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Efficiency of Haloaerosol Therapy in Rehabilitative Treatment in Cases of Children with Recurrent Respiratory Diseases

Skuteczność haloterapii w rehabilitacji dzieci z nawracającymi chorobami układu oddechowego

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SUMMARY

Aim: To study the effectiveness of complex rehabilitation treatment with using Haloaerosol therapy in cases of children with recurrent respiratory diseases, immediate and long-term results, based on of external respiration function investigation and metabolic status.

Materials and Methods: We examined 37 patients aged 7-11 years with recurrent respiratory diseases out the acute period. Before and at the end of the treatment, spirometry was performed, biochemical parameters were analyzed, which determine the state of the lipid peroxidation system and antioxidant protection. Rehabilitation treatment was performed according to two complexes, which included physical therapy and physical physiotherapy. In addition, the second treatment complex included haloaerosol therapy, which involves staying in a haloaerosol environment with a certain (35 mg/m³ - 40 mg/m³) concentration of rock salt aerosol.

Results: Rehabilitation treatment based on haloaerosol therapy in children with recurrent respiratory diseases leads to an increase in spirometry tests, reducing the imbalance of the lipid peroxidation system, antioxidant protection. The effectiveness is confirmed in the long-term period, because during the year after treatment the frequency and duration of acute episodes were decreased, the number of days during which the child did not attend school decreases (from 30.35±2.39 to 16.90±1.44 days; p<0.001) too. These changes were less pronounced in the children from comparison group.

Conclusions: Children with recurrent respiratory disease need rehabilitation treatment. Preference should be given on complexes with the inclusion of haloaerosol therapy, which have direct affects on the mucous membrane of the respiratory tract and indirect – have reduces of endogenous intoxication manifestations.

Key words: children, respiratory diseases, Haloaerosol therapy

Słowa kluczowe: dzieci, choroby układu oddechowego, haloterapia

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INTRODUCTION

The Respiratory lesions continue to occupy one of the first places in the structure of childhood morbidity. The acute respiratory infections (ARI) issue of and the impact of their frequency on the general health of the child is relevant. Even in modern conditions of scientific and technological progress, it is impossible to reliably predict the course of ARI in children. The consequences of such pathology depend not only on the correct and timely treatment, but also on the general condition of the child's body against which the ARI arose. Residual effects in the form of cough, fatigue, etc. can have duration more than 4 weeks [1-5].

Respiratory diseases are a stimulus for the body's protection, however, increasing their frequency and severity contribute

to the development of endogenous intoxication, respiratory dysfunction and significantly impair the quality of life of the child and his family. Therefore, patients with recurrent respiratory disease (RRD) include children who have 6 or more episodes of ARI per year, require long-term follow-up, according to most researchers [6-12].

The search of the best methods of prevention and rehabilitation by this category of children continues. In this aspect, Haloaerosol therapy (GAT) pays attention, because Haloaerosol directly affects the respiratory tract mucous membrane, which is involved in the pathological process in the first place, improves mucociliary clearance and has a healing effect [13-15].

AIM

To study the effectiveness of complex rehabilitation treatment with using Haloaerosol therapy in the children with recurrent respiratory diseases, immediate and long-term results, based on of external respiration function investigation and metabolic status.

MATERIALS AND METHODS

37 patients were examined (aged 7-11 years, the average age 8.8 ± 0.4 years) with RRD out of the acute period. The criterion for inclusion in the study group was the presence of six episodes of ARI, lasting at least 7 days during the calendar year. A spirometric examination was performed before and at the end of the course of treatment on a Cardio + device (production by Metekol, Ukraine) for the function assessing of external respiration. The following indicators were analyzed: forced vital capacity of the lungs (FVC), the Forced expiratory volume in 1 second (FEV_1) – Forced expiratory flow at points (FEF) FEF25%, FEF50%, FEF75%, which characterize the patency of the bronchi at different levels of the bronchial tree.

Biochemical parameters that determine the state of the lipid peroxidation system (LPS) and antioxidant protection (AOP), which reflect the activity of the inflammatory process and the severity of endogenous intoxication, were also recorded. The intensity of LPS processes was studied by the level of secondary (malonic dialdehyde – MDA) and final Schiff bases (SB) products of lipid oxidation in the blood (according to the method of Ovsyannikova LM and co-authors) spectrophotometric method (Spectrophotometer SF-46) [16]. The state of the body's antioxidant protect system was determined by the activity of superoxide dismutase (SOD) and Catalase of blood erythrocytes (by the method of Galaktionova LP and co-authors) [17].

