JOURNAL OF MULTIDISCIPLINARY SCIENCES AND INNOVATIONS
GERMAN INTERNATIONAL JOURNALS COMPANY
ISSN: 2751-4390
IMPACT FACTOR (RESEARCH BIB) : 9,08. Academic research index

UDK: 612.172.2-053.2

RISK FACTORS IN THE DEVELOPMENT OF EARLY VENTRICULAR REPOLARIZATION SYNDROME AND ANALYSIS OF PHASE INDICES ON ECG

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Relevance. To date, pediatric arrhythmology still faces many unresolved and pressing issues that require active attention [6,8]. The growing interest in the problem of rhythm and conduction disorders of the heart is due to the steady increase in the proportion of arrhythmias within the structure of cardiological pathology over recent decades. These disorders are often a cause of death in childhood [1,2].

Experience has shown that the widespread introduction of electrocardiological methods (especially 24-hour ECG monitoring), ultrasound diagnostics, and other non-invasive and invasive electrophysiological methods, as well as interventional technologies and advances in scientific research on the pathophysiological mechanisms of arrhythmias in children—including studies on autonomic regulation of heart rhythm—has significantly advanced the early diagnosis of arrhythmias. This, in turn, makes it possible to develop preventive programs for the treatment and prevention of heart rhythm disorders in children [2,3,7].

The choice of methods and tools for treating rhythm disturbances in childhood remains a major challenge. It must take into account the multifactorial nature and complex pathophysiological mechanisms of such disorders. Late diagnosis and inadequate prognosis of arrhythmias are key contributors to high morbidity and mortality at older ages, and the success of preventive programs directly depends on their early implementation [1,2,6].

One of the most frequently observed cardiac rhythm disorders is the Early Repolarization Syndrome (ERS) — an ECG phenomenon whose pathogenesis and clinical significance continue to attract the attention of practicing physicians. This is due to its high prevalence, as it occurs both in healthy individuals and in those with heart diseases, while its clinical implications remain uncertain. It is assumed that ERS is based on congenital individual features of the electrophysiological processes in myocardial cells, including ion mechanisms that lead to early repolarization of the subepicardial layers of the myocardium [4,5].

According to studies by other authors, the development of ERS involves enhanced parasympathetic influence on heart rhythm, increased sympathetic activity in the area of the interventricular septum and the anterior wall of the left ventricle; the activity of accessory conduction pathways; and disturbances in electrophysiological processes within myocardial cells, leading to impaired potassium current across the cell membrane in the apex and lateral wall of the left ventricle [1,3,8].

Objective of the study: To identify risk factors involved in the development of Early Repolarization Syndrome (ERS) and to present and analyze the phase parameters of electrical systole based on ECG data.

Materials and methods. A population-based approach was used in the selection and analysis of material to identify schoolchildren with various types of cardiac rhythm and conduction disorders.

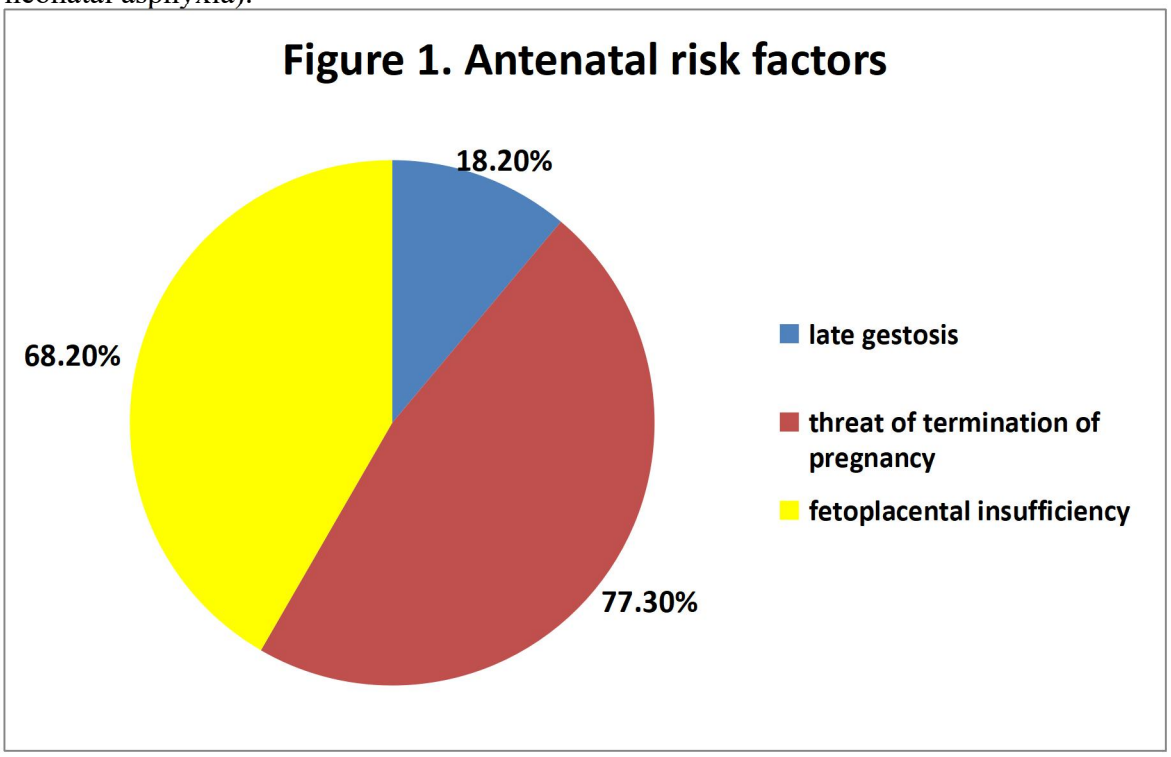
For each child, a specially designed questionnaire was completed, including anamnesis data and findings from objective examination, along with anthropometric measurements (height, weight, circumferential dimensions with calculation of index parameters).

