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EXPERIENCE OF USING THE «BARK VIBROLUNG» DEVICE IN THE COMPLEX TREATMENT OF COMMUNITY-ACQUIRED PNEUMONIA

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***ABSTRACT*:** Currently, much attention is paid to pathogenetic methods of treatment of community-acquired pneumonia. As a rule, pneumonia is accompanied by a violation of the balance of formation and discharge of bronchial secretions. In order to normalize the drainage function of the bronchi, both pharmacological and mechanical methods of influencing the mucociliary clearance are successfully used. The comprehensive use of the entire arsenal of therapeutic capabilities allows you to minimize the duration of the patient's stay in a hospital bed, as well as speed up the process of restoring impaired lung functions after pneumonia. The study was conducted in the pulmonology Department of the district hospital of the Eastern military district. The effectiveness of using the device of vibroacoustic influence on the chest using the BARK VibroLUNG device in the treatment of community-acquired pneumonia was studied. In addition to the traditional therapy regimens, 5 to 7 sessions of hardware vibration massage were performed. In patients who received a course of vibroacoustic massage, there was a decrease in the duration of General intoxication, productive cough, and physical signs of lung tissue consolidation. Regression of the main clinical manifestations of pneumonia was accompanied by an increase in sputum discharge, simultaneously with a decrease in the time of its production. The main group of patients was characterized by the best time for normalization of acute-phase indicators, restoration of lung ventilation function, and resolution of pneumonic infiltration according to X-ray data. The use of a course of vibration exposure to the chest allowed to reduce the duration of stationary treatment by an average of 3 days.

Keywords: community-acquired pneumonia; mucociliary clearance; bronchial drainage, pathogenetic therapy of pneumonia; vibroacoustic massage; high-frequency percussion ventilation; acute phase indicators.

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INTRODUCTION

Community-acquired pneumonia (VP) traditionally occupies a leading position in the general morbidity of the population. Thus, in 2017, the incidence of VP in the Russian Federation (RF) was 412.3, the mortality rate was 17.3 per 100 thousand population. At the same time, the share of pneumonias in the structure of mortality from respiratory diseases accounted for 41.5% [1]. Lower respiratory tract infections are included by the World Health Organization in the list of the leading causes of death in the world. In 2018, according to Rospotrebnadzor, 721,926 cases of EAP were registered in Russia, which is 492.2 per 100 thousand population [2].

Pneumonia is an acute infectious disease characterized by a focal lesion of the respiratory parts of the lungs with the presence of intraalveolar exudation, detected during physical and X-ray examinations, as well as expressed in various degrees of inflammatory reaction and intoxication [3]. Due to the fact that pneumonia is often the result of a complicated course of acute respiratory disease, the inflammatory process, as a rule, is of a descending nature with the involvement of almost all structures of the respiratory tract [4]. The effect of an infectious factor leads to edema of the tracheobronchial tree mucosa, increased mucus production, and impaired muciliary clearance [4, 5].

The main pathogens of VP are well known. Most often, lung inflammation is caused by a mixed infection of Pureococcus with mycoplasmas, chlamydia, etc. In recent years, much attention in the etiological structure of VP has been paid to pneumotropic viruses that can directly damage the respiratory epithelium, or cause lung inflammation together with bacterial or intracellular agents. The virus, penetrating into the epithelium of the mucous membrane, damages it, leading to cell sloughing, paves the way for bacterial infection, aggravating inflammatory changes, violating the multicomponent protective pulmonary barrier [4, 6].

The basis of successful treatment of pneumonia is adequate antibacterial therapy. The main purpose of etiotropic treatment is to suppress the growth of pathogenic flora in the lung tissue [1, 7]. Currently, the growth of resistance of pathogens of community-acquired infectious diseases of the lower respiratory tract to basic antibacterial drugs is of serious concern. Microbiological monitoring data indicate a wide spread of pneumococcal strains resistant to penicillin and erythromycin. The frequency of allocation of pneumococci, insensitive to these antibiotics, in some European countries (Cyprus, Malta) reaches 47%. In some regions of the Russian Federation, sustainable pneumococcal resistance to cephalosporins and macrolides exceeds 60%, while there is a steady tendency to increase the number of strains with multiple drug resistance [1, 6, 8].

