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Regular paper

Relationship between chemical industrial environment and allergic skin diseases

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Objective: This study is an exploration of the relationship between chemical industrial environment and allergic skin diseases. Methods: In this retrospective analysis, 200 patients with allergic skin diseases who worked or lived in a chemical industrial zone and were admitted in our hospital between January 2018 and January 2020 were enrolled as Group A. Besides, 500 patients with allergic skin disease who lived in Zhenhai New District, five kilometers away from the chemical radiation zone, were selected as Group B. The specific immunoglobulin E (IgE) levels were determined by Western blotting. The allergen positivity, as well as allergen positivity between different age, sex and body mass index (BMI) were compared between the two groups. The positive food-specific allergen IgE antibody (sIgE) and positive inhalational sIgE were compared between the two groups. Results: The positive rate of total IgE and inhalational sIgE in Group A was higher than that in Group B (P<0.05), while there was no significant difference in positive rate in food sIgE between the two groups (P>0.05). In Group A, the differences in positive rates of total IgE, food-induced sIgE and inhalational sIgE were not significant between patients with different ages, sexes and BMI (P>0.05). There was no significant difference between the two groups in sIgE positive rates of wheat, mango, soybean/peanut/cashew nut combination, limb/beef combination, crab/shrimp/fish combination, milk and egg white (P>0.05). The positive rates of inhalational sIgE in tree combination and dust mites/household dust mites combination in Group A were higher than those in Group B (P<0.05), but had no significant difference between the two groups in the positive rates of inhalational sIgE in *Humulus japonicus*, mold combination 1, cockroach, cat/dog hair combination, and ragweed/artemisia combination (P>0.05). Conclusion: Chemical industrial environment is closely associated with allergic dermatosis, and the positive rate of total IgE and inhalational sIgE increases significantly in patients living there.

Keywords: Chemical industrial environment, sIgE, skin disease, allergic dermatosis, relevancy

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Abbreviations: IgE, specific immunoglobulin E; SPT, skin prick test

INTRODUCTION

Allergic diseases are frequent diseases, which are mediated by the production of specific immunoglobulin E (IgE) antibody. They seriously impair health and have become a major public health issue (Tramper-Stranders *et al.,* 2021). Allergic diseases can occur at all ages and are primarily caused by the combined effects of environmental factors and genetic factors (Golebski *et al.*, 2020). In recent years, with the change of human dietary structure, the increase of antigenic substances, the aggravation of environmental pollution and the improvement of industrialization, the incidence of allergic diseases has continued to increase (Zhang *et al.*, 2021). With the continuous deterioration of environmental pollution, Zhenhai, as one of the chemical industrial zones, has particularly serious air pollution, and the occurrence of allergic diseases has also increased in this area (Lau *et al.*, 2021). It has been reported that air pollution in residential environment is significantly correlated with the high incidence of allergic diseases (Larson *et al.*, 2020).

At present, serum-specific allergen IgE assay (sIg) and skin prick test (SPT) are commonly used for detecting allergens (Du Toit *et al.*, 2018). However, there are rarely reports on chemical industrial environment and allergic skin diseases, and most of which analyzed the allergens in patients with allergic skin diseases (Eljaszewicz *et al.*, 2021). But the differences in allergic skin diseases between people in chemical and non-chemical areas have not been reported yet. This study explored the relationship between chemical industry environment and allergic skin diseases, aiming to provide reference for the prevention of allergic skin diseases.

MATERIALS AND METHODS

General Information

This is a retrospective analysis. A total of 200 patients with allergic skin diseases, who worked or lived in the chemical industry zone and were admitted to the hospital from January 2018 to January 2020, were selected as Group A. Besides, 500 patients with allergic skin diseases, who lived in Zhenhai New District, five kilometers away from the chemical radiation zone, were selected as Group B. This study was approved by the ethic committee of Ningbo Zhenhai People's Hospital.

Inclusion criteria (Eljaszewicz *et al.*, 2021): (1) Patients were diagnosed by examinations based on the criteria of Clinical Dermatology. Allergies occurred on the skin of the body, most of which were located on the head and face. The patient's skin lesions turned white and ap-

Table 1. Comparison of clinical data of two groups

Clinical data	Group A (n=200)	Group B (n=500)	t/χ_2	*r*
Sex				
Male	124	287		
Female	76	213	.	.
Age (years, $\bar{x}\pm s$)	45.62±9.83	46.51±8.78	1.170	0.242
Body mass index (kg/m², x±s)	23.24±1.97	22.95±1.89	1.812	0.071
Season of onset				
Spring & summer	135	342		
Autumn & winter	65	158	.	.
Disease type				
Urticaria	112	269		
Atopic dermatitis	88	231	.	.

peared as typical white spots, most of which were the size of nails and coins. The lesion shapes were round, oval or irregular, and expanded or merged into a large area with different shapes. Another typical leukoplakia was a strip or cord of discoloration along the nerve, with knife-cut edges. The histopathological features: the epidermis obviously lacked melanocytes and melanin granules, and the basal layer lacked dopa-positive melanocytes. (2) Patients had complete clinical data. (3) Patients received blood sampling after admission.

