

## **ELECTROCARDIOGRAPHIC FEATURES OF CHILDREN IN AN EARLY NEONATAL PERIOD**

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**Abstract.** *The article provides a brief overview of the features of the cardiovascular system and its role in the process of adaptation of newborn children. As a screening method has been chosen by routine methods electrocardiography (ECG). Review of published information did not provide with a full picture of normal ECG parameters in infants of early and late neonatal period. The usage of the method of electrocardiography was studied as a screening for early diagnostics of adaptation failure and identification of diseases of the cardiovascular system in neonates. The findings of the study can be used in screening for cardiovascular disorders.*

**Keywords:** *healthy neonate, early neonatal period, adaptation, ECG.*

Childbirth and early neonatal life is a unique combination of extreme effects on the organism of a child, requiring continuous change of adaptation mechanisms at different levels of self-regulation. After the birth, in the organism of a newborn compensatory-adaptive mechanisms engage aiming at the adaptation of organs and systems to changed life conditions such as the beginning of the external breathing. A crucial role in this is played by the restructuring of the circulatory system [1,2].

The global restructuring of hemodynamic includes desolation of placental communications; the launch of the pulmonary circulation; deterioration of blood viscosity, closing fetal communications - foramen ovale and patent ductus arteriosus stop functioning; the diameter of the right atrium changes - right atrium decreases and becomes approximately equal to the left one; the change in the basic hemodynamic load leads to a reduction of the right ventricular diastolic diameter and an increase in the diameter and diastolic left ventricular ejection. The ventricles of the heart work in series, each of them separately pumps a half of the total cardiac output. The tone of blood vessels and peripheral regulatory systemic blood pressure (BP), which depends on the mass of the child, gradually increase [1,2,3].

Significant changes in the metabolism are expressed in conjugation processes of anaerobic glycolysis and oxidative phosphorylation. Lactate along with glucose are important sources of energy for the heart muscle in the first two weeks after the

birth. The simultaneous use of these two energy sources depicts the transition in energy supply of the myocardium of a newborn baby and characterizes the energy adaptation of myocardium to extrauterine life [1,2,3].

Features of ion exchange in the myocardium. The myocardium of a newborn has a reduced amount of sarcoplasmic reticulum, which regulates calcium metabolism in cardiomyocytes. The blood plasma is determined by the specific digoxin-like immunoreactive substance, the maximum content of which is reached between the 4th and 6th days of life. Its physiological importance lies in the regulation of metabolism of sodium and water by impacting the sodium pump and cardiac glycoside receptors [1,2].

The histological structure of the myocardium of a newborn is characterized by the presence of badly divided thin myofibrils containing a large number of oval nuclei and the lack of cross-striation. Connective tissue is represented insignificantly and the amount of elastic elements is small. Endocardium is characterized by a loose structure and consists of two layers. The capillary network, which has a large number of anastomosis between the coronary arteries, is well-developed [3].

The muscle of the heart is constantly developing, differing in general from the adult heart muscle by functional immaturity, relatively low motility and speed reduction. A complex and stressful process of postpartum adjustment of intracardiac and general blood circulation, undoubtedly, is reflected in the electrocardiogram of a newborn.

The literature review on the subject revealed that newborns, especially in the early neonatal period, are characterized by high lability of the main ECG parameters and varying limits of the so-called physiological norm at this time.

A wide range of parameter variation in the same child during the process of the general adaptation is the measure of the high reserve capacity of the organism of a newborn. Data analysis of contemporary literature indicates that the interest to this problem is not decreasing, leading cardiologists continue to study the features of neonatal ECG [4,5,6]. Nowadays, enough data have been accumulated in the literature on the features of the ECG of healthy children of different ages. The

problem of diagnosis of pathological conditions of the cardiovascular system in children using the electrocardiogram has been widely studied [7,8,9]. However, these works did not investigate ECG features in children of early and late neonatal period. Currently, there is a need for an intensive study of neonatal cardiology. New results constantly appearing in foreign literature serve as the basis for revising the interpretation of some of the previously accepted electrocardiographic phenomena and regulations.

**Materials and methods.** To clarify the parameters of ECG standards in newborns in the early neonatal period and early diagnosis of the heart adaptation, ECG parameters in infants were studied in the Kharkov regional perinatal center during the period from November 2012 to January 2013. The study included 31 healthy newborns of  $3.3 \pm 1.4$  days of life, of which 48% boys and 52% girls, divided into two groups by age — the children of the first 3 days of life (the first group of 20 persons) and children 4-7 days of life (the second group of 11 persons).

