Journal of Medicinal and Chemical Sciences

Journal homepage: http://www.jmchemsci.com/

Original Article

Cardiac Conduction Disorders in Children with Community-Acquired Pneumonia

Ekaterina Anatolevna Ivanova[1], Liudmila Ivanovna Gerasimova[2,3,*], Olga Viktorovna Sharapova[2,4], Olga Nikolaevna Bragina[1], Elvira Valerianovna Bushueva[1], Andrey Georgievich Petrov[1], Mikhail Yurievich Mikhaylov[5]

[1]*Internal Medicine Department of the Chuvash State University I.N. Ulyanov, 428017, Chuvash Republic, Cheboksary city, Moskovsky prospect, 45, Russia*

[2]*State Budgetary Institution of Health "City clinical hospital of Vinogradov V.V." of the Healthcare Department of Moscow, 117292, Vavilova street, 61, Moscow, Russia*

[3]*Medical Institute of Continuing Education of Federal State Budgetary Educational Institution of Higher Education "Moscow State University of Food Production", 125080, Volokolamskoe highway, 11, Moscow, Russia*

[4]*Institute of Clinical Medicine of Federal State Autonomous Educational Institution of Higher Education I.M. Sechenov First Moscow State Medical University of the Ministry of Healthcare of the Russian Federation (Sechenovskiy University), 119435, Bolshaya Pirogovskaya st., 2, building 4, Moscow, Russia*

[5]*Budgetary institution «City Children's Clinical Hospital» of the Healthcare Ministry of Chuvashia, 428015, Traktorostroiteley Avenue, 12, Cheboksary city, Russia*

ARTICLE INFO

Article history

Received: 2021-06-08
Received in revised: 2021-08-10
Accepted: 2021-08-24
Manuscript ID: JMCS-2106-1204
Checked for Plagiarism: **Yes**
Language Editor:
Dr. Behrouz Jamalvandi
Editor who approved publication:
Dr. Zeinab Arzehgar

DOI:10.26655/JMCHEMSCI.2021.5.14

KEYWORDS

Children
Community-acquired pneumonia
Electrocardiogram
Teenagers

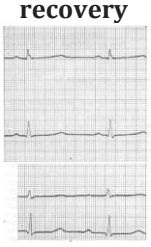
ABSTRACT

The purpose of this study was to evaluate the cardiac conduction in children with non-severe community-acquired pneumonia during inpatient treatment and period of convalescence by electrocardiographic examination. The study involved 166 children aged 1 to 17 years, patients with non-severe community-acquired pneumonia, undergoing inpatient treatment in Pediatric Hospital. On the second day of treatment, each child underwent a heart ECG. The control sample consisted of 271 healthy children. Then, after dispensary observation, children with abnormalities in cardiac conduction had another ECG. The study found that 76% of children with non-severe pneumonia had ECG changes. The majority of children had conduction disorders of different localization and degree. Intraventricular conduction disorder in pneumonia occurred in 38% of cases, 2.5 times more often than in the control sample. Considering pathology of heart excitability, 3.96% of children had signs of right atrium overload, and 2.85 % - of left ventricle. 70 % of children with conduction disorders still had these changes after the ECG study in dynamics. This study showed that children with pneumonia had significant changes in the electrophysiological activity of the heart, which may have persisted after the convalescence period. This group of patients requires special management tactics at the stage of therapy and rehabilitation.

GRAPHICAL ABSTRACT

A child with pneumonia

Long-term ECG changes after recovery



Special therapy and rehabilitation

* Corresponding author: Liudmila Ivanovna Gerasimova
✉ E-mail: profgera@mail.ru

Introduction

According to the World Health Organization (WHO), pneumonia is the cause of death in 15% of children under 5 years of age [1]. Inflammatory processes in the lung tissue lead to the pulmonary circulation disorders, which subsequently cause heart failure and a depression of myocardial contractility. Increased cardiac load leads to increased myocardial oxygen demand, which can be an inducer of cardiomyocytes apoptosis, especially in respiratory failure [2-6].

