

Original article

Efficacy of vibroacoustic therapy in treatment of pneumonia in children with bronchopulmonary dysplasia

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Abstract: Background — Advances in neonatal intensive care have resulted in high survival rates for infants born with extremely low birth weight. Accordingly, the treatment and rehabilitation of premature neonates with bronchopulmonary dysplasia (BPD) is indisputably an urgent problem.

Objective — To evaluate the efficacy of vibroacoustic therapy in patients with BPD in the complex of therapeutic measures.

Material and Methods — The study was a prospective, non-randomized open-label controlled clinical trial conducted in 2018-2020 in Astana, Kazakhstan. It included 69 children with BPD hospitalized with a concomitant diagnosis of pneumonia between the ages of 1 and 2 years. The study subjects were distributed among two groups: Group 1 (the main group, n=37) receiving vibroacoustic therapy with the VibroLung apparatus in combination with the main treatment and Group 2 (the control, n=32) receiving solely the main treatment.

Results — The inclusion of the vibroacoustic method of treatment in the combination therapy of pneumonia in children with BPD resulted in early leveling of the following clinical symptoms: a reduction in the duration of the high fever by 1.18 days vs. the control group ($p<0.05$), relief of respiratory failure 1.4 days earlier vs. the control group ($p<0.05$) and a decrease in the duration of inpatient treatment by 2.9 days, compared with the control group ($p<0.05$). All of these implied the efficacy of this treatment method.

Conclusion — Our results demonstrated that vibroacoustic therapy was a relevant addition to the treatment of pneumonia in children with BPD.

Keywords: Vibroacoustic therapy, bronchopulmonary dysplasia, pneumonia, premature infants.

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Introduction

Preterm birth has become a global health problem worldwide due to its higher occurrence in recent decades [1, 2]. Over 70% of premature babies are born between 34 and 36 weeks of gestation [3]. At the same time, significant progress has been made in the tactics of nursing infants with very low birth weight (VLBW), including the introduction of surfactant replacement therapy, prenatal steroids and noninvasive ventilation methods, which can improve survival of preterm babies [4]. In Kazakhstan, concern about this problem increased in 2008 with the introduction of international criteria for live births and stillbirths recommended by the WHO [5]. From 2008 to 2016, 3,441,751 cases of live births were registered in Kazakhstan, including 204,613 preterm births, of which 82.5, 10.9% and 6.6% of neonates were born with low birth weight (LBW), VLBW and extremely low birth weight (ELBW), respectively [6].

Among the problem issues of preterm infants, respiratory pathology is the most frequent and adverse outcome in those with VLBW (<1500 g), with an overall incidence of about 30% [7]. Bronchopulmonary dysplasia (BPD) is a chronic inflammatory lung disease associated with delayed lung development and a need for supplemental oxygen. According to the National Institute of Child

Health and Human Development (NICHD), USA, the 2001 clinical definition of BPD includes the need for supplemental oxygen at the post-conceptual age of 36 weeks [8].

Over the past decades, the incidence of BPD has increased significantly as a result of improved survival in case of extreme preterm birth, as a result of which neonates require mechanical ventilation. Data from large cohort studies (such as ELGAN, the Canadian Neonatal Network, Korean Neonatal Network, Vermont Oxford Network, and Swiss Neonatal Network), along with studies in China, Taiwan, and India, demonstrated a prevalence of BPD in the range of 11-50%. Such a wide range was due to differences in criteria for gestational age or birth weight for diagnosing BPD [9]. BPD is known to seriously compromise the wellbeing of extremely preterm neonates in both the short-term and long-term perspectives of their lives via higher risks of respiratory infections, asthma, and chronic obstructive pulmonary disease later in life [10-12]. Also, surviving children with BPD usually suffer from long-term impairment of lung function [13-15].

In addition to the above, newborns, especially preterm neonates, are among the most vulnerable age group in terms of morbidity and mortality from infections [16]. The immaturity of the innate immune system and the high need for invasive medical

procedures for preterm birth make these children highly susceptible to various pathogens [17].

BPD has various long-term effects that were previously described in numerous studies, such as altered lung function, increased susceptibility to infections, and airway hyperresponsiveness. Children with such pathologies often undergo long and repeated hospitalizations. A persistent inflammatory process can lead to lifelong changes in lung function impairing their quality of life [18].

Despite severe lung dysfunction, some children with BPD achieve significant recovery in lung structure and function [9]. The future introduction of new methods of treatment and rehabilitation will contribute to the achievement of effective results. To date, most intervention studies did not detect a clear reduction in the incidence of BPD [19]. Therefore, research into new treatment methods of BPD is of paramount importance.

