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ABSTRACT

of the dissertation for the degree of Doctor of Philosophy

**HEART RATE VARIABILITY AND VENTRICULAR
ELECTRICAL STABILITY IN CHILDREN WITH
IDIOPATHIC RIGHT BUNDLE BRANCH BLOCK**

Specialty: 3220.01 — “Pediatrics”

Field of science: Medical Sciences

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GENERAL DESCRIPTION OF THE WORK

Relevance of the research: The most common cardiovascular pathology in children is various types of arrhythmia, which arise due to impaired cardiac conduction. The increase in the incidence of these pathologies over the past decade is considered one of the leading causes of disability and sudden cardiac death^{1,2}.

The inexhaustible interest of morphologists, electrophysiologists and arrhythmologists in the cardiac conduction apparatus is associated with the search for pathophysiological causes of various cardiac rhythm disorders-bradyarrhythmias, tachyarrhythmias^{3,4}.

In right bundle branch block (RBBB), the conduction of supraventricular sinus or ectopic impulses along the bundle branches is either slowed (incomplete block) or absent (complete block). Idiopathic RBBB has a different course than complete block and is typically seen in apparently healthy individuals and is discovered incidentally. Although its prevalence is apparently three times higher than that of complete block, its relationship with age has not been thoroughly studied^{5,6}.

RBBB can develop for various reasons, both functional and structural, causing delayed depolarization of the right ventricle, and its

¹ Groenewegen A. Epidemiology of Heart Failure / A. Groenewegen, Rutten F.H, Mosterd A [et al.] // Eur. J. Heart Fail, – 2020, 22, – p. 1342–1356.

² Duncker D. Smart wearables for cardiac monitoring real-world use beyond atrial fibrillation / D. Duncker, W.Y. Ding, S. Etheridge [et al.] // Journal Sensors, – 2021, 21 (7), – p. 2539.

³ Bagnall R.D. A Prospective Study of Sudden Cardiac Death among Children and Young Adults / R. D. Bagnall, R. G. Weintraub, J. Ingles [et al.] // N Engl J Med, – 2016. Vol. 374. №25, – p. 2441-2452.

⁴ Ban J.E. Neonatal arrhythmias: diagnosis, treatment, and clinical outcome / J.E. Ban // Korean journal of pediatrics, – 2017. Vol. 60. №11, – p. 344- 352.

⁵ Takanori Ikeda. Right Bundle Branch Block: Current Considerations / Takanori I // Curr Cardiol Rev, – 2021 Jan; 17(1): – p. 24-30.

⁶ Prakriti G. Mortality in patients with right bundle branch block in the absence of cardiovascular disease / G. Prakriti, P. Dawn, C.V. DeSimone [et al.] // Journal of the American Heart Association, – 2020, vol. 9 (19), JAHA.120.017430.

differential diagnosis with other arrhythmic disorders is important in clinical practice⁷.

Given the dependence of cardiac function on autonomic nervous system activity, heart rate variability (HRV), an indicator of sympathetic and parasympathetic activity, serves as a measure of cardiac autonomic function and an indicator of the cardiac receptor system, allowing for the timely detection of autonomic dysfunctions arising in the cardiac conduction system. This noninvasive test is used to assess cardiac autonomic function. This method evaluates the sympathetic and parasympathetic activity of the heart by measuring the period and spectral parameters of HRV⁸.

In the modern era, mathematical analysis of the QT interval duration, QT dispersion and its corrected derivatives, as well as the study of the parameters of the ventricular late potential (VLP) using highly informative ECG (HI ECG) are diagnostic methods for assessing the electrical stability of the myocardium for the early prediction of critical ventricular arrhythmias (VA) and sudden cardiac death (SCD)^{9,10}.

Therefore, in our study, it is appropriate to conduct these examinations in children with idiopathic right bundle branch block (IRBBB), and although we were familiar with scientific studies devoted to the study of heart rate variability, QT interval, and ventricular late potential (VLP) parameters to assess different types of rhythm disturbances in these children, we were unable to obtain

⁷ Brugada P. Right bundle branch block, persistent ST segment elevation and sudden cardiac death: a distinct clinical and electrocardiographic syndrome: a multicenter report / P. Brugada, Brugada J. // J Am Coll Cardiol, – 1992. 20, – p.1391-1396.

⁸ Tiwari R. Analysis of Heart Rate Variability and Implication of Different Factors on Heart Rate Variability / R. Tiwari, R. Kumar, S. Malik [et al.] // Curr Cardiol Rev, – 2021. Vol.17. No 5.

⁹ Ramalho D. Drug-induced life-threatening arrhythmias and sudden cardiac death: A clinical perspective of long QT, short QT and Brugada syndromes / D. Ramalho, J. Freitas // Revista Portuguesa de Cardiologia, – 2018, vol. 37 (5), – p. 435-446.

¹⁰ Galinier M. Prognostic value of late potentials in patients with congestive heart failure / M. Galinier, J.P. Albenque, N. Afchar [et al.] // ESC. European Heart Journal, – 1996, vol 17 (2), – p. 264-271.

information on the combined study of these parameters in children with IRBBB.

Thus, given the significance of cardiac conduction system pathologies, studying heart rate variability and myocardial bioelectrical stability in children with IRBBB may play an important role in the early diagnosis and prediction of complications.

Object and subject of the study: The study included 91 children with IRBBB and 36 children in the control group. HRV, QT interval, and VLP parameters were studied as the subject of the research.

The purpose of the study: To investigate age-related changes in heart rate variability, myocardial electrical stability, and ventricular late potentials in children with IRBBB.

Objectives of the study:

1. To study periodic and spectral parameters of heart rate variability in children with IRBBB depending on age.
2. To study myocardial electrical stability based on QT interval analysis in children with IRBBB depending on age.
3. To study the state of ventricular late potentials in children with IRBBB depending on age.
4. Study of the relationship between HRV and VLP in children with IRBBB and signs of impaired myocardial homogeneity

Research methods:

The examination methods included anamnestic and clinical examination, parameters of heart rate variability and the QT interval obtained via electrocardiography (ECG), parameters of VLP have been entered via the HI ECG.

Main propositions of the Dissertation for defense:

- A study of periodic and spectral parameters of heart rate variability in children with IRBBB shows that most of them exhibit an imbalance in the autonomic regulation of the cardiovascular system.
- Analysis of the QT interval in children with IRBBB allows us to identify disturbances in myocardial electrical homogeneity, which are more pronounced in older school-age children.

- The detection of a tendency toward the formation of late potentials in the myocardium using HI ECG in children with IRBBB can be assessed as a factor determining the occurrence of arrhythmias associated with autonomic imbalance, depending on age.

Scientific novelty of the study:

- Based on periodic and spectral parameters of heart rate variability in children with IRBBB, age-related characteristics and features of autonomic regulation were studied.
- Based on QT interval analysis in children with IRBBB, changes in myocardial electrical homogeneity were identified depending on age and autonomic regulation type.
- It was shown that children with IRBBB tend to develop late ventricular potentials, which is due to impaired myocardial electrical stability.
- In children with IRBBB, the reciprocal changes between the HRV parameters, QT interval, and VLP were determined depending on age to determine the state of myocardial electrical homogeneity.

Theoretical and practical significance of the research:

When assessing the cardiovascular system in children, periodic and spectral HRV parameters, detailed analysis of the QT interval, and study of VLP parameters will be considered important diagnostic criteria and will form the basis for the early diagnosis of possible arrhythmias and the improvement of appropriate treatment methods.

