

ORIGINAL ARTICLE

EFFECT OF HIGH-FREQUENCY CHEST WALL OSCILLATION ON CLINICAL INDICES OF COMMUNITY-ACQUIRED PNEUMONIA IN CHILDREN

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ABSTRACT

The aim: To study the effect of high-frequency chest wall oscillation (HFCWO) on clinical indices of community-acquired pneumonia (CAP) in children.

Materials and methods: The main clinical symptoms were assessed in 107 children (girls - 45.79% and boys - 54.21%) aged 6 to 17 years with acute and uncomplicated course of CAP of moderate severity. The main group (MG) consisted of 55 children who were prescribed basic therapy (BT) in combination with HFCWO procedures. The control group (CG) comprised 52 children who received BT exclusively.

Results: In the children of MG, the intensity of cough decreased to 0.28 ± 0.06 points compared with children of CG - 0.5 ± 0.07 points ($p < 0.05$) on the 10th day of treatment. A positive dynamics of CAP in the form of the amount of sputum reduction was revealed in the MG children up to 0.06 ± 0.03 points compared with the CG children - 0.42 ± 0.07 ($p < 0.05$). On the 10th day of therapy the MG children with CAP had decrease in the number of râles in the lungs up to 0.08 ± 0.04 points compared with those of CG - 0.4 ± 0.07 points ($p < 0.05$).

Conclusions: High efficacy of HFCWO method in complex treatment of CAP in children is confirmed by the dynamics of the main clinical symptoms, such as reduction of intensity and productivity of cough as well as absence shortness of breath and moist râles in the lungs. The data obtained indicate recovery of mucociliary clearance (MCC) functions and the bronchopulmonary system as a whole.

KEY WORDS: high-frequency chest wall oscillation, community-acquired pneumonia, children

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INTRODUCTION

Pneumonia is one of the most common nosologies of the respiratory tract and remains the leading cause of morbidity and mortality in children worldwide, including Ukraine [1-4].

According to current data on the pathogenesis of pneumonia, effective airway protection is provided by MCC, which provides rehabilitation of the respiratory tract and necessary potential for the barrier, immune and cleansing function of the bronchopulmonary system [5-7].

MCC dysfunction leads to changes in the drainage function of the bronchial tree, which in turn leads to the manifestation of clinical symptoms in the form of cough, shortness of breath, infection and inflammation in children with pneumonia [8-10].

A modern method of restoring bronchial tree drainage is high-frequency chest wall oscillation based on the vibrational-compression effect of The Vest Airway Clearance System [11-14]. The Vest device has proven its effectiveness in the treatment of children with cystic fibrosis (CF) who had improvement of MCC of the airways [15-18].

THE AIM

The aim of the study was to investigate the effect of high-frequency chest wall oscillations on the clinical indices of community-acquired pneumonia in children.

MATERIALS AND METHODS

There were examined 107 children aged 6 to 17 years (11.73 ± 0.53 years) with community-acquired pneumonia of acute and uncomplicated moderate severity in the open, comparative clinical study who were treated in the pulmonology department of the Communal non-profit enterprise "Odessa Regional Children's Clinical Hospital" of Odessa regional council. The diagnosis of pneumonia was in conformity with modern standards for the diagnosis of pneumonia, was based on radiological confirmation of focal infiltrative process in the lungs and was established in accordance with the criteria approved by Order N 18 of the Ministry of Health of Ukraine [19]. The examined patients comprised 58 boys (54.21%) and 49 girls (45.79%) who were divided into groups depending on treatment. The main group (MG) consisted of 55 children (30 - boys and 25 - girls) who received basic therapy (BT) [19] with additional administration of HFCWO procedures using 1, 2, 3, 4, 5 and 6 modes of The Vest, model 105, (Hill-Rom, USA) [20]. The control group (CG) consisted of 52 children (25 boys and 27 girls) who were prescribed only basic therapy (BT).