That is why pneumonia is associated with heart dysfunction both during and after illness [7]. It has been reported that the majority of medical articles covers mostly the severe forms of pneumonia, where you can see the most apparent pathophysiological changes in the heart. In addition, there were no studies we could find about the cardiac electrophysiology in non-severe pneumonia in children [8]. Importantly, results of ECG studies, obtained in the adult sample cannot be used in pediatrics, due to morphological and functional characteristics of children [9]. Evaluation of cardiac conduction by ECG in children with non-severe community-acquired pneumonia (CAP) during inpatient treatment and period of convalescence.

Material and methods

It was conducted longitudinal prospective and retrospective study.

The study sample was formed in the pediatric department № 3 of the Budgetary Institution «City Children's Clinical Hospital» of the Healthcare Ministry of Chuvashia (Cheboksary city). The study was carried out from October 2019 until February 2020. The control group was formed in the Budgetary Institution «City Children's Clinical Hospital» of the Healthcare Ministry of Chuvashia (Cheboksary city) at the same period. After dispensary observation of the children with abnormalities in cardiac conduction during community-acquired pneumonia, they were re-examined by an ECG.

Compliance criteria

Inclusion criteria were:

- Patients with non-severe community-acquired pneumonia from 1 to 17 years (group of health I-II - initially healthy children), and
- Healthy children without pneumonia (group of health I-II) for control group.

Non-inclusion criteria were:

- Children with severe chronic pathology; and
- Children with severe and complicated forms of community-acquired pneumonia.

The diagnosis of "community-acquired pneumonia" was established in the department of the City Children's Clinical Hospital in Cheboksary, according to the criteria of the Federal clinical Recommendations for community-acquired pneumonia in children. Non-severe community-acquired pneumonia was considered an inflammation of the lung tissue with intoxication syndrome, respiratory failure of I-II degree, syndrome of local changes and without clinical manifestations of pulmonary and extrapulmonary complications. The severity of the disease was determined in accordance with the clinical symptoms: Fever lasting more than three days above 38.5 S, O2 saturation below 94%, shortness of breath with the participation of accessory muscles and local changes of lungs [14].

Information about the health group was obtained from the patient's outpatient medical record and the medical history of the inpatient receiving medical care.

The comparison groups were selected in a ratio of 1:1.5, the number of children with non-severe CAP to the number of healthy children during the study. The selection of couples was carried out by age and health groups.

We focused on the cardiac conduction system, intraventricular conduction disorders, bundle branch conduction disorders, as well as the rapid conduction in the atrioventricular node.

Additional indicators in the study group included ventricular repolarization disorders, overload of the right and left parts of the heart, nomotopic rhythm disorders. The dependence of the frequency of pathological changes in the work of the heart on the severity of clinical manifestations of pneumonia, the localization of the lesion and the degree of damage to the lung

tissue was also studied. Regression of disorders in the cardiac conduction system in convalescents was evaluated. The effect of the antibacterial drug "Azithromycin" on the QT was not ignored.

The assessment of the heart electrical activity was carried out on the second day of treatment using a standard ECG (12 leads). Heart rhythm and conductivity, the determination of the heart electrical axis, the atrial P wave, the ventricular QRST complex, and the amplitude of other waves and duration of the PQ and QT were analyzed for each patient [15]. The age standards were evaluated according to the guidelines of the Association of Pediatric Cardiologists of Russia "Standard parameters of ECG in children and adolescents" edited by Shkolnikova et al. [16].

Statistical processing of the results was carried out using MS Excel 2007 and the SPSS application software package version 21.0 (IBM, USA). In all groups, the distribution was different from the normal one. The differences were considered statistically significant at the achieved significance level of $p<0.05$ (Tables 2, 3)

Prior to the study, the Ethical Committee of the Chuvash State University (Protocol No. 19-10 of 25.10.2019) agreed that the study complied with the ethical standards set out in the Helsinki Declaration. After the completion of the study, a positive conclusion was made about the outcome of the study (protocol No. 20-03 of 24.03.2020). The prospective part of this study was conducted after obtaining the voluntary informed consent of the parents.

Result and Dissection

For the study, we selected 271 children aged 1-17 years with community-acquired pneumonia. The inclusion criterion was the presence of non-severe community-acquired pneumonia in children of I-II health groups (166 patients). Another 105 children were excluded according to the following criteria: Severe CAP and children of III-V health group. The control group included 271 healthy children of the I-II health groups. Further research was continued with a CAP-group of 166 children and a control group of 271 children.