Approval and application of the research work:

Dissertation discussion: May 6, 2023, at the International Scientific and Practical Congress "Current Problems of Medicine", dedicated to the 100 th anniversary of the birth of national leader Heydar Aliyev, on the topic "Innovations in Pediatrics and Neonatology" (Baku, 2023); May 29-31, 2023, at the VII International Scientific and Practical Conference of the Caspian Sea Countries "Current Problems of Modern Medicine" (Russia, Astrakhan, 2023); June 22-25, 2023, at the 41st National Congress of the Azerbaijan Pediatricians Association, dedicated to the 100 th anniversary of

Heydar Aliyev's birth (Baku, 2023); December 12-14, 2025, at the XIV National Congress of Cardiology.

The initial discussion of the dissertation took place on December 20, 2024 (Protocol № 5) at a joint meeting of the staff of the Family Medicine, Childhood Diseases I, and Childhood Diseases II departments of AMU. The dissertation was discussed at the 13 th meeting of the Scientific Seminar of Dissertation Council ED 2.27, operating at AMU, on June 3, 2025.

The research results were applied in the clinical work of the Childhood Diseases Department (Pediatrics I) of the AMU Educational-Therapeutic Clinic and in the research of the Family medicine department of AMU.

Name of the organization where the dissertation was completed: This dissertation was completed at the department of Childhood Diseases (Pediatrics I) and the Department of Family Medicine of the Educational-Therapeutic Clinic of the AMU. Patient data was collected at the department of Pediatrics I of the AMU from 2016 to 2021.

Published research works: 13 research papers in periodicals related to the research conducted – 8 articles (3 in international review journals) and 5 conference abstracts (1 abroad) have been published.

Volume and structure of the dissertation: The dissertation was annotated on 155 pages (202081 characters), printed on a computer. Of these: Introduction (10754 characters), Chapter I (55144 characters), Chapter II (12075 characters), Chapter III (29478 characters), Chapter IV (19758 characters), Chapter V (20008 characters), Chapter VI (16138 characters), Conclusion (35110 characters), Results (2261 characters), Practical Recommendations (1355 characters). The list of literature used in writing the dissertation includes 187 literary sources. Of these, 5 sources are in Azerbaijani, 6 in Turkish, 40 in Russian and 136 in English. The dissertation is illustrated with 12 tables and 11 figures.

MATERIALS AND METHODS OF THE RESEARCH

In accordance with the study's objective, 127 children included in the study were divided into three groups based on age. Of these, 91 were children aged 3-6 years (7 boys, 7 girls), 34 were children aged 7-11 years (19 boys, 15 girls), 43 were children aged 12-17 years (27 boys, 16 girls) with IRBBB, and the remaining 36 children were apparently healthy children of the corresponding age, included in the control group.

The main inclusion criteria for the control group were normal weight and height, harmonious (or moderately disharmonious) physical development, normal blood pressure (measured using the Korotkoff method), and the absence of signs of cardiovascular disease during clinical examination. The study included children diagnosed with IRBBB based on random examinations. Acute and chronic genetic cardiovascular diseases, rheumatic and autoimmune diseases, congenital heart defects (CHD), cardiomyopathy, and infectious myocarditis were excluded.

During the study, all children were registered in their passports, and medical history information was obtained from the child and their parents. To achieve the objectives, all children were assessed a 12-lead ECG, HRV, for myocardial electrical stability QT interval and its derivatives. VLP with HI ECG has been assigned.

HRV was assessed by studying the following periodic and spectral parameters:

- SDNN (ms) - standard deviation, of all analyzed RR intervals
- Reflects the overall HRV over the entire recording period
- RMSSD (ms) - root mean square difference between consecutive RR intervals. With increased sympathetic activity a decrease in RMSSD is observed and conversely, an increase in RMSSD is observed with increased parasympathetic activity
- PNN50% - percentage of RR intervals with a difference exceeding 50 ms
- Aver RR (ms) – duration of normal RR intervals
- Max RR (ms) - maximum duration of normal RR intervals

- Min RR (ms) - minimum duration of normal RR intervals
 - VLF (ms²) (very low frequency) - power of the very low frequency component of the rhythm (0.003-0.04 Hz)
 - LF (ms²) - (low frequency) power of the low frequency component of the rhythm (0.04-0.15 Hz)
 - HF (ms²) (high frequency) - power of the high-frequency component of the rhythm (0.15-0.4 Hz)
 - LF/HF index - (sympatho-vagal index)
- To study the heterogeneity of myocardial electrical stability, the following QT interval parameters were analyzed:
- QT aver (ms) - average QT interval
 - QT max (ms) - maximum QT interval
 - QT min (ms) - minimum QT interval
 - QTd (ms) - QT interval dispersion (QTd = QT max – QT min)
 - QTc (ms) - corrected QT interval
 - QTc max (ms) - maximum QTc interval
 - QTc min (ms) - minimum QTc interval
 - QTcd (ms) - QTc interval dispersion (QTcd = QTc max - QTc min)
- Using HI ECG with VLP below parameters were determined:
- Total ORS (ms) - duration of the filtered QRS complex
 - Last 40 (ms) - duration of electrical signals with an amplitude below 40 μ V at the end of the filtered QRS complex
 - RMS 40 (μ V) - root-mean-square amplitude of the last 40 ms of the filtered QRS complex
 - Total QRS/RMS40 ratio

Statistical analysis of study results. To characterize the group of parameters, their mean value (M), its standard error (m), and variation interval (min-max) were determined. The absolute number and its share (in %) in the occurrence of qualitative features were calculated. To assess the statistical significance of differences between parameters, nonparametric methods were used, including the Mann-Whitney U-test for independent groups. The Pearson correlation coefficient was used to determine the presence of a linear relationship between parameters. The ROC test was used to statistically determine

the sensitivity and specificity of the parameters. In all cases, probability was considered statistically significant at $p < 0.05$. Statistical data processing was performed on a personal computer using Microsoft Office Excel, MedCalc 22.0, and IBM SPSS Statistics 27, a statistical package designed for medical research.

RESULTS AND DISCUSSION

In the main subgroup of children with IRBBB Group I (3-6 years old), the SDNN of the periodic HRV parameters decreased by $20.95 \pm 1.16\%$ compared to the control group, which was a statistically significant difference ($p < 0.05$). In this group, the RMSSD decreased by $13.03 \pm 2.40\%$, the PNN50 decreased by $7.80 \pm 2.67\%$, the MaxRR decreased by $10.02 \pm 1.99\%$, and the AverRR decreased by $5.17 \pm 2.27\%$ compared to the control group, with no statistically significant differences observed ($p > 0.05$) (Table 1).

The MinRR increased by $14.51 \pm 1.45\%$ compared to the control group level, which was statistically significant across groups ($p < 0.05$). In this group, the spectral parameters of the VLF index, which increased by $9.10 \pm 2.90\%$, the LF index, which increased by $9.81 \pm 3.41\%$, and the PNS's parameter HF index which decreased by $11.67 \pm 3.31\%$, did not have statistically significant differences ($P > 0.05$) compared with the control group. The LF/HF sympathovagal balance index increased by $16.59 \pm 4.36\%$ compared with the control group and had statistically significant differences ($p < 0.05$). Although no statistically significant differences were found in the VLF, LF, and HF indices when comparing the main and control groups of young preschool children, the fact that the LF/HF ratio was so pronounced reflects a pronounced tendency towards sympathetic activity in this group.

