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Value of impulse oscillometry in evaluating the illness in children with asthma and analysis of its correlation with serum indicators

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ABSTRACT

Objective: To Value of impulse oscillometry in evaluating the illness in children with asthma and its correlation with serum indicators. **Methods:** Children with asthma attack, children with asthma remission and healthy children were selected for study, impulse oscillometry was conducted to obtain related parameters, and serum and peripheral blood were collected to detect related indicators. **Results:** Zrs, R5, R20, R5-R20, absolute value of X5 and Fres of asthma attack group and asthma remission group were higher than those of control group, eosinophil, YKL-40, Hes-1, Cyr61, Eotaxin, IgE, IgG4, LT-B4, LT-C4, LT-D4 and Cys-LT contents in peripheral blood were higher than those of control group, positive proportion of Th2, Th17, cTfh and Th19 in peripheral blood were higher than those of control group, and positive proportion of Th1 and Treg in peripheral blood were lower than those of control group; the changes of above indicators of asthma attack group were more significant than those of asthma remission group; Zrs, R5, R20, R5-R20, absolute value of X5 and Fres were positively correlated with eosinophil, YKL-40, Hes-1, Cyr61, Eotaxin, IgE, IgG4, LT-B4, LT-C4, LT-D4 and Cys-LT contents in peripheral blood as well as positive proportion of Th2, Th17, cTfh and Th19 in peripheral blood, and negatively correlated with positive proportion of Th1 and Treg in peripheral blood. **Conclusion:** Impulse oscillometry detection can provide evidence for diagnosis of bronchial asthma and judgment of its illness, and IOS-related parameters can judge the abnormal degree of inflammatory response and immune response.

1. Introduction

Bronchial asthma (Asthma) is one of the common chronic respiratory diseases in children, which needs long-term systemic treatment. In clinical practice, standardized diagnosis and treatment are helpful to improve the level of asthma control and improve patients' quality of life and effective disease evaluation and monitoring method can provide accurate basis for the establishment of standardized treatment. A variety of molecules in serum can be used for evaluation of the illness in children with bronchial asthma, but the children are young, repeated blood sampling is difficult, and reducing the number of blood sampling can affect the assessment of disease. Routine pulmonary function testing is an exertion-dependent examination technique that is easy to cause smooth muscle spasm and affect the authenticity of airway resistance, and at the same time, the degree of cooperation of preschoolers with examination is also poor[1]. Impulse oscillometry (IOS) is the lung function assessment method rising in recent years, examination process is simple and only needs spontaneous breathing of the subjects, and influence factors of the examination results are fewer[2,3]. In the following research, in order to further confirm the value of IOS in assessment of the illness in preschool children with asthma, the value of impulse oscillometry in evaluating the illness in children with asthma and its correlation with serum indicators were analyzed.

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2. Subjects and methods

2.1. Included subjects

A total of 30 cases of preschool children with asthma attack and 30 cases with asthma remission were collected from Pediatric Clinic and ward, and all were 3-6 years old and met Children Asthma Prevention and Treatment Routine diagnostic criteria established by National Pediatric Asthma Prevention and Treatment Cooperation Group. Also 30 cases of children receiving physical examination in outpatient clinic were selected as control group, and they were 3-6 years old.

2.2. IOS testing methods

Pulmonary function testing system from German Ganshorn Company was used, and those under examination were relaxed and sat with buccal apparatus in mouth, nose clipped, head slightly up and neck stretched, and then breathed calmly for 45-60 s, total respiratory impedance (Zrs), total respiratory viscous resistance (R5), central airway viscous resistance (R20), peripheral airway viscous resistance and resonance frequency (Fres) were detected, the testing was repeated for 2-3 times, and the best was chosen and assessed.

