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Prevalence of inhaled allergen sensitization among patients with suspected allergic diseases in Sichuan province: 3-year data from a single center

Wei Liu^{a†}, Juanli Zhang^{b†}, Xu-dong Wen^{c†}, Ronggui Wu^d, Jian Wang^d, Jinshuang Huang^d, Jing Xian^d, Tao Pan^{b*}, Feng Qin^{d*}

^aSichuan Center for Food and Drug Evaluation, Inspection & Monitoring, SCFDA Adverse Drug Reaction Monitoring Center Medical Device Technology Review and Evaluation Center, Chengdu, PR China

^bHenan Institute of Medical Device Inspections, Zhengzhou, Henan Province, PR China

^cDepartment of Gastroenterology, Chengdu First People's Hospital, Chengdu, Sichuan Province, PR China

^dC-Luminary Biotechnology Co., Ltd, Chengdu, Sichuan Province, PR China

[†]These authors contributed equally to this work.

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Abstract

Allergic diseases are becoming increasingly common, and they are a threat to people's health. Exploring the distribution characteristics of allergen-specific immunoglobulin E (sIgE) in people from Sichuan province, southwest China, can provide clinical epidemiological data. This study enrolled 12,204 consecutive patients with suspected allergies from May 2018 to May 2021. Among the patients, 4206 were diagnosed with allergic rhinitis or asthma. The Rayto Lumiray 1600 detection system and sIgE and total IgE (tIgE) detection kits were used to measure the levels of nine common sIgE and tIgE. sIgE \geq 0.35 IU/mL was considered positive. The sensitization rate of D1 (*Dermatophagoides pteronyssinus*) is the highest (22.97%), followed by D2 (*Dermatophagoides farinae*) (23.33%); M3 (*Aspergillus fumigatus*) has the lowest positive rate (1.5%). E5 (*Canis familiaris*) and I6 (*Blatella germanica*) exhibited relatively high sensitization rates (8.64% and 12.35%, respectively). Allergen sensitization was significantly higher in men than in women. Moreover, 90.3% of sensitization samples from D1 were combined with at least one of the other eight allergens. Similarly, a positive correlation was demonstrated between D1, D2, and E1 (*Felis domesticus*). In addition, patients with allergic rhinitis (91.88% and 91.54%, respectively), allergic asthma (72.44% and 74.01%, respectively), and allergic rhinitis with asthma (92.12% and 93.22%, respectively) were mainly sensitized to D1 and D2. D1, D2, I6, and E5 are the main allergens. Moreover, D1 and D2 are the main allergens in patients with

*Corresponding authors: Tao Pan, Henan Institute of Medical Device Inspections, Zhengzhou, Henan Province, 450003. Email address: audiliu@126.com; Feng Qin, C-Luminary Biotechnology Co., Ltd, Chengdu, Sichuan Province, 610097. Email address: Qinfeng@c-luminary.com

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respiratory allergic diseases. Research focusing on the distribution of allergens and the characteristics of hypersensitivity in different people helps prevent, diagnose, and treat allergic diseases.

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Introduction

According to reports, the number of people with allergic diseases has risen rapidly. This is seriously affecting the quality of life of patients and even becoming life-threatening.^{1,2} These diseases, including anaphylactic shock, bronchial asthma, allergic rhinitis, and atopic dermatitis, have become an increasingly serious public health problem.^{3,4} Allergy diseases can cause various functional disorders or tissue damage and sometimes even death.⁵ A survey in China illustrated that the prevalence of asthma in people over aged 14 years is approximately 1.24%.⁶ In addition, the questionnaire-based, self-reported prevalence of allergic rhinitis in 11 cities in China ranged from 8.5% to 24.1% in 2009.⁷ Therefore, allergies have become a global health issue endangering human health.