For the dynamic ECG study, we selected a group of 93 children with identified cardiac conduction disorders, 63 people with intraventricular conduction disorders, 30 people with accelerated conduction in the atrioventricular node during non-severe CAP.

General characteristics of the children under study are presented in Table 1.

Table 1: Characteristics of children with CAP and children from control group

Indicators	CAP-group children, n=166	Control group, n=271
Boys	53,6%	57,4%
Girls	46,4%	42,6%
1-3 years old	21,68%	18,2%
4-6 years old	18,07%	22,1%
7-12 years old	31,92%	35,7%
13-17 years old	28,31%	24%

Table 2: Comparative characteristics of the identified electrocardiographic disorders in the groups (main results)

Indicators	CAP-group children, n=166	Control group, n=271	p
Intraventricular conduction disorders	63 (38%)	47 (17,3%)	0,015
Bundle branch conduction disorders	32 (19,83%)	10 (3,69%)	0,025
Rapid conduction in the atrioventricular node	30 (18,07%)	10 (3,6%)	0,023

Most children have conduction disturbances of varying localization and severity. Intraventricular conduction disorders in pneumonia occur in 38% of cases (Table 2). Bundle branch conduction disorders were registered in 19.83%: Incomplete right bundle branch block (incomplete RBBB) - in 18.25% of children, complete right bundle branch block (complete RBBB) in 1 patient (0.79%), incomplete left bundle branch block (incomplete LBBB) – also in 1 patient (0.79%). Rapid conduction in the atrioventricular node - in

18.07%, was 5 times more often than in control group (3.6%, p < 0.05).

ECG results of children from CAP-group were compared with ECG results of control group. It was found that in pneumonia, intraventricular conduction disorder occurred 2,5 times more often (control group - 17.3% % (p< 0.05)), incomplete RBBB - 5 times more often (control group - 3.69% (p<0.05)), rapid conduction in the atrioventricular node was 6 times more often (control group – 3.6%).

Table 3: Comparative characteristics of the identified electrocardiographic disorders in the groups (additional results)

Indicators	CAP-group children, n=166	Control group, n=271	p
Dysfunctions of early ventricle repolarization	43 (26,1%)	26 (9,75%)	0,027
Nomotopic heart rhythm dysfunctions	44 (26,9%)	0	0,03
Sinus tachycardia	26 (15,8%)	0	0,065
Sinus bradycardia (below the 3rd percentile)	5 (3,17%)	0	0,084
Sinus arrhythmia	13(7,93%)	0	0,07
Predominance of the left ventricle potentials	5(2,85%)	0	0,09
Right heart overload	8(4,76%)	0	0,085

We also found that the pathology of the heart electrical activity was detected in 126 children - 76% (Table 3). Sinus node was the main pacemaker in all the examined children. Nomotopic heart rhythm dysfunctions in children with normal temperature occurred in 26.9% (p<0.05). In addition, 15.8% (p>0.05) of them have sinus tachycardia, 3.17% (p>0.05) - sinus bradycardia, 7.93% - sinus arrhythmia. There were no heterotopic rhythm disturbances.

There were also signs of overload, mainly right heart overload - in 4.76% of children. Predominance of the left ventricle potentials occurred two times less (2.85% of cases). Dysfunctions of early ventricle repolarization (mostly the right heart repolarization) were found in 26.1%.

The greatest percentage of pathology was revealed in right-sided pneumonia cases (77.4%): Intraventricular conduction disorder - in 34.3%, which was 1.5 times more often than in left-sided pneumonia, incomplete RBBB - in 15.68% of cases. Also found more severe problems were found with heart in right-sided cases: Complete undocumented before the case of pneumonia (RBBB), incomplete left bundle branch block (LBBB).

In left-sided pneumonia, sinus tachycardia prevailed in 20.4% of cases. Overload of the right heart was 6 times more frequent (13.33% versus 2.04% of right-sided localization and 2.94% of left-sided) occurred in children with bilateral pneumonia.

Assessing the degree of the lung tissue damage, we noticed that in 83.73% of cases of diseases, there was focal localization of pneumonia. Patients with this localization had ECG abnormalities in 70% of cases. Of the severe pathologies – incomplete LBBB was noticed. Intraventricular conduction disorders were revealed in 27.14% of children, which was almost 2 times more often than in patients with segmental pneumonia (11.1%), but 1.5 times less often than with polysegmental pneumonia (37.7%). Children with polysegmental lung tissue lesions had incomplete RBBB more often (in 37.5% of patients).

