cardiology

The main methods of instrumental research in the field of non-invasive electrocardiology are: standard ECG, Holter monitoring (HM ECG), other technologies for studying the electrical field of the heart, 24-hour blood pressure monitoring.

Electrocardiography is a method of studying the heart that does not lose its importance over time. The method remains one of the most common and integral methods of cardiac diagnostics and continues to develop and improve. In order to objectify the assessment of the state of the cardiovascular system, ECG has been introduced into the practice of medical examination of children. In some cases, it is advisable to connect an ECG during stress tests. This is all the more relevant due to the growing number of children suffering from cardiovascular diseases. Without solving the problem of prevention, early detection and treatment of cardiac pathology in childhood, it is impossible to solve the problem of morbidity in adults. The structure of cardiovascular pathology in childhood has undergone significant changes over the past decades. The proportion of heart rhythm disorders, cardiomyopathies, and congenital heart defects has increased [10].

In recent years, the problem of connective tissue dysplasia of the heart (CDTS), the most common manifestations of which are abnormally located chords and mitral valve prolapse, has attracted close attention. This is due to the high frequency of their detection in the population and the high risk of developing cardiac rhythm and conduction disorders [11]. Our observations indicate that the degree and nature of heart rhythm disturbances depend on the presence and characteristics of microstructural abnormalities of the heart and are more pronounced when they are combined. Changes detected in these children on the ECG may relate to both heart rhythm disturbances and repolarization processes. The heterogeneity of clinical and functional manifestations of STS in children dictates the need for its differentiated individual assessment. Patients with SDSTS in combination with arrhythmias require a comprehensive examination to decide on the need for medication and, if necessary, surgical treatment. Timely diagnosis and correct management tactics for these children are possible only by combining a thorough clinical assessment with the mandatory determination of the phenotypic severity of connective tissue dysplasia and data from instrumental research methods, including EchoCG and ECG.

Currently, the method of long-term continuous recording of ECG in the process of everyday life - HM ECG - has become firmly established in the practice of ECG studies. The introduction of this highly informative research method into therapy dates back to the early 60s, while in pediatrics - only to the early 80s. Consultative and diagnostic centers must be equipped with such equipment to conduct research and train specialists.

Indications for performing a HM ECG are: 1) cardiac rhythm and conduction disturbances detected during clinical or ECG examinations; 2) presence of complaints of short-term loss of consciousness, palpitations, dizziness, pain and discomfort in the heart area; 3) diseases with a high risk of arrhythmia: pre-excitation syndrome, long Q-T interval syndrome, sinus node dysfunction, mitral valve prolapse with regurgitation and cardiomegaly, atrioventricular block, cardiomyopathy; 4) children from families with a burdened heredity, in particular, the sudden death of close relatives; 5) assessment of the functioning of the artificial pacemaker; 6) to decide on the advisability of prescribing antiarrhythmic drugs and to monitor the effectiveness of therapy.

To correctly interpret the data obtained from HM ECG in children with cardiac pathology, it is necessary to know the limits of permissible pulse fluctuations and arrhythmias in healthy children. As our studies have shown, the minimum heart rate value at night was 41 per 1 min, the maximum value during wakefulness was 175 per 1 min. We established the presence of weak and moderate sinus arrhythmia in all children, significant arrhythmia at night in 46%, migration of the atrial pacemaker mainly at night in 80% of children, sporadic sinoatrial block at night in 12%, supraventricular extrasystole (up to 30 per day) in 41%, ventricular extrasystole in the daytime during physical activity and emotional excitement (up to 10 per day) in 6% of children.

The use of HM ECG helped to identify cardiac rhythm and conduction disturbances in 65% of children with autonomic dystonia syndrome, in 77% with mitral valve prolapse, in all children with mitral regurgitation, in 83% of children with hypertrophic and in 100% of children with dilated cardiomyopathy, Moreover, 29 had prognostically unfavorable, clinically significant arrhythmia, 36, 80, 30 and 45% of children, respectively. By clinically significant arrhythmia we mean high-grade ventricular extrasystoles, tachyarrhythmias, high-grade atrioventricular (AV) blockade, sick sinus

syndrome. If in practically healthy children changes in heart rhythm are usually pronounced during emotional and physical stress, then in functional heart pathology arrhythmias also appear during the change in physiological states "wakefulness - sleep", and in organic heart diseases arrhythmias are often recorded during sleep. At the first stages of examining a child, the severity of heart damage is assessed mainly on the basis of an ECG. In this regard, knowledge of the ECG features for a particular pathology can provide significant assistance in the practical work of a doctor.

