https://doi.org/10.17816/PED11365-72

ACOUSTIC ASSESSMENT OF PULMONARY VENTILATION IN CHILDREN WITH BRONCHIAL ASTHMA ON THE BACKGROUND OF A SINGLE EXPOSURE TO MICROWAVE RADIATION

© N.L. Potapova, I.N. Gaymolenko

Chita State Medical Academy, Ministry of Healthcare of the Russian Federation, Chita, Russia

For citation: Potapova NL, Gaymolenko IN. Acoustic assessment of pulmonary ventilation in children with bronchial asthma on the background of a single exposure to microwave radiation. *Pediatrician (St. Petersburg).* 2020;11(3):65-72. https://doi.org/10.17816/PED11365-72

Received: 03.04.2020 Revised: 18.05.2020 Accepted: 23.06.2020

Summary. Diseases of the respiratory organs of children, occurring with obstructive syndrome, represent one of the most serious problems in terms of transition to chronic forms. The chronic process is accompanied by a decrease in pulmonary ventilation, which leads to the search for effective methods of complex therapy of diseases. **The purpose** of this study was to evaluate the dynamics of acoustic indicators of pulmonary ventilation in children with bronchial asthma, against the background of non-invasive non-thermal microwave radiation. **Materials and methods.** 122 children with bronchial asthma aged from 3 to 17 years were examined. 113 patients underwent a single session of non-invasive microwave therapy with the Aster device. Comparison of acoustic characteristics of pulmonary ventilation was carried out taking into account the severity of the disease and the age of children with bronchial asthma. Acoustic assessment of ventilation function was performed using the computer bronchophonography complex Pattern-01 before the Aster procedure, after 5 and 15 minutes. In 20 (16.4%) patients with bronchial asthma, the dynamics of cough was evaluated against the background of Aster therapy for 7 days. **Results.** Improvement of bronchial patency was registered in all age groups with mild bronchial asthma. In the group of moderate asthma, exposure to electromagnetic radiation led to a significant reduction in ventilation disorders in children aged 7–11 years. As patients grow older, as well as with severe bronchial asthma, the smallest dynamics of the parameters of pulmonary ventilation was observed against the background of Aster therapy. The use of electromagnetic radiation in addition to traditional basic therapy for 7 days leads to a faster regression of cough in patients with bronchial asthma. **Conclusion.** The combination of traditional basic therapy with electromagnetic non-thermal radiation in patients with bronchial asthma reduces obstructive pulmonary ventilation disorders and promotes faster cough regression.

Keywords: bronchial asthma; children, microwave therapy; Aster.

АКУСТИЧЕСКАЯ ОЦЕНКА ЛЕГОЧНОЙ ВЕНТИЛЯЦИИ У ДЕТЕЙ С БРОНХИАЛЬНОЙ АСТМОЙ НА ФОНЕ ОДНОКРАТНОГО ВОЗДЕЙСТВИЯ МИКРОВОЛНОВОГО ИЗЛУЧЕНИЯ

© Н.Л. Потапова, И.Н. Гаймоленко

Федеральное государственное бюджетное образовательное учреждение высшего образования «Читинская государственная медицинская академия» Министерства здравоохранения Российской Федерации, Чита

Для цитирования: Потапова Н.Л., Гаймоленко И.Н. Акустическая оценка легочной вентиляции у детей с бронхиальной астмой на фоне однократного воздействия микроволнового излучения // Педиатр. – 2020. – Т. 11. – № 3. – С. 65–72. https://doi.org/10.17816/PED11365-72

Поступила: 03.04.2020 Одобрена: 18.05.2020 Принята к печати: 23.06.2020

Актуальность. Заболевания органов дыхания детского возраста, протекающие с обструктивным синдромом, представляют одну из самых серьезных проблем из-за риска перехода в хронические формы. Хронический процесс сопровождается снижением легочной вентиляции, что обусловливает поиск эффективных методов комплексной терапии заболеваний. **Целью** настоящего исследования явилась оценка динамики акустических показателей легочной вентиляции у детей с бронхиальной астмой на фоне неинвазивного нетеплового микроволнового излучения. **Материалы и методы.** Обследовано 122 ребенка с бронхиальной астмой в возрасте от 3 до 17 лет. 113 пациентам однократно проведен сеанс неинвазивной микроволновой терапии аппаратом «Астер». Сравнение акустических характеристик легочной вентиляции проведено с учетом степени тяжести болезни и возраста детей с бронхиальной астмой. Акустическая оценка вентиляционной функции проводилась с помощью комплекса компьютерной бронхофонографии «Паттерн-01» до процедуры «Астер», через 5 и 15 мин. У 20 (16,4 %) пациентов