Rehabilitation treatment was performed according to two treatment complexes (LK-1 and LK-2). Both included therapeutic exercise (therapeutic exercises, physical therapy) and physiotherapy (with the appointment of singlet-oxygen therapy (SCT)) in the form of oxygen foam, which was obtained using the device MIT-C (Ukraine). There were 12 procedures by 200 ml with a duration of 10 min each. Vibroacoustic effects on the chest was created by the device "Vitaфон" (Russia). The above course included 12 procedures by 10 min. each.

LC-1 included an additional 18 sessions of GAT with increased intensity of haloaerosol exposure. The concentration of rock salt aerosol ranged from 40 mg/m^3 at the start to 35 mg/m^3 at the end of a 30-minute session. The aerosol particles (up to $6 \mu\text{m}$ in size ranging) composed from 70% to 75%. The course of treatment included a period of adaptation to the therapeutic haloaerosol – 2-3 days with a duration of procedures of 10-20-30 minutes and the main period – with a duration of sessions of 30 minutes each.

Long-term results were analyzed using specially designed questionnaires, one year after treatment. Questionnaire points concerned the duration of remission before the first episode of respiratory disease, the frequency and duration of ARI, and the number of missed school days during the year after treatment.

Statistical processing of the obtained results was performed using the standard software package "Statistica 6.0 for Windows".

RESULTS

The analysis of indicators of external respiration function (ERF) in the examined patients of both groups ($n=37$) before treatment, according to FVC and FEV_1 indicators presented the absence of ventilation disorders, as they were $92.8 \pm 0.93\%$ and $87.6 \pm 0.79\%$, respectively. However, mild patency disorders were detected at the level of the middle and small bronchi, and the indicators were less than the reference value (80%): FEF50% – $76.9 \pm 0.83\%$, and FEF75% was only $72.4 \pm 0.85\%$. Disturbances in the POL-AOS were also registered in children with ARI even after the abatement of acute phenomena in comparison with the reference value. Thus, the subjects showed a significant increase in MDA to $3.66 \pm 0.07 \text{ nmol/ml}$ in comparison with the reference values, where this figure is $3.23 \pm 0.06 \text{ nmol/ml}$ ($p < 0.001$), which probably indicates a prolonged pathological process [18]. The rise in the content of final POL products was also registered. The SB rate in children with RRD was equal an $0.36 \pm 0.01 \text{ units/ml}$, compared with the regional normative levels – $0.30 \pm 0.02 \text{ units/ml}$ ($p < 0.01$), which indicates about the intensification of lipoperoxidation and the accumulation of their excess in the blood.

In addition, the indicators of AOS that counteract the general toxic effects of reactive oxygen species in children with ARI were significantly reduced. The values of SOD and Catalase were $3.44 \pm 0.07 \text{ IU/mg Hb}$ and $55.2 \pm 1.22\%$, respectively, against $3.94 \pm 0.10 \text{ IU/mg Hb}$ ($p < 0.001$) and $64.42 \pm 0.89\%$ ($p < 0.001$) according the reference value. This insufficiency of AOS on the background of activation of the POL system promotes to the development of oxidative stress and the accumulation of toxic metabolites in the blood, which indicates the presence of endogenous intoxication in this group of children [5, 12].

Rehabilitation treatment in children with different treatment schemes contributed to the improvement of the studied indicators of external respiration function. However, a significant increasing in the integrated indicators of spirometry (FJEL, FEV_1) occurred only in patients of LC-1, which used Haloaerosol therapy (Table 1).

The LC-1 prescribing in children also led to the normalization of patency at all levels of the bronchi, and FEF_{75} reached an average of 80,00%. In contrast, after LC-2 prescribing the indicators had only a tendency to increasing, and FEF_{75} reached only to $75.50 \pm 1.43\%$, which is significantly less than date after the course of GAT ($p < 0.05$).

Simultaneously, under the influence of treatment in children there was a positive dynamics of the POL-AOS tests (Table 2).

In particular, after prescribing LC-1 there was a significant decreasing and normalization of the level of secondary (MDA) and end (SB) products of lipoperoxidation, which reduces or eliminates the negative influence of excess POL products on body tissues and reflects a decrease in endogenous intoxication [8, 9]. There was also a significant increasing in SOD and Catalase levels, which reached the reference level, indicating the restoration of AOS activity.

