PEDIATRICS

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SPIRAL COMPUTED TOMOGRAPHY IN DIAGNOSIS OF BRONCHOPULMONARY DYSPLASIA

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Abstract: Bronchopulmonary dysplasia is one of the pressing challenges in pediatrics, which significance goes beyond the field of neonatology and is regarded as a chronic obstructive disease of young children. The article presents an assessment of typical chest radiographic findings detected by spiral computed tomography according to the form of the disease.

KeyWords: Bronchopulmonary dysplasia, spiral computed tomography, chest cavity, children.

INTRODUCTION

A concept of natural disease development has been formed for a number of pathological conditions, that is disease course from the onset to regress or control, which is understood as the programs aimed at reducing the incidence or prevalence or elimination of these diseases. Bronchopulmonary dysplasia in this regard is not an exception [1]. However, despite the scientific process in the study of etiological factors, pathogenesis and clinical presentation of bronchopulmonary dysplasia, the desired level of control over the disease has not been achieved [1, 2].

The diagnosis of bronchopulmonary dysplasia (BPD) is clinical radiological. According to the literature, radiological methods are leading not only in the diagnosis of BPD, but in recognition of its consequences and complications [3, 4, 6]. Radiographic study is used for follow-up monitoring of the disease development in the lungs. W. H. Northway described 4 radiographic successive stages of BPD. However, not all children demonstrate stages in BPD formation.

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Development of BPD is possible with minimal radiographic changes inherent to the new form of BPD and do not fit those described by W. N. Northway. This requires further study of this issue. The methods of X-ray diagnosis visualize macrostructure and anatomical topographic features of the respiratory organs [6]. According to many authors, the combined analysis of these data and the findings of clinical and laboratory investigation can improve sensitivity and specificity of each of them as well as allow to switch from probable to nosological diagnosis. Many researchers consider that doing plain chest X-ray the doctors face the problem of projection and summary distortion of the pulmonary picture. And it is not always regarded as morphological changes characteristic of bronchopulmonary dysplasia [6, 7]. This is due to the fact that traditional radiography is insufficiently informative because due to superposition and subtraction the X-ray images poorly resemble a morphological substrate, which sometimes complicates clinical and radiological diagnosis of BPD [6]. Therefore, the search for more informative and highly sensitive imaging methods was justified. Introduction of spiral computed tomography (SCT) into the diagnosis of chronic lung diseases in children, which is due to its high sensitivity has the ability to detect the details inaccessible by the traditional X-ray examination, led to a real revolution in this area. According to many authors, the advantages of CT include the capability to explore subtle signs of parenchy-

mal changes in a separate section of the lungs, spatial location of trachea, vessels, bronchial tree [6, 7]. Thus, radiographic diagnosis is the leading instrument in identification of bronchopulmonary dysplasia in children. However, the data of Ukrainian and foreign literature are controversial and the problem has not been investigated in detail, which dictates the need for further improvement and refinement of radiological semiotics of bronchopulmonary dysplasia, according to the form of the disease, determination of prognostic signs of respiratory and cardiovascular complications in children with bronchopulmonary dysplasia.

2 PURPOSES, SUBJECTS AND METHODS:

2.1 Purpose

To improve diagnosis of various forms of bronchopulmonary dysplasia by identification of specific radiological changes using spiral computed tomography of the chest.

2.2 Subjects

The study was conducted at the Department of Pediatrics No. 1 and Neonatology of KhNMU (Head of Department – Doctor of Medical Science, Professor H.S.Senatorova) at Regional Centre for Diagnosis and Treatment of Bronchopulmonary Dysplasia in Children (Head of the Center – Candidate of Medical Science, O.L.Logvinova) of Kharkiv Regional Children Clinical Hospital (Head Doctor – Candidate of Medical Science, Associate Professor H.R.Muratov).

The study group included 71 children aged 1 month - 3 years, of them 35 (49.3%) were diagnosed with classical form of BPD (group 1), 19 (26.8%) a new form of BPD (group 2), 17 (23.9%) full-term BPD (group 3).

2.3 Methods

The diagnosis of bronchopulmonary dysplasia was made according to the International Classification of Diseases, revision 10 (P 27.0). Severity criteria were determined by clinical forms of bronchopulmonary diseases in children of Russian Respiratory Society (2009) [8]. Radiographic criteria were evaluated on the 28th day of life by spiral computed tomography of the chest in the phase of physiological or pharmacological sleep. The study was performed in accordance with the ethical principles of medical research involving human subjects that have been approved by Helsinki Declaration. Statistical analysis of the findings was performed using statistical software package Statistica 7.0. Median (Me) and interquartile scope (Lq - bottom quartile; Uq - top quartile) were determined for samples with distribution that did not comply with Gaussian law. Nonparametric U-Mann-Whitney test (MW) was used to compare two samples. To compare the values, which were characterized by opposing more than 2 points, Kruskal-Wallis analysis of variance was used, the differences were considered probable with Bonferroni adjustment (at $p^{\wedge} = p / k$, where k is the number of paired comparisons). Fisher's criterion (F) was used to compare two variances. The method of angular transformation of F-test assessment was used to contrast sample particles. The findings were considered statistically significant at values of $p < 0.05$.