Many years of experience working with children with cardiovascular pathology led to the need to evaluate the role of HM ECG in clarifying the causes of syncope in children. Establishing their causes is a difficult task due to their diversity and the transient nature of the episodes. A thorough examination of the child and painstaking analysis of the data obtained are required. With the introduction of HM ECG into clinical practice, the likelihood of identifying cardiac causes of symptoms such as fainting and dizziness has doubled. All children with atypical epilepsy must be examined with mandatory long-term recording of heart potentials to exclude long Q-T interval syndrome.

The following dysrhythmias can be considered as potential causes of fainting and their equivalents: 1) sinus bradycardia with an average heart rate during wakefulness less than 55 - 60 per 1 min and during night sleep less than 35 - 40 per 1 min; 2) frequent sinus pauses of more than 1.5 - 2 s due to stop (failure) of the sinoatrial node or repeated sinoatrial blockade; 3) AV blockade II - III degree; 4) ventricular preexcitation syndrome; 5) persistent supraventricular tachycardia with a frequency of more than 160 per 1 min; 6) atrial fibrillation with slow ventricular response; 7) paroxysms of ventricular tachycardia, especially the “pirouette” type.

Patients with complete AV block represent a clinically heterogeneous group. Some children do not complain, while others experience Morgagni-Adams-Stokes attacks and develop heart failure. All these children need a HM ECG to obtain reliable information about heart rhythm disturbances and its variability. Factors indicating the severity of the pathological process and the advisability of prophylactic pacemaker implantation in children with complete AV block are: decrease in average heart rate per day less than 55 per 1 min, lack of pacemaker response to physical and emotional stress, low heart rate variability during the day, frequent ventricular extrasystoles, periodic ventricular asystole, paroxysms of tachyarrhythmias, widening of the QRS complex to 0.12 s or more , the presence of congenital anomalies of heart development, dilatation of the ventricular myocardium.

In recent years, HM ECG has been used to assess the function of the sinus node and the activity of the autonomic nervous system by studying heart rate variability (HRV), which has not only scientific but also practical value. HRV refers to changes in heart rate or the duration of successive R - R intervals over time, or their fluctuations around the average value. A decrease in HRV, along with such clinical and instrumental indicators as episodes of myocardial ischemia, ventricular arrhythmia, a decrease in the left ventricular ejection fraction, and registration of late potentials is associated in patients with cardiac pathology with a poor prognosis. A decrease in HRV was noted with age and in diseases such as myocardial infarction, hypertension, congestive heart failure, cardiomyopathy, diabetes mellitus, and chronic pulmonary diseases. Children are characterized by significantly pronounced pulse lability, therefore, great importance has always been attached to the study of the frequency and severity of sinus arrhythmia in children at different age periods [12].

It has been established that the individual daily dynamics of heart rhythm over a short period of time is stable compared to other ECG indicators. The high reproducibility of other HRV indicators allows them to be used as a criterion for assessing the course of the disease, as well as the effects of various interventions. A Holter ECG recording can be analyzed using various mathematical and statistical programs to calculate various HRV parameters. The method for studying HRV is in continuous development, materials are being accumulated and the experience of various researchers is being generalized, and its complex software remains at the stage of clinical evaluation. The main capabilities of CM ECG in pediatrics: 1) more accurately than a conventional ECG study, determine the shape, nature and severity of arrhythmias, as well as determine their prognostic significance; 2)

monitor transient heart rhythm disturbances during the day; 3) compare the frequency of rhythm disturbances at different times of the day; 4) compare the detected ECG changes with the child's subjective sensations and activity; 5) in the presence of a special program, use a HM ECG to determine the circadian variability of the Q-T interval as a marker of inhomogeneity of repolarization processes and late potentials of the ventricles of the heart, reflecting slow, fragmented myocardial activity (a risk factor for the development of ventricular arrhythmia); 6) facilitate the choice of optimal individual therapy and objective assessment of the effectiveness of treatment; 7) expand the possibilities of studying heart rate variability, which is of great importance in pediatrics; 8) take a new approach to studying the mechanisms of extracardiac regulation.

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