Exclusion criteria: (1) Patients accompanied by other allergic diseases that might affect the research. (2) Patients had recently taken medications such as glucocorticoids or immunosuppressants. (3) Patients were affected by serious abnormalities of heart, lung, liver or kidney.

Methods

Collection of serum specimens

Peripheral venous blood (5 mL) was collected from all patients, stood for 30 min and was centrifuged for 12 min (centrifugation radius 10.5 cm, 3000 r/min). The collected serum was stored at –70°C until testing.

Measurement of IgE

The reagent strips were put in an incubator box, added with diluted washing solution thickly and put on a mixer to fully wet for 5 min. After the reagent strips were dried, 1 ml of serum specimens were added and incubated in the mixer for 45 min. The above procedures were repeated 5 times. Thereafter, anti-human IgE antibody (Hangzhou Aibo Biotechnology Co., LTD.) was added, incubated for 45 min, and then rinsed repeatedly 5 times. The enzyme conjugate (Hangzhou Aibo Biotechnology Co., LTD.) was incubated in the mixer for 20 min, and then rinsed 5 times. The substrate was added and incubated in the mixer for 20 min. The strips were rinsed under running water, dried and scanned by an allergen scanner (Mediwiss Medical Diagnostics GMBH).

Detection of allergens

The detected allergens included total IgE and allergen-specific IgE antibodies (sIgE). The sIgE included food allergens and inhalational allergens. Food allergens contained wheat, mango, soy/peanut/cashew combination, limb/beef combination, crab/shrimp/fish combination, milk and egg white. Inhalational allergens included tree combination (Willosa/Ulmus/Quercus/Parasitae/Popu-

Table 2. Comparison of allergen positive cases between two groups (%)

Group	Number of cases	Total IgE immunoglobulin E	Food-induced	Inhalational immunoglobulin E
Group A	200	161 (80.50)	42 (21.00)	113 (56.50)
Group B	500	307 (61.40)	87 (17.40)	204 (40.80)
χ_2		23.520	1.232	14.212
P		<0.001	0.267	<0.001

Table 3. Comparison of allergen positive rates between patients at different ages in Group A (%)

Age	Number of cases	Total IgE	Food-induced immunoglobulin	Inhalational immunoglobulin
			E	E
>45 Years old	106	87 (82.07)	24 (22.64)	62 (58.49)
≤45 Years old	94	74 (78.72)	18 (19.15)	51 (54.26)
χ_2		0.357	0.366	0.364
P		0.550	0.545	0.547

Table 4. Comparison of allergen positive rates between males and females in Group A (%)

Gender	Number of cases	Total IgE	Food-induced immunoglobulin	Inhalational immunoglobulin
			E	E
Male	124	97 (78.23)	28 (22.58)	72 (58.06)
Female	76	64 (84.21)	14 (18.42)	41 (53.95)
χ_2		1.075	0.491	0.325
P		0.300	0.483	0.569

lus deltoides), *Humulus scandens*, mold combination 1 (*Penicillium persicillium/Aspergillus fumigatus/Mycospora/alternaria*), cockroach, cat/dog hair combination, ragweed/Artemisia, and dust mite/house dust mite combination.

Observation of Indicators

(1) Allergen positive cases in the two groups were observed. (2) In Group A, allergen positive cases with different ages, different sexes and different body mass index (BMI) were observed. (3) The positive cases of food-induced sIgE and inhalational sIgE were observed in the two groups.

Statistical Processing

SPSS 26.0 software was applied for data processing. Measurement data were represented by (mean ± standard deviation), and the analysis method was independent samples *t*-test. Enumeration data were represented by *n* (rate), and the analysis method was χ_2 test. Two-tailed $P<0.05$ was considered as statistically significant.

RESULTS

Clinical data

There was no statistical significance between the two groups in sex, age, BMI, seasons of onset and disease types ($P>0.05$); see Table 1.

Comparison of allergen positive cases between two groups

The positive rates of total IgE and inhalational sIgE in Group A were higher than those in Group B ($P<0.05$). While there was no significant difference in the positive rate of food sIgE between the two groups ($P>0.05$); see Table 2.

Comparison of allergen positive rates between patients at different ages in Group A

There was no significant difference in the positive rates of total IgE, food-induced sIgE and inhalational sIgE between patients of different ages in Group A ($P>0.05$); see Table 3.