с бронхиальной астмой проведена оценка динамики кашля на фоне терапии аппаратом «Астер» в течение 7 дней. **Результаты.** Улучшение бронхиальной проходимости регистрировалось при бронхиальной астме легкого течения во всех возрастных группах. В группе среднетяжелой астмы воздействие электромагнитного излучения приводило к существенному уменьшению вентиляционных нарушений у детей 7–11 лет. По мере взросления пациентов, а также при тяжелом течении бронхиальной астмы отмечена наименьшая динамика параметров легочной вентиляции на фоне терапии «Астер». Использование электромагнитного излучения дополнительно к традиционной базисной терапии в течение 7 дней приводит к более быстрому регрессу кашля у пациентов с бронхиальной астмой. **Выводы.** Сочетание традиционной базисной терапии с электромагнитным нетепловым излучением у пациентов с бронхиальной астмой уменьшает обструктивные нарушения легочной вентиляции и способствует более быстрому регрессу кашля.

Ключевые слова: бронхиальная астма; дети; микроволновая терапия; «Астер».

INTRODUCTION

Heterogeneity of broncho-obstructive syndrome (BOS) is a subject of considerable practical interest for pediatricians, allergists, and pulmonologists. Over the past 10 years, the understanding of the details of the pathogenesis of respiratory tract obstruction syndrome has been significantly expanded [2, 8]. However, there is no doubt that to objectively assess clinical states in diseases accompanied by BOS, additional criteria must be taken into account, such as the reaction of the bronchial tree in response to therapeutic effects. Regarding the selection of complex treatment methods, a combination of basic and alternative therapy for bronchial obstruction is currently being considered [7]. Previous studies have shown positive results of using non-thermal microwave radiation for prolonged coughing and respiratory diseases with bronchial obstruction syndrome [3]. The efficiency of the unit "Aster" on bronchial asthma (BA) was examined for a long time by a course from 8 to 14 treatments. It revealed no clear bronchodilator effect in one case, but in another case, it tended to increase the indicators of bronchial obstruction, decrease the frequency of β2-agonists administration with a quick regression of day and night symptoms of the disease [10].

The results obtained are contradictory and no clear data explains the mechanism of exposure to the respiratory tract and the possibility and rationale of using ultra-weak electromagnetic waves in patients of different age groups with different severity of BA [12, 13].

This study aims to conduct an acoustic assessment of the functional state of the bronchopulmonary system of children with BA of various severities after single microwave exposure.

MATERIALS AND METHODS

Acoustic parameters were evaluated for a single exposure to the Aster unit in the "pre-experiment" mode (without randomization, the initial data were used as a control) [14]. Taking into account the conflicting data on the influence of electromagnetic radiation in bronchopulmonary diseases, a single application of non-thermal electromagnetic radiation was done to clarify the nature of changes in pulmonary ventilation.

The main group was initially made of 122 patients with BA, aged from 3 to 17 years who gave informed voluntary consent to participate in the study. The exclusion criterion was the presence of chronic diseases in the acute stage and acute infectious diseases. The initial parameters of patients were used as control data.

The diagnosis of BA was made per the diagnostic criteria of the consent documents [6]. Nine patients (7%) had virus-induced exacerbations of BA (BOS more than three times in the last year after acute respiratory viral infection and a burdened allergic history). Patients with virus-induced exacerbations received leukotriene receptor antagonists (montelukast) as basic therapy and were subsequently excluded from the study. In the main group of subjects, the allergic phenotype of asthma prevailed: 113 (93%) patients had increased immunoglobulin E (IgE) levels and peripheral blood eosinophilia. These patients were divided according to the severity of BA as follows: mild BA – 33 (29.2%), moderate asthma – 36 (31.9%), and severe BA – 44 (38.9%). At the time of hospitalization in the department of pulmonology of the Regional Children Clinical Hospital of Chita, patients were in a period of acute asthma.

The assessment of acoustic parameters was carried out between the 5th and 7th day of relief from an acute attack, which did not exclude the presence of hidden bronchospasm.

