HEART RHYTHM DISTURBANCES IN NEWBORNS IN THE EARLY NEONATAL PERIOD

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Abstract. Neonatal arrhythmia is not a rare condition, and may occur both in patients with structural heart disease and in children with functional cardiovascular disorders as well as in a relatively small number of healthy newborns. The article presents the results of the study of basic parameters of electrical activity of the heart in newborns with administration of daily ECG monitoring. The study involved examination of 187 infants in the early neonatal period. Assessment of the data of obstetric and gynecological history and extragenital pathology of the mothers of the examined children, analysis of the data of Holter ECG monitoring of newborns showed the most frequently occurring types of neonatal arrhythmias and significant risk factors for their development.

Key words: *cardiac rhythm disturbances in newborns, neonatal arrhythmias, risk factors.*

Introduction. Childbirth and the early neonatal period are a combination of extreme impact on the child's body, requiring rapid adaptation at different levels of self-regulation. A cascade of compensatory and adaptive mechanisms, aimed at adapting organs and systems to the conditions of extrauterine life, is activated in the child's body immediately after birth. Restructuring of the circulatory system plays the most important role in this physiological process [1, 2].

It is reported that the incidence of neonatal arrhythmias and conduction disturbances ranges from 1 to 5 % among all newborns. Neonatal arrhythmias have variable clinical manifestations and are classified as both benign and those with adverse effects on the health and life of a newborn child [3]. That is why studying the range and nature of violations of cardiac rhythm and conduction in newborns remains an urgent area of development in neonatology.

The use of modern recorder devices does not significantly interfere with vital activity of the newborn and does not violate psycho-emotional state of the child, providing a possibility to register changes in the parameters of electrocardiography during normal functioning (sleep, feeding, anxiety, medical procedures, etc.) and obtaining important data on the time course of the cardiac rhythm in newborn during the day. Round-the-clock recording of electrocardiogram with the help of Holter ECG monitoring (HECGM) ensures the accuracy of measuring the basic parameters of electrical activity of the heart for a long period of time, followed by their analysis [4].

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2. Purposes, subjects and methods:

2.1. Purpose – to improve early diagnosis of cardiac rhythm and conduction disorders in newborns in the early neonatal period and identify significant risk factors for their development based on the analysis of the results of daily ECG monitoring.

2.2. Subjects & Methods. The study involved 187 newborns in the early neonatal period with cardiac rhythm disturbances at auscultation of the heart. All the newborns were administered daily ECG monitoring, following which they were divided into 2 groups. Group 1 (n=126) included newborns with heart rate and conduction impairment, Group 2 (n=61) comprised newborns with no rhythm and conduction disorders. Taking into account the gestational period, Group 1 and 2 newborns were divided into subgroups of full-term and pre-term infants: Group 1a with arrhythmia (n=34), Group 1b pre-term with arrhythmia (n=92), Group 2a full-term without arrhythmia (n=24), Group 2b pre-term without arrhythmia (n=37). The exclusion criterion was the presence of birth defects and/or the organic

pathology of the cardiovascular system. The study implied the assessment of obstetric and gynecological history data and extragenital pathology of mothers of the examined newborns and analysis of daily Holter ECG monitoring (HECGM) data. The recording and analysis of HECGM was performed using electrocardiographic hardware and software complex "ECGpro" (Holter monitor "EP810"), IMESC. Interpretation of findings was performed using ECGproHolter v.7.44.7-S12 software. The data obtained in the study was processed by Statistica 10.0 Microsoft software package using Mann–Whitney U test and analysis of conjugation tables using Pearson $\chi 2$ criterion.

Conflict of interests. There is no conflict of interests.

3. Results and discussion. The study of histories of mothers of the examined infants showed that 86.5 % of mothers of Group 1 newborns and 67.2% of mothers of Group 2 newborns had obstetric-gynecological complications, which became a significant risk factor for the development of cardiac rhythm disturbances in the groups of examined infants ($\chi 2$=9.641; p<0.002). Obstetric and gynecological pathologies of mothers of newborns of both groups mainly included gestosis of pregnant, the development of which is due to the inability of the adaptive mechanisms of the parent to adequately meet the needs of the developing fetus, resulting in the development of different degrees of severity of perfusion-diffusion insufficiency in the mother-placenta-fetus system [5]. This was confirmed by a rather high percentage of placental malfunctioning in mothers of the examined neonates (17.1 %). A significant number of complications during pregnancy was due to anemia of pregnant (24.0 %), infectious disorders of reproductive system in mother and fetal membranes of different etiologies (16.0 %), development of oligohydroamnion (16.0 %), multiple pregnancies with threatened miscarriage and preterm delivery (33.7 %) and premature rupture of fetal membranes (37 %). Assessment of incidence of a specific type of obstetric-gynecological disorder did not show any statistically significant difference between the groups of the examined children.