37.5% had the syndrome of early ventricle repolarization, which was 2 times more often than in focal localization. Children with polysegmental lung tissue damage has overload of the left heart (in 25% of patients). Such severe disorders as complete RBBB, overload of the right heart were found in focal localization. Comparing the ECG of CAP-children with ECG of children in the control group, we found that impaired repolarization of the ventricles was 2.5 times more often than in the group of healthy children (control group - 9.75% (p<0.05)).

Changes in the electrical systole of the heart are of great clinical importance. We calculated QTc and revealed a pathology of electrical systole in the form of QTc lengthening in 13.3% of children

and shortening - in 15%. It was shown that among children who took Azithromycin at the prehospital stage (16 people), after the calculations, the QTc interval lengthening over 440 ms occurred in 50% of cases (8 people). The maximum lengthening was observed in patients treated with Azithromycin with incomplete RBBB and impaired repolarization of the right heart in right-sided focal pneumonia. The maximum QTc shortening was also observed in a patient with right-sided localization of focal pneumonia.

We obtained the following results during a dynamic ECG study: Disturbances in the cardiac conduction system remained in 69.89% of patients, nomotopic rhythm disturbances remained in a third of the studied (32.35%), and accelerated conduction of excitation in the AV node remained in 10.7% of the studied. The predominance of the potentials of the right and left heart regions regressed.

Almost three-quarters of children with non-severe community-acquired pneumonia have a pathology of heart electrical activity, manifested by disorders affecting both excitation and conduction of impulse [10]. The right heart overload is more common in bilateral localization, and left heart overload - in left-sided localization. Bundle branches conduction disorders, up to a complete block, acceleration of atrioventricular node conduction are mainly observed in right-sided pneumonia. Intraventricular conduction disorders were observed in every 3-4th child. It should be noted that these pathological changes do not regress even after convalescence and the completion of dispensary observation.

In our study, the pathology of the heart electrical activity in right-sided focal localization prevails. With outpatient use of "Azithromycin", every second patient had QTc prolongation. This drug can cause a significant change in the electrical systole of the heart. [11] These children are at risk of developing potentially fatal cardiac arrhythmias. There are no adverse events.

In this study, both reference conditions necessary for comparison of groups were fulfilled. The subjects of the study in the groups were comparable at the time of the beginning of the exposure. The evaluation of the outcomes of the study in the compared samples was carried out in all subjects of the study according to the same criteria using the same methods after the expiration of the same tracking period.

The close relationship of the respiratory and circulatory organs is beyond doubt. Dysfunction of the cardiovascular system is an almost constant companion of pulmonary tissue inflammation since the onset of the disease [12]. The breadth of these dysfunctions depends on the severity of CAP. In severe CAP, the impact of pathological reactions on the circulatory system is most apparent.

The criteria for early detection of heart pathology in patients with CAP have not been sufficiently developed, which was the reason for studying this topic [7].

The pathogenesis of cardiovascular system damage is based on processes such as oxygen deficiency, inflammation, and pathogenicity factors of an infectious agent. The more hypoxia, the less energy resources cardiomyocytes have. Lipid peroxidation (LPO) triggers the inflammatory process, and LPO products have an arrhythmogenic effect, which may be the cause of monotopic sinus node dysfunctions, which, as noted above, were found in 26.9% of the examined children. The effect on the entire cardiac conduction system was also noted, affecting the disruption of the atrioventricular node in the form of acceleration, activation in conditions of respiratory failure of additional conduction pathways, along the bundle branches and Purkinje fibers. Thus, hypoxic damage to the cells of the myocardial conduction system may underlie cardiac arrhythmias [13].

According to the literature, in our study, right-sided localization of pneumonia was more common. The anatomical features of the bronchial tree explain the predominance of right-sided pneumonia. In patients with right-sided localization of pneumonia, a statistically significant prevalence of disturbances in the electrical activity of the heart was revealed - 3 times more than with left-sided localization and 2 times more than with bilateral localization. However, the most severe processes leading to

circulatory failure occurred in bilateral lung pathology.

It deserves noting that it is necessary, first of all, to exclude heart complications such as myocarditis, pericarditis, etc. in a non-severe pneumonia with an ECG pathology.