Table 1.
Age-related changes in periodic parameters of heart rate
variability in children with idiopathic right bundle branch block
M±m (min–max)

Parameters		SDNN (ms)	RMSS D (ms)	AverR R (ms)	MinRR (ms)	MaxRR (ms)	PNN50 (%)
I group	Main group n=14	55,3±1, 88 (48,0- 74,0)	56,3±3, 44 (38,0- 86,0)	615±2 1,0 (545- 800)	460,4±15 ,4 (350,0- 552,0)	869,6±32,74 (580,0-1074,0)	22,7±3,9 0 (7,0– 52,0)
	Contr ol group n=11	67,1±5, 95 (36,0- 94,0)	64,6±6, 04 (30,0- 98,0)	630±2, 0 (621- 640)	401,6±21 ,92 (320,0- 508,0)	940,6±49,48 (646,0-1210,0)	26,6±4,5 0 (6,0– 49,0)
	P	<0,05	>0,05	>0,05	<0,05	>0,05	>0,05
	P1	>0,05	>0,05	<0,001	>0,05	>0,05	>0,05
II group	Main group n=34	60,3±3, 60 (24,0– 98,0)	60,1±4, 22 (15,0– 101,0)	708±1 2,0 (535 - 820)	464,0±16 ,41 (340,0 - 657,0)	893,3±16,24 (628,0 - 1135,0)	27,4±2,8 4 (4,0– 55,0)
	Contr ol group n=11	67,2±4, 99 (31,0– 98,0)	64,8±6, 12 (22,0– 104,0)	680±1 0,0 (632 - 710)	430,5±25 ,87 (319,0 - 612,0)	963,5±33,83 (743,0 - 1226,0)	25,5±2,1 8 (18,0– 44,0)
	P	>0,05	>0,05	>0,05	>0,05	<0,05	>0,05
	P1	>0,05	>0,05	<0,001	>0,05	>0,05	>0,05
III group	Main group n=43	79,9±2, 81 (38,0– 110,0)	78,5±3, 45 (35,0– 107,0)	775±1 5,0 (605 - 949)	430,2±15 ,13 (315,0 - 742,0)	1091,3±20,04 (673,0 -1341,0)	31,0±2,9 (5,0– 58,0)
	Contr ol group n=14	68,1±5, 32 (31,0– 94,0)	65,1±5, 45 (36,0– 94,0)	750±4, 0 (731 - 770)	470,7±22 ,41 (342,0 - 627,0)	978,6±42,69 (614,0 - 1236,0)	25,6±1,9 5 (13,0– 35,0)
	P	<0,05	<0,05	0,05	>0,05	<0,05	>0,05
	P1	<0,001	<0,01	<0,001	>0,05	<0,001	>0,05
	P2	<0,001	<0,01	<0,01	>0,05	<0,001	>0,05

Note: P – statistical significance of the difference compared to the control group; P1 – compared to group I; P2 – compared to group II

The obtained data indicate that in children aged 3–6 years with IRBBB, overall heart rate variability (HRV) is reduced, the sympathetic component predominates, and there is a significant imbalance in the functioning of the two divisions of the autonomic nervous system, along with a decrease in vagal control of the heart. Such notable changes in the HRV parameters of these children with idiopathic right bundle branch block may indicate a relative increase in the activity of the sympathetic division of the autonomic nervous system specifically the sympathetic nervous system leading to an imbalance in the autonomic regulation of sinus node activity.

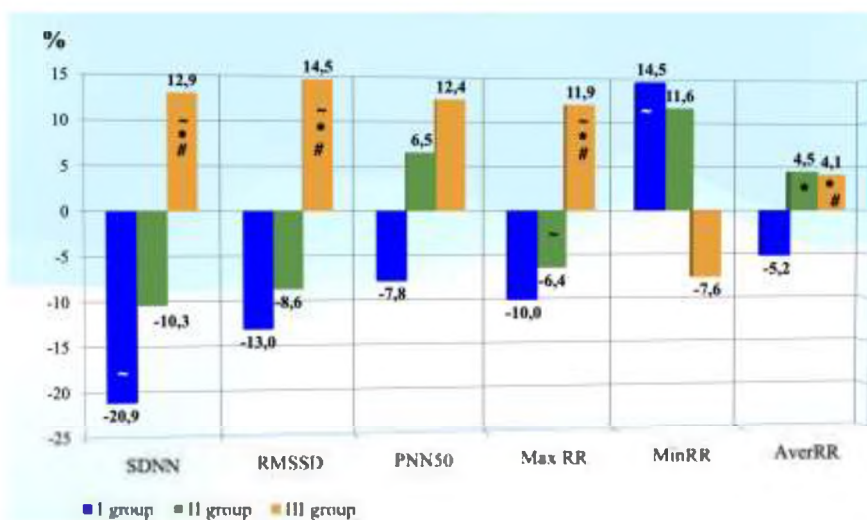
In children of group II (7-11 years old) with IRBBB, there was a decrease of $10.33 \pm 3.31\%$ in the SDNN index, one of the periodic parameters of HRV an increase of $6.46 \pm 0.69\%$ ($p > 0.05$) in the PNN50 index and a decrease of $8.61 \pm 2.14\%$ in the RMSSD index ($p > 0.05$) compared with the control group, while no statistically significant differences were found ($p > 0.05$). Among the periodic parameters of this group, the MaxRR duration in the main subgroup statistically differed significantly from the control group, decreasing by $6.41 \pm 0.42\%$ compared with the control group ($p < 0.05$). The MinRR index increased by $11.59 \pm 1.40\%$, and the AverRR index increased by $4.46 \pm 1.57\%$, and no statistically significant differences were found compared with the control group ($p > 0.05$). In the intergroup comparison, the mean value of RR intervals, Aver RR, was statistically significantly different from group I ($P < 0.001$).

Among the spectral parameters, the VLF indicator increased on average by $6.42 \pm 1.09\%$, the LF indicator by $5.38 \pm 1.45\%$, the LF/HF ratio by $14.06 \pm 1.85\%$, and the HF indicator decreased by $7.16 \pm 1.47\%$, while no significant difference was found ($P > 0.05$) (Table. I). All this indicates that the balance of autonomic regulation is maintained in primary school-age children with IRBBB, but tendencies towards relative sympathetic activity are observed. When comparing children aged 7-11 with IRBBB with children aged 3-6, it is clear that autonomic imbalance manifests itself with varying trends at the ages of 7-11, but in younger children (3-6 years), HRV indices suggest that sympathetic tone is more active at this age. Given the lack of marked differences between these two groups of children with

incomplete right bundle branch block, it can be inferred that while such a block does not cause acute cardiovascular imbalance associated with aging in children aged 7-11 even minor deviations in autonomic balance during the transition to adolescence a period when physiological neurohumoral regulation is not yet fully established could potentially lead to the development of life-threatening arrhythmias.

Figures 1 and 2 show the range of changes in the periodic and spectral parameters of heart rate variability by group in the form of a diagram.

In group III (12-17 years) of children, the SDNN index of periodic HRV parameters increased by $12.92 \pm 1.94\%$ compared to the control group of children suffering from IRBBB, and the RMSSD index reflecting PNS activity, increased by $14.50 \pm 1.74\%$ ($P < 0.05$).