2.4 Conflict of interests

There is no conflict of interests.

3 RESULTS AND DISCUSSION

Group age patterns in children with BPD coincided with the relevant trends in general, namely, demonstrated statistically significant predominance of patients of the first year of life among the total number of patients (Group 1 – 81.4 ± 6.0%; Group 2 – 77.4 ± 9.1%; group 3 – 61.1 ± 7.5%, respectively). By sexual dimorphism the majority of children with various forms of bronchopulmonary dysplasia were boys.

Multiple comparison using Kruskal-Wallis analysis of H criterion for gestation term and birth weight high (Table 1) allows to suggest that statistical characteristics of different groups of children with bronchopulmonary dysplasia were quite different, and the level of these values depended on a particular group.

Table 1

Statistical characteristics of the parameters of gestation period and body weight in children with bronchopulmonary dysplasia

Parameter	Statistical value	Groups		
		Group 1	Group 2	Group 3
Gestation period	Me	32	27	38
	(Lq; Uq)	(28; 34)	(26; 30)	(38; 39)
KW ANOVA by Ranks: H=44.9, p=0.0000; MW U Test: p_{1-2}=0.0007;p_{1-3}=0.0000; p_{2-3}=0.0000;				
Body weight at birth	Me	1700	1105	2835
	(Lq; Uq)	(1100; 2390)	(800; 1450)	(2480; 3500)
KW ANOVA by Ranks: H=32.5, p=0.0000; MW U Test: p_{1-2}=0.005; p_{1-3}=0.00001; p_{2-3}=0.0000				

In pairwise comparison with nonparametric Mann-Whitney (MW) method, p <0.017 was taken as the level of statistical significance of differences between the groups, according to Bonferroni correction. The presence of possible differences in children with bronchopulmonary dysplasia was determined only by gestation period and birth weight, reflecting the immaturity of all organs and, first of all, bronchopulmonary system. The assessment of correlations between groups 1 and 2 demonstrated that the level of correlation between the gestation period and the duration of mechanical ventilation was significantly higher (p = 0.0199) than between the period of gestation and birth weight (p = 0.2024) and between birth weight and duration of mechanical ventilation (p = 0.8001). Mature children with bronchopulmonary dysplasia were not found to have possible links between the period of gestation, birth weight, duration of mechanical ventilation and oxygen dependence (all p> 0.05). Primarily, this is due to the fact that the children from group 3 were full-term and failure of spontaneous unassisted respiration was not associated with the development of respiratory disorders inherent to premature babies, but the presence of comorbidities, which severity necessitated artificial ventilation (CNS congenital lesions, abnormal development, and surgery).

Assessment of specific radiological changes on plain chest film in bronchopulmonary dysplasia showed that fibrosis and interstitial changes in Group 1 were diagnosed only in every eighth child, Group 2 - one in four, and group 3 - every second child (Table 2).

Table 2

The frequency of radiographic changes of the chest in children with bronchopulmonary dysplasia

Sign	Group 1 n=35	Group 2 n=7	Group 3 n=12
	$p\%\pm s_{p\%}$	$p\%\pm s_{p\%}$	$p\%\pm s_{p\%}$
Signs of hyperinflation: -increased lung markings	74.3±7.4	71.4±18.4	83.3±11.2
-enriched lung markings	100.0±0.02	71.4±18.4	83.3±11.2
-lengthening of the lung fields	57.1±8.4	42.9±20.2	58.3±14.8
-indistinct lung fields	48.6±8.5	14.3±14.3	66.7±14.2
-increased transparency of the lung tissue	71.4±7.7	57.1±20.2	58.3±14.8
Fibrosis or interstitial changes	22.9±7.2	57.1±20.2	16.7±11.2

That is, changes in plain X-ray investigation cannot always be interpreted as morphological features of bronchopulmonary dysplasia. According to the literature, pathomorphological signs of bronchopulmonary dysplasia at postmortem examination develop on the 6th day of the infant's life [9]. It is not surprising that changes on CT scans of the chest were detected in all the examined children with various forms of BPD. All children with bronchopulmonary dysplasia, regardless of the particular form, were found to have fibrotic changes in the lung parenchyma, adhesions, pleural thickening and emphysema (Table 3). However, evaluation of CT changes in the lungs in children with various forms of BPD demonstrated some peculiarities. In Group 1 children mosaic marking of lung tissue was observed much more frequently than in Group 2 (F1-2=4.4; p<0.05), and areas of consolidation occurred significantly more often than in Group 3 (F1-3=4.05; p <0.05). In Group 2 relative number of children with pleural thickening and pneomocele was significantly higher than in Group 3 (F2-3=4.11; p <0.05 and F2-3= 6.0; p <0.05, respectively).