The main clinical symptoms of pneumonia were evaluated on the 1st, 3rd, 5th, 7th and 10th days of inpatient treatment. The main clinical signs assessed included axillary body tem-

Table I. Comparative characteristics of body temperature in children during 10 days of treatment.

Days of treatment	Groups of children		p-value
	Main group (n=55)	Control group (n=52)	
1	1.08±0.06	1.1±0.06	0.91
3	body temperature was normalized	body temperature was normalized	-
5			
7			
10			

Table II. Comparative characteristics of symptoms of intoxication in children during 10 days of treatment.

Days of treatment	Groups of children		p-value
	Main group (n=55)	Control group (n=52)	
1	1.04±0.06	1.08±0.07	0.89
3	symptoms of intoxication disappeared	symptoms of intoxication disappeared	-
5			
7			
10			

Table III. Comparative characteristics of shortness of breath in children during 10 days of treatment.

Days of treatment	Groups of children		p-value
	Main group (n=55)	Control group (n=52)	
1	2.12±0.1	2.1±0.09	0.91
3	1.36±0.09*	1.94±0.09	0.001
5	0.72±0.08*	1.3±0.08	0.001
7	0.26±0.06	0.42±0.08	0.05
10	shortness of breath was not observed	shortness of breath was not observed	-

perature, manifestations of intoxication, shortness of breath at rest, intensity and productivity of cough, auscultatory changes in the lungs (the presence of moist râles).

The severity of these criteria was evaluated on a scale from 0 to 3 according to the generally accepted gradations, indicating an integer from 0 (absent), 1 (slightly expressed), 2 (moderately expressed) and up to 3 (significantly expressed) [21]. The data obtained were presented in the form of arithmetic mean (M) and standard error (m) using Microsoft Excel 2010, online calculator SISA (Simple Interactive Statistical Analysis). Comparative analysis between groups was performed on the basis of analysis of variance (ANOVA). Statistically significant indices were considered at $p < 0.05$.

The study was carried out in accordance with the principles of the Declaration of Helsinki. The study protocol was approved by the Local Ethics Committee of the institution. Informed consent of parents and children was obtained for the study.

RESULTS

According to the results of the study the body temperature in the MG children was estimated as 1.08 ± 0.06 points on the 1st day of treatment compared with those of CG - 1.1 ± 0.06 points (p=0.91). On the 3rd day of treatment, positive clinical dynamics was determined: the body temperature response was normalized in all children under study (Table I.).

In the children of MG the symptoms of intoxication were estimated as 1.04 ± 0.06 points on the 1st day of therapy compared with the CG children - 1.08 ± 0.07 points (p=0.89). On the 3rd day of therapy, the manifestations of intoxication syndrome disappeared in children of both study groups (Table II).

On the 1st day of monitoring shortness of breath was estimated as 2.12 ± 0.1 points in the MG children, compared with those of CG - 2.1 ± 0.09 points (p=0.91). On the 3rd day of treatment shortness of breath decreased to 1.36 ± 0.09 points in the MG children, compared with those of CG - 1.94 ± 0.09 points ($p < 0.001$). On the 5th day of therapy, positive clinical dynamics was revealed: dyspnea decreased in the children of MG to 0.72 ± 0.08 points compared with the children of CG - 1.3 ± 0.08 points ($p < 0.001$). On the 7th day of therapy, a decrease in dyspnea to 0.26 ± 0.06 points was noticed in the MG children compared to the children of CG - 0.42 ± 0.08 points ($p < 0.05$). All children did not have shortness of breath on the 10th day

Table IV. Comparative characteristics of intensity of cough intensity in children during 10 days of treatment.

Days of treatment	Groups of children		p-value
	Main group (n=55)	Control group (n=52)	
1	2.4±0.09	2.44±0.08	0.89
3	1.86±0.11*	2.26±0.1	0.01
5	1.38±0.09*	1.9±0.08	0.001
7	0.8±0.09*	1.08±0.08	0.01
10	0.28±0.06	0.5±0.07	0.05

Note: * - differences between MG and CG ($p < 0.05$).