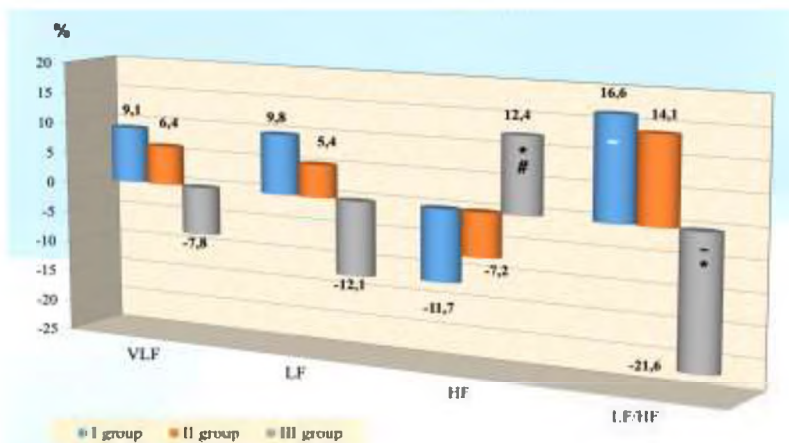
*Note: differences in intergroup comparisons are statistically significant ($p < 0.05$): * - with the control group; # - with group I; # - with group II*

Figure 1. Characteristics of periodic HRV parameters in children with IRBBB aged 3–17 years

Intergroup comparison revealed a statistically significant difference between the mean values of the corresponding SDNN ($p<0,001$) and RMSSD ($p<0,01$) index limits in this age group and in group 1 (3-6 years) and group 2 (7-11 years). Although the PNN50 index increased by $12.39\pm1.98\%$ compared to the control group, the MinRR index decreased by $7.57\pm1.13\%$, no statistically significant differences were found ($p>0.05$). The MaxRR duration in the main subgroup increased by $11.91\pm0.82\%$ compared to the control group, which is also statistically significant ($P<0.05$).

In the individual analysis of the indicators, the VLF index level was found to be low in 26 individuals within the group, while the LF index level was low in 27 individuals. The index levels were balanced between girls and boys. The VLF index level was elevated in 12 children, and the LF index level was elevated in 11 children, showing a similar pattern.

Changes in the VLF indicator which assesses the influence of the neuroendocrine system on cardiac rhythms and the LF variability indicator in this context signal an increased tendency toward the destabilization of autonomic regulation.



*Note: differences between groups are statistically significant ($p<0.05$): compared to the control group; * - compared to group I; # - compared to group II*

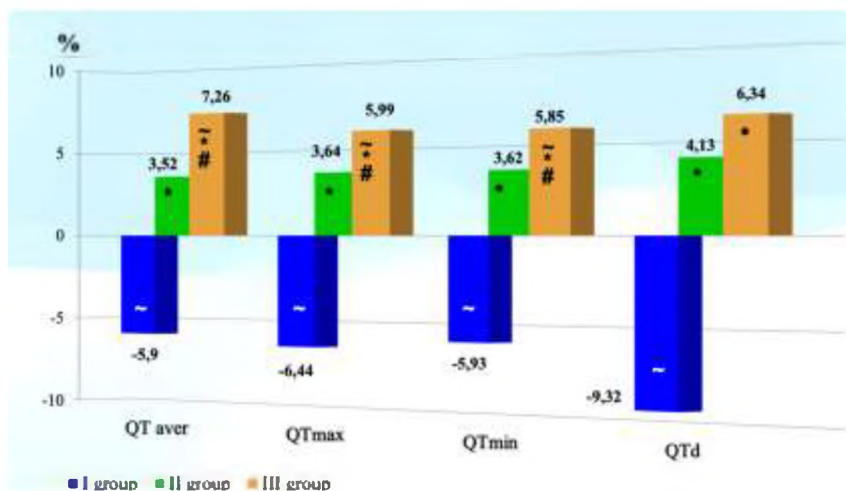
Figure 2. Characteristics of the spectral parameters of HRV in children with IRBBB aged 3-17 years

The remaining small number of children were monitored against the normative levels of the control group.

In the intergroup comparison, a statistically significant difference was found between the mean values of the corresponding limits of the MaxRR and AverRR indicators in children of group 3 (12-17 years old) and children of group 1 (3-6 years old) and group 2 (7-11 years old) ($p < 0.001$).

Increased activity of parasympathetic regulatory mechanisms in children with IRBBB as they mature may create a tendency toward ventricular arrhythmias at this age. Therefore, assessing and studying HRV parameters when identifying changes in autonomic regulation in children with idiopathic right bundle branch block may have a significant impact on the organization of effective cardiovascular management in these children in the future. Although the VLF parameter decreased by $7.80 \pm 2.37\%$, and the LF parameter by $12.11 \pm 2.43\%$ compared to the spectral parameters, no statistically significant difference was observed compared to the average values in the control group ($P > 0.05$). The HF index increased by $10.48 \pm 2.19\%$ in this group and did not differ statistically significantly. When compared between groups, the HF index in this group differed significantly from the mean value of the corresponding index in groups I and II ($p < 0.05$). The LF/HF ratio decreased by $21.56 \pm 1.46\%$ ($P < 0.05$) in accordance with the indicators, indicating the risk of autonomic imbalance at this age. A statistically significant difference was obtained between the mean values of the corresponding limits of group 1 and group 3 for the LF/HF index ($p < 0.05$) (Table.1). Figures 3 and 4 show the range of changes in the QT parameters in the form of a diagram.

Our results once again clearly demonstrate changes in heart rate variability during the manifestation of vagal activity in older school-age children with idiopathic incomplete RBBB. Mathematical analysis of the QT interval and its derivatives in children participating in the study revealed various patterns of changes, with a downward trend in preschool-aged children and an upward trend in school-aged children.

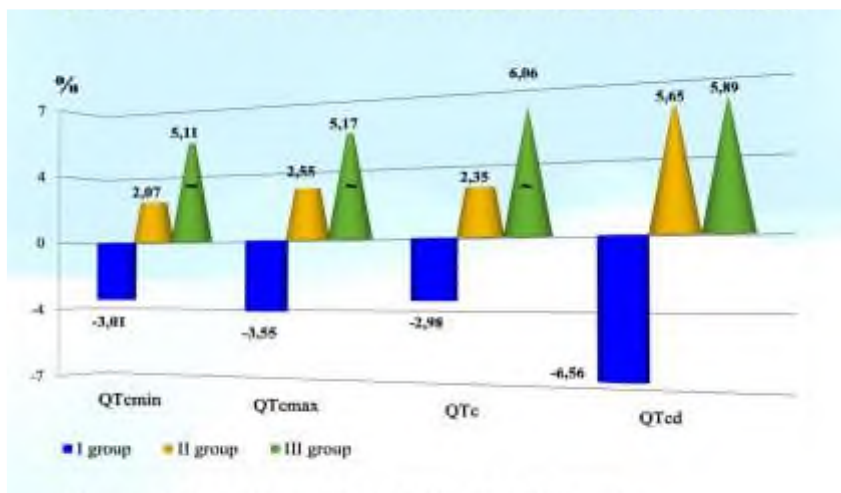


*Note: differences between groups are statistically significant ($p < 0.05$): compared to the control group; * - compared to group I; # - compared to group II*

Figure 3. Characteristics of the QT interval in children with IRBBB aged 3-17 years

As can be seen, while the QT interval and its derivatives tended to decrease in preschool-aged children, they showed a tendency to increase in school-aged children. Shortening or prolongation of the QT interval is considered a major risk factor for the development of dangerous arrhythmias, such as ventricular and supraventricular tachycardias, as well as ventricular and atrial fibrillation.

Children aged 3-6 years showed statistically significant decreases in the maximum, minimum, mean, and dispersion of the QT interval compared to the control group. Significant differences were observed, with decreases in QTmax - 6.44% ($p < 0.001$), QTmin - 5.93% ($p < 0.001$), QTaver - 5.90% ($p < 0.001$), and QTd - 9.32% ($p < 0.05$). Parallel changes in QTmin and QTaver were observed. Although QTcmax remained close to normal in age group 1, a trend toward a partial decrease was noted. In this age group, there was a statistically insignificant decrease in QTcmax ($3.55 \pm 1.85\%$), QTcmin (3.01%), QTc (2.98%), and QTcd (6.56%) ($p > 0.05$).