The problem of prolonged course of pneumonia remains relevant in the modern world. Prolonged pneumonia is reported in the case of an increase in the terms of its resolution for more than 4 weeks. The clinical harbingers of slowly developing pneumonia are an increase in the febrile period of more than 4 days, the persistence of cough for more than 4-9 days, and physical phenomena of pneumonia for more than 7 days. The main risk factors for development include new chronic diseases of the bronchopulmonary apparatus (chronic bronchitis, bronchial asthma), old age, etc. The duration of resolution of lung inflammation is significantly affected by the multilobar character of lung tissue damage and severe, complicated forms of the disease. According to some authors, the "persistent" course of pneumonia is observed in 15-25% of cases of all hospitalized patients [7, 8]. The prerequisites for the persistence of endobronchial infection, the torpid course of VP are created during the formation of a mucopurulent "plug" inside the bronchus [5, 6].

Pathogenetic therapy is an important component of successful treatment of VP [9-11]. The main measures of pathogenetic orientation include various ways to normalize the drainage function of the bronchi. Correction of mucociliary clearance disorders is possible in various ways. The most common and available in clinical practice is drug therapy (mucolytics, mucokinetics, expectorants). Nebulizers are widely used as an optimal means of delivering medicines to the respiratory tract in cases of VP, allowing the drug to be delivered to the distal parts of the respiratory tract [11-13].

To improve the evacuation of bronchial secretions, various methods of physiotherapeutic effects on the chest are used. Percussion massage and postural drainage improve the discharge of sputum in patients with limited mobility. The patient is placed in such a way as to ensure the outflow of sputum from the affected areas of the lungs, and preliminary nebulizer inhalation of bronchodilators and / or mucolytics improves the draining effect [4, 8, 12].

Methods that allow creating a variable positive pressure at the end of exhalation (flutter) have proven themselves well. Moderate resistance to exhalation creates conditions for additional opening of the intra-thoracic airways, the ex - piratory collapse of the bronchi is overcome, hyperinflation decreases, and pulmonary ventilation improves. A breathing simulator with a constant positive pressure at the end of exhalation (MPC) can be made independently by lowering the plastic tube from the infusion system into a container with water.

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Modern industrial samples of these tripods can be connected to a nebulizer, and there are also scales for changing the degree of resistance to the air flow. Devices with variable MPC due to the oscillation of the built-in metal ball create rapid changes in the pressure level in the respiratory tract, causing bronchial oscillations, which contribute to the stabilization of sputum with subsequent evacuation [3, 11].

Recently, the method of high - frequency percussion ventilation of the lungs, which is based on the supply of small volumes of air to the patient ("percussion"), has proven itself well with a high adjustable frequency (60-400 cycles per minute) and a controlled pressure level through a special open breathing circuit. "Percussion" can be supplied through a mask, a mouthpiece, an intubation tube or a tracheostomy.

High-frequency vibrations (oscillations) can be transmitted to the respiratory tract through the chest wall. Currently, there are several methods of compression-vibration impact on the chest, among which are the hardware effect of the BARK VibroLUNG devices (Kazakhstan), "VQV-01" (Russia) and The Vest respiratory tract cleaning system (United States of America) [14, 15]. A number of authors have proved the high efficiency of using compression-vibration effects in the treatment of patients with chronic obstructive pulmonary disease (COPD), pneumonia and for coughing in pediatric practice [15-18].

In 2016, in the 1st clinic (advanced medical training therapy) The Military Medical Academy named after S. M. Kirov conducted a study to assess the effectiveness of vibration and compression effects (VQV) on the chest in the complex therapy of VP with the help of the device "VQV-01", in addition to the traditional treatment. The essence of the improvement of mucociliary clearance is the external vibration effect on the chest cell in the projection of the affected lung segments in combination with the rhythmic supply of air under pressure through the breathing mask.

Рис. Внешний вид аппарата BARK VibroLUNG
Fig. Appearance of BARK VibroLUNG set

It was found that as a result of complex treatment, regression of clinical symptoms occurred on average 2-3 days earlier than in the control group. The immediate effect of the ECV was manifested in an increase in the amount of sputum being separated, starting from the 4th to the 9th session of the vibration massage. An indirect positive effect of hardware diagnostics on laboratory markers of inflammation was revealed. In patients receiving sessions of HCV therapy, there was a significant increase in individual spirometry indicators (forced vital capacity of the lungs, forced expiratory volume in 1 min of respiratory maneu - ra), which together allowed to reduce the duration of the solution of infiltrative changes in the lung tissue and the duration of treatment [15].

Currently, the BARK vibroacoustic apparatus BARK VibroLUNG has appeared in the arsenal of additional physical effects on the chest (fig.).