2.3. Serum sample collection and detection

Peripheral blood of asthma attack group was collected at the time of diagnosis, peripheral blood of control group was collected during physical examination, blood routine analyzer was used to detect eosinophil content and enzyme-linked immunosorbent assay was used to detect YKL-40, Hes-1, Cyr61, Eotaxin, IgE, IgG4, LT-B4, LT-C4, LT-D4 and Cys-LT contents.

2.4. Peripheral blood sample collection and detection

Peripheral blood of asthma attack group was collected at the time of diagnosis, peripheral blood of control group was collected during physical examination, related T lymphocyte subset surface marker molecules were incubated respectively and then flow cytometry was used to detect the positive proportion of Th1, Th2, Th17, Treg, cTfh and Th19.

2.5. Statistical methods

SPSS 19.0 software was used to input and statistically analyze data, analysis among groups was by variance analysis and correlation analysis was by Pearson analysis. Differences were considered to be statistically significant at a level of $P<0.05$.

3. Results

3.1. IOS parameters

IOS parameters Zrs, R5, R20, R5-R20, X5 and Fres were different among three groups, and specific pair-wise comparison and analysis was as follows: Zrs, R5, R20, R5-R20, absolute value of X5 and Fres of asthma attack group and asthma remission group were higher than those of control group; Zrs, R5, R20, R5-R20, absolute value of X5 and Fres of asthma attack group were higher than those of asthma remission group.

3.2. Inflammatory indicators in peripheral blood

Eosinophil, YKL-40, Hes-1, Cyr61 and Eotaxin contents in peripheral blood were different among three groups, and specific pair-wise comparison and analysis was as follows: eosinophil, YKL-40, Hes-1, Cyr61 and Eotaxin contents in peripheral blood of asthma attack group and asthma remission group were higher than those of control group; eosinophil, YKL-40, Hes-1, Cyr61 and Eotaxin contents in peripheral blood of asthma attack group were higher than those of asthma remission group.

3.3. Humoral immunity indicators in serum

Humoral immunity indicators IgE, IgG4, LT-B4, LT-C4, LT-D4 and Cys-LT contents in serum were different among three groups, and specific pair-wise comparison and analysis was as follows: serum IgE, IgG4, LT-B4, LT-C4, LT-D4 and Cys-LT contents of asthma attack group and asthma remission group were higher than those of control group; serum IgE, IgG4, LT-B4, LT-C4, LT-D4 and Cys-LT contents of asthma attack group were higher than those of asthma remission group.

3.4. T lymphocyte subset contents in peripheral blood

Positive proportion of T lymphocyte subsets Th1, Th2, Th17, Treg, cTfh and Th19 in peripheral blood were different among three groups, and specific pair-wise comparison and analysis was as follows: positive proportion of Th2, Th17, cTfh and Th19 in peripheral blood of asthma attack group and asthma remission group were higher than those of control group, and positive proportion of Th1 and Treg were lower than those of control group; positive proportion of Th2, Th17, cTfh and Th19 in peripheral blood of asthma attack group were higher than those of asthma remission group, and positive proportion of Th1 and Treg were lower than those of asthma remission group.

3.5. Correlation between IOS parameters and serum indicators, peripheral blood indicators

Pearson analysis showed that Zrs, R5, R20, R5-R20, absolute value of X5 and Fres were positively correlated with eosinophil, YKL-40, Hes-1, Cyr61, Eotaxin, IgE, IgG4, LT-B4, LT-C4, LT-D4 and Cys-LT contents in peripheral blood as well as positive proportion of Th2, Th17, cTfh and Th19 in peripheral blood, and negatively correlated with positive proportion of Th1 and Treg in peripheral blood.

Table 1

Comparison of IOS parameters among three groups.

Group	Zrs	R5	R20	R5-R20	X5	Fres
Asthma attack	1.14±0.12	1.27±0.13	0.78±0.08	0.41±0.05	-0.48±0.05	23.45±2.58
Asthma remission	0.97±0.10	0.92±0.08	0.63±0.07	0.27±0.03	-0.33±0.04	18.48±1.94
Control	0.65±0.07	0.61±0.08	0.49±0.05	0.09±0.02	-0.15±0.02	15.82±1.77
F	8.228	8.917	7.785	19.292	17.687	6.293
P	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05

Table 2

Comparison of inflammatory indicators in peripheral blood among three groups.

