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Clinical and Functional Characteristics of Long-Term Respiratory Outcomes in Children with Neonatal Respiratory Distress Syndrome

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Abstract

The aim of this study is to comprehensively evaluate the clinical and functional characteristics of long-term respiratory outcomes in children with neonatal respiratory distress syndrome (RDS) in the Uzbek healthcare system. The methodological framework includes a retrospective analysis of medical data, dynamic observation, and functional diagnostics of the respiratory system using spirometry, pulse oximetry, and assessment of bronchial reactivity.

Keywords: Respiratory distress syndrome, neonatal period, bronchopulmonary dysplasia, perinatal factors, hypoxia, mechanical ventilation.

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1. Introduction

Respiratory distress syndrome of newborns remains one of the key causes of neonatal morbidity and subsequent disability in children, especially in countries with a transforming healthcare system. According to national statistical reports of the Republic of Uzbekistan, the share of respiratory disorders in the structure of neonatal pathology reaches 28–34%, while RDS is registered mainly in premature newborns with a gestational age of less than 34 weeks.

The combined influence of surfactant deficiency, immaturity of the alveolar apparatus and hypoxic tissue damage forms a complex pathogenetic cascade that has a prolonged effect on the child's respiratory system. Analysis of international and regional clinical observations demonstrates that a significant proportion of children who have suffered RDS continue to have functional lung disorders between the ages of 3 and 10 years.

The incidence of bronchopulmonary dysplasia (BPD) among this category of patients varies from 20 to 45%, while severe forms of the disease are associated with long-term oxygen therapy and invasive ventilation. In the conditions of Uzbekistan, where more than 800 thousand births are registered annually, the increase in the survival rate of premature babies leads to an increase in the number of patients with chronic respiratory complications, which increases the burden on pediatric services.

Functional changes in the respiratory system after neonatal RDS are characterized by a decrease in forced vital capacity (FVC), a decrease in forced expiratory volume in the first second (FEV1) and an increase in bronchial reactivity. In school-age children who have suffered severe forms of

RDS, FEV1 levels may decrease by 12–25% compared to the age norm, which indicates the formation of chronic airway obstruction. An additional risk factor is the impact of unfavorable environmental conditions, including air pollution in the industrial regions of the country.

Cause-and-effect mechanisms for the formation of long-term respiratory disorders include damage to the epithelium of the respiratory tract, impaired vascularization of lung tissue, and low-intensity chronic inflammation. Perinatal factors, such as intrauterine hypoxia, infectious complications and low birth weight, increase the likelihood of developing persistent functional abnormalities. The interaction of these factors forms an individual risk profile that determines the clinical course and prognosis of the disease.

Of particular importance is the early diagnosis of functional disorders of the respiratory system using modern methods, including computer spirometry and assessment of the diffusion capacity of the lungs (DLCO). In pediatric practice in Uzbekistan, the implementation of these methods remains limited, which makes it difficult to timely identify subclinical changes and carry out preventive measures. Establishing clinical and functional correlations makes it possible to increase the efficiency of clinical observation and individualize therapeutic approaches.

A comprehensive study of long-term outcomes of RDS in children in the national context is of particular relevance due to the need to develop programs for medical rehabilitation and prevention of chronic respiratory pathology. Systematic analysis of clinical and functional parameters creates the prerequisites for improving neonatal care, optimizing respiratory support and reducing the incidence of disabling consequences.

The study was carried out on the basis of specialized pediatric and neonatal institutions of the Republic of Uzbekistan, covering data for the period 2015–2025, which made it possible to take into account the dynamics of clinical outcomes against the background of modernization of neonatal care. The sample included 214 children aged 3 to 12 years who suffered respiratory distress syndrome (RDS) in the neonatal period, confirmed by clinical and radiological criteria. The control group consisted of 96 apparently healthy children of comparable age without a history of severe neonatal pathology.

The clinical block of the study included the analysis of anamnestic data (gestational age, birth weight, duration of mechanical ventilation), the frequency of respiratory diseases, the presence of episodes of bronchial obstruction and chronic cough syndrome. Functional assessment of the respiratory system was carried out using computer spirometry (FEV1, FVC, Tiffno index), pulse oximetry (SpO_2) and bronchodilator tests to determine the degree of reversibility of obstruction. Additionally, physical endurance was assessed using a 6-minute walking test. Statistical data processing was performed using SPSS 27.0 and Statistica packages.

Methods of variation statistics, correlation analysis (Pearson coefficient), as well as a multivariate regression model were used to identify the influence of perinatal factors on long-term respiratory outcomes. The level of statistical significance was accepted at $p < 0.05$. To assess the risk of developing chronic pathology, relative risks (RR) and confidence intervals (95% CI) were calculated. The methodological approach was based on a comparative analysis of groups depending on the severity of RDS (mild, moderate, severe), duration of respiratory support and the presence of complications in the neonatal period.

The study included data on the influence of environmental factors, including the level of air pollution in urbanized regions (Tashkent, Fergana Valley), which made it possible to integrate clinical and external determinants into a single analytical model.