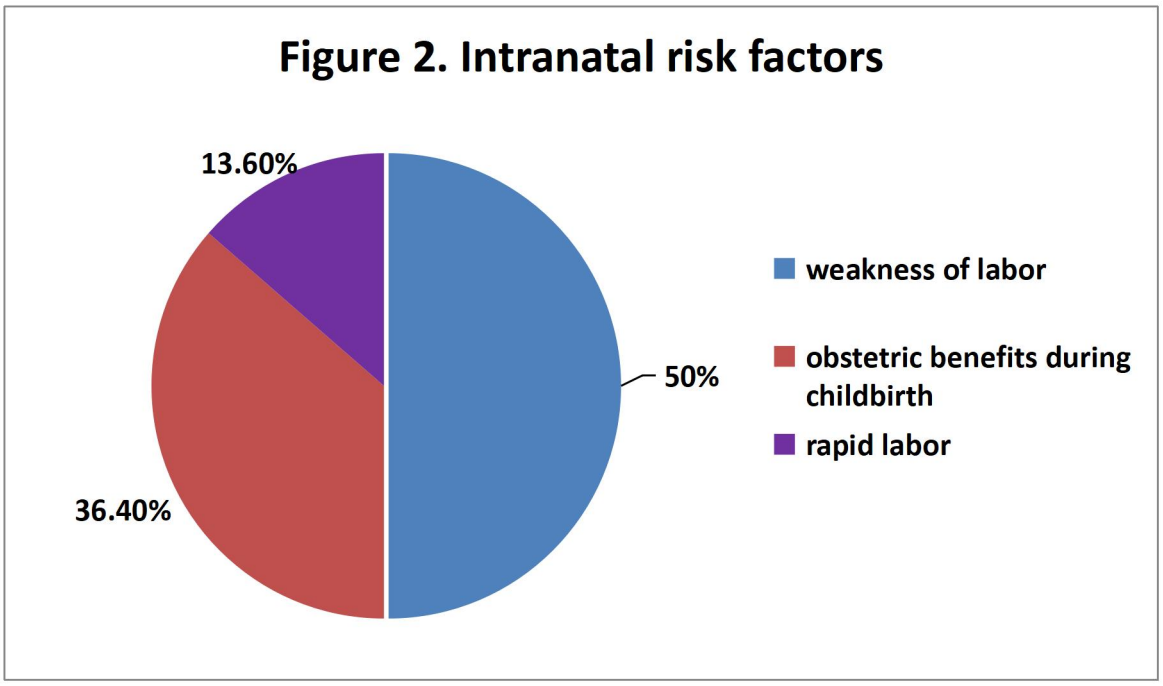
All children underwent electrocardiography according to the standard 12-lead method. Interval and phase parameters were calculated, including electrical diastole, the duration of electrical activity and cardiac stability, as well as their ratios. In addition, the amplitude values of the ventricular complex were determined.

Results. Out of a total of 562 ECG examinations conducted among schoolchildren aged 7 to 14, Early Repolarization Syndrome (ERS) was identified in only 22 children among the various types of rhythm and conduction disorders. The diagnostic criterion for this rhythm abnormality was an elevation of the ST-T segment above the isoelectric line, beginning from an elevated junction point (J-point) on the descending limb of the R wave or from a J-wave.

In our study, the frequency of this syndrome decreased with age among girls (from 1,21% to 0,72%), while it increased among boys (from 0,43% to 1,59%, $p < 0,01$).

Anamnesis revealed that all children with ERS had a history of pathological pregnancy and delivery in their mothers. It is evident that the development of the cardiovascular system, including the cardiac conduction system during the postnatal period, is significantly influenced by the course of the intranatal period — specifically, complications during pregnancy and childbirth (such as late gestosis, threatened miscarriage, weak labor activity, intrauterine fetal hypoxia, placental and umbilical cord pathologies, obstetric interventions during delivery, and neonatal asphyxia).