Table V. Comparative characteristics of productivity of cough in children during 10 days of treatment.

Days of treatment	Groups of children		p-value
	Main group (n=55)	Control group (n=52)	
1	2.48±0.08	2.4±0.09	0.76
3	1.44±0.07*	2.08±0.09	0.001
5	0.94±0.09*	1.72±0.09	0.001
7	0.4±0.07*	0.92±0.06	0.001
10	0.06±0.03	0.42± 0.07	0.05

Note: * - differences between MG and CG ($p < 0.05$).

Table VI. Comparative characteristics of râles in children during 10 days of treatment.

Days of treatment	Groups of children		p-value
	Main group (n=55)	Control group (n=52)	
1	2.32±0.1	2.24±0.1	0.76
3	1.76±0.1*	2.06±0.1	0.01
5	1.22±0.11*	1.78± 0.08	0.001
7	0.58±0.09*	0.94±0.1	0.01
10	0.08±0.04	0.4± 0.07	0.05

Note: * - differences between MG and CG ($p < 0.05$).

of treatment (Table III) (Figure 1).

According to the results of the study, the severity of cough was estimated as 2.4 ± 0.09 points in the children of MG on the 1st day of monitoring compared with those of CG - 2.44 ± 0.08 points (p=0.89). On the 3rd day of therapy, the intensity of cough decreased to 1.86 ± 0.11 points in the children of MG compared with the CG children - 2.26 ± 0.1 points ($p<0.01$). On the 5th day of treatment cough decreased to 1.38 ± 0.09 points in the MG children compared with the children of CG - 1.9 ± 0.08 points ($p < 0.001$). It was found that the severity of cough in the children of MG decreased to 0.8 ± 0.09 points from the 7th day of therapy compared with the CG children - 1.08 ± 0.08 points ($p < 0.01$). On the 10th day of treatment, a positive dynamics of CAP as of a decrease in the intensity of cough in the MG children to 0.28 ± 0.06 points was noted compared with those of CG - 0.5 ± 0.07 points ($p < 0.05$) (Table IV) (Figure 2).

On the 1st day of treatment, the productivity of cough (sputum discharge) was estimated as 2.48 ± 0.08 points in the children of MG compared with the CG children - 2.4 ± 0.09 points (p=0.76). On the 3rd day of therapy, the amount of sputum in the children of MG decreased to 1.44 ± 0.07 points compared with those in CG - 2.08 ± 0.09 points ($p < 0.001$). From the 5th day of treatment, the improvement of clinical symptoms was revealed, namely in the children of MG the productivity of cough decreased to 0.94 ± 0.09 points compared with those of CG - 1.72 ± 0.09 points ($p < 0.001$). On the 7th day of therapy there was a decrease in the amount of sputum to 0.4 ± 0.07 points in the MG children compared with the CG children - 0.92 ± 0.06 points ($p < 0.001$). According to the results of dynamic monitoring, it was found that discharge of sputum decreased to 0.06 ± 0.03 points in the MG children on the 10th day of treatment compared with the CG children - 0.42 ± 0.07 points ($p < 0.05$) (Table V) (Figure 3).

According to the results of the study, the number of râles in the lungs was estimated as 2.32 ± 0.1 points on the 1st day of monitoring in the MG children compared with the children of CG - 2.24 ± 0.1 points (p=0.76). On the 3rd day of treatment, the number of râles in the lungs decreased to 1.76 ± 0.1 points