Assessment of the presence and structure of extragenital disorders showed impairments of the structure and / or function of different organs and systems in 60.3 % of mothers of Group 1 newborns and 42.6% of mothers of Group 2 infants, which was a significant risk factor for the development of cardiac rhythm disturbances ($\chi 2$=5.190; p<0.02). The most common disorders of organs and systems included cardiovascular (23 %), endocrine (21.4 %), gastrointestinal (10.7 %), urinary (16.6 %), nervous (3.7 %) and respiratory (0.5 %) diseases, but there was no significant difference between the groups regarding the prevalence of a specific type of disorder in any of the systems.

The examined infants were born from 2.57 + 0.16 delivery. Cesarean section was performed during the delivery of 57.9 % of Group 1 and 47.5 % of Group 2 infants.

Assessment of the groups of examined neonates by weight and gestational age showed that in the group of infants with cardiac arrhythmias (Group 1) the term of gestation at birth was lower than in the group of children without arrhythmia (32.5 weeks (30.0, 37.0) for Group 1 and 34.0 weeks (33.0; 39.0) for Group 2, p <0.0006). By weight criterion at birth, Group 1 infants also had lower rates (1900.0 g (1440.0; 2950)) than Group 2 neonates (2375.0 g (1940; 3125)), p<0.01.

The Apgar scores were lower both in the 1st minute in the group of children with arrhythmia (5 (4; 6) points) than in the group of infants without cardiac rhythm disturbances (6 (5; 8) points; p<0.000003); and on the 5th minute (7 (6; 7) and 7 (7; 9) respectively, p?0,000008).

Asphyxia at birth was diagnosed in 50 % of Group 1 newborns and 23 % Group 2 newborns ($\chi 2$=12.416; p <0.001). The presence of asphyxia in newborns was confirmed by a low Apgar score on the first and fifth minutes of life respectively, by acid-alkaline state of the umbilical blood (pH <7.15 and (or) base deficiency (BE) greater than 12 mmol / L) and the presence of diagnostic criteria for asphyxia at birth in the form of clinical symptoms of central nervous system damage and/ or signs of transient impaired function of the respiratory and cardiovascular system. Hypoxic-ischemic and hypoxic-hemorrhagic damage of the central nervous system was detected in 61.9 % of Group 1 and 37.8 % of Group 2 infants ($\chi 2$=9.691; p<0.002).

In the group of infants with arrhythmias diagnosed by HECGM (Group 1), 70.6 % had sinus tachyarrhythmia accompanied by signs of myocardial repolarization of the left ventricle. Sinus bradyarrhythmia was diagnosed in 7.1 %, supraventricular extrasystole in 33.3 %, ventricular extrasystole in 11.1 % (including 3 children with frequent ventricular arrhythmia (more than 60 episodes of ventricular ectopia per hour)). Atrioventricular (AV) nodal extrasystole was detected in 7.9 % of newborns with cardiac

rhythm disturbances, 1st degree transient atrioventricular blockade in 11.9 %, episodes of 2nd degree transient atrioventricular blockade in 8.7 %, migration of pacemaker from sinus node to the lower parts of atria in 27.8 %, transient QT prolongation in 28.6 % of newborns, rhythm pause in 11.1 %, disturbance of repolarization in left ventricle in 54 % of children.

Assessment of the prevalence of diagnosed neonatal arrhythmias showed that sinus tachycardia ($\chi 2=15.786$; $p<0.001$) and atrial extrasystole ($\chi 2=3.948$; $p<0.05$) were more common in pre-term infants than among full-term infants in the group of children with heart rhythm disturbances (*Table 1*).