Analysis of the data obtained demonstrated that 47.2% of the examined children developed stable disorders of external respiration function, manifested by a decrease in FEV1 below 80% of the required values. An obstructive type of ventilation disorders was detected in 31.5% of patients, while a mixed type was diagnosed in 15.7% of cases. In the control group, similar figures did not exceed 8.3%, which confirms a statistically significant difference ($p < 0.01$).

The frequency of repeated episodes of broncho-obstructive syndrome among children with a history of RDS reached 54.6%, with the highest prevalence noted in the group with severe disease in the neonatal period (up to 68.9%). The duration of artificial pulmonary ventilation for more than 7 days was associated with an increase in the risk of developing chronic respiratory disorders by 2.3 times (RR = 2.3; 95% CI: 1.6–3.1). Oxygen saturation indicators at rest (SpO_2) in most children were within the normal range (94–98%), however, with physical activity in 22.8% of patients there was a decrease to 90–92%, which indicates hidden respiratory failure.

Data from a 6-minute walk test showed a decrease in exercise tolerance by an average of 18–27% compared to the control group. Correlation analysis revealed a statistically significant relationship between gestational age and FEV1 indicators (r = 0.61), as well as between the duration of mechanical ventilation and the degree of reduction in lung capacity (r = -0.58). It has been established that low birth weight (<1500 g) increases the likelihood of developing bronchopulmonary dysplasia to 42.5%.

Table 1. Clinical and functional indicators in children with previous RDS

Indicator	Main group (n=214)	Control group (n=96)
FEV1 reduction < 80%		8,3%
Obstructive disorders	31,5%	5,6%
Repeated bronchial obstruction	54,6%	12,1%
Decrease in SpO_2 during exercise	22,8%	4,2%
Bronchopulmonary dysplasia	36,4%	—

Additionally, it was found that children living in regions with high levels of atmospheric pollution demonstrated more pronounced respiratory dysfunction, which was manifested by a decrease in FEV1 by an additional 6–9% compared to rural regions.

The results obtained form a comprehensive picture of the long-term consequences of respiratory distress syndrome, demonstrating a steady tendency towards the formation of chronic pathology of the respiratory system in a significant proportion of patients.

The frequency of identified violations of the ventilation function exceeds similar indicators presented in a number of European studies, where the prevalence of such changes ranges from 30–40%, which indicates the influence of regional factors, including the level of medical care and environmental stress. The formation of obstructive changes in the airways is caused by structural damage to the bronchial tree resulting from hypoxic exposure and mechanical trauma during mechanical ventilation.

Prolonged ventilation support leads to disruption of alveolar architecture, decreased elasticity of lung tissue and the development of fibrotic changes. These processes are accompanied by chronic inflammation, which persists for several years after RDS. The relationship between gestational age and functional parameters of the lungs reflects the degree of morphological maturity of the respiratory system at the time of birth.

Prematurity is associated with surfactant deficiency, incomplete formation of alveoli and vasculature, which increases susceptibility to damaging factors. In the conditions of Uzbekistan, where the proportion of premature births is about 9–11%, the problem of long-term respiratory outcomes takes on a pronounced socio-medical nature. Analysis of the influence of environmental factors reveals an additional burden on the respiratory system of children living in industrial regions.

Increased concentrations of fine particles (PM2.5) and nitrogen oxides contribute to increased inflammatory processes and a decrease in the functional reserves of the lungs. The combination of perinatal damage and postnatal exposure to a polluted environment forms a cumulative effect leading to accelerated progression of chronic pathology.

Comparison with international data demonstrates that the introduction of modern neonatal technologies, including the use of exogenous surfactant and non-invasive ventilation, can reduce the incidence of severe outcomes. However, even under optimal treatment conditions, there remains a risk of the formation of subclinical disorders that are detected only during functional diagnostics. This emphasizes the need for long-term follow-up and early intervention. The pathogenetic mechanisms underlying the identified changes include an imbalance in the processes of regeneration and remodeling of lung tissue.

Chronic inflammation is accompanied by activation of fibroblasts and excessive collagen synthesis, which leads to loss of elasticity and decreased diffusion capacity of the lungs. Disruption of microcirculation enhances hypoxic changes and contributes to the formation of a vicious circle of pathological processes. The clinical significance of the identified patterns is determined by their impact on the quality of life of patients. Decreased tolerance to physical activity, frequent episodes of bronchial obstruction and increased susceptibility to infections limit the adaptive capabilities of children and increase the risk of developing chronic diseases in adulthood.

This requires the development of comprehensive rehabilitation programs, including breathing exercises, drug correction and monitoring of functional indicators.

Long-term respiratory outcomes in children who have suffered respiratory distress syndrome are characterized by a high incidence of functional disorders of the respiratory system, reaching almost half of the observations. The most significant risk factors are prematurity, prolonged artificial ventilation and low birth weight.

Identified clinical and functional changes include obstructive and mixed types of ventilation disorders, decreased exercise tolerance and latent hypoxia during exercise. Environmental living conditions increase the severity of pathological changes and create an additional risk of disease progression.

The data obtained justify the need for early diagnosis, implementation of functional monitoring and development of individualized rehabilitation programs. Improving neonatal care and preventive measures can reduce the incidence of chronic respiratory diseases and improve the long-term prognosis in this category of patients.

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