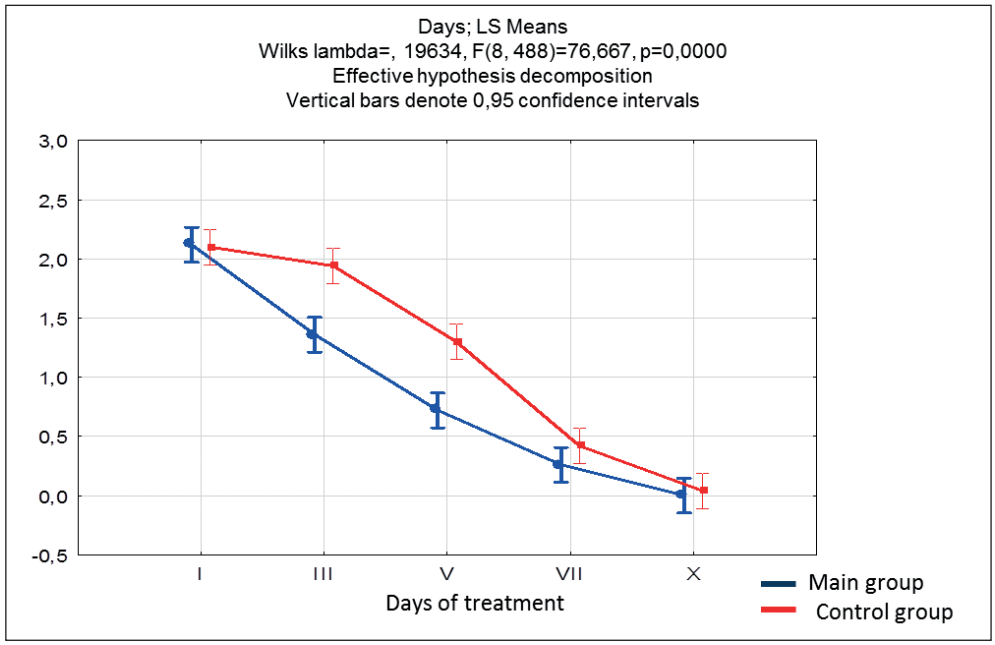

Fig. 1. Shortness of breath in the children during 10 days of treatment

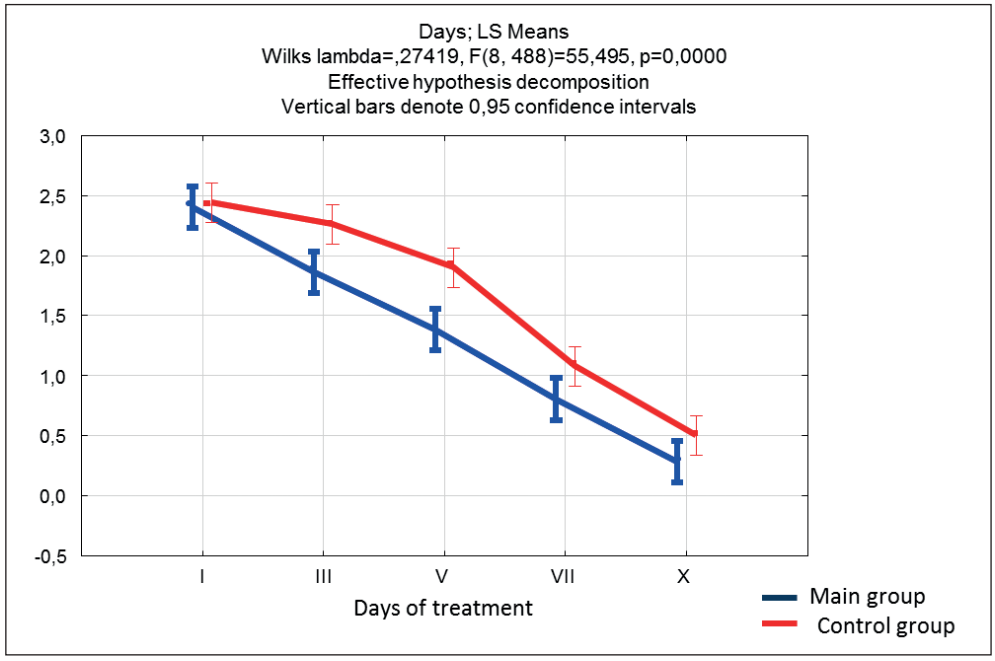

Fig. 2. Intensity of cough in the children during 10 days of treatment

in the MG children in comparison with the children of CG - 2.06 ± 0.1 points ($p < 0.01$). On the 5th day of therapy there was a decrease in the number of râles to 1.22 ± 0.11 points in the MG children compared with those of CG - 1.78 ± 0.08 points ($p < 0.001$). On the 7th day of treatment the number of râles in the lungs decreased to 0.58 ± 0.09 points in the MG children compared with the CG children - 0.94 ± 0.1 points ($p < 0.01$). On the 10th day of therapy, the positive dynamics of CAP in the MG children was proved by reducing the number of râles in the lungs to 0.08 ± 0.04 points compared with the children of CG - 0.4 ± 0.07 points ($p < 0.05$) (Table VI) (Figure 4).

DISCUSSION

Pneumonia is one of the most common diseases of the respiratory system in children and remains an important medical and social problem of modern pediatrics. Insufficient effectiveness of the applied methods of drug therapy is stated, which is confirmed by a constant tendency to a steady increase in the number of children with pneumonia [1,4].

Effective solution of the problem of basic treatment of CAP in children is associated with the development of new methods of non-drug therapy. One such method is high-frequency chest wall oscillation using the airway cleaning system The Vest Airway Clearance System [11,13,15]. The influence of The Vest device on the respiratory tract is achieved due to the oscillation parameters - vibration frequency, pressure, duration of the procedure, which the modes of HFCWO form [20].

The HFCWO system is a modern, highly effective and easily feasible method of the bronchial tree drainage, which aims to stimulate the clearance of the respiratory tract, improve lung ventilation and pulmonary gas exchange [9].