Material and Methods

This article presents the results of our prospective clinical controlled nonrandomized parallel-group study of preterm infants 1-2 years of age with a primary diagnosis of BPD and a concomitant diagnosis of pneumonia. All children were hospitalized in the Department of Early Childhood Pathology of the City Children's Hospital in Astana, Kazakhstan, from April 2018 to December 2020. A total of 69 preterm babies were included in the study. They were distributed among two groups: Group 1 with children who received vibroacoustic therapy in combination with standard treatment for pneumonia and Group 2 with infants who received solely standard treatment. The characteristics of the study groups are presented in [Table 1](#).

All study subjects were monitored from the first day of hospitalization until discharge from the hospital. Upon admission to the hospital, they were offered vibroacoustic therapy as an additional method of therapy with an explanation of the scientific goal. Those whose parents signed the informed consent were in the main group, while those whose parents did not agree to vibroacoustic treatment were in the control group. Accordingly, patients were not randomized.

Inclusion and exclusion criteria

The criteria for inclusion in the study were as follows:

- Children 1-2 years of age with BPD who were hospitalized with a diagnosis of pneumonia.

The criteria for exclusion from the study were as follows:

- Infants with coronary artery disease or with signs of heart failure;
- Children with sepsis;
- Infants with epilepsy or convulsive syndrome.

Description of medical intervention

Vibroacoustic therapy for children was carried out using the VibroLUNG apparatus with attachments suitable for children. To do so, before the session, the children were given inhalations of bronchodilators (Berodual, salbutamol) at the age-specific dosage. After that, we proceeded directly to the vibroacoustic therapy per se. The attachments were applied to the chest, bypassing the area of absolute cardiac dullness. The scheme of this therapy was

selected individually depending on age and body type. The procedure was carried out 3-4 times a day.

The efficacy of vibroacoustic therapy was determined by assessing the state of respiratory failure syndrome and intoxication syndrome, and by the duration of inpatient treatment.

Statistical data processing

Statistical data processing was carried out using the Microsoft Office Home and Business 2013 x32/x64 Spreadsheet Application Package and IBM SPSS Statistics Base Campus Value Unit License v.24 (license agreement No. 20160805-1 of 30 August 30 2016 with Predictive Solutions CJSC). The nature of the data distribution was assessed using the Shapiro-Wilk test. Quantitative data were presented by central trends and scatter: median (Me) and interquartile range (Q1-Q3) in case of non-normal distribution of the data. The statistical hypothesis of equality of mean ranks was tested using the Mann-Whitney U test to compare two independent groups on one or more traits if at least one of the groups had data distribution other than normal or if the type of distributions was not checked. Relative indicators (shares, %) were used for qualitative characteristics. To assess the differences in relative values, we employed the analysis of contingency tables (χ^2). Parameter values with $p < 0.05$ were considered statistically significant.

Table 1. Characteristics of the study groups

Characteristics	Group 1 n=37	Group 2 n=32	p
Gender:			
Male	20 (54.05%)	17 (53.12%)	0.558
Female	17 (45.95%)	15 (46.8%)	
Vaginal labor (%)	15 (40.6%)	11 (34.4%)	0.232
Cesarian section (%)	22 (59.4%)	21 (65.6%)	
Birth weight, g	840.0	790.0	0.078
[IQR]	[745.0-940.0]	[680.0-900.0]	
Birth length, cm	34.70	35.00	0.059
[IQR]	[31.0-35.0]	[33.5-38.0]	
Gestational age	26.8	27.5	0.361
[IQR]	[26.0-27.1]	[27.1- 28.0]	
Age, months	14.0	16.0	0.051
[IQR]	[13.0-16.0]	[14.0-19.0]	
Apgar score	6[5.0-6.0]/	6[5.0-6.5]/	0.09
[IQR]	7[5.0-7.0]	7[7.0-7.5]	
C-reactive protein content, g/L	5.8	7.1	0.063
[IQR]	[3.5-9.0]	[4.9-11.2]	

Table 2. Clinical course of the disease in the study groups

Indicators	Group 1 n=37	Group 2 n=32	p
Duration of intercostal retraction, days [IQR]	4.4 [2.0-7.1]	6.3 [4.02-8.0]	0.013
Oxygen saturation upon admission to the hospital, % [IQR]	91 [89-93]	90 [88-93]	0.537
Day of hospitalization when oxygen saturation returned to normal (>95), [IQR]	7.9 [5.0-9.1]	9.4 [7.5-10.0]	0.009
Duration of fever, days [IQR]	3 [1.6-4.4]	4.2 [2.8-5.6]	0.01
Duration of inpatient treatment, days [IQR]	8.9 [6.0-12.4]	11.8 [7.1-16.0]	0.008

Results

Our results on the efficacy of vibroacoustic therapy are presented in [Table 2](#). The combination therapy in patients with BPD and pneumonia yielded statistically significant differences in all investigated parameters.