**Results of the study.** The children of both groups had the average duration of the P wave  $0.04 \pm 0.01$  sec.; amplitude  $0.12 \pm 0.05$  mV (Group 1);  $0.15 \pm 0.05$  mV (Group 2). The most pronounced in the II, III, aVR, aVF and right chest leads, which is probably due to the predominance of work of the right heart compartments; it is negative in aVR and may be reducing the amplitude of up to the contour in aVL leads. In Group 2, it becomes most pronounced in the left chest leads.

The duration of the interval PQ  $0.23 \pm 0.34$  sec (Group 1). In children of 4-7 days age (Group 2) it is shortened to  $0.21 \pm 0.29$  seconds. This indicates an improvement in impulse conduction in pathways of the heart.

The duration and amplitude of the QRS complex in children in both groups were not significantly different ( $p < 0.05$ ) -  $0.05 \pm 0.01$  sec. (Group 1);  $0.06 \pm 0.00$  sec. (Group 2),  $0.06 \pm 0.12$  mV (Group 1);  $0.05 \pm 0.09$  mV (Group 2).

The amplitude of the Q wave in children of both groups did not differ —  $0.06 \pm 0.12$  mV (Group 1);  $0.05 \pm 0.09$  mV (Group 2). Its duration was  $0.02 \pm 0.01$  sec. (group 1);  $0.01 \pm 0.01$  sec. (Group 2). Q wave was absent in I, aVL and all chest leads, but in the child of 7 days of life Q wave appears in I, aVL, V4, V5 leads.

The duration of R wave in children of both groups were not significantly different  $0.02 \pm 0.01$  sec. The amplitude of the R wave -  $0.06 \pm 0,12$  mV (Group 1);  $0.09\text{mV} \pm 005$  (Group 2), and varies depending on the lead: R wave amplitude increases from the first to third lead in standard leads; highest amplitude was recorded in lead aVF in limb leads; in the chest leads highest R-wave amplitude was recorded in the right chest leads, and decreases in left chest leads. It characterizes right axis deviation.

The duration of S wave in children of both groups were not significantly different ( $p < 0.05$ )  $0.02 \pm 0.01$  sec. The amplitude of the S wave in infants also varies depending on the lead — the highest amplitude of the S wave is in the I standard lead; the highest amplitude in lead aVL in the limb leads; the highest amplitude of the wave S is recorded in the chest leads, and right chest leads can reach  $0,65 \pm 0,57$  mV. S wave is absent in III and aVR leads, but in some children S wave is recorded in the III standard lead.

ST complex in children early of neonatal period is variable, and it is not possible to explore its duration, therefore only its description is given: ST complex is not expressed in I and III standard leads, S wave goes into the rising T wave when entering the contour line; ST complex in II standard lead is largely shifted up over the contour line at  $0.05\text{-}0.1$  mV; in the limb leads, ST complex has the following characteristics: in aVR it is shifted down to a negative T wave; ST complex is in the contours in aVL; mostly shifted up to  $0.05\text{-}0.1$  mV in aVF or may not be expressed and go directly to the T wave, in the chest leads the complex mostly shifted in relation to the contour: in V1-V4 is shifted down to  $0.05\text{-}0.1$  mV, but in some children ST complex has been shifted upward to  $0.05$  mV in leads V3-V4; ST complex is most inconstant and can be shifted up or down by  $0.05\text{-}0.1$  mV, or be unexpressed and transform into the rising T wave; ST complex is located on the contour or goes into the rising T wave. These changes characterize the processes associated with the significant restructuring of the physiological hemodynamics, show the physiological adaptation of the heart and can be partly explained by the

relative shortage of oxygen in the process of transition from a post-natal placental circulation.

The amplitude of the T wave —  $0.13 \pm 0.05$  mV (Group 1);  $0.14 \pm 0.05$  mV (Group 2). In standard leads T wave is positive, but a negative or flattened T wave was observed in the standard lead III. The limb leads have different characteristics: in aVR—negative in aVL—mostly flattened, may be positive and in aVF—mostly positive. In chest leads T wave is mainly biphasic and may be positive or negative, in the V6 it is always positive, sometimes flattened.