The QT interval is one of the most clinically significant ECG parameters, since changes in the QT interval of any origin are a risk factor for ventricular tachyarrhythmias [6, 7]. In the groups of the examined infants transient QT prolongation was observed in 28.6 % of Group 1 newborns, therefore this parameter was considered in more detail.

QT interval analysis was performed by determining the following parameters: daily QT duration; daily mean corrected QT (QTc) which is a value independent of the heart rate; QT mode which is QT length, corresponding to the maximum number of complexes; SDQT (NN) which is a standard deviation of all QT intervals from normal complexes; SVQT (NN) is the coefficient of QT variation.

Detailed examination of QT interval parameters showed that only daily mean corrected QT (QTs) duration values were greater in Group 1 children ($p<0.01$) as compared to Group 2 infants. However, other QT parameters were higher in the subgroup of full-term Group 1 infants (with arrhythmia) as compared to pre-term infants of the same group, and the index of QT variation (SVQT (NN)) also had higher values in the subgroup of full-term Group 2 newborns (without arrhythmia) as compared to pre-term infants of the same group (*Table 2*).

Table 1

The prevalence of cardiac rhythm and conduction disturbances

Cardiac rhythm and conduction disturbances	Infants with arrhythmia (Group 1), % (n=126)	Full-term infants with arrhythmia (Group 1a), % (n=34)	Pre-term infants with arrhythmia (Group 1b), % (n=92)
Sinus tachyarrhythmia	70.6	44.1	80.4; **$P_{1a,1в}<0.001$**
Sinus bradyarrhythmia	7.1	11.8	5.4
Supraventricular extrasystole	33.3	47.0	28.3; **$P_{1a,1в}<0.05$**
Ventricular extrasystole	11.1	23.5	6.5
AB-nodular extrasystole	7.9	8.8	7.6
1st degree AV block	11.9	5.9	3.3
2nd degree AV block	8.7	17.7	5.4
Migration of pacemaker	27.8	17.7	31.5
QT prolongation	28.6	32.4	16.7
Rhythm pauses	11.1	14.7	9.8
Repolarization disturbances	54.0	41.2	58.7

A recent study of the variability of cardiac rhythm indices in newborns who were in the intensive care unit revealed a link between the incidence of changes in the characteristics of the cardiac rhythm of newborns with the development of systemic inflammatory response, infectious

Table 2

Daily QT intervals

QT indices	Group 1 (n=126)	Group 2 (n=61)	Group 1a (n=34)	Group 2a (n=24)	Group 1b (n=92)	Group 2b (n=37)
Mean QT, ms	294.5 (264.0; 326.0)	297.0 (275.0; 317.0)	309.0 (294.0; 356.0)	300.0 (288.0; 323.5)	284.0 (261.0; 318.0) **$p_{1a,1в}<0.001$**	295.0 (265.0; 309.0)
QTc, ms	435.0 (412.0; 475.0)	427.0 (415.0; 435.0) **$p_{1,2}<0.01$**	444.0 (424.0; 484.0)	430.5 (418.0; 436.5)	446.4 (411.0; 470.0)	426.0 (409.0; 435.0)
QT mode	289.0 (264.0; 320.0)	294.0 (273.0; 315.0)	303.5 (289.0; 335.0)	299.5 (282.5; 321.0)	281.5 (258.5; 316.0) **$p_{1a,1в}<0.01$**	279.0 (263.0; 312.0)
SDQT (NN)	29.0 (20.0; 45.0)	29.0 (23.0; 43.0)	42.0 (25.0; 55.0)	32.0 (28.0; 46.0)	26.0 (17.0; 39.5) **$p_{1a,1в}<0.0001$**	27.0 (18.0; 41.0) **$P_{2a,2в}<0.05$**
SVQT (NN)	9.6 (7.0; 13.0)	9.8 (7.0; 13.0)	12.0 (8.0; 16.0)	10.5 (8.0; 14.5)	8.5 (5.0; 12.0) **$P_{1a,1в}<0.001$**	9.0 (6.0; 12.0) **$P_{2a,2в}<0.05$**

diseases of the urinary tract, necrotizing enterocolitis, apnea and deterioration of external respiration rates [8]. As already outlined above, the violation of sinus node automatism, the main driver of the heart rate, in the form of sinus tachyarrhythmia was diagnosed in 70.6 % of Group 1 newborns. Therefore, we assessed heart rate parameters in detail.