The device has up to 10 executive programs that implement a wide range of vibro-acoustic vibrations in amplitude and frequency. Each program is designed for a specific pulmonary pathology (pneumonia, COPD, bronchial asthma, etc.) with the implementation of percussion effects, low - frequency vibration with a smooth change in frequency, which are combined with high - frequency "inserts". The complexity of the output signal modulation is due to several reasons: the induction of resonant waves in the depth of the lung parenchyma, which are inhomogeneous in their density characteristics; the gradient of blood filling of the lungs; different body weight, height and age of patients. The operating frequency range of the device is in the range from 20 to 300 Hz. The sanogenic effect of vibroacoustic chest massage is provided by several mechanisms. Firstly, due to resonant effects on the walls of the bronchi of various calibers, mucociliary clearance improves. Sound vibrations contribute to the" detachment " of sputum from the bronchus, followed by its movement in the direction of least resistance, i.e. up. Secondly, the vibration "displaces" the intraalveolar exudate, which contributes to their speedy purification. Under the pressure of vibroacoustic waves, microatellectases are opened. Thirdly, mechanical stimulation of the lungs contributes to the normalization of ventilation-perfusion relationships, normalizing the microcirculation of the alveoli and interstitial space.

AIM OF STUDY — to study the effectiveness of the BARK VibroLUNG device in the complex treatment of patients with VP.

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MATERIALS AND METHODS

We examined 181 patients with VP, average age 21.1 years, who were on inpatient treatment in the pulmonology department of the 301st Military Clinical Hospital in Khabarovsk in the period from December 2019 to April 2020. The study included military personnel of young age, without concomitant chronic diseases. The patients were divided into two groups. The 1st (main) group included 98 patients, the 2nd (control) group-83 patients. The groups were comparable in terms of the onset of the disease and hospitalization. Approximately 30% of cases in each group had acute concomitant pathology of the upper respiratory tract in the form of acute maxillary sinusitis, tonsillitis, rhinopharyngitis. The ratio of severe forms of VP in each group also did not have a statistical difference (Table 1).

Таблица 1. Некоторые клинические показатели обследуемых больных
Table 1. Some clinical indicators of the examined patients

INDICATOR	1st group	2nd group
Average Age, yrs	21,1 ± 5,2	20,4 ± 1,6
Duration of pre-hospital period, days	2,7 ± 1,2	2,95 ± 1,6
Volume of infiltrative changes in the lungs, number of segments	1,3 ± 0,8	1,6 ± 1,3
Bilateral pneumonia, %	7,1	6,6
Concomitant pathology of upper respiratory tract pain, %	30,2	28,3
Severe course of community acquired pneumonia, %	13,4	12,8

Chest radiography was performed in all patients in direct and lateral projections to identify the localization of the process and assess the volume of lung tissue damage at admission to the hospital and in dynamics after 10-14 days. Patients with prolonged pneumonia were not included in the sample. The assessment of the ventilation function of the lungs was carried out using peak flowmetry performed at admission. The peak expiratory velocity (PSV) was estimated as a percentage of the proper values in accordance with age and anthropometric indicators. Subsequent PSV measurements were carried out with an interval of 2 days. All patients were treated in accordance with national and international recommendations for the treatment of VP [1, 3].

Upon admission to the hospital, in most cases, patients suffering from mild VP were treated with the following antimicrobial therapy according to the scheme: ceftriaxone intramuscularly 1-2 g per day, azithromycin 500 mg orally per day.

Patients with severe pneumonia were mainly prescribed the following treatment regimen: ceftriaxone 2-4 g per day in combination with azithromycin 500 mg per day or moxifloxacin intravenously 400 mg per day. If necessary, the correction of antibacterial therapy was carried out in accordance with the results of sputum cultures.

Mucokinetic agents (acetylcysteine, ambrogexal) and according to the indications of bronchitis (ipraterol) through a nebulizer were used as pathogenetic therapy in both groups.

In addition to traditional therapy, after the symptoms of infectious intoxication were relieved, but not earlier than the third day of hospital stay, vibroacoustic (VA) effects on the chest using the BARK VibroLUNG device were additionally applied to patients of group 1. Patients of the 2nd group as already noted, they received only drug therapy [1, 3].

In patients of group 1, the course of vibroacoustic therapy included from 5 to 7 daily morning sessions, lasting 5 minutes. Sessions were scheduled from the 3rd-4th day of hospital stay, after the patient's condition was stabilized and data from laboratory and instrumental research methods were obtained.