All patients of the main group (113 people) were given a session of non-thermal electromagnetic radiation using the Aster unit[1] [5]. The duration of the session was 7 minutes following instructions: The examination was done in a separate room without extraneous noise. The time for a re-evaluation of bronchial patency was chosen empirically, taking into account the subjective feeling of a breathing relief of patients. The respiratory cycles were recorded at the following time points: T_0 – the initial measurement, T_1 – after 5 minutes, and T_2 – 15 minutes after the Aster session. Patients received therapy with the Aster device. Broncholytic drugs were excluded for 7–8 hours before the study and, thus, could not affect bronchial patency.

Improvement of bronchial patency indicators was chosen as the endpoint of the study when using the Aster device. The result at the endpoint of the study was classified as "there is an outcome/no outcome." The result of exposure to electromagnetic radiation on bronchial patency was evaluated using the computer bronchophonography unit "Pattern 01." To assess the intensity of the acoustic phenomenon of breathing, the K_2 coefficient was used (a relative value reflecting the ratio of data on the acoustic work of breathing in the high-frequency range to the acoustic work in the low-frequency range of the bronchophonogram). The K_2 coefficient characterizes the acoustic work of respiration performed by the respiratory system to promote air at the level of the bronchi of a medium and small caliber [2–4, 11]. An increase in K_2 indicates the presence of obstructive disorders.

Next, to assess the dynamics of clinical symptoms, a group of A – 20 (17.7%) patients (average age is 6.5 years (4.0–9.0)) was randomly selected. They received a traditional basic therapy in combination with microwave therapy sessions for 7 days, twice a day. A comparison group–group B was randomly selected and matched for gender and age with group A. It included 12 patients (10.6%) with BA who received only traditional basic therapy.

[1] Registration certificate № FS 022a2005/2581-05 dated 2005/12/19.

Statistical processing of the results was performed using the program Statistica Stat Soft 10.0. Quantitative values were presented as median (*Me* 25–75 percentile) and relative (%) values. Statistical significance between unrelated groups was determined using the Mann–Whitney test, and between related groups using the Wilcoxon test. The confidence level $p < 0.05$ was taken as statistically significant changes.

RESULTS AND DISCUSSION

All patients underwent a standard examination, including the collection of complaints, anamnesis, examination, laboratory methods (hemogram with the determination of the relative and absolute number of eosinophils, the concentration of total serum IgE), imaging methods (chest X-ray), and spirography in children older than 5 years.

A brief clinical description of patients depending on the severity of BA is presented in Table 1. In the main group, patients with mild, moderate, and severe BA did not differ in age and gender ($p > 0.05$). Fifty-nine (52.3%) patients with severe disease had a burdened family history of BA. Allergic rhinitis was dominant for 36 (31.8%) patients with severe asthma, the frequency of atopic dermatitis in the groups did not significantly differ, making up 30.3% (10), 36.1% (11), and 22.7% (10) for mild BA, moderate, and severe asthma, respectively ($p > 0.05$). Therapy in the Pulmonology Department included inhalation of budesonide suspension and ipratropium bromide/phenoterol via a nebulizer. The duration of hospitalization, depending on the severity, did not significantly differ ($p > 0.05$). According to the results of laboratory examination, eosinophilia and an increase in the level of IgE were detected for patients of the main group, and are more pronounced in moderate and severe BA. The X-ray picture of mild asthma for 26 (78.8%) children was characterized by a diffuse enrichment of the lung pattern. In severe cases, 21 (47.7%) patients showed signs of lung tissue hyperinflation.

All children received basic therapy for at least 3 months before the start of the study: 3 (2.6 %) received montelukast, 38 (33.6 %) received low doses of inhaled corticosteroids (fluticasone propionate, beclomethasone dipropionate, up to 250 mcg

Table 1 / Таблица 1

Clinical characteristics of patients in the main cohort
Клиническая характеристика пациентов основной группы