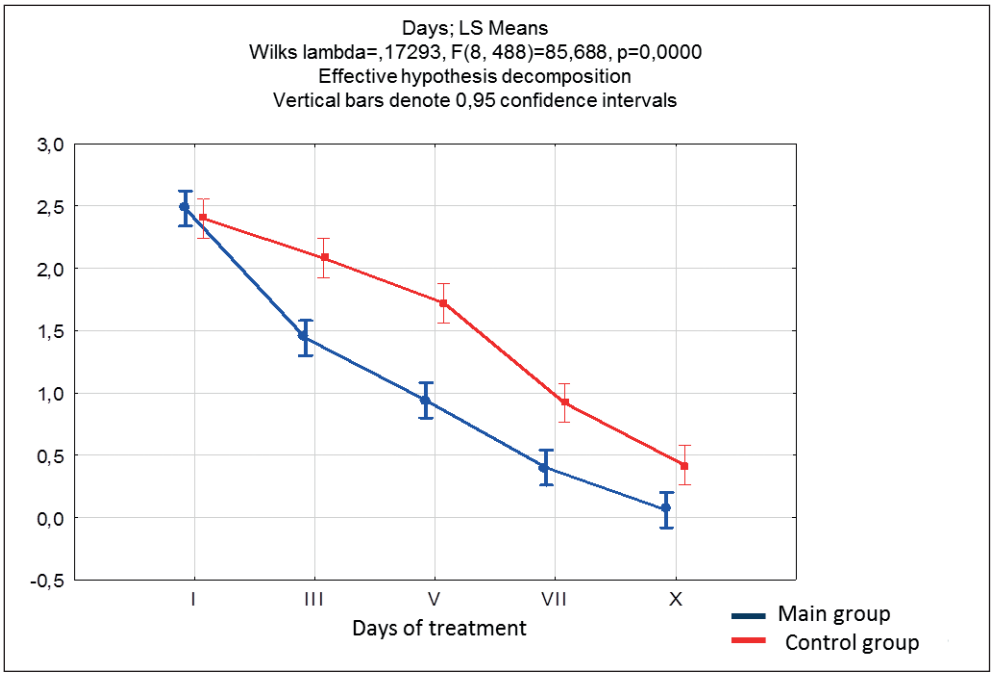

Fig.3. Productivity of cough in the children during 10-day treatment

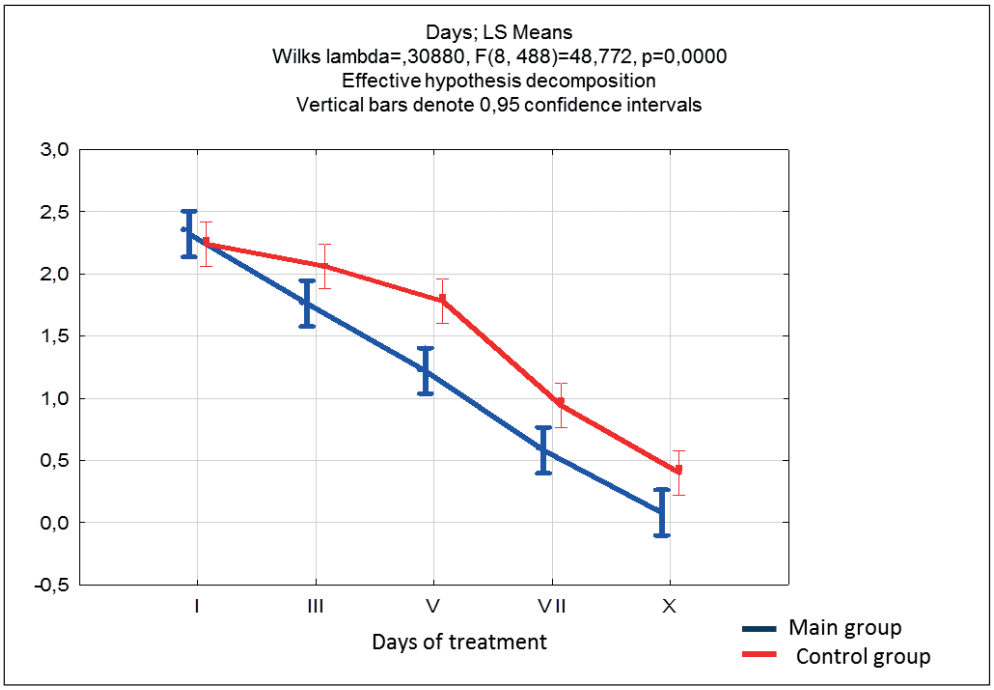

Fig.4. Râles in the children during 10 days of treatment

Thus, in order to optimize the complex therapy of CAP in children, it is necessary to include the method of airway cleansing, namely HFCWO in the daily therapy by using the airway cleansing system The Vest Airway Clearance System. Based on the study, the data obtained confirm the beneficial effect of the HFCWO method on the positive dynamics of clinical symptoms of pneumonia in the form of a decrease in the intensity and productivity of cough, the number of râles and shortness of breath.

CONCLUSIONS

1. Bronchial tree drainage procedures based on HFCWO with the use of innovative and modern airway cleaning system The Vest Airway Clearance System increase the effectiveness of the basic CAP therapy in children.
2. High efficacy of HFCWO as a part of complex treatment of CAP in children is confirmed by positive dynamics of clinical symptoms in the form of decrease in the amount of sputum by 2.42 ± 0.45 points in the children of MG, in comparison with the control group children – 1.98 ± 0.61 points, reduction of cough intensity by 2.12 ± 0.52 points compared with the control group of children - 1.94 ± 0.68 points, the number of râles in the lungs by 2.24 ± 0.48 points compared with children in the control group – 1.84 ± 0.61 points, shortness of breath by 2.12 ± 0.51 points compared with the control group of children - 2.1 ± 0.50 points.
3. The results of studies indicate the feasibility of prescrib-

ing oscillation procedures in the daily comprehensive treatment of CAP, which improves drainage function of the bronchial glands, improves pulmonary gas exchange, which in turn leads to rapid recovery of the respiratory system in children.

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Conflict of interest:

The Authors declare no conflict of interest.

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