*Note: differences between groups are statistically significant ($p < 0.05$): compared to the control group; * - compared to group I; # - compared to group II*

Figure 4. Characteristics of the QTc interval in children with IRBBB aged 3-17 years

Given that the cardiac conduction apparatus and autonomic nervous system (ANS) are not yet fully developed in children aged 3-6 years, the presence of RBBB may lead to impaired ventricular myocardial heterogeneity. Studying myocardial electrical stability parameters in this age group helps to further monitor the activity of the cardiac conduction system.

In primary school-aged children (7-11 years), the maximum QT interval increased by 3.64%, the minimum by 3.62%, the mean by 3.52%, and the QTd by 4.13% ($P > 0.05$). A comparative analysis of QT interval parameters (QTmax, QTmin, QTaver, QTd) with Group I revealed a statistically significant difference between the groups ($p < 0.001$). In Age Group II, an increase in QTc max by $2.55 \pm 1.07\%$, QTc min by 2.07% , QTc by $2.35 \pm 1.25\%$, and QTcd by 5.65% ($p > 0.05$) was observed. Although IRBBB influenced myocardial

bioelectrical activity in children aged 7-11 years, unlike in preschool-aged children, signs of a disruption in its homogeneity were not very pronounced.

The increase in maximum, minimum, and average values reflecting the duration of the QT interval was more noticeable in children aged 12-17 years compared to children aged 7-11 years. In older school-age children with IRBBB, compared with the control subgroup, there was a significant difference in QTmax by 5.99% ($p<0.01$), QTmin by 5.85% ($p<0.01$), QTaver by 7.26% ($p<0.01$). QTd statistically significantly differed by 6.34% ($p>0.05$). In mathematical analysis between age groups, three indicators (QTmax, QTmin, QTaver) statistically significantly differed in both age groups ($p<0.01$). QTd statistically significantly differed from the same parameter in age group I ($p<0.001$).

Mathematical analysis of the study results revealed that the wide range of variation in the maximum, minimum, and mean QT interval values in children with idiopathic right bundle branch block reflects heterogeneity in the ventricular repolarization process. Heterogeneity of the repolarization process in the myocardium is one of the key factors leading to a disruption of its electrical stability.

QTcmax increased by $5.17\pm 1.54\%$ ($p<0,05$), QTcmin by 5.11% ($p<0,05$), QTc by 6.06% ($p<0,01$) and statistically significantly differed from the same indicators in the control group. In Group III, the QTcd interval increased by 5.89% and did not differ significantly from the control group ($p>0.05$).

In general, the observed changes in the corrected QT interval values in children with idiopathic incomplete right bundle branch block indicate impaired myocardial electrical stability and serve as a predictive warning sign for the development of more serious and dangerous disturbances in the heart's conduction system.

Statistical analysis shows that significant changes in the QT interval and its parameters were more pronounced in older school-age children. Given the various methods used for the timely detection of life-threatening arrhythmias in children aged 3-17 years with idiopathic incomplete right bundle branch block, we can consider them

as predictors of disruption of the homogeneity of the myocardial repolarization process.

According to the results obtained during the study, certain changes in the parameters of the VLP were observed in all three groups of children with IRBBB between the main and control subgroups, as well as in the intergroup comparison. These changes are shown in table 2 and figure 5. In children of group I (3-6 years old), the VLP's parameters Total QRS increased by $4.92 \pm 0.67\%$ compared with the control group and had statistically significant differences ($p < 0.05$). Although the RMS 40 index increased by $2.84 \pm 0.71\%$, the TotalQRS/RMS 40 index increased by $2.18 \pm 0.45\%$, and the Last 40 index decreased by $11.3 \pm 1.35\%$ compared with the control group, they did not deviate statistically significantly from the normal values of the control group ($p > 0.05$). During the individual analysis of elderly children in a small school, it is clear from the determination of the duration and amplitude indicators of the VLP that a higher level of the Total QRS indicator has been observed in 6 children exceeding the maximum limit of the control group, which accounts for 42.9% of the children examined in the main half-group IRBBB, confirming a tendency towards VLP and late myocardial electrical potentials at this age can strengthen the risk of dangerous rhythm disturbances.

Based on the results of the research, it can be said that the Total QRS/RMS 40 index in young children of preschool age has changed within the range of 0.89 ± 0.027 (0.69-1.08) ms. During the individual analysis of the index, the level of the indicator in 9 children with IRBBB was higher than the average level of healthy children, and in 3 children, the level of the indicator was higher than the maximum level of the normal range of healthy children. Although we hope that the processes occurring in intraventricular conduction disturbances in children aged 3-6 are transient and can be addressed with proper examination and treatment methods in time, based on the analysis of the parameters of the VLP in children with IRBBB, it is recommended to include these children in the risk group for cardiac pathologies due to the presence of late myocardial potentials.

Assessing the parameters of the VLP in young children with IRBBB using the HI ECG method, the indicators of the delayed potentials of the cerebellum have been found to be different in the main subgroup of this group compared to school-aged children.

In group II (7-11 years old) of children with IRBBB, the Total QRS value increased by $9.2 \pm 1.40\%$ compared to the control group and was statistically significantly different ($p < 0.01$). The Total QRS index was statistically significantly different from the corresponding index of children aged 3-6 years ($p < 0.05$). The tendency of indicators to fluctuate in children with IRBBB leads to the development of non-homogeneity in the heart muscle, and an increased likelihood of pathological conditions in repolarization. This intensifies the tendency of myocardial electrical stability to be disrupted.

Although the duration of the Last40 index, which characterizes the duration of late potentials, tended to increase by $12.0 \pm 1.14\%$ in this group, it did not statistically differ from the indices of practically healthy children ($p > 0.05$). When comparing the study results with the corresponding index of younger preschool-age children, it is also evident that in children with IRBBB, the level of Last40 duration tended to increase with age, and a statistically significant difference was observed between the groups ($p < 0.001$). This explains the deepening of the late of electrical impulses in the myocardium in children with IRBBB aged 7-11 years. Although the RMS40 power, which is considered the energy of late potentials and characterizes the root-mean-square amplitude of the filtered ventricular complex during the last 40 ms, tended to decrease by $4.43 \pm 1.48\%$, unlike other parameters of this group, it did not differ significantly from the control group indicators ($p > 0.05$).

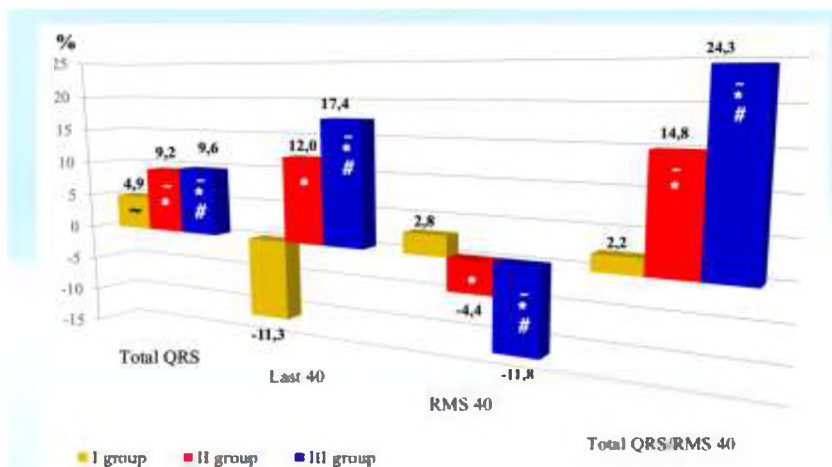
In the obtained results, the Total QRS / RMS 40 index increased by $14.76 \pm 1.81\%$ and was statistically significantly different from the control group ($p < 0.001$). It is evident that both the RMS 40 and TotalQRS/RMS 40 indicators differ significantly from the statistical comparison of the corresponding indicator of group 1 ($p < 0.001$).