Conclusion

In children with non-severe pneumonia, there are significant changes in the heart electrophysiological activity - acceleration of AV conduction, ventricles conduction disorders, which tend to persist after the treatment and rehabilitation of the underlying disease, as well as overload of the heart, lengthening and shortening of the QTc. It was noted that in children who received macrolide antibiotics ("Azithromycin") on an outpatient basis, there was an elongation of the QTc interval. These children are at risk for developing potentially fatal cardiac arrhythmias. In the treatment and rehabilitation of children who have suffered from pneumonia, you need to pay attention at heart function and, if necessary, conduct a serious examination of concomitant pathology.

Acknowledgement

The study had no sponsorship.

Funding

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Authors' contributions

All authors contributed toward data analysis, drafting and revising the paper and agreed to be responsible for all the aspects of this work.

Conflict of Interest

We have no conflicts of interest to disclose.

References

[1]. Pneumonia. News bulletin. WHO, 2016; November: Пневмония (who.int) (the link is active on 01.09.2020). (in Russ) [Crossref]

[2]. Ali R., Baban R., Ali S., *Baghdad J. Biochem. Appl. Biol. Sci.,* 2021, **2**:118 [Crossref], [Publisher]

[3]. Abid H., Abid Z., Abid S., *Baghdad J. Biochem. Appl. Biol. Sci.,* 2021, **2**:59 [Crossref], [Publisher]

[4]. Kabir A.I., Karim R., Hossain M. I., Newaz S., *J. Asian Afr. soc.,* 2018, **4**:1 [Google Scholar]

[5]. Mousa T. H., Al-Obaidi Z.M.J., Alkhafaji S.L., *Lat. Am. J. Pharm.,* 2021, **40**:128 [Scholar Google]

[6]. Shalaby M.N., Sakoury M.M., Kholif M.A., Alsayed N.I., *J. Adv. Pharm. Educ. Res.,* 2020, **10**:141 [Google Scholar]

[7]. Vysochina I.L., Krivusha E.L., Rusakova E.A., *Child. Health,* 2014, **53**:101 [Crossref]

[8]. Israilova N.A., *Europ. Sci. Rev.,* 2015, 11 [Google scholar], [Publisher]

[9]. Gerasimova L.I., Bogdanova T.G., Shuvalova N.V., Tyurnikova S.R., Barsukova E.V., *Mod. Probl. Sci. Educ.,* 2013, **4**:103 [Crossref]

[10].Bushueva E.V., Sokolova I.S., Gerasimova L.I., *Mod. Probl. Sci. Educ.,* 2015, **3**:130 [Crossref]

[11].Kramarov S.A., Zakordonets L.V., Actual Infectology, 2020, **8**:38 [Crossref], [Google scholar], [Publisher]

[12].Boytsova E.V., Ovsyannikov D.Y., Belyashova M.A. *Pediatrics,* 2016, **95**:72 [Google Scholar]

[13].Ghorbani S., Dana A., Christodoulides E., *Biomed. Human Kinet.*, 2020, **12**:69 [CrossRef], [Google Scholar], [Publisher]

[14]. Dana A., Christodoulides E., *J. Rehabil. Sci. Res.*, 2020, **7**:25 [CrossRef], [Google Scholar], [Publisher]

[15].Stein P.D., Matta F., Ekkah M., Saleh T., Janjua M., Patel Y.R., Khadra H., *J. Am. Coll. Cardiol.,* 2012, **110**:1836 [CrossRef], [Google Scholar], [Publisher]

[16].Shkolnikova M.A., Miklashevich I.M., Kalinina L.A., Moscow: publishing House: Association of pediatric cardiologists of Russia, 2017

HOW TO CITE THIS ARTICLE

Ekaterina Anatolevna Ivanova, Liudmila Ivanovna Gerasimova, Olga Viktorovna Sharapova, Olga Nikolaevna Bragina, Elvira Valerianovna Bushueva, Andrey Georgievich Petrov, Mikhail Yurievich Mikhaylov. Cardiac Conduction Disorders in Children with Community-Acquired Pneumonia, *J. Med. Chem. Sci.*, 2021, 4(5) 519-524

DOI: 10.26655/JMCHEMSCI.2021.5.14

URL: http://www.jmchemsci.com/article_136139.html