All these risk factors apparently had a certain impact on the development of an imbalance in the functioning of the sympathetic and parasympathetic nervous systems.

In addition, all children with ERS were found to have a high incidence of background pathology at early ages (36.3%), droplet-transmitted infections (22,7%), and upper respiratory tract infections of viral and bacterial origin (81,8%). A notably high proportion of these children had chronic foci of infection (90,9%).

The complaints reported by children with ERS were predominantly of autonomic nature—restlessness, irritability, sudden mood swings, various sleep disturbances (delayed sleep onset, difficulty waking up, night terrors), palmar hyperhidrosis, headaches and dizziness, as well as decreased attention span.

Table 1. Complaints of children with early ventricular repolarization syndrome.

Complaint	abs	%
Anxiety	20	90,9%
Irritability	18	81,8%
Sharp mood swings	22	100%
Late falling asleep	6	27,3%
Difficulty waking up	9	40,9%
Night terrors	4	18,2%
Hyperhidrosis	19	86,4%
Headaches and dizziness	22	100%
Decreased attention	12	54,5%

When assessing physical status, the children were divided into two age groups: 7–10 years and 11–14 years.

Analysis of calculated indicators in the 7–10-year age group revealed no significant changes in the main anthropometric parameters. However, in children with ERS, an increase in Erisman and Pignet indices was observed.

This suggests that children with ERS have disproportionate chest circumference development relative to their body weight and height.

In the 11–14-year-old group, the analysis of physical development parameters in children with ERS showed increased height and decreased body mass, as well as high values for body surface area and the "asthenic" index. These findings indicate that children with ERS in this age group

tend to have a dolichomorphic growth pattern—that is, a predominance of longitudinal growth. This was confirmed by low values of the Varga index (as increased height lowered the calculated Varga index) and high values of the "asthenia" index.
Further examination of children with ERS included an analysis of interval and phase parameters based on ECG data. Given that Early Repolarization Syndrome remains poorly understood in pediatric pathogenesis and that its ECG criteria are still not fully established, we analyzed several additional ECG parameters beyond those commonly described in the literature.
We found that in children with Early Repolarization Syndrome (ERS), there is a shortening of the cardiac cycle (RR interval, sec) (0.64±0.02) and an increased heart rate compared to normative values for healthy children of the same age.
In children with ERS, there was a significant shortening of the P-Q interval (0,10±0,002), the actual QRST phase duration (QRSTa, sec) (0,320±0,004), the expected QRST duration (QRSTd, sec) (0,312±0,003), and R-wave peak time in lead V1, sec (0,02±0,001), as well as shortening of the QRS segment (0,07±0,001) and rightward deviation of the electrical axis of the heart (EAX).
When examining the duration of electrical activity (P-T), cardiac stability (T-R), and electrical diastole (T-Q), a more pronounced shortening of the P-T interval compared to the T-P interval was noted, along with a significant reduction in the T-Q interval.
Thus, a distinguishing feature of Early Repolarization Syndrome (ERS) is that certain ECG segments should be attributed to the repolarization phase. In this regard, we studied the structure of repolarization on the ECG: the "excitation phase" of the ventricles (Q–T_1) and the "termination phase of excitation" in the ventricles (T_1–T). The analysis revealed a shortening of the Q-T_I and ST–T intervals, while the final part of repolarization, i.e., the T_I-T interval, remained unchanged.
At the same time, the ratios of Q–T and ST–T to the total electrical systole (QT_I/QT_I % and ST-T/QT_I %) were reduced, whereas the T_I–T/Q–T_I ratio was increased. This trend was also observed in the ratios of Q–T_I and ST–T to the entire cardiac cycle. However, the share of the T_I–T segment within the total cardiac cycle remained unchanged.
Thus, in children with ERS, the Q–T_I ECG parameter—which includes the depolarization phase (QRS) and the early phase of repolarization (ST–T)—was shortened. This led to a decrease in QT_I values both within the structure of electrical systole (QT_I/QT%) and throughout the cardiac cycle (Q–T_I/RR%). The resulting electrophysiological situation suggests that repolarization begins earlier, due to shortening of the QRS complex and the early part of the repolarization phase (ST–T), while the T_I–T segment, representing the late repolarization phase, is prolonged.

Since early ventricular repolarization precedes the shortening of atrioventricular conduction (P–Q interval) and the QRS complex, we propose that ERS should be regarded as a variant of the ventricular pre-excitation syndrome. Premature ventricular depolarization facilitates early onset of repolarization. This origin of ERS is likely related to the postnatal functioning of an accessory atriofascicular Mahaim–Levy fiber, which conducts impulses from the atria—most often to the anterosuperior branch of the left bundle of His—causing segmental, premature, asynchronous ventricular excitation.

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