Table 2.

**Parametrs of ventricular late potentials in children with
idiopathic right bundle branch block. $M \pm m$ (min-max)**

Parameters		TotalQRS (ms)	RMS40 (mkv)	Last40 (ms)	Total QRS/ RMS40	QRS (ms)
I group	Main group n=14	79,3±1,60 (69,0 - 89,7)	89,5±2,43 (76,4 - 109,0)	20,3±1,18 (15,7 - 28,4)	0,89±0,027 (0,69 - 1,08)	88,6±1,76 (79,0- 100,0)
	Control group n=11	73,3±1,57 (67,4 - 82,3)	84,3±2,48 (72,0 - 98,0)	21,4±1,19 (16,0 - 29,0)	0,87±0,020 (0,76 - 0,96)	80,7±0,76 (75,-83,0)
	P	<0,05	>0,05	>0,05	>0,05	<0,01
II group	Main group n=34	83,4±1,02 (69,0 - 94,0)	75,1±1,10 (62,0 - 90,0)	27,1±0,88 (18,0 - 35,0)	1,12±0,020 (0,87 - 1,39)	89,6±1,28 (77,0- 112,0)
	Control group n=11	77,2±1,72 (66,8 - 86,3)	79,2±1,79 (71,0 - 92,0)	24,1±1,04 (18,2-31,7)	0,98±0,023 (0,82-1,11)	82,9±1,40 (76,0-93,0)
	P	<0,01	>0,05	>0,05	<0,001	<0,01
	P1	<0,05	<0,001	<0,001	<0,001	>0,05
III group	Main group n=43	87,8±0,80 (75,0 - 96,0)	58,7±0,54 (51,0 - 66,0)	33,9±0,61 (26,0 - 39,0)	1,50±0,021 (1,19 - 1,86)	92,0 ±1,17 (73,0- 108,0)
	Control group n=14	80,5±1,65 (68,7 - 87,8)	66,1±1,44 (57,4 - 74,8)	29,1±0,98 (22,0 - 34,5)	1,22±0,030 (1,03 - 1,46)	84,2±1,98 (69,0-98,0)
	P	<0,001	<0,001	<0,001	<0,001	<0,01
	P1	<0,001	<0,001	<0,001	<0,001	>0,05
	P2	<0,01	<0,001	<0,001	<0,001	>0,05

Note: P – statistical significance of the difference compared to the control group; P1 – compared to group I; P2 – compared to group II



*Note: the difference in intergroup comparison is statistically significant ($p < 0.05$): * compared with the control group; * - compared with group I; # - compared with group 2*

Figure 5. Range of changes in the VLP parameters in children with IRBBB aged 3-17 years

The late electrical potentials during intraventricular conduction can lead to the development of irreversible metabolic and electrophysiological changes in the myocardium and cardiomyocytes of prepubertal children. Given that the nature, severity, and future prognosis of cardiac processes resulting from these delays in children with idiopathic right bundle branch block remain unclear, the importance of establishing parameters for VLP in neonatal ECG with in pediatric practice is undeniable.

In group III (12-17 years old) of children with IRBBB, the TotalQRS complex significantly differed from the corresponding parameter in the control subgroup by an increase of $9.6 \pm 1.31\%$ ($p < 0.001$). When comparing the duration of the Total QRS complex with similar parameters in children aged 3-6 and 7-11 years with IRBBB, a significant difference was observed ($p < 0.001$). The Last 40 parameter increased somewhat more, by $17.4 \pm 0.74\%$, compared with primary school-age children. The obtained parameters were

statistically significantly different from the control group ($p < 0.001$). In this group, the RMS 40 index, which characterizes the root-mean-square amplitude of the filtered QRS complex in the last 40 ms, decreased by $11.8 \pm 0.77\%$ and was statistically significantly different from the control group ($p < 0.001$). A significant decrease in the RMS 40 index in children with IRBBB compared to other groups once again indicates that the tendency towards slowing of the myocardial electrical potentials in these children increases with age. Thus, in this group, the RMS 40 index differed significantly from the average value in both preschool and primary school children ($p < 0.001$). When determining the Total QRS/RMS 40 index, it became clear that the index increased by $24.3 \pm 1.35\%$ and was significantly different from the control group ($p < 0.001$). During individual analysis of these children, it was found that the levels of 27 individuals exceeded the normative limits of the control group, showing a maximum increase and being followed by an equal number of traces in all age groups. The manifestation of this tendency according to age in children aged 12–17, with IRBBB, indicates a disruption of myocardial repolarization, as well as the presence of fragmented heterogeneous areas, i.e. foci of VLP.

Based on the study results, we observed that the Total QRS/RMS 40 index, as well as other VLP parameters, differed significantly ($p < 0.001$) in this group of children with idiopathic right bundle branch block when compared between groups.

During individual analysis within this group, the Last 40 score in 23 children exceeded the maximum normative value of the control group for their age. This phenomenon was observed almost exclusively in children aged 13–17. Only two of the children aged 13–17 showed index levels comparable to those of the control group. Such changes in the index level indicate that, as children with IRBBB grow older, there is a greater late in the impairment of myocardial electrical stability and in the development of fragmented ventricular activity.

Based on these results, we conclude that VLP foci are identified due to electrophysiological heterogeneity of the cardiac muscle in children with IRBBB. These conditions, in turn, increase the risk of more dangerous VA in the future due to the addition of any other

metabolic disorders and pathologies. Therefore, the fact that ventricular depolarization heterogeneity is so pronounced at different ages necessitates including children at risk for arrhythmias.

To study possible relationships between ventricular repolarization parameters, slow potentials, and autonomic regulation, as well as to assess the specificity and sensitivity of these parameters, statistical correlation analysis and ROC analysis were performed to further clarify conduction abnormalities. Thus, when conducting a correlation analysis between the main indicators of the QT interval and heart rate variability in children aged 3-6 years, a positive correlation was recorded between QTc and SDNN ($r=0.155$, $p=0.597$), RMSSD ($r=0.488$, $p=0.076$), VLF ($r=0.041$, $p=0.890$), LF/HF ($r=0.101$, $p=0.730$), a positive correlation between the dispersion of the QT interval (QTd) and SDNN ($r=0.148$, $p=0.613$), RMSSD ($r=0.114$, $p=0.699$), PNN50 ($r=0.288$, $p=0.318$), as well as a negative correlation between VLF ($r=-0.036$, $p=0.903$), LF/HF ($r=-0.136$, $p=0.643$). The obtained results emphasize the existence of a relationship between autonomic regulation and QT interval parameters in young preschool children.