Group	Eosinophil ($\times10^6$/L)	YKL-40 (ng/mL)	Hes-1 (ng/mL)	Cyr61 (ng/mL)	Eotaxin (ng/mL)
Asthma attack	534.85±64.42	56.59±6.48	75.69±8.19	105.86±11.38	81.35±9.32
Asthma remission	373.31±39.51	33.52±4.15	40.39±4.58	70.51±8.13	34.86±4.28
Control	84.42±9.33	10.39±1.28	22.35±2.85	33.58±4.48	11.58±1.39
F	24.592	21.383	17.866	15.282	26.593
P	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05

Table 3

Comparison of humoral immunity indicators in serum among three groups.

Group	IgE ($IU\times10^4$/L)	IgG (μmol/L)	LT-B4 (nmol/L)	LT-C4 (nmol/L)	LT-D4 (nmol/L)	Cys-LT (pg/mL)
Asthma attack	203.33±20.94	74.49±7.95	129.36±14.46	78.33±9.34	104.52±11.39	193.32±20.13
Asthma remission	83.48±9.48	34.49±3.88	70.45±8.71	40.35±4.86	56.58±6.68	128.43±14.91
Control	10.39±1.33	12.94±1.55	31.38±4.29	11.39±1.24	24.58±2.9	74.42±8.93
F	58.638	17.713	15.496	19.394	23.942	13.285
P	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05

Table 4

Comparison of T lymphocyte subset contents in peripheral blood among three groups.

Group	Th1	Th2	Th17	Treg	cTfh	Th19
Asthma attack	11.34±1.32	3.94±0.44	4.88±0.50	2.87±0.33	14.83±1.85	13.77±1.48
Asthma remission	13.86±1.52	2.87±0.30	3.36±0.38	3.91±0.44	12.03±1.33	11.35±1.44
Control	17.59±1.85	2.14±0.22	1.56±0.18	5.27±0.61	9.59±0.95	8.12±0.98
F	7.583	8.396	23.192	9.781	6.128	6.593
P	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05

4. Discussion

Bronchial asthma is the most common respiratory system disease in children, and its pathological nature is chronic airway inflammation and airway hyperresponsiveness. In recent years, a large number of studies have confirmed that peripheral airway of children with bronchial asthma is the important part causing airflow-limited airway inflammation and remodeling, change of the structure and function of peripheral airway plays an important role in the pathogenesis of bronchial asthma. Routine pulmonary function testing has the characteristics such as stability and repeatability, and is still the gold standard for diagnosis and assessment of asthma, but as a exertion-dependent pulmonary function testing technology, routine pulmonary function testing is easy to cause smooth muscle spasm and affect the authenticity of airway resistance; in addition, it is often difficult for preschool children to understand, accurately cooperate with and complete pulmonary function testing, thus the testing process is not smooth, and the results are relatively inaccurate[4].

Impulse oscillometry (IOS) is a pulmonary function evaluation method based on constrained oscillation principle and determining patients' respiratory impedance under different pulse frequency in resting respiratory condition. The method is easy to operate, only needs spontaneous breathing of the participants to fast and accurately get respiratory resistance and compliance status, and basically not affected by patient' degree of cooperation[5,6]. IOS can determine the change of the viscous resistance, elastic resistance and inertial resistance respectively, and can also differentiate large and small airway resistance. Compared with the traditional pulmonary function testing, lOS pulmonary function testing technology is simple, convenient and easy to cooperate, it avoids forced breathing-caused tracheal spasm and makes up for the deficiency of the normal lung function to a certain extent, and detected lung function results are more reliable[7,8].