*Table 1.*

**ECG-norms for the children of early neonatal period the real research**

	1 group, N = 20		2 group, N = 11	
<b>Heart rate</b>	141,00±17,52 (p<0,05)		150,45±10,77 (p<0,05)	
	<b>Amplitude (mV)</b>	<b>Duration (sec)</b>	<b>Amplitude (mV)</b>	<b>Duration (sec)</b>
<b>P wave</b>	0,12±0,05 (p>0,05)	0,04±0,01 (p>0,05)	0,15±0,05 (p>0,05)	0,04±0,00 (p>0,05)
<b>Interval P-Q</b>	—	0,23±0,34 (p>0,05)	—	0,21±0,29 (p>0,05)
<b>Complex QRS</b>	—	0,05±0,01 (p<0,05)	—	0,06±0,00 (p<0,05)
<b>Q wave</b>	0,06±0,12 (p>0,05)	0,02±0,01 (p>0,05)	0,05±0,09 (p>0,05)	0,01±0,01 (p>0,05)
<b>R wave</b>	0,06±0,12 (p>0,05)	0,02±0,01 (p>0,05)	0,05±0,09 (p>0,05)	0,02±0,01 (p>0,05)
<b>S wave</b>	0,65±0,57 (p>0,05)	0,02±0,01 (p<0,05)	0,65±0,57 (p>0,05)	0,02±0,01 (p<0,05)
<b>Segment S-T</b>	—	—	—	—
<b>T wave</b>	0,13±0,05 (p>0,05)	—	0,14±0,05 (p>0,05)	—
<b>Interval Q-T</b>	—	0,24±0,04 (p>0,05)	—	0,51±0,52 (p>0,05)

The average duration of the QT complex reached  $0.24 \pm 0.04$  sec. in examined infants (Group 1);  $0.51 \pm 0.52$  sec. (Group 2). Since heart rate was  $141.00 \pm 17.52$

(Group 1);  $150.45 \pm 10.77$  (Group 2) beats per minute ( $p < 0.05$ ), which does not contradict the research of a number of the QT complex done by several researchers.

**Conclusions.** Established standards of the ECG in children of early neonatal period, characterized by the adaptation of the cardiovascular system to the new changed conditions of life, are important for early detection of cardiovascular disorders in newborns.

Significant differences in heart rate in children of surveyed groups were detected. The duration of the QRS complex and the S wave did not differ significantly in healthy newborn of 1st-3rd and 4th-7th days of life, which showed the normal course of adaptation. There were no significant differences between the other ECG parameters in infants of both studied groups.

The findings confirm the expediency of an electrocardiogram as a highly informative screening method for diagnosing pathology of the cardiovascular system and features of adaptation period in newborns of the early neonatal period.

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**Особливості електрокардіограми у новонароджених раннього неонатального періода**

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**Резюме.** В статті розглянуто особливості та роль серцево-судинної системи в процесах адаптації новонароджених дітей та важливість ранньої діагностики серцево-судинних порушень в даному віковому періоді. В якості скринінгового метода був обраний рутинний метод електрокардіографії (ЕКГ). В ході огляду літератури виявлено недостатню вивченість та систематизованість параметрів ЕКГ-норми у новонароджених. В ході даного дослідження були уточнені та систематизовані параметри ЕКГ у новонароджених раннього неонатального періоду. Автори пропонують використовувати отримані показники в процесі скринінгу серцево-судинних розладів перинатального періоду.

**Ключові слова:** здоровий новонароджений, ранній неонатальний період, процес адаптації, ЕКГ.

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**Особенности электрокардиограммы у новорожденных раннего неонатального периода**

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**Резюме.** В статье представлен краткий обзор особенностей сердечно-сосудистой системы и ее роли в процессах адаптации новорожденных детей и обоснована необходимость ранней диагностики сердечно-сосудистых нарушений в данном возрастном периоде. В качестве скринингового метода был выбран рутинный метод электрокардиографии (ЭКГ). В процессе обзора литературы выявлено недостаточную изученность и систематизированность параметров ЭКГ-нормы у новорожденных. В ходе данного исследования были уточнены и систематизированы параметры ЭКГ-нормы у детей раннего неонатального периода. Результаты могут быть использованы в процессе скрининга сердечно-сосудистых расстройств перинатального периода.

**Ключевые слова:** здоровый новорожденный, ранний неонатальный период, процесс адаптации, ЭКГ.

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