Detailed analysis of heart rate indices showed that the levels of the mean daily and the mean maximum daily heart rate were higher both in Group 1 (infants with arrhythmia) as compared to Group 2 (infants without arrhythmia) and in subgroups of pre-term infants (Groups 1 and 2) as compared to subgroups of full-term newborns (Groups 1a and 2a). Indices of the mean minimum heart rate were also higher in the subgroups of pre-term infants (Groups 1b and 2b) as compared to subgroups of full-term infants (Groups 1a and 2a) of both main groups. Assessment of RR length parameters showed that the parameters of the minimum RR-interval were higher in Group 2 infants ($p<0.0001$), and the maximum RR-interval values were higher in Group 1 newborns ($p<0.01$). Indices of circadian index (the ratio of the mean daily to the mean nightly heart rate) were higher ($p<0.05$) only in the subgroup of full-term infants with arrhythmia (Group 1a) as compared to the subgroup of pre-term children (Group 1b) of the same group (*Table 3*).

Table 3

Daily heart rate parameters

Herat rate parameter	Group 1 (n=126)	Group 2 (n=61)	Group 1a (n=34)	Group 2a (n=24)	Group 1b (n=92)	Group 2b (n=37)
Mean heart rate, beats	148.0 (135.0; 158.0)	141.0 (132.0; 148) **$p_{1,2}<0.05$**	139.0 (123.0; 144.0)	127.5 (124.0; 141.0)	152.0 (142.0; 160.0) **$P_{1a,1в}<0.0001$**	146.0 (139.0; 155.0) **$P_{2a,2в}<0.00001$**
Minimum heart rate, beats	114.5 (102.0; 126.0)	111.0 (102.0; 123.0)	104.5 (94.0; 114)	103.0 (93.0; 113.0)	119.5 (106.5; 128.5) **$p_{1a,1в}<0.001$**	116.0 (108.0; 130.0) **$P_{2a,2в}<0.001$**
Maximum heart rate, beats	194.0 (182.0; 206.0)	189.0 (178.0; 200.0) **$p_{1,2}<0.05$**	187.0 (175.0; 203.0)	182.5 (171.5; 193.0)	197.0 (185.5; 206.5) **$P_{1a,1в}<0.05$**	194.0 (182.0; 202.0) **$P_{2a,2в}<0.01$**
Minimum RR-interval, ms	253.5 (226.0; 281.0)	281.0 (265.0; 304.0) **$P_{1,2}<0.0001$**	250.0 (203.0; 281.0)	292.5 (277.0; 312.0)	261.0 (230.0; 281.0)	265.0 (257.0; 281.0) **$P_{2a,2в}<0.01$**
Maximum RR-interval, ms	875.0 (718.0; 1085.0)	718.0 (648.0; 882.0) **$P_{1,2}<0.01$**	875.0 (757.0; 992.0)	726.0 (663.0; 867.0)	874.0 (714.0; 1085.0)	710.0 (632.0; 937.0)
Circadian index	1.0 (0.98; 1.03)	1.0 (0.97; 1.03)	1.01 (0.99; 1.03)	1.01 (0.98; 1.04)	0.99 (0.97; 1.03) **$P_{1a,1в}<0.05$**	0.99 (0.97; 1.02)

Conclusions:

1. The study showed a relationship between obstetric and gynecological disorders ($\chi2=9.641$; $p<0.002$), extragenital diseases in pregnant ($\chi2=5.190$; $p<0.02$), perinatal hypoxia ($\chi2=12.416$; $p<0.001$) and the development of neonatal heart rhythm disorders in the early neonatal period.

2. Newborns during this age period were more frequently found to have impairment of automatism and excitability of the sinus node with the development of sinus tachycardia and supraventricular extra systole ($\chi2=15.786$; $p<0.001$ and $\chi2=3.948$; $p<0.05$, respectively).

3. Considering the above, in further studies it is expedient to study the correlation of cardiovascular system disorders with the presence of cardiac rhythm and conduction disturbances in newborns at different gestation periods by comparing the state of electrical activity of the heart, central hemodynamics and the data of biochemical markers of hypoxic myocardial damage.

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