In the research, in order to confirm the value of impulse oscillometry in evaluating the illness in children with asthma, IOS-related parameters of children with bronchial asthma and healthy children were compared and analyzed at first. Comparison of IOS parameters between children with asthma and healthy children showed that Zrs, R5, R20, R5-R20, absolute value of X5 and Fres of children with asthma were higher than those of control group. It indicated that IOS parameters of children with asthma significantly changed, and IOS parameters could provide evidence for diagnosis of asthma. Further analysis of IOS-related parameters between asthma attack children and asthma remission children showed that Zrs, R5, R20, R5-R20, absolute value of X5 and Fres of asthma attack group were higher than those of asthma remission group. It indicated that IOS could not only provide evidence for diagnosis of asthma, but also provide evidence for judgment of the severity of disease.

Serological indexes have been important standard for clinical judgment of the severity of asthma, but young children do not cooperate with repeated blood sampling, and therefore, it is subject to certain restrictions in long-term follow-up process[9]. As mentioned earlier, the IOS parameters have a certain value on the diagnosis of the disease and the evaluation of disease. In order to further clarify the accuracy of the IOS parameters and its correlation with disease, asthma-related serum indexes and their relationship with the IOS parameters were analyzed. First of all, the pathological essence of bronchial asthma is airway inflammation, and a variety of inflammatory factor play an important role in the process of asthma attack. Studies have confirmed that eosinophil as well as inflammatory indexes such as YKL-40, Hes-1, Cyr61 and Eotaxin in peripheral blood of children with bronchial asthma are significantly abnormal and directly related to the severity of the illness[10–12]. Analysis of serum inflammatory factor contents among three groups showed that eosinophil, YKL-40, Hes-1, Cyr61 and Eotaxin contents in peripheral blood of asthma attack group were higher than those of control group, and above inflammatory indicators in serum of asthma attack group were higher than those of asthma remission group and positively correlated with Zrs, R5, R20, R5-R20, absolute value of X5 and Fres. It indicated that IOS parameters had good consistency with inflammatory indicators and could assess the degree of inflammation in children with asthma.

Research in recent years has confirmed that abnormal immune response is the important mechanism causing the occurrence of bronchial asthma, and both humoral immunity and cellular immunity are involved in the increased airway responsiveness[13]. Asthmatic children, especially children with asthma attack are in a high sensitization state, and serum IgE, IgG4 and leukotriene B4 (LT-B4), LT-C4, LT-D4, cysteinyl leukotrienes (Cys-LT) contents increase significantly, which can trigger immune response[14,15]. Analysis in the research showed that serum IgE, IgG4, LT-B4, LT-C4, LT-D4 and Cys-LT levels significantly increased in children with asthma, and the increase of above indicators in children with asthma attack was more significant and is correlated with IOS parameters. Besides, abnormal proportion of T lymphocyte subsets is also involved in the occurrence of asthma, including Th1/Th2 imbalance, Treg/Th17 imbalance as well as newly discovered abnormally increased cTfh and Th19 contents[16,17]. Analysis of T lymphocyte subset proportion in peripheral blood showed that positive proportion of Th2, Th17, cTfh and Th19 in peripheral blood of asthma attack group were higher than those of control group, positive proportion of Th1 and Treg were lower than those of control group, and changes of above indicators of asthma attack group were more obvious and correlated with IOS parameters. It indicated that IOS parameters had good consistency with abnormal degree of immune function and could assess the abnormality of immune function in children with asthma.

To sum up, impulse oscillometry can provide evidence for diagnosis of bronchial asthma and judgment of the illness, and IOS-related parameters can judge the abnormal degree of inflammatory response and immune response.

References

[1] Gastaldi AC, Paredi P, Talwar A, Meah S, Barnes PJ, Usmani OS. Oscillating positive expiratory pressure on respiratory resistance in chronic obstructive pulmonary disease with a small amount of secretion: a randomized clinical trial. *Medicine (Baltimore)* 2015; **94**(42): e1845.