Comparison of allergen positive rates between males and females in Group A

There were no significant differences in the positive rates of total IgE, food-induced sIgE and inhalational sIgE between males and females in Group A ($P>0.05$); see Table 4.

Comparison of allergen positive rates between patients with different BMI in Group A

There was no significant difference in the positive rates of total IgE, food-induced sIgE and inhalational sIgE between patients with different BMI in Group A ($P>0.05$); see Table 5.

Comparison of food-induced sIgE positive cases between the two groups

There was no significant difference between the two groups in sIgE positive rates of wheat, mango, soybean/peanut/cashew nut combination, limb/beef combination, crab/shrimp/fish combination, milk and egg white ($P>0.05$); see Table 6.

Table 5. Comparison of allergen positive rates between patients with BMI in Group A (%)

BMI	Number of cases	Total IgE	Food-induced	Inhalational immunoglobulin
			sIgE	E
>24 kg/m²	81	67 (82.72)	19 (23.46)	47 (58.02)
≤24 kg/m²	119	94 (78.99)	23 (19.32)	66 (55.46)
χ_2		0.426	0.495	0.129
P		0.514	0.482	0.720

BMI, body mass index.

Table 6. Comparison of food-induced sIgE positivity between the two groups (%)

Group	Number of cases	Wheat	Mango	Soybean/peanut/ cashew nut	Sheep/beef	Crab/shrimp/fish	Milk	Egg white
Group A	200	4 (2.00)	5 (2.50)	12 (6.00)	8 (4.00)	7 (3.50)	2 (1.00)	4 (2.00)
Group B	500	9 (1.8)	12 (2.40)	23 (4.60)	19 (3.20)	12 (2.40)	6 (1.20)	6 (1.20)
χ_2		0.018	0.038	0.590	0.015	0.655	0.029	0.205
P		0.895	0.846	0.443	0.901	0.419	0.866	0.650

Table 7 Comparison of positive inhalational- sIgE between two groups (%)

Group	Number of cases	Tree combination	Humulus scandens	Mold combination 1	Cockroach	Cat/dog dander combination	Ragweed/Artemisia combination	Ragweed/Artemisia combination
Group A	200	10 (5.00)	1 (0.50)	2 (1.00)	1 (0.50)	1 (0.50)	3 (1.50)	95 (47.50)
Group B	500	6 (1.20)	8 (1.60)	15 (3.00)	10 (2.00)	9 (1.80)	19 (3.80)	137 (27.40)
χ_2		7.613	0.633	1.641	1.222	0.916	2.483	26.047
P		0.006	0.426	0.200	0.269	0.339	0.115	<0.001

Comparison of inhalational-sIgE positive cases between the two groups

The positive rates of inhalational-sIgE in tree combination and dust mites/household dust mites' combination in Group A were higher than those in Group B ($P<0.05$). There was no significant difference between the two groups in sIgE positive rates of Humulus japonicus, mold combination 1, cockroach, cat/dog hair combination, and ragweed/artemisia combination ($P>0.05$); see Table 7.

DISCUSSION

Allergic dermatosis is one of the most common and complex skin diseases with a large number of pathogenic causes and types. Allergens can enter the human body through multiple ways. The inhalational or ingested allergens can combine with antibodies to produce sensitization, form an immune complex to stimulate mast cells to degranulate and release transmitters such as leukotriene and histamine, thus inducing rapid allergic reactions (Venter *et al.*, 2022; Orengo *et al.*, 2018; Hereford *et al.*, 2021). Common allergic skin diseases include atopic dermatitis, eczema, urticaria and Henoch-Schönlein purpura. Atopic dermatitis refers to skin conditions such as peeling, wind, itching and redness caused by exposure to certain allergens. The most common causes of atopic dermatitis include fungal allergies, chemical fiber materials, rubber shoes, detergents, fertilizers, pesticides, air pollution, dust, pollen, insects, mites, animal fur, food, etc. Atopic dermatitis is usually caused by an allergy to a substance and can gradually disappear when the allergen is removed (Güngör *et al.*, 2019). Eczema is a common allergic skin disease that can occur in any part of the body. The specific cause of eczema has not been completely clarified. It is considered that allergic constitution may be the main cause of the disease (Holl *et al.*, 2020). Clinical surveys have shown that the increasing incidence of eczema may be related to continuous mental stress,

accelerated pace of life, poor management of wastes, environmental pollution and the abuse of chemical products (Yang *et al*., 2020). Urticaria is a common skin disease with acute and chronic types. The causes of urticaria are various and complex, including parasites, bacteria, sunlight, drugs, nettle, mushrooms, pollen, animal feathers, crab, shrimp, fish, etc. (Fang *et al*., 2021; Xiang *et al*., 2021). Due to the extensive food intake and contact with objects in daily life, it is often difficult to identify the fundamental cause of allergies, which leads to recurrent urticaria (Hoof *et al*., 2020). Henoch-Schönlein purpura is usually considered to be caused by antigenic substances entering the body, reacting with antibodies in the body of the patient, and depositing in the blood vessel wall and causing vascular damage. It is mainly a skin and mucosal lesion caused by allergic inflammation of blood vessels, with petechia or bruise as the main clinical manifestations (Ünal, 2020). The etiology of allergic purpura remains unspecified, and it is considered to be related to immune factors. At the same time, it can be induced by insect bites, drug pollen allergy, viral and bacterial infections, and exotic protein foods such as crab, shrimp and fish (Hanif *et al*., 2019; Beaulieu *et al*., 2022).