Criteria / Критерии	Light BA, $n = 33$ / Легкая БА, $n = 33$	Moderate BA, $n = 36$ / Среднетяжелая БА, $n = 36$	Severe BA, $n = 44$ / Тяжелая БА, $n = 44$
Boy/girl / Мальчики/девочки	20/13	25/11	24/20
Age, years (Me, Q_{25}–Q_{75}) / Возраст, лет (Me, Q_{25}–Q_{75})	5.5 (2.0–8.0)	7.0 (3.0–9.0)	8.5 (4.0–11.0)
Duration of the disease, years (Me, Q_{25}–Q_{75}) / Длительность заболевания, лет (Me, Q_{25}–Q_{75})	3.0 (1.5–4.0)	4.0 (3.0–7.0)	6.0 (4.0–9.0)
BA in parents, abs. (%) / БА у родителей, абс. (%)	4 (12.1)	13 (36.1)	23 (52.3)*
Atopic dermatitis, abs. (%) / Атопический дерматит, абс. (%)	10 (30.3)	11 (36.1)	10 (22.7)
Allergic rhinitis, abs. (%) / Аллергический ринит, абс. (%)	6 (14.3)	10 (27.7)	14 (31.8)
Serum immunoglobulin E, IU/ml (Me, Q_{25}–Q_{75}) / Сывороточный иммуноглобулин Е, МЕ/мл (Me, Q_{25}–Q_{75})	88.5 (56.75–128.5)	216.5 (94.0–360.5)	183.5 (154.3–215.6)
Eosinophils (Me, Q_{25}–Q_{75}) / Эозинофилы (Me, Q_{25}–Q_{75})	182.5 (130.5–351.0)	295.0 (212.0–782.0)	369.5 (208.0–565.8)
Enrichment of the lung pattern, abs. (%) / Обогащение легочного рисунка, абс. (%)	33 (78.6)	30 (83.3)	23 (52.3)
Hyperinflation of the lungs, abs. (%) / Гиперинфляция легких, абс. (%)	2.4 (1)	16.6 (6)	47.7 (21)*
FEV1 – Forced Expiratory Volume in one second, l/min (Me, Q_{25}–Q_{75}) / ОФВ1 — Объем форсированного выдоха за первую секунду, л/мин (Me, Q_{25}–Q_{75})	76.5 (68.0–89.0)	74.0 (58.0–83.0)	51.0* (46.0–71.0)
Duration of hospitalization, days (Me, Q_{25}–Q_{75}) / Длительность госпитализации, дней (Me, Q_{25}–Q_{75})	12.0 (9.0–14.0)	14.0 (12.0–14.0)	13.5 (9.5–15.0)

Note. * Significant differences in the Mann–Whitney criterion in comparison with a group of patients with mild asthma: $p < 0.05$. BA – bronchial asthma. *Примечание.* * Достоверные различия по критерию Манна–Уитни в сравнении с группой пациентов с легкой бронхиальной астмой — $p < 0{,}05$. БА — бронхиальная астма.

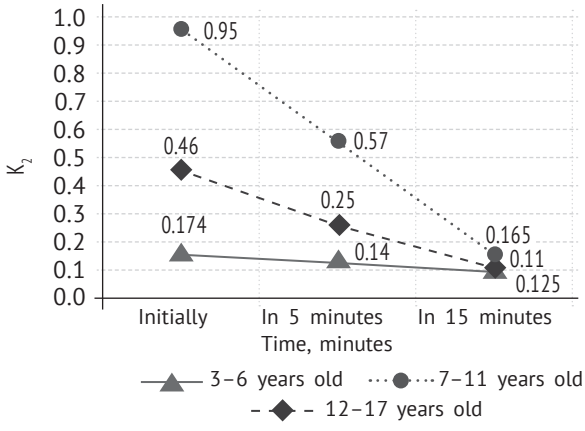

Fig. 1. Dynamics of the acoustic work of respiration coefficient at the level of small bronchi (K_2) under the electromagnetic influence of "Aster" in patients with mild bronchial asthma

Рис. 1. Динамика коэффициента акустической работы дыхания на уровне мелких бронхов (K_2) при электромагнитном воздействии аппарата «Астер» у пациентов с легкой бронхиальной астмой

per day), and 16 (14.2%) and 44 (38.9%) patients with moderate and severe asthma received medium doses and high doses (fluticasone propionate, beclomethasone dipropionate, fluticasone/salmeterol, 500–1000 mcg per day), respectively.

The acoustic work of breathing was analyzed for patients with mild, moderate, and severe BA. A significant advantage of the method for evaluating ventilation disorders using the computer diagnostic complex "Pattern 1" is its ability to detect disorders that are not registered during auscultation, as well as the ability to apply this method for children from the newborn period, which is impossible when using spirometry. In the initial assessment of pulmonary ventilation, a correlation analysis was performed between the acoustic coefficient of the high-frequency range (K_2) and the forced expiratory