If we consider the correlations between QT parameters and VLP parameters in this age group, we see a positive correlation between QTc and Total QRS ($r=0.135$, $p=0.646$), RMS 40 ($r=0.260$, $p=0.370$), and a negative correlation with Last 40 ($r=-0.047$, $p=0.874$) and Total QRS/RMS 40 ($r=-0.123$, $p=0.675$). These results indicate the existence of the identified relationships between ventricular repolarization parameters and potential late. If we examine the correlations between autonomic regulation and ventricular late potentials in this group, we see a statistically significant positive and significant relationship between the LF/HF parameter, which is the main indicator of autonomic imbalance, and the RMS 40 ($r=0.793$, $p=0.001$), confirming the importance of the relationship between these two parameters in the susceptibility to VA. The statistical results also show a statistically significant negative and significant relationship between the LF/HF parameter and the Total QRS/RMS 40 ($r=-0.685$, $p=0.007$). Based on these results, it can be concluded that the existing relationships between autonomic imbalance and ventricular late

potentials once again recommend monitoring intracardiac conduction to eliminate the risk of VT in children with IRBBB.

In children aged 7-11 years, a correlation analysis was performed between the QT interval parameters and HRV indices, as well as ventricular late potential indices, and statistical relationships were recorded. A significant inverse relationship was obtained between the maximum QTc value and the VLF ($r=-0,462$, $p=0.006$), PNN50 ($r=-0,398$, $p=0.020$) parameters and the minimum QTc value and the VLF ($r=-0,501$, $p=0.003$), PNN50 ($r=-0,396$, $p=0.020$) parameters. Positive correlations were obtained between QTc and SDNN ($r=0.009$, $p=0.958$), RMSSD ($r=0.067$, $p=0.707$), as well as negative correlations between VLF ($r=-0.247$, $p=0.159$), LF/HF ($r=-0.217$, $p=0.217$) and PNN50 ($r=-0.141$, $p=0.426$). The presence of a relationship between the heterogeneity of myocardial repolarization and the autonomic regulation of the heart in primary school-aged children is important for children with right bundle branch block.

If we examine the correlations between QT parameters and VLF parameters in this age group, we see a true positive correlation between QTc and Total QRS/RMS40 ($r=0,373$, $p=0.030$) and a true negative correlation with RMS40 ($r=-0,436$, $p=0.010$). When analyzing the correlations between autonomic regulation and ventricular late potentials in children aged 7-11 years, we see a true inverse correlation between the VLF parameter and Total QRS/RMS40 ($r=-0,377$, $p=0.028$) and a true positive correlation with RMS40 ($r=0,444$, $p=0.008$). Such statistically significant changes in the parameters indicate a functional dependence of late potentials on autonomic regulation. In children aged 12-17 years, a correlation analysis was also performed between these parameters, and statistically significant relationships were recorded. A true positive correlation was found between QTaver and SDNN ($r=0,356$, $p=0.019$), RMSSD ($r=0,361$, $p=0.018$) and PNN50 ($r=0,404$, $p=0.007$). A negative inverse correlation was obtained between QTcmax and LF ($r=-0,330$, $p=0.031$). Negative correlations were found between QTc and SDNN ($r=-0.017$, $p=0.914$), VLF ($r=-0.164$, $p=0.292$), LF/HF ($r=-0.115$, $p=0.464$) and positive correlations between RMSSD ($r=0.102$, $p=0.514$). A negative inverse correlation

was obtained between QTcd and RMSSD ($r=-0,387$, $p=0.010$). The relationship between cardiac electrical conductivity and the autonomic nervous system (ANS) also suggests the identification of relationships caused by the influence of common mechanisms. If we consider the correlations between autonomic regulation and ventricular late potentials in children aged 12-17 years, we will see a positive correlation between the SDNN parameter and the Total QRS ($r=0.053$, $p=0.736$), RMS 40 ($r=0.001$, $p=0.993$) indicators, as well as a negative correlation with the Last 40 indicators ($r=-0.031$, $p=0.846$). There is a negative correlation between the LF/HF parameter and the TotalQRS ($r=-0.116$, $p=0.458$), Last 40 ($r=-0.139$, $p=0.375$) parameters, as well as a positive correlation with the RMS 40 parameters ($r=0.020$, $p=0.897$). The tendency of these parameters to correlated changes suggests that late potentials depend on autonomic regulation. To determine the specificity and sensitivity of the indicators, the results of ROC analysis were statistically analyzed. Based on the test analysis, it can be concluded that in children aged 3-6 years with IRBBB, QTaver (AUC = 0.909, $p \leq 0.001$, Youden index = 0.785) are statistically reliable diagnostic indicators with high discriminatory ability, QTd (AUC = 0.792, $p = 0.003$, Youden index = 0.5649) and Total QRS (AUC = 0.789, $p = 0.002$, Youden index = 0.493) are statistically reliable diagnostic indicators with moderate discriminatory ability (figure 6 (a, b)).

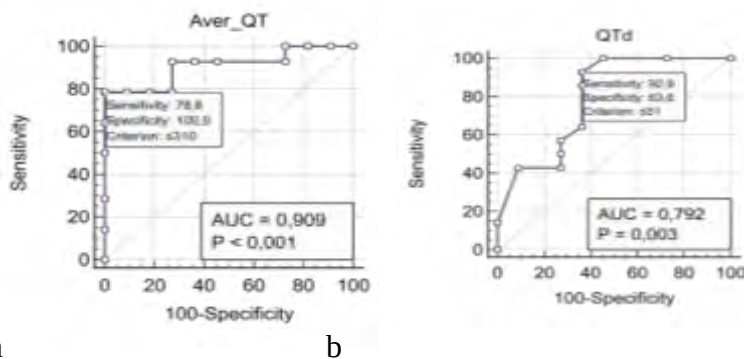


Figure 6. ROC curves of the parameters in children with IRBBB aged 3-6 years

Based on the ROC curve analysis in children aged 7-11 years, it can be concluded that Total QRS/RMS40 (AUC=0.850, $p<0.001$, Youden index=0.762) are statistically reliable diagnostic indicators with good discriminatory ability, while Total QRS (AUC=0.773, $p=0.001$, Youden index=0.550) has moderate discriminatory ability for determining the discriminatory ability of these children in relation to IRBBB (figure 7).

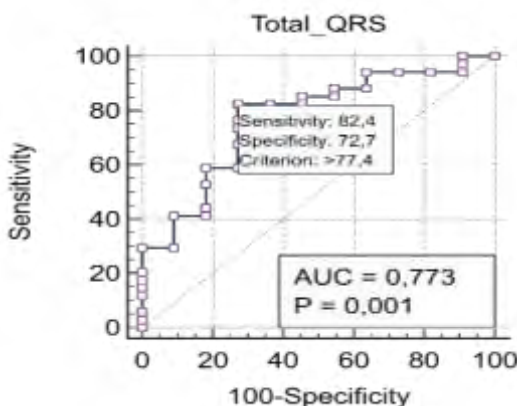
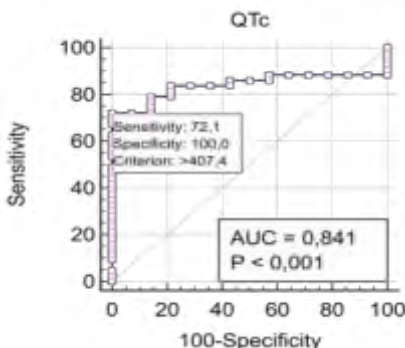
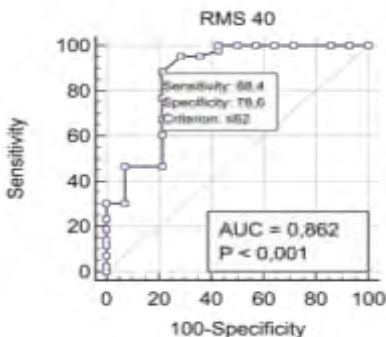