As a coastal chemical industrial area, Zhenhai provides local people with a lot of seafood. Therefore, total IgE, inhalational allergens and food-induced allergens were selected for detection in this study. We intended to understand the influence of the chemical industrial environment on allergic skin diseases through detecting allergenic factors. At present, the detection of allergens is usually by serum specific allergen IgE and skin prick. Skin prick test is to drop a small amount of highly purified allergen liquid on the forearm of the patient, and then to gently puncture the skin surface.

Allergic response is showing as red and swollen masses similar to mosquito bites and itching reaction at the spot within 15 minutes, and the skin color may also change. However, the skin prick test is an invasive test, which may cause severe systemic reactions, and accidents may occur in patients with severe allergies in acute phase. Serum specific allergen IgE detection, as an in-vitro test, is safe, painless and non-irritating. Serum specific allergen IgE detection can simultaneously conduct quantitative detection of more than a dozen specific IgE to identify allergens (Rauber *et al*., 2020).

Chemical industrial pollution mainly exists in the chemical industrial zone, and the pollution sources include air pollution, water pollution, etc. Research reports in Zhenhai District have shown that the harmful substance in its chemical zone is ainly sulfur dioxide in the air. Such polluting substances, especially the inevitable large amount of dust, toxic gas and waste, may lead to the variation of the protein structure on the surface of pollens in the air, so that pollens that originally are not allergenic become highly allergenic (Guttman-Yassky *et al*., 2019). In order to study the impact of the chemical industrial environment on allergic diseases, this article explored the connected factors of allergic skin diseases in patients who lived in Zhenhai chemical industrial district and Zhenhai New District, aiming to clarify that the identification of allergens is the primary method for prevention, clinical diagnosis and treatment of allergic diseases. The detection results of allergens, serum total IgE degree, and allergen-specific IgE may be different for people of different regions, races and ages. The detection of allergen-specific IgE can clarify the substances that cause allergic reactions in the region and help determine appropriate immunotherapy (Ryu *et al*., 2020). Therefore, the application of serum allergen-specific IgE can help find allergens and provides a valuable basis for the prevention and treatment of allergic diseases. With regard to the selection of research population, it was reported that air pollution was significantly reduced in areas 5 kilometers away from the chemical radiation zone (Sadreameli *et al*., 2021). Therefore, patients with allergic skin diseases living in Zhenhai New District, which was 5 km away from the chemical industry zone, were selected as the control group in this study. This study showed that the positive rates of total IgE and inhalational sIgE of patients in Group A were higher than those in Group B, indicating that the positive rates of total IgE and inhalational sIgE in patients living or working in chemical industrial district were greatly increased. In terms of inhalational sIgE, allergies in tree combination and dust mites/household dust mites were significantly increased in patients living or working in chemical area. Our results are consistent with the previous results (Drislane *et al*., 2020), which reported states that people living in chemical industrial areas showed more inhalational sIgE. We believe that it may be due to the presence of polluting substances in the air, which change the protein structure of pollen surface, thus triggering an increase in inhalation allergens.

In addition, in order to understand whether individual factors have an influence on allergic skin diseases, we analyzed sex, age and BMI (with 24.0 kg/m^2 as cut-off value) of patients in the chemical zone. It was found that patient's sex, age or BMI had no effect on the allergens detection results.

However, this is only a preliminary exploration in patients from different regions. We did not conduct in-depth investigations on the main pollutants and their concentrations in the chemical industrial area and did not analyze the mechanism of allergic reactions triggered by pollutants. Therefore, there are certain limitations in the current research. In follow-up studies, we will monitor pollutants and their concentrations in the chemical industrial area to determine whether the concentration of pollutants is related to the incidence of allergic skin diseases, and analyze the influence of chemical pollutants on the immune function of the body and the induction mechanism of allergic reactions *via* animal experiments.

In summary, the chemical industrial environment is significantly involved with allergic dermatosis, and patients who live there have significantly increased total positive IgE and positive aspirational sIgE.

Declarations

Data Availability. The data used to support this study is available from the corresponding author upon request.

Conflicts of Interest. Authors declare that they have no conflicts of interest.

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