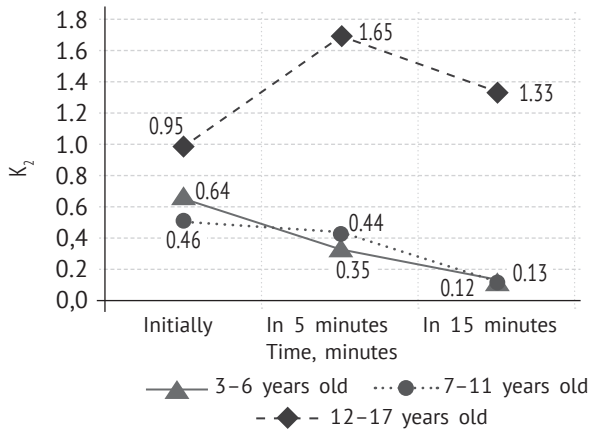

Fig. 2. Dynamics of the coefficient of acoustic work of respiration at the level of small bronchi (K_2) under the electromagnetic influence of "Aster" in patients with moderate bronchial asthma

Рис. 2. Динамика коэффициента акустической работы дыхания на уровне мелких бронхов (K_2) при электромагнитном воздействии аппарата «Астер» у пациентов со среднетяжелой бронхиальной астмой

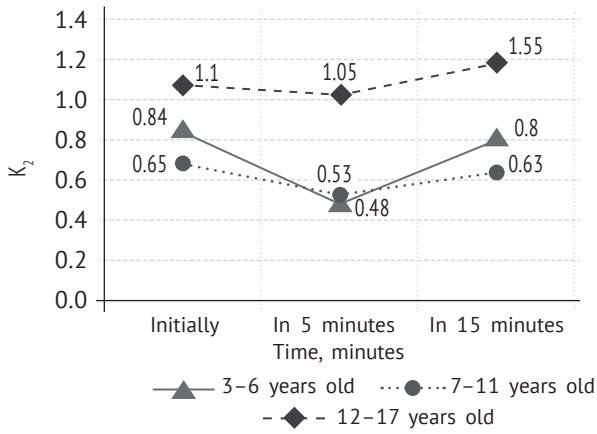

Fig. 3. Dynamics of the coefficient of acoustic work of respiration at the level of small bronchi (K_2) under the electromagnetic influence of "Aster" in patients with severe bronchial asthma

Рис. 3. Динамика коэффициента акустической работы дыхания на уровне мелких бронхов (K_2) при электромагнитном воздействии аппарата «Астер» у пациентов с тяжелой бронхиальной астмой

volume in the first second (FEV1), a significant feedback $r_s = -0.61$ ($p < 0.05$) was found, indicating a decrease in bronchial patency with an increase in acoustic indicators. The results are shown in Figs. 1-3.

In the course of our study, exposure to ultra-weak electromagnetic waves led to a decrease in the acoustic work of respiration, and therefore to a decrease in obstructive disorders in all age subgroups of patients with mild BA. Note that with a mild course of the disease, the same direction of changes in bronchial patency was registered at both the 5th and 15th minutes of the study. The greatest decrease in K_2 was recorded for patients with mild asthma of age 7–11 years (5.7 times, $p < 0.05$), and the smallest in an older age group (12–17 year) – 1.4 times ($p > 0.05$) (Fig. 1).

With moderate BA, 5 minutes after exposure to the Aster unit, children aged 3–6 and 7–11 years old showed a slight increase in the acoustic work of breathing at the level of medium and small-caliber bronchi. By the 15th minute, a significant regression of ventilation disorders was observed for patients aged 7–11 years (by 3.5 times, $p < 0.05$) and a tendency of K_2 to decrease among patients aged 12–17 years, in comparison with preschool-aged individuals who showed a slight decrease in bronchial patency compared to the baseline level (Fig. 2).

The patency of the bronchi of patients with severe asthma after a single exposure to electromagnetic waves had the form of a "plateau" in the subgroups of patients aged 3–6 and 7–11 years, remaining in the range of initial values by the end of the 15th minute of observation. Among patients aged 12–17 years with a severe BA, a slight increase in acoustic respiration was registered ($p > 0.05$) (Fig. 3).

We assume that a single exposure to electromagnetic radiation may be short-lived, but improved microcirculation in the bronchial wall leads to a decrease in edema, improved sputum removal from the bronchi, which was noted by researchers during a long-term therapy (14–20 days) of patients with obstructive bronchitis, BA, and cystic fibrosis [1, 2, 9, 12]. This study showed signs of improved airflow in the respiratory tract.