According to previous studies, allergic diseases are mainly caused by type I allergic reactions. The related mechanism involves combining the allergen and the sIgE antibody which mediates the release of active media, such as histamine, in mast cells and basophils. Although the roles of tIgEs and sIgEs induced by various allergens in hypersensitivity remain controversial, tIgE and sIgE detection are objective indicators of the body's response to allergens and help predict disease progression and guide clinical treatment.^{1,8,9} Understanding the allergen types in patients via sIgE detection is of great clinical significance. At present, enzyme-linked immunosorbent assay is the main method used to detect sIgE, which is limited by sensitivity and accuracy.

Therefore, detecting tIgE and sIgE to explore sensitization rates of different allergens of people is significant for learning the distribution and variation trend of allergen spectrum, and it helps prevent, diagnose, and treat allergic diseases. Limited work has been conducted regarding the tIgE and sIgEs of these allergens in southwest China.¹⁰ In the present study, a magnetism particulate immune-chemistry luminescence assay (CLIA) was performed to detect serum tIgE and sIgE in people in southwest China. Statistical analysis was used to study the differences in allergies between different sex and age groups.

Materials and Methods

Baseline clinical data

A total of 12,204 people detecting allergens from May 2018 to May 2021 in Chengdu First People's Hospital were enrolled in this study. It included 6096 men and 6108 women aged between 1 and 82 years (mean 40.7±22.9). Of

the patients, 40.6% came from towns, and 59.4% were from rural areas. Among the patients, 4206 were diagnosed with allergic rhinitis or asthma. This study was approved by the Chinese Ethical Review Committee for Registered Clinical Trials (no. ChiECRCT20210393). All the enrolled subjects signed an informed consent form.

tIgE and sIgE detection

Chemiluminescence immunoassay was applied to detect tIgE and sIgE on Rayto Lumiray 1200 and Rayto Lumiray 1600 (Rayto Life and Analytical Sciences Co., Ltd., Shenzhen, China), respectively. sIgE and tIgE detection kits were obtained from Sichuan C-Luminary Biotechnology Co., Ltd. (Chengdu, Sichuan). The sIgE detection items included Houses D1, D2, E1, E5, I6, M3, M6 (*Alternaria tenuis*), and W1 (*Ambrosia artemisiifolia*). According to clinical standard, the cutoff values of sIgE and tIgE are 0.35 IU/mL and 105.29 IU/mL, respectively.

Statistical analysis

All statistical analyses were performed using SPSS 22.0. The difference in positive rate between groups was tested by the Chi-square test (if the theoretical frequency appeared less than 5, the fish exact probability method was used for calibration), and the Bonferroni method was used to adjust the significance level for pairwise comparison. Spearman's test was performed to analyze nine allergen correlations. Statistical significance was set at $P < 0.05$.

Results

Allergen sensitization to common allergens

Among the patients, 4262 (34.92%) tested positive for sIgE and to at least one of the nine allergens. D1 (2803, 22.97%), D2 (2847, 23.33%), I6 (1507, 12.35%), and E5 (1054, 8.64%) were the top four inhaled allergens. Moreover, 4624 (37.89%) tested positive for tIgE (Table 1).

Sensitization in different sex groups

Allergen sensitization was significantly higher in the male group than in the female group ($\chi^2 = 48.57$, $P < 0.01$). As shown in Table 2, the overall sIgE-positivity rate was higher among men than among women (44.87% vs. 39.34%, respectively).

Sensitization in different age groups

According to age, the individuals were divided into seven groups (0-6, 7-12, 13-18, 19-30, 31-40, 41-60, and >60). Sensitization to different allergens was also analyzed. The results in Table 3 show that any allergen was significantly different between the groups ($P < 0.01$). The sIgE-positive rates for allergens were low in the younger groups, increased with age, peaked, and then declined. For example, the sIgE-positive rates for D1, D2, and I6 peaked in the 19-30 age group. However, the rates of positive sIgE responses to the others peaked in the 31-40 age group.

Table 1 Overall allergen sensitization.

Allergens	Patients (N)	Positive rate (%)
D1	2803	22.97
D2	2847	23.33
E1	257	2.11
E5	1054	8.64
I6	1507	12.35
M3	171	1.4
M6	183	1.5
W1	284	2.33
W6	306	2.51
tIgE	4624	37.89

Allergen analysis of D1-positive patients with other allergens

Of the positive samples of house dust mites, 90.3% were combined with at least one of the other eight allergens, mainly D2, E5, I6, and E1; M3, M6, W1, and W6 were not obvious (Table 4).