The use of LC-2 significantly reduced the content of POL products excess, according to the studied indicators. But the MDA indicator did not decrease significantly ($p < 0.2$). There was also

Table 1. Changes in the external respiration function indicators of the children depended on the using of different therapeutic schemes

Parameters	LC-1 (n=20)		LC-2 (n=17)	
	Before treatment	After treatment	Before treatment	After treatment
FVC, % p	91,1±1,79	98,2±1,61 <0,01	94,8±2,10	98,7±1,96
FEV ₁ , % p	87,1±1,89	93,2±1,39 <0,02	88,5±1,29	92,5±1,59 <0,1
FEF ₂₅ , % p	81,2±2,35	88,4±1,76 <0,02	82,8±1,89	87,4±1,54 <0,1
FEF ₅₀ , % p	76,6±2,34	84,1±1,60 <0,02	77,2±1,91	82,2±1,62 <0,1
FEF ₇₅ , % p	72,7±2,27	79,9±1,63 <0,02	72,3±1,66	75,5±1,43

Table 2. Changes in lipid peroxidation and antioxidant protection in the children with recurrent respiratory diseases depended on the using of different therapeutic schemes

Parameters	Regional Reference value (n=18)	LC-1 (n=20)		LC-2 (n=17)	
		Before treatment	After treatment	Before treatment	After treatment
MDA, nmol/ml p	3,23±0,06	3,64±0,13	3,24±0,12 <0,05	3,51±0,16	3,23±0,12
Schiff bases, IUg./ml p	0,30±0,02	0,34±0,02	0,28±0,01 <0,02	0,38±0,03	0,29±0,03 <0,05
SOD, U/mg Hb p	3,94±0,10	3,38±0,12	4,00±0,10 <0,001	3,45±0,17	4,05±0,11 <0,05
Catalase, % p	64,4±0,89	54,1±2,63	67,2±2,17 <0,001	55,4±2,92	67,7±2,13 <0,01

Note: p – the reliability of the difference in patients before and after treatment.

a positive dynamics of the AOS tests, which the studied enzymes levels were significantly increased, especially Catalase. This fact have explanation about the singlet-oxygen therapy influence.

In general, the changes in the indicators were of the same tendency and were manifested by a decrease in the lipoperoxidation processes intensity and activation of the AOS, without a significant difference between LCs. However, the long-term results of treatment showed a significant difference between the studied LCs (Table 3, Figure 1).

Thus, the remission duration in the patients that were using LC-2 («light» interval) at the end of treatment was longer than after using LC-1.

The frequency of ARI during the year after the complex, which included HAT(LC-1), significantly decreased (p <0.001) to 4.30 ± 0.37 episodes. The prescribing of LC-2 reduced the frequency of ARI episodes to 5.39 ± 0.39 episodes, which is significantly more than after LC-1 (p <0.05).

The average duration of one episode of ARI after LC-1 with using GAT was 6.32±0.41 days, which is significantly less than compared with LC-2 (p <0.05), and was 8.17±0.66 days.

An important indicator is the days number of during which the child did not attend school, because these days most likely needed outside care, which negatively affects on the quality of

child life and his family. Thus, during the year after rehabilitation therapy, the number of days during which the child did not attend school decreased significantly only after using LC-1, which is significantly less than after LC-2 (p <0.01).

In general, the inclusion of HAT in the complex of rehabilitation treatment provides to an duration increasing of the long-term results, which is probably associated with its sanitizing effect and indirect effect on the overall resistance of the organism.

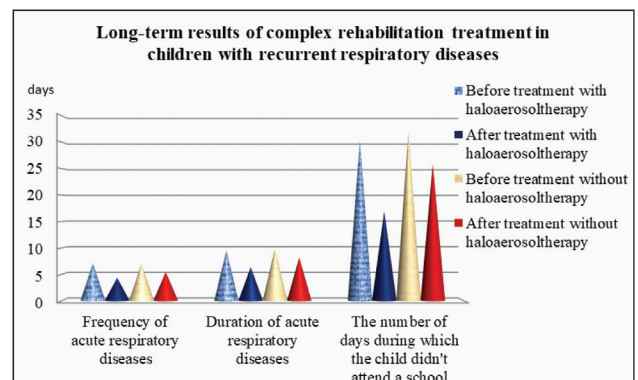


Figure 1. Long-term results of rehabilitation treatment in the children with recurrent respiratory diseases depended on the using of different therapeutic schemes

Table 3. Long-term results of rehabilitation treatment in the cases of children with recurrent respiratory diseases depended on the using of different therapeutic schemes

Parameters	LC-1 (n=20)		LC-2 (n=17)	
	Before treatment	After treatment	Before treatment	After treatment
Duration of remission after treatment, months		2,72±0,21		2,17±0,18
Frequency of ARI per year p	7,10±0,38	4,30±0,37 p<0,001	7,02±0,41	5,39±0,39 p<0,02
Frequency of ARI, days p	9,47±0,87	6,32±0,41 <0,01	9,92±0,97	8,17±0,66
The number of days during which the child did not attend school p	30,35±2,39	16,90±1,44 <0,001	32,17±2,30	25,95±2,28

Note: p – the reliability of the difference in patients before and after treatment.