To assess the clinical effectiveness of the Aster device, group A patients (20 children with an allergic variant of BA) received basic therapy in combination with electromagnetic radiation from the Aster device for 7 days. Patients in group B (comparison group) received only basic therapy. The dynamics of symptoms of the disease was evaluated

Table 2 / Таблица 2

Basic therapy regimens for patients with bronchial asthma
Режимы базисной терапии пациентов с бронхиальной астмой

Groups / Группы	The severity of bronchial asthma / Степень тяжести бронхиальной астмы	Montelukast / Монтелукаст	Inhaled corticosteroids (up to 250 mcg/s) / Ингаляционные кортикостероиды (до 250 мкг/с)	Inhaled corticosteroids (500–1000 mcg / s) / Ингаляционные кортикостероиды (500–1000 мкг/с)
Group A (basic therapy + Aster) / Группа А (базисная терапия + «Астер»)	Light, *n* = 5 / Легкая, *n* = 5	3 (15 %)	2 (10 %)	–
	Moderate, *n* = 9 / Среднетяжелая, *n* = 9	–	4 (20 %)	5 (25 %)
	Severe asthma, *n* = 6 / Тяжелая, *n* = 6	–	–	6 (30 %)
Group B (basic therapy) / Группа В (базисная терапия)	Light, *n* = 3 / Легкая, *n* = 3	3 (25 %)	–	–
	Moderate, *n* = 4 / Среднетяжелая, *n* = 4	–	4 (33.3 %)	–
	Severe asthma, *n* = 5 / Тяжелая, *n* = 5	–	–	5 (41.7 %)

Table 3 / Таблица 3

Dynamics of the state of patients in groups A and B depending on the treatment regimen, *Me* (Q_{25}–Q_{75})
Динамика состояния пациентов групп А и В в зависимости от режима терапии, *Me* (Q_{25}–Q_{75})

Groups / Группы	The severity of bronchial asthma/ Степень тяжести бронхиальной астмы	Cough, points / Кашель, баллы			
		1 day / 1-й день	3 day / 3-й день	5 day / 5-й день	7 day / 7-й день
Group A (basic therapy + Aster) / Группа А (базисная терапия + «Астер»)	Light, *n* = 5 / Легкая, *n* = 5	2 (1–2)	1 (1–1)	1 (0–1)	0 (0–1)
	Moderate, *n* = 9 / Среднетяжелая, *n* = 9	3 (1–3)	2 (1–2)	1 (0–1)	1 (1–1)
	Severe asthma, *n* = 6 / Тяжелая, *n* = 6	3 (2–3)	2 (2–2)	1(1–2)	1(0–2)
Group B (basic therapy) / Группа В (базисная терапия)	Light, *n* = 3 / Легкая, *n* = 3	2 (2–3)	2 (2–2)	1 (1–2)	0 (0–1)
	Moderate, *n* = 4 / Среднетяжелая, *n* = 4	2.5 (2–3)	2 (0–2)	2 (1–2)	1 (0–1)
	Severe asthma, *n* = 5 / Тяжелая, *n* = 5	3 (3–3)	3 (2–3)	2 (2–2)	1.5 (1–2)

Note. No significant differences were found in the compared groups: $p > 0.05$.
Примечание. Достоверные различия в сравниваемых группах не выявлены: $p > 0.05$.

on a scale of cough severity (0 – no symptoms, 1 – slightly, for a short period, 2 – short episodes during the day, 3 – most of the day, awakens during night sleep, 4 – most of the day with impaired daytime activity and sleep). A cough severity was assessed on days 1, 3, 5, and 7. The modes of basic therapy are presented in Table 2.

The dynamics of children's condition in groups A and B after different therapy modes are shown in Table 3.

In the first days, the dynamics of cough severity after traditional therapy and treatment in combination with the Aster unit is almost the same, but children who received physiotherapy with electromagnetic radiation stopped night cough by the 5th day of treatment and were slightly disturbed for a short period by the 7th day, while 6 (50 %) patients of group B had 2–3-fold episodes of paroxysmal cough by this point of the study. At the same time, the acoustic coefficient of K_2 decreased from the initial

0.63 to 0.1 ($p < 0.05$), indicating a decrease in obstructive pulmonary ventilation disorders.

Thus, a single application of electromagnetic radiation changes the acoustic parameters of pulmonary ventilation. The least labile with a single microwave exposure is the acoustic work of breathing for older children and severe BA.

The combination of basic therapy with electromagnetic radiation for 7 days caused a more expressed effect on the clinical condition.