Correlation analysis of common allergen sIgE

Based on previous results, we assume that there is a certain correlation among different allergens. Thus, Spearman's correlation analysis was used to explore their relevance. As shown in Table 5, consistent with the previous results, there is a significant positive correlation between D1 and D2, with a correlation coefficient of 0.874. In addition, a correlation exists between E1 and D1 or D2.

Sensitization to different allergic diseases

To determine the correlation between allergens and allergic diseases, sensitization to different allergic diseases was analyzed. Patients with allergic rhinitis, allergic asthma, or allergic rhinitis with asthma were mainly sensitized to D1 and D2. The positive rates of D1, D2, I6, and W6 allergen sIgE in allergic rhinitis combined with asthma and allergic rhinitis

Table 2 Allergen sensitization in different genders.

Allergens	Male (N)	Positive rate (%)	Female (N)	Positive rate (%)	Chi-square test (χ^2)	P-value
D1	1622	26.61	1181	19.34	48.57	0.006
D2	1511	24.79	1336	21.87		
E1	154	2.53	103	1.69		
E5	603	9.89	451	7.38		
I6	898	14.73	609	9.97		
M3	94	1.54	77	1.26		
M6	94	1.54	89	1.46		
W1	162	2.66	122	2.00		
W6	174	2.85	132	2.16		
tIgE	2412	39.57	2212	36.21		

Table 3 Allergen sensitization in different age groups.

Allergens	Number of sIgE positive patients (%)							Chi-Square (χ^2)	P-value
	0-6	7-12	13-18	19-30	31-40	41-60	≥60		
D1	453	1212	2034	1521	3423	2234	2539	857.475	0.000
D2	40	173	476	504	751	457	402		
E1	78	184	507	517	737	416	408		
E5	3	12	26	22	111	56	27		
I6	12	50	109	99	433	224	127		
M3	22	71	182	177	512	282	261		
M6	2	9	18	17	77	28	20		
W1	3	11	16	22	82	25	23		
W6	4	15	31	25	122	48	39		
tIgE	4	11	44	34	108	56	49		

groups were significantly higher than those in the allergic asthma group. However, the positive rate of I6 allergen sIgE in allergic rhinitis combined with asthma and allergic asthma groups was significantly higher than that in the allergic rhinitis group. There was no significant difference in the positivity rates of other allergens among the disease groups ($P > 0.05$).

Discussion

The World Health Organization data demonstrated that 22% to 25% of people had allergic diseases, and in China, this number was approximately 200 million.¹¹ At present, allergic diseases are mainly diagnosed based on the patient's clinical symptoms, in vivo provocation tests, and in vitro allergen sIgE detection. In vitro allergen sIgE detection is not affected by the patient's skin, medication, or other factors, which can effectively avoid the inconvenience caused by individual differences. Moreover, hundreds of allergens can be specifically and accurately detected via sIgE analysis simultaneously. Accurate results and the occurrence of

adverse reactions in patients play important roles in the prevention, diagnosis, and treatment of allergic diseases. These have been widely used in clinical practice.¹²⁻¹⁵

Allergy involves a wide range of clinical manifestations, including mucocutaneous, digestive, and respiratory symptoms, such as eczema, urticaria, vomiting, abdominal pain, bronchitis, cough, and asthma.^{16,17} Severe cases can lead to anaphylactic shock, which may be life-threatening. Avoiding allergen exposure, standardized drug therapy, and specific immunotherapy are the main methods for the treatment of allergies. Accurate sIgE detection provides the possibility of avoiding allergens and allergen-specific immunotherapy and is of great clinical significance. CLIA for IgE detection demonstrates better precision and accuracy than traditional methods,^{18,19} which is crucial for both doctors and patients. In addition, rational allergen group detection could result in correct screening diagnosis for more than 96% of patients with allergic diseases.²⁰ In this study, the sIgEs for D1, D2, E1, E5, I6, M3, M6, W1, and W6 inhalation allergens were detected. The results showed that more than 34.92% of people were allergic to at least one of the above nine allergens.