When examining respiratory failure due to BPD in the study groups, we discovered that most children (59.5%) of the main group had grade 2 respiratory failure, while grade 1 and grade 3 were observed in 37.8% and 2.7% of cases, respectively. In the control group, 54.7% of study subjects exhibited grade 2 respiratory failure, whereas grade 1 and 3 were observed in 42.9% and 2.4% of cases, correspondingly. We detected no statistically significant difference between the study groups ($p=0.07$). However, the duration of the respiratory failure syndrome (oxygen saturation, intercostal retraction) in the studied groups was statistically significantly different ($p<0.05$), as seen in [Table 2](#). For this comparison, we used the Mann-Whitney U test for independent samples.

Analysis of the fever response in the studied patients showed the following trend: the average measured temperature in the main group was 37.2 ± 0.9 °C vs. 37.2 ± 1.01 °C in the comparison group, and the duration of the fever response was 3.02 ± 1.6 d. Hence, an assessment of the fever response in the groups did not reveal a statistically significant difference between them ($p=0.103$), while the duration of fever was statistically significantly different ($p=0.01$, [Table 2](#)).

In addition to clinical data, we also analyzed the duration of inpatient treatment, which may indirectly indicate the efficacy of combination therapy. In the control group, the duration of inpatient treatment was, on average, 2.9 d shorter ($p=0.008$).

Therefore, the inclusion of the vibroacoustic treatment method in the combination therapy of pneumonia in children with BPD resulted in early leveling of the following clinical symptoms: a reduction in the duration of the fever response by 1.18 d vs. the control group ($p=0.01$), relief of respiratory failure by 1.4 d earlier vs. the control group ($p=0.009$) and a shorter duration of inpatient treatment by 2.9 d vs. the control group ($p=0.008$). All of these results confirmed the efficacy of this treatment method.

Discussion

Previous studies demonstrated that gestational age was not always a risk factor for hospital readmission. However, the developed BPD contributed more to the risk of rehospitalization of extremely preterm infants. The association between BPD and readmission was demonstrated in many studies [20-22]. Preterm neonates, especially those with BPD, exhibited varying degrees of lung damage with increased susceptibility to infection and bronchospasm [23]. Reducing the duration of inpatient treatment is one of the priorities in the management of premature babies. Early combined rehabilitation intervention can improve the degree of dyspnea in this category of patients [24].

Our study on the use of vibroacoustic therapy for infants with BPD demonstrated high efficacy. It is the first of the kind in this field. The inclusion of such therapy for patients with BPD made it possible to quickly stop clinical symptoms and, as a result, reduce the length of their hospital stay. To assess the efficacy of vibroacoustic therapy were examined the duration of the respiratory failure syndrome, intoxication syndrome and inpatient treatment. The first indicator differed significantly between the

groups (dyspnea lasted 1.4 d less in the group with vibroacoustic therapy, $p=0.009$).

The duration of the fever response also had a statistically significant difference ($p=0.01$). In the main group, fever persisted 1.2 d less than in the control group. The duration of inpatient treatment declined in the main group vs. the control group by 3.1 d ($p=0.008$). The obtained data on the use of the combination therapy of pneumonia in patients with BPD allowed assessing the efficacy of vibroacoustic therapy and the expansion of the therapeutic possibilities of using this method of treatment.

Our study had certain limitations. This was a single-center trial with a small sample size without randomization, in which only relevant indicators were assessed during hospitalization. To further confirm our short-term results, we need to increase the sample size.

Conclusion

Experts and caregivers of BPD look forward to advances in the treatment of this disease, for which there exist many evidence-based options for the prevention and symptom relief but no definitive treatment recommendations to date [25]. It is now known that children who experienced BPD suffer from decreased lung function in adulthood and, as a result, are at higher risk of developing chronic obstructive pulmonary disease in the future [26-28]. Based on our results, we can conclude that the inclusion of vibroacoustic therapy in the complex of measures for long-term management of BPD patients with the development of acute respiratory pathology can be an effective measure to reduce the inpatient treatment time. Effective and rapid treatment of recurrent conditions in BPD will improve the quality of life of these patients.

Conflict of interest

The authors declare no conflicts of interest.

Ethical approval

This study was reviewed by the Bioethics Committee at Astana Medical University. Excerpts from the Protocol No. 1 of 15 March 15 v2018 are attached. The authors complied with the ethical principles of the Declaration of Helsinki and World Medical Association. The informed consent was signed by all patients prior to their participation in the study.

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