Table 3

The frequency of radiographic changes of the chest in children with bronchopulmonary dysplasia

Sign	Group 1 n=35	Group 2 n=7	Group 3 n=12
	$p\%\pm s_{p\%}$	$p\%\pm s_{p\%}$	$p\%\pm s_{p\%}$
Thickening of interlobular septum	42.9±8.4	26.3±10.3	31.3±11.9
Thickening of intralobular interstitial tissue	40.0±8.4	36.8±11.3	68.8±11.9
Striped parenchymal bands	40.0±8.4	42.1±11.6	18.8±10.1
Pleuropulmonary adhesions	17.1±6.4	26.3±10.3	12.5±8.5
Pleurophrenic adhesions	20.0±6.8	10.5±7.2	12.5±8.5
Pneumocele	11.4±5.4	31.6±10.9	6.3±6.3
Frozen glass sign	34.3±8.1	47.4±11.7	25.0±11.1
Fibrotic parenchymal scars	34.3±8.1	31.6±10.9	50.0±12.9
Increase and deformation of the lung markings pattern	34.3±8.1	21.1±9.6	37.5±12.5
Net picture	14.3±6.0	10.5±7.2	43.8±12.8
Thymomegaly	5.7±3.9	10.5±7.2	0.0±0.06
Reduced lung airiness	14.3±6.0	5.3±5.3	12.5±8.5
Areas of lung tissue consolidation	8.6±4.8	5.3±5.3	0.0±0.06
Mosaic of lung marking	8.6±4.8	0.0±0.05	6.3±6.3
Pleural thickening	2.9±2.9	15.8±8.5	0.0±0.06

Every second child of Group 3 had interlobular interstitial thickening (F3 = 5.1; $p < 0.05$), and the proportion of children who were diagnosed with net picture in the lung tissue was significantly greater in contrast to the children of Groups 1 and 2 (F1-3= 5.1, $p < 0.05$; F F2-3= 5.5, $p < 0.05$).

Thus, assessment of frequency of SCT changes in children with various forms of bronchopulmonary dysplasia allowed to suggest that radiographic methods, especially spiral computed tomography of the chest, are a "gold standard" in the diagnosis, follow-up monitoring of the disease development in the lungs and evaluation of the response to treatment

4 CONCLUSIONS

1. Spiral computed tomography of the chest can detect minimal changes of the lung parenchyma and thus, plays an important role in the diagnosis of bronchopulmonary dysplasia in children.
2. Children with classical form of bronchopulmonary dysplasia much more frequently develop diffuse striped fibrosis secondary to significant hyperinflation, reflecting more severe lesions in the lung tissue.
3. Interstitial changes with minimal signs of fibrosis are more likely to occur in patients with a new form of bronchopulmonary dysplasia, as evidenced by the more frequent incidence of pneumocele.
4. Full-term children with bronchopulmonary dysplasia were found to have signs of thickening and intralobular interstitial net picture with marked fibrotic changes of the lung tissue.

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РЕЗЮМЕ

Сенаторова Г.С., Черненко Л.М., Корнейко І.І.

ЗНАЧЕННЯ СПІРАЛЬНОЇ КОМП'ЮТЕРНОЇ ТОМОГРАФІЇ В ДІАГНОСТИЦІ БРОНХОЛЕГЕНЕВОЇ ДИСПЛАЗІЇ

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Бронхолегенева дисплазія – одна із актуальних проблем педіатрії, значення якої виходить за межі неонатології і розглядається як хронічне обструктивне захворювання дітей раннього віку. У статті наведений аналіз характерних рентгенологічних змін методом спіральної комп'ютерної томографії органів грудної порожнини в залежності від форми захворювання.

Ключові слова: бронхолегенева дисплазія, спіральна комп'ютерна томографія, органигрудноїпорожнини, діти.

РЕЗЮМЕ

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ЗНАЧЕНИЕ СПИРАЛЬНОЙ КОМПЪЮТЕРНОЙ ТОМОГРАФИИ В ДИАГНОСТИКЕ БРОНХОЛЕГОЧНОЙ ДИСПЛАЗИИ

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Бронхолегочная дисплазия – одна из актуальных проблем педиатрии, значение которой выходит за пределы неонатологии и рассматривается как хроническое обструктивное заболевание детей раннего возраста. В статье приведен анализ характерных рентгенологических изменений методом спиральной компьютерной томографии органов грудной полости в зависимости от формы заболевания.

Ключевые слова: бронхолегочная дисплазия, спиральная компьютерная томография, органы грудной полости, дети.

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