Therefore, identifying specific allergens prevalent in a particular region can facilitate early diagnosis and inform the development of strategies to prevent allergic diseases. Chengdu, located at 102°54'–104°53' E longitude and 30°05'–31°26' N latitude, has a population of more than 20 million. However, few studies have focused on the prevalence and distribution of allergen sensitization. Moreover, there is a prevalence of allergen sensitization among different population subsets.²¹ Similar to the distribution of allergens in other regions of China, our results demonstrate that D1 and D2 are the main allergens with positivity rates

Table 4 Sensitization percentage of house dust mite-positive patients complicated with other allergens.

SUM	D2	E1	E5	I6	M3	M6	W1	W6
90.3%	78.5%	8.6%	19.4%	57.0%	2.2%	1.1%	1.1%	4.3%

SUM: positive rate of D1 combined with at least one of the other eight allergens.

Table 5 Spearman correlation analysis of nine allergen sIgE concentrations.

	D1	D2	E1	E5	I6	M3	M6	W1	W6
D1	1	-	-	-	-	-	-	-	-
D2	0.874**	1	-	-	-	-	-	-	-
E1	0.404**	0.479**	1	-	-	-	-	-	-
E5	-0.018	0.002	0.217**	1	-	-	-	-	-
I6	0.141**	0.187**	0.004	0.024	1	-	-	-	-
M3	-0.008	-0.007	-0.006	0.033	-0.002	1	-	-	-
M6	0.098*	0.113**	0.060	0.138**	0.008	-0.002	1	-	-
W1	0.021	0.032	0.012	0.103*	0.187**	0.031	0.102*	1	-
W6	-0.011	0.002	0.004	0.013	0.052	0.011	0.106*	0.120**	1

*, $P < 0.05$; **, $P < 0.01$.

Table 6 Allergen sensitization in different allergic disease groups.

Diseases	Number of sIgE-positive patients (%)								
	D1	D2	E1	E5	I6	M3	M6	W1	W6
Allergic rhinitis	91.88	91.54	11.12	5.66	8.16	3.12	4.22	5.22	7.11
Allergic asthma	72.44	74.01	8.87	4.01	18.61	2.87	3.99	2.12	1.22
Allergic rhinitis with asthma	92.12	93.22	14.88	6.71	22.01	4.55	5.01	5.78	8.65
Chi-Square (χ^2)									
P-value	<0.01	<0.01	>0.05	0.05	<0.01	0.05	0.05	0.05	<0.01

of 16.4% and 16.3%, respectively. I6 is the most common inhalation allergen, second only to D1 (15.0%), which is consistent with related reports in other regions of China.^{22,23} Aging can significantly affect related functions of the immune system, and many studies have shown that the prevalence of allergies and IgE levels is affected by age.²⁴⁻²⁶ Therefore, we aimed to explore the effect of age on sIgE; all samples were divided into three groups according to age. The results showed that for D1 and D2, the positive rates for all sexes showed a downward trend with increasing age. Reports have shown that sensitization in women is more frequent than that in men.²⁷ In our study, no significant difference was observed in the prevalence between men and women. Several studies have reported that tropomyosin is the main cross-allergen of D1, D2, I6, and E1; therefore, D1-positive patients may be allergic to D2, I6, and E1.^{28,29} In this study, 90.3% of the positive samples of D1 were combined with at least one of the other eight allergens, to which the results of the Spearman analysis were similar. We acknowledge the limitations of our study, including the relatively small number of enrolled patients and the types of sIgE, which could reduce the credibility of the results.

Conclusion

Allergic diseases are mainly caused by allergens D1, D2, I6, and E5. Thus, exploring the distribution of allergens and the characteristics of hypersensitivity in different individuals is important for the prevention, diagnosis, and treatment of allergic diseases.

Conflict of Interest

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