DISCUSSION

Haloaerosol therapy is an important component of the complex treatment in the children with respiratory tract pathology and it presented the inhibition of blood cell function and correction of Lipid Peroxidation. The given clinical and morphofunctional studies again confirm that halo-aerosol therapy addition to combined treatment and rehabilitation of patients with respiratory diseases is importante and reasonable. Therefore, HAT with increased haloaerosol loading ($40 \text{ mg/m}^3 - 35 \text{ mg/m}^3$) significantly increases the indicators of the external respiration function – FVC, FEV₁. The dynamics of the main indicators of spirometry is associated with the mucolytic and sanitizing effects of haloaerosol therapy primarily, which are achieved due to the dry hyperosmolar effect of haloaerosols. This is reflected in changes in the nature of sputum, improving its rheological properties, inflammatory edema reducing of the bronchial mucosa, which leads to a bronchial obstruction decreasing [5].

The achieved effect is explained by reduction of swelling, improvement of mucociliary clearance and sputum discharge. The improvement of patency at the level of small bronchi with an increase in FEF₇₅ from $72.7 \pm 2.27\%$ to $79.9 \pm 1.63\%$ ($p < 0.02$) is due to the presence of a high concentration (70%-75%) of finely dispersed aerosol, with the size particles up to 6 μm , which come through directly into the distal bronchi and has a hyperosmolar effect. In general, at the end of TC-1 (which included GAT), as well as vibroacoustic effects on the chest and ventilation rates reach the level of the reference norm, which confirms the bronchial obstruction significant reversibility, the feasibility and validity of comprehensive rehabilitation treatment based on GAT in children with RRI out of exacerbation.

The vibroacoustic effect on the chest improves blood circulation in the affected area and due to the vibrational physical effect improves the discharge of sputum and, thus, increases the drainage function of the bronchi, when used restorative treatment without GAT. However, these effects are significantly less pronounced than with complex treatment (TC-1).

One of the factors that reflect the activity of the inflammatory process is oxidative stress. Even, in children with ARI out of exacerbation revealed an increasing in all Lipid Peroxidation

indicators, which is combined with discordant changes in the Antioxidant System exponents. This leads to development oxidative stress, helps maintain inflammation at the stage of reducing of the pathological process even [4].

It was found that in children with ARI under the influence of both TC there is a decrease in the intensity of oxidative stress, which is manifested by a decrease in the content of LPO products in the blood with a simultaneous improvement in Antioxidant System. SOD and Catalase levels increased to $4.00 \pm 0.10 \text{ IU/mgHb}$ ($p < 0.02$) and $67.2 \pm 2.17\%$ ($p < 0.02$) due to anti-inflammatory and antibacterial haloaerosol actions, which activate sanogenetic mechanisms. Significant reduction and normalization of the level of Lipoperoxidation can be explained by the antioxidant enzymes activation and the haloaerosol detoxifying effect. The additional prescribing of singlet oxygen therapy enhances antioxidant protection.

The frequency and duration of ARI during the year after treatment decreased significantly due to the fact that GAT improves anti-infective protection and promotes the development of an adequate immune response. Significant reduction in the frequency of ARI to 4.30 ± 0.37 ($p < 0.001$) and their duration to 6.32 ± 0.41 ($p < 0.01$) during the year after therapy leads to a decreasing in the number of days during which the child did not attend school institution.

However, the main influence on the inflammatory process inhibition in the bronchi and the improvement of pulmonary ventilation has GAT, which is confirmed not only by the high efficiency of TC-1 at the end of treatment, but it presents the better results in the long term.

CONCLUSIONS

1. In cases of children with recurrent respiratory diseases, acute period out even, functional respiratory disorders persist (FEF₇₅ is $72.4 \pm 0.85\%$) and an imbalance in the system of lipid peroxidation - antioxidant protection, which dictates the needing of rehabilitation.
2. Comprehensive rehabilitation treatment with the inclusion of Haloaerosol therapy improves the external respiration function, which is confirmed by an increasing in FEV₁ to 93.2 ± 1.39 ($p < 0.02$), FEF₇₅ to $79.9 \pm 1.63\%$ ($p < 0.02$). The com-

plex has a positive effect on the state of oxidative-antioxidant balance, with an increasing in the level of antioxidant enzyme Catalase from 54.1 ± 2.63 to 67.2 ± 2.17 ($p < 0.001$), which reflects the inhibition of the inflammatory process intensity, endogenous intoxication reducing and helps to restore the child organism reactivity as a whole.

3. Rehabilitation treatment based on Haloaerosol therapy in children with recurrent respiratory diseases reduces the frequency and duration of acute respiratory diseases and the number of days during which the child did not attend school during the year after therapy from 30.35 ± 2.39 to 16.90 ± 1.44 ($p < 0.001$).

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