Figure 7. ROC curves of the Total QRS parameter in children with IRBBB aged 7-11 years

As for the ROC curve analysis in children aged 12-17 years, it can be concluded that QTc (AUC=0.841, $p<0.001$, Youden index=0.720) is a statistically strong and reliable diagnostic tool with good discriminatory ability for risk identification. In this group, Last40 (AUC=0.811, $p<0.001$, Youden index=0.558) and RMS40 (AUC=0.862, $p<0.001$, Youden index=0.669), which are indicators of late ventricular potentials, are statistically reliable diagnostic indicators with good discriminatory ability, and the Total QRS/RMS40 ratio (AUC=0.937, $p<0.001$, Youden index=0.762) has high discriminatory ability (figure. 8 (a, b)).



a



b

Figure 8. ROC curves of the parameters in children with IRBBB aged 12-17 years

Thus, the study of arrhythmias arising from ventricular conduction disturbances in children with IRBBB, the investigation of myocardial repolarization heterogeneity with QT and QTc parameters, the determination of HRV parameters the study of autonomic imbalance activity, the determination of VLP parameters using high-resolution electrocardiography (HI ECG), and the assessment of the relationships between them can be considered a very important topic in the field of modern pediatric cardiology. These examination methods can be used as useful and preventive measures in the diagnosis and prevention of ventricular blocks and arrhythmias occurring in children aged 3-17 years, as well as in the prevention of other arrhythmic conditions that can develop at an older age.

RESULTS

1. In children with IRBBB, an increase in age and duration of the block is characterized by an increase in disintegrative tendencies in the autonomic regulation of cardiac rhythm control. At the age of 3-6 years, an increase in sympathetic tone activity is observed with SDNN (-20.95%, $p < 0.05$), LF / HF (16.59%, $p < 0.05$), and at the age of 7-11 years - relative sympathetic activity against the background of sympathovagal imbalance. At the age of 12-17 years, an increase parameters such as SDNN, RMSSD, PNN50, HF, by (12.92%, $p < 0.05$), (14.5%, $p < 0.05$), 12.39%, 10.48%, respectively, leads to HRV dysregulation against the background of vagal activity in autonomic regulation [2, 4, 5, 9].
2. In children with IRBBB, a decrease in the duration of the QT interval parameters QTmax (-6.44%, $p < 0.001$), QTaver (-5.90%, $p < 0.001$), QTd (-9.32%, $p < 0.05$) against the background of hypersympathicotonia at the age of 3-6 years compared to the control group indicates an acceleration of ventricular repolarization, a tendency to an increase in QT parameters at the age of 7-11 years and an increase in QTc (6.06%, $p < 0.001$), QTd (6.34%), and QTcd (5.89%) durations in high school students is associated with prolonged non-homogeneity in myocardial electrical conductivity, indicating continuous disturbance in repolarization [3, 7, 8].
3. In children with IRBBB, compared to the control group, there was an increase in the Total QRS (4.92%, $p < 0.05$), RMS 40 (2.84%) VLP in children aged 3-6 years, an increase in the Total QRS (9.2%, $p < 0.05$), Total QRS / RMS 40 (14.76%, $p < 0.001$) in children aged 7-11 years, as well as an increase in the Last 40 parameter by (17.4%, $p < 0.001$) and a decrease in RMS 40 by (-11.8%, $p < 0.001$) in children aged 12-17 years, which indicates the presence of late potentials in the myocardium, which increases the risk of ventricular arrhythmias [6, 11].
4. The conducted correlation analysis showed the presence of possible relationships between the HRV parameters, QT indices and VLP, with the following significant correlations: in group I

– LF / HF with RMS 40 ($r = 0,793$, $p = 0,001$); in group II – VLF, QTc with RMS 40 ($r = 0,444$, $p = 0,008$; $r = -0,436$, $p = 0,010$), QTc max with VLF, RMS40 ($r = -0,462$, $p = 0,006$; $r = -0,398$, $p = 0,020$), QTc min with PNN50 ($r = -0,396$, $p = 0,020$); in group III – QT aver with SDNN, RMSSD, PNN50 ($r = 0,356$, $p = 0,019$; $r = 0,361$, $p = 0,018$; $r = 0,404$, $p = 0,007$); QTc max with LF ($r = -0,330$, $p = 0,031$), QTcd with RMSSD ($r = -0,387$, $p = 0,010$) [13].

5. In the statistical calculation based on the results of the ROC analysis, in group I, the QTaver ($p < 0.001$) was high, QTd ($p < 0.01$) was average; in group II, the Total QRS/RMS40 ($p < 0.001$) was good, the Total QRS ($p < 0.01$) was average; in group III, QTc ($p < 0.001$), Last 40 ($p < 0.001$), RMS 40 ($p < 0.001$) were good, the Total QRS/RMS40 ($p < 0.001$) was a significant parameter with high discriminatory ability [13].

PRACTICAL RECOMMENDATIONS

1. During a routine examination of children diagnosed with IRBBB or various types of arrhythmia, it is advisable to classify them as at risk for developing cardiac pathologies and monitor the progression of the disease, assess the autonomic regulation of the cardiovascular system, and use and analyze periodic and spectral HRV parameters, such as SDNN, RMSSD, PNN50, VLF, LF, HRF, LF/HF and application and analysis of the QT interval and its derivatives, such as QTc, QTd, and QTcd in children with repolarization abnormalities.
2. The analysis of parameters such as Total QRS, Last 40, RMS 40 in HI ECG for determining the bioelectrical and metabolic activity of the myocardium in pediatric population provides a non-invasive method of assessing the risk of critical and life-threatening arrhythmias during RBBB or other rhythm disturbances as age advances.
3. The combined study of these examination methods in children with rhythm and conduction disturbances, as well as their analysis in clinical practice, allows for the early prediction of the worsening of cardiac pathologies in the future. These parameters can be used for early diagnosis and prevention of dangerous cardiac arrhythmias in children with RBBB.
 - SDNN: 3-6 years ≤ 55.3 ms; 7-11 years ≤ 60.3 ms; 12-17 years ≥ 79.9 ms
 - LF/HF: 3-6 years ≥ 1.2 ; 7-11 years ≥ 1.1 ; 12-17 years ≤ 0.9
 - QTd: 3-6 years ≤ 47.1 ms; 7-11 years ≥ 52.4 ms; 12-17 years ≥ 54.8 ms
 - Last 40: 3-6 years ≤ 20.3 ms; 7-11 years ≥ 27.1 ms; 12-17 years ≥ 33.9 ms

THE LIST OF PUBLISHED SCIENTIFIC WORKS ON THE DISSERTATION TOPIC

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13. Abdullayeva, A.Ə, İsayev İ.İ, Mustafayeva A.A, Fətəliyeva M.M. İdiopatik Hiss dəstəsinin sağ ayaqcığının blokadası olan uşaqlarda miokardın bioelektrik fəallığı ilə ürək ritminin tənzimlənməsi parametrləri arasında korrelyativ əlaqənin öyrənilməsi // Azərbaycan perinatologiya və pediatriya jurnalı, Bakı. 2026. № 1, cild 12, s. 8-14.

LIST OF ABBREVIATIONS

AMU	– Azerbaijan Medical University
ECG	– Electrocardiography
HI ECG	– High- informative electrocardiography
HRV	– Heart rate variability
IRBBB	– Idiopathic right bundle branch block
RBBB	– Right bundle branch block
ROC	– Receiver Operating Characteristic
VA	– Ventricular arrhythmia
VLP	– Ventricular late potentials



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