Vibroacoustic effects on the chest were carried out using standard emitters, placing them over the zone of infiltration of lung tissue. In order to increase the efficiency of the procedure, for example, every 30 seconds, the location of the vibroacoustic detectors was changed within the affected area of the lung. To assess the tolerability of the procedures, the first session was performed with a reduced radiation power of up to 70%, with subsequent sessions the power was increased to 100%.

The obtained data were entered into an Excel table, the work was carried out using the Statistica for Windows 10.0 package. All data are presented in the form of the average value and the standard error of the average (M ± m), the difference in features was determined using the Mann - Whitney U-test.

RESULTS AND ANALYSIS

All patients suffering from VP had symptoms of general intoxication(OI), fever, cough. There were no significant differences in the frequency of detection of shortness of breath (group 1 - 18.3%, group 2-14.8%) and chest pain (48 and 51%, respectively).

Against the background of the treatment, there was a regression of clinical symptoms in both groups. However, in group 1, an earlier regression of the main clinical signs and symptoms of the disease was noted (Table 2). Thus, in patients of group 1, the general intoxication syndrome (OI) persisted for 3.2 ± 1.3 days, a productive cough with sputum for 7.2 ± 1.4 days, wet

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Таблица 2. Длительность отдельных клинических признаков заболевания у больных с нетяжелой внебольничной пневмонией, сутки
Table 2. Duration of individual clinical signs of the disease in patients with mild community-acquired pneumonia, day

Indicator	1st group	2nd group
Manifestation of OI	3,2 ± 1,3	5,1 ± 1,2*
Fever	1,64 ± 0,7	2,4 ± 0,9
Shortness of breath	0,86 ± 0,2	1,2 ± 0,4
Chest pain	4,3 ± 0,7	5,8 ± 1,2
Duration of cough	7,2 ± 1,4	12,5 ± 2,9*
Dry wheezing	8,1 ± 1,3	9,4 ± 1,7
Wet wheezing	5,4 ± 1,2	8,5 ± 1,6*

note: * — $p < 0,05$.

Таблица 3. Лабораторные показатели больных внебольничной пневмонией при поступлении в стационар
Table 3. Laboratory parameters of patients with community-acquired pneumonia at admission to the hospital

Indicator	1st group	2nd group
White blood cells, ×10⁹/l	8,91 ± 4,2	7,6 ± 3,5
N/I,%	7 ± 2,1	6 ± 3,5
ESR, mm/h	28 ± 9,4	24 ± 5,3
CSR, mg/l	42,5 ± 12,0	39,8 ± 9,6
Fibrinogen, g/l	5,3 ± 2,2	4,85 ± 2,6

Note: P/I — rod-shaped neutrophils; ESR — erythrocyte sendimentation rate; CRP-C-reactive protein.

Таблица 4. Лабораторные показатели больных внебольничной пневмонией на 10-е сутки лечения
Table 4. Laboratory parameters of patients with community-acquired pneumonia on the 10th day of treatment

Indicator	1st group	2nd group
White blood cells, ×10⁹/l	6,3 ± 2,8	6,6 ± 3,1
N/I, %	2,0 ± 0,3	5,2 ± 1,5*
ESR, mm/h	12,1 ± 3,7	21,0 ± 4,1*
CSR, mg/l	1,48 ± 1,2	6,3 ± 2,4*
Fibrinogen, g/l	2,4 ± 2,1	3,7 ± 2,6

Note: * — $p < 0,05$.

Таблица 5. Объем мокроты в зависимости от сроков лечения на фоне проведния сеансов виброакустической (ВА) терапии в обеих группах, мл
Table 5. Sputum volume depending on the duration of treatment against the background of vibroacoustic therapy sessions in both groups, ml

Day of treatment / VA Treatment	1st group	2nd group
3 / 1	6,3 ± 1,7	5,7 ± 1,2
4 / 2	5,5 ± 1,2	6,1 ± 1,8
5 / 3	7,9 ± 1,4	4,8 ± 1,2
6 / 4	9,3 ± 2,0*	3,3 ± 1,7
7 / 5	13,9 ± 1,9*	6,3 ± 1,5
8 / 6	14,2 ± 2,1*	8,2 ± 1,3
9 / 7	15,3 ± 1,6*	8,4 ± 1,3
10 / –	8,4 ± 1,3	8,2 ± 1,3

Note: * — $p < 0,05$ when compared with the control group.

small-bubble wheezing was 5.4 ± 1.2 days, which was statistically significantly different ($p < 0.05$) from patients of the 2nd group, where these symptoms were observed for a longer time.

Positive clinical dynamics in the 1st group of patients in the form of faster relief of symptoms of VP was also noted for other analyzed clinical signs of the disease: chest pain, local weakening of breathing, pleural friction noise, normalization of heart rate.