The limit of this study is the small number of patients who received traditional therapy in combination with the electromagnetic influence of a non-thermal intensity of the Aster unit, which does not allow a reliable acoustic assessment of the functional state of the bronchopulmonary system and hence the need for further research.

CONCLUSION

Summarizing the results, we draw the following conclusions:

1. With a single exposure to ultra-weak electromagnetic waves of non-thermal intensity, the greatest change in acoustic parameters is registered for patients with mild BA in the age groups 3–6, 7–11, and 12–17 years, as well as in the group of 7–11 years with moderate BA. The minimum change was observed in those with severe BA.

2. A possible response to a single exposure to ultra-weak waves of a non-thermal intensity (as an addition to ф basic therapy) in patients with BA was improved bronchial patency.

REFERENCES

1. Будневский А.В., Бурлачук В.Т., Чернов А.В., и др. Роль нетеплового электромагнитного излучения в достижении контроля над бронхиальной астмой // Пульмонология. – 2014. – № 3. – С. 78–82. [Budnevskiy AV, Burlachuk VT, Chernov AV, et al. Rol' neteplovogo elektromagnitnogo izlucheniya v dostizhenii kontrolya nad bronkhial'noy astmoy. *Pul'monologiia*. 2014;(3): 78-82. (In Russ.)]
2. Геппе Н.А., Иванова Н.А., Камаев А.В., и др. Бронхиальная обструкция на фоне острой респираторной инфекции у детей дошкольного возраста: диагностика, дифференциальная диагностика, терапия, профилактика. – М.: МедКом-Про, 2019. [Geppe NA, Ivanova NA, Kamaev AV, et al. Bronkhial'naya obstruktsiya na fone ostroy respiratornoy infektsii u detey doshkol'nogo vozrasta: diagnostika, differentsial'naya diagnostika, terapiya, profilaktika. Moscow: MedKom-Pro; 2019. (In Russ.)]
3. Геппе Н.А., Шаталина С.И., Крылова Н.А., Малышев В.С. Физиотерапевтическое лечение детей с обструктивным бронхитом и затяжным кашлем // Сеченовский вестник. – 2014. – № 2. – С. 49–53. [Geppe NA, Shatalina SI, Krylova NA, Malyshev VS. Fizioterapevticheskoe lechenie detey s obstruktivnym bronkhitom i zatyazhnym kashlem. *Sechenovskii vestnik*. 2014;(2):49-53. (In Russ.)]
4. Лерхендорф Ю.А., Лукина О.Ф., Петренец Т.Н., Делягин В.М. Бронхофонография у детей 2–7 лет при бронхообструктивном синдроме // Практическая медицина. – 2017. – № 2. – С. 134–137. [Lerkhendorf YuA, Lukina OF, Petrenets TN, Delyagin VM. *Prakticheskaya meditsina*. 2017;(2):134-137. (In Russ.)]
5. Малышев В.С., Мельникова И.М., Мизерницкий Ю.Л., и др. Опыт использования компьютерной бронхофонографии в педиатрической практике // Медицинский совет. – 2019. – № 2. – С. 188–193. [Malyshev VS, Melnikova IM, Mizernitskiy YuL, et al. Experience in using computer bronchophonography in paediatric practice. *Meditsinskiy sovet*. 2019;(2): 188-193. (In Russ.)]. https://doi.org/10.21518/2079-701X-2019-2-188-193.
6. Национальная программа «Бронхиальная астма у детей. Стратегия лечения и профилактика». – М.: Оригинал-макет, 2017. – 160 с. [Natsional'naya programma "Bronkhial'naya astma u detey. Strategiya lecheniya i profilaktika". Moscow: Original-maket; 2017. 160 p. (In Russ.)]
7. Овчинникова А.Н., Рассулова М.А., Куандыкова М.В. Физиотерапевтические методы лечения заболеваний органов дыхания // Астма и аллергия. – 2018. – № 1. – С. 3–7. [Ovchinnikova AN, Rassulova MA, Kuandykova MV. Fizioterapevticheskie metody lecheniya zabolevaniy organov dykhaniya. *Astma i allergiya*. 2018;(1):3-7. (In Russ.)]
8. Петрова А.И., Гаймоленко И.Н., Терешков П.П. Клинико-иммунологические маркеры течения острого обструктивного бронхита у детей дошкольного возраста // Сибирское медицинское обозрение. – 2019. – № 6. – С. 32–36. [Petrova AI, Gaymolenko IN, Tereshkov PP. Clinical and immunological markers of acute obstructive bronchitis in preschool children. *Siberian medical review*. 2019;(6):32-36. (In Russ.)] https://doi.org/10.20333/2500136-2019-6-32-36.
9. Потапова Н.Л., Гаймоленко И.Н. Микроволновая терапия бронхиальной астмы у детей // Врач-аспирант. – 2013. – Т. 61. – № 6.2. – С. 272–277. [Potapova NL, Gaymolenko IN. Mikrovolnovaya tera-