[2] Brashier B, Salvi S. Measuring lung function using sound waves: role of the forced oscillation technique and impulse oscillometry system. *Breathe (Sheff)* 2015; **11**(1): 57-65.

[3] Price OJ, Ansley L, Bikov A, Hull JH. The role of impulse oscillometry in detecting airway dysfunction in athletes. *J Asthma* 2015; **19**: 1-7.

[4] Short PM, Anderson WJ, Manoharan A, Lipworth BJ. Usefulness of impulse oscillometry for the assessment of airway hyperresponsiveness in mild-to-moderate adult asthma. *Ann Allergy Asthma Immunol* 2015; **115**(1): 17-20.

[5] Li Y, Chen Y, Wang P. Application of impulse oscillometry and bronchial dilation test for analysis in patients with asthma and chronic obstructive pulmonary disease. *Int J Clin Exp Med* 2015; **8**(1): 1271-1275.

[6] Manoharan A, Anderson WJ, Lipworth J, Lipworth BJ. Assessment of spirometry and impulse oscillometry in relation to asthma control. *Lung* 2015; **193**(1): 47-51.

[7] Bickel S, Popler J, Lesnick B, Eid N. Impulse oscillometry: interpretation and practical applications. *Chest* 2014; **146**(3): 841-847.

[8] Lauhkonen E, Koponen P, Nuolivirta K, Paassilta M, Toikka J, Saari A, et al. Obesity and bronchial obstruction in impulse oscillometry at age 5-7 years in a prospective post-bronchiolitis cohort. *Pediatr Pulmonol* 2015; **50**(9): 908-914.

[9] Pezato R, Swierczynska-Krepa M, Nizankowska-Mogilnicka E, Holtappels G, De Ruyck N, Sanak M, et al. Systemic expression of inflammatory mediators in patients with chronic rhinosinusitis and nasal polyps with and without aspirin exacerbated respiratory disease. *Cytokine* 2016; **77**: 157-167.

[10]Specjalski K, Chełminska M, Jassem E. YKL-40 protein correlates with the phenotype of asthma. *Lung* 2015; **193**(2): 189-194.

[11]Wang LF, Chien CY, Tai CF, Chiang FY, Chen JY. Vitamin D decreases the secretion of eotaxin and RANTES in nasal polyp fibroblasts derived from Taiwanese patients with chronic rhinosinusitis with nasal polyps. *Kaohsiung J Med Sci* 2015; **31**(2): 63-69.

[12]Ma HP, Li W, Liu XM. Matrix metalloproteinase 9 is involved in airway inflammation in cough variant asthma. *Exp Ther Med* 2014; **8**(4): 1197-1200.

[13]Hulse KE. Immune mechanisms of chronic rhinosinusitis. *Curr Allergy Asthma Rep* 2016; **16**(1): 1.

[14]Trischler J, Muller CM, Konitzer S, Prell E, Korten I, Unverzagt S, et al. Elevated exhaled leukotriene B_4 in the small airway compartment in children with asthma. *Ann Allergy Asthma Immunol* 2015; **114**(2): 111-116.

[15]Smith-Norowitz TA, Mandal M, Joks R, Norowitz LT, Weaver D, Durkin HG, et al. IgE anti-respiratory syncytial virus antibodies detected in serum of pediatric patients with asthma. *Hum Immunol* 2015; **76**(7): 519-524.

[16]Huber M, Lohoff M. Change of paradigm: CD8+ T cells as important helper for CD4+ T cells during asthma and autoimmune encephalomyelitis. *Allergo J Int* 2015; **24**(1): 8-15.

[17]Jiang H, Wu X, Zhu H, Xie Y, Tang S, Jiang Y. FOXP3(+)Treg/Th17 cell imbalance in lung tissues of mice with asthma. *Int J Clin Exp Med* 2015; **8**(3): 4158-4163.