Upon admission to the acute phase of the disease, all patients with VP in the compared groups had an increase in comparison with the reference values of certain laboratory blood parameters characterizing the inflammatory response of the body (Table 3).

On the 10th day of treatment (Table. 4) in the compared groups, significant differences in the dynamics of individual acute-phase indicators were revealed. Thus, in the 1st group of patients, there was a faster normalization of the percentage content of rod - shaped neutrophils, ESR and C-reactive protein. This difference in the dynamics of the studied indicators in the compared groups indicated faster sanogenic reactions in the body of patients with pneumonia against the background of VA therapy sessions.

By the 15th day of treatment, the laboratory parameters in patients in the compared groups did not significantly differ from the reference values.

The maximum separation of bronchial secretions against the background of VA therapy in patients of group 1 was noted in the period from the 4th to the 6th session. The volume of stimulated sputum in group 1 was 1.5 times higher than this indicator in patients of group 2 ($p < 0.05$). After the course of VA therapy, on average, by the 10th day of treatment, the intensity of exposure decreased and the amount of sputum excreted in patients of group 1 no longer differed from the indicators of group 2 (Table 5).

Thus, the positive effect of VA-therapy on the state of the drainage function of the bronchi was also obtained. At the same time, there were no indications for performing rehabilitation fibrobronchoscopies in the 1st group of patients. In the control group, due to the persistence of symptoms of active bronchitis, six rehabilitation bronchological aids were performed.

In 34% of all patients with VP at the beginning of the disease, a decrease in pulmonary ventilation indicators was registered without statistically significant differences in the groups. Against the background of complex treatment of VP with the inclusion of VA therapy, a significant ($p < 0.05$) increase in PSV was noted in patients of group 1 by the time of recovery, in contrast to group 2, where there was only a tendency to improve the indicator of pulmonary ventilation (Table 6).

In the first 5 days of treatment, ventilation indicators in the groups of patients did not have significant differences. The maximum effect of restoring bronchial

conductivity was observed by the last session of VA therapy. At the same time, a positive increase in PSV in patients of the first group was observed even after the end of VA therapy sessions.

Thus, the use of VA therapy in the complex treatment of patients with VP led to a more complete restoration of lung ventilation function in patients of group 1, while in patients of group 2, the improvement of ventilation parameters was significantly slower.

The terms of resolution of pneumonic infiltration according to the results of X - ray examination in the compared groups significantly differed. Thus, in the 1st group of patients, X-ray recovery occurred on 9.2 ± 1.4 days of treatment, in the 2nd - only on 13.4 ± 1.8 days ($p < 0.05$). The duration of inpatient treatment in the compared groups was 12.6 ± 1.6 and 16.9 ± 2.1 days, respectively ($p < 0.05$), Table 7.

The obtained data indicate a positive effect of the use of VA therapy on the course of VP, as well as an increase in sanogenic reactions that determine the speed of restoration of the structure of lung tissue and the timing of resolution of infiltration in the lungs.

Таблица 6. Динамика пиковой скорости выдоха, %
Table 6. Dynamics of peak expiratory velocity, %

Day of treatment	1st group	2nd group
1-й	74	76
3-й	79	74
5-й	83	78
7-й	94*	81
9-й	98*	80
11-й	97*	78

Note: * — $p < 0,05$.

Таблица 7. Сроки рентгенологического разрешения пневмонии и длительность стационарного лечения, дни
Table 7. Terms of radiological resolution of pneumonia and duration of inpatient treatment, days

Indicator	1st group	2nd group
Terms of resolution of lung tissue infiltration	9,8 ± 1,4*	13,4 ± 1,8
Duration of treatment	12,6 ± 1,6*	16,9 ± 2,1

Note: * — $p < 0,05$.

The use of VA-effects on the chest contributes to the speedy restoration of the drainage function of the bronchi, stimulates the expectoration of sputum, and also reduces the duration of manifestations of symptoms of active bronchitis. Under the influence of vibro - acoustic influences, the ventilation function of the lungs improves, which is manifested in a significant increase in PSV.

Thus, the course of active bronchial drainage using the VibroLUNG device has shown its effectiveness and can be recommended for implementation in the scheme of complex treatment of patients with VP.

CONCLUSION

The use of the VibroLUNG device in the complex treatment of VP contributes to a faster regression of clinical symptoms, acceleration of clinical and X - ray resolution of lung tissue infiltration, normalization of laboratory parameters and a reduction in the duration of hospitalization (on average by 3 days).

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