piya bronkhial'noy astmy u detey. *Vrach-aspirant*. 2013;61(6.2):272-277. (In Russ.)]
10. Савенкова Н.Д., Джумагазиев А.А., Безрукова Д.А., Райский Д.В. Использование аппарата неинвазивного микроволнового воздействия в реабилитации детей с рецидивирующим бронхитом // Экология человека. – 2017. – № 12. – 53–58. [Savenkova ND, Dzhumagaziev AA, Bezrukova DA, Rajsky DV. Rehabilitation of children with recurrent bronchitis using a non-invasive apparatus of microwave exposure. *Ecology, human*. 2017;(12):53-58. (In Russ.)]
11. Сибира О.Ф., Игнатьева А.В., Гаймоленко И.Н. Бронхиальная проходимость при бронхообструктивном синдроме у детей // Забайкальский медицинский вестник. – 2018. – № 1. – С. 127–132. [Sibira OF, Ignatieva AV, Guymolenko IN. The bronchialal patency in broncho-obstructive syndrome in children. *Zabaykal'skiy meditsinskiy vestnik*. 2018;(1):127-132. (In Russ.)]
12. Тютюнников С.В., Сероклинов В.Н., Чурсин А.А., и др. Опыт применения микроволнового аппарата «Астер» в лечении бронхолегочных заболеваний // Практическая пульмонология. – 2010. – № 3. – С. 47–49. [Tyutyunnikov SV, Seroklinov VN, Chursin AA, et al. Opyt primeneniya mikrovolnovogo apparata "Aster" v lechenii bronkholegochnykh zabolevaniy. *Prakticheskaya pul'monologiya*. 2010;(3):47-49. (In Russ.)]
13. Хан М.А. Применение электромагнитного излучения (ЭМИ) сантиметрового диапазона нетепловой интенсивности от аппарата «Астер» при заболеваниях органов дыхания у детей. Методические рекомендации. – М.: Медицина, 2011. [Khan MA. Primenenie elektromagnitnogo izlucheniya (EMI) santimetrovogo diapazona neteplovoy intensivnosti ot apparata "Aster" pri zabolevaniyakh organov dykhaniya u detey. Metodicheskie rekomendatsii. Moscow: Meditsina; 2011. (In Russ.)]
14. Холматова К.К., Харькова О.А., Гржибовский А.М. Экспериментальные исследования в медицине и здравоохранении: планирование, обработка данных, интерпретация результатов // Экология человека. – 2016. – № 11. – С. 50–58. [Kholmatova KK, Kharkova OA, Grjibovski AM. Experimental studies in medicine and public health: planning, data analysis, interpretation of results. *Ecology, human*. 2016;(11):50-58. (In Russ.)]
15. Sterling M, Rhee H, Bocko M. Automated Cough Assessment on a Mobile Platform. *J Med Eng*. 2014;2014. https://doi.org/10.1155/2014/951621.

◆ Information about the authors

Natalya L. Potapova — MD, PhD, Associate Professor, Head Department of Outpatient Pediatrics with a Course of Medical Rehabilitation. Federal State Budgetary Educational Institution of Higher Education Chita State Medical Academy, Chita, Russia. E-mail: nataliapotap@yandex.ru.

Inessa N. Gaymolenko — MD, PhD, Dr. Med. Sci., Professor, Head Department of Pediatrics. Federal State Budgetary Educational Institution of Higher Education Chita State Medical Academy, Chita, Russia. E-mail: ingaim@mail.ru.

◆ Информация об авторах

Наталья Леонидовна Потапова — канд. мед. наук, доцент, заведующий, кафедра поликлинической педиатрии с курсом медицинской реабилитации. ФГБОУ ВО «Читинская государственная медицинская академия» Минздрава России, Чита. E-mail: nataliapotap@yandex.ru.

Инесса Никандровна Гаймоленко — д-р мед. наук, профессор, заведующий, кафедра педиатрии. ФГБОУ ВО «Читинская государственная медицинская академия» Минздрава России, Чита. E-mail: ingaim@mail.ru.