



Atopy patch test in children with atopic dermatitis

Nualanong Visitsunthorn, MD; Sunsanee Chatpornvorarux, MD; Punchama Pacharn, MD; Orathai Jirapongsananuruk, MD

Division of Allergy and Immunology, Faculty of Medicine, Department of Pediatrics, Siriraj Hospital, Mahidol University, Bangkok, Thailand

ARTICLE INFO

Article history:

Received for publication December 23, 2015.

Received in revised form September 27, 2016.

Accepted for publication September 28, 2016.

ABSTRACT

Background: Atopic dermatitis is frequently associated with food and/or aeroallergen allergy.

Objective: To evaluate atopy patch tests (APTs) and skin prick tests (SPTs) in children with atopic dermatitis, using allergen extracts from locally lyophilized foods (cow's milk, egg white, egg yolk, wheat, soy, and shrimp), *Dermatophagoides pteronyssinus*, *Dermatophagoides farinae*, and American cockroach.

Methods: This study was a prospective, self-controlled study in children with atopic dermatitis. APTs, SPTs, and oral food challenge tests were performed in the cases with written informed consent.

Results: Fifty-six children with atopic dermatitis were enrolled. According to the Severity Scoring of Atopic Dermatitis Index, moderate atopic dermatitis was the most common severity (49.1%) followed by mild (20%) and severe atopic dermatitis (13.2%). APT results were positive for food allergens in 49% of participants; SPT results were positive in 54.7%. The sensitivity, specificity, positive predictive value, and negative predictive value of APTs for foods were 40%, 90.2%, 65.2%, and 76.6%, respectively. For SPTs, those values were 40%, 93.9%, 75%, and 77.3%, respectively. APT results for *D farinae*, *D pteronyssinus*, and American cockroach were positive in 33.9%, 35.8%, and 21.8% of participants, respectively. SPT results for these allergens were positive in 28.3%, 24.5%, and 9.4% of participants, respectively. No serious complications occurred.

Conclusion: APTs with locally prepared lyophilized allergen extracts were safe and had high specificity, median positive predictive value, and low sensitivity for evaluation of suspected food allergy in children with atopic dermatitis.

Trial Registration: clinicaltrials.gov Identifier: NCT01164293

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Introduction

Atopic dermatitis is a common chronic inflammatory skin disease in children. The International Study of Asthma and Allergies in Childhood¹ reported a 9% to 16% incidence of atopic dermatitis among children in Thailand, according to the diagnostic criteria of Hanifin and Rajka.² Both foods and aeroallergens can stimulate symptoms in children with atopic dermatitis. A previous study reported that approximately 10% to 40% of patients with atopic dermatitis had allergic reactions to food.³ Food allergy was found in 40% of infants and young children with moderate to severe atopic dermatitis.³ The most common allergens in infants and young children are cow's milk, egg, wheat, and soy proteins, whereas in

older children and adults, aeroallergens are most common.³ Hypersensitivity in atopic dermatitis can be immediate type (IgE mediated) or delayed type (cell mediated, non-IgE mediated). In immediate reactions, symptoms such as urticarial eruptions and angioedema usually occur within a few minutes to a few hours after allergen exposure, so diagnosis is quite easy. In delayed reactions, allergy symptoms usually occur after 6 to 48 hours,^{4,5} making diagnosis of the cause more challenging. The gold standard for diagnosing food allergy is the double-blind, placebo-controlled oral food challenge (OFC) test, which cannot be routinely performed in general hospitals or in patients with severe allergic risk. For these reasons, children with atopic dermatitis often unnecessarily avoid food that is suspected but not confirmed to be a cause of their symptoms.

The allergens that precipitate rashes in patients with atopic dermatitis can be evaluated based on the history of allergen exposure, together with laboratory tests, including skin prick tests (SPTs), serum specific IgE tests, and atopy patch tests (APTs). SPTs and serum specific IgE are used to evaluate IgE-mediated reactions. There are no appropriate tests for non-IgE-mediated or mixed type (IgE- and non-IgE-mediated) hypersensitivity. APTs are reported to

Reprints: Nualanong Visitsunthorn, MD, Division of Allergy and Immunology, Faculty of Medicine, Department of Pediatrics, Siriraj Hospital, Mahidol University, 2 Prannok Rd, Bangkoknoi, Bangkok 10700, Thailand; E-mail: nualanongv@yahoo.com.

Disclosures: Authors have nothing to disclose.

Funding Sources: This study was supported by a Research Development Fund and a Chalermprakait grant from the Faculty of Medicine at Siriraj Hospital, Mahidol University, Bangkok, Thailand.

be useful in diagnosing non-IgE-mediated food allergy in children with atopic dermatitis.⁵ Previous studies using APT have reported a sensitivity of 18% to 93%, specificity of 41% to 97%, and positive predictive value (PPV) of 40% to 96% for diagnosing food allergy in patients with atopic dermatitis.^{7–16} The main problems with APTs are the wide variations in its testing methods, antigens, and interpretation of results.¹¹ APTs were found to yield better results with fresh foods than with commercial food extracts.¹⁷ However, some foods are not available out of season, and whole foods can be rotten. For these reasons, the Allergy Group at Siriraj Hospital, Mahidol University, Thailand, had locally lyophilized food extracts prepared. Prior studies have found lyophilized food extracts to be safe, with fewer false-positive results and fewer significant irritating effects than commercially available preparations.¹⁸ A study in children with gastrointestinal symptoms related to food allergy revealed that SPTs and APTs provided better results with locally lyophilized food extracts than with commercial food extracts.¹⁹ In the present study, we used these locally lyophilized allergen extracts for APTs and SPTs. We also performed SPTs and APTs with house dust mite and cockroach allergen extracts because dust mites and cockroaches are reported causes of atopic dermatitis exacerbation.^{20–26}

The purpose of this study was to evaluate APT and SPT results in children with atopic dermatitis, using locally lyophilized food allergen extracts (cow's milk, egg white, egg yolk, wheat, soy, and salt water shrimp), as well as *Dermatophagoides pteronyssinus*, *Dermatophagoides farinae*, and commercial American cockroach allergen extracts.

Methods

Study Population

This prospective, self-controlled study was performed from 2011 to 2013 in children with atopic dermatitis, aged 1 month to 18 years. Atopic dermatitis was diagnosed using criteria by Hanafin and Rajka. The severity was assessed by an allergist using the Severity Scoring of Atopic Dermatitis Index (score <25 indicates mild; 25–50, moderate; and >50, severe atopic dermatitis).²⁷ Those with chronic disease (such as autoimmune disease, immune deficiency, and cancer) or who were pregnant were excluded. The use of antihistamines, systemic corticosteroids (≥ 20 mg/d), and topical corticosteroids was discontinued for at least 7 days before testing. Approval for the study was obtained from the institutional ethics committee. Written informed consent and informed assent were obtained from the parents and patients before enrollment in the study. The study was registered with clinicaltrials.gov (Identifier: NCT01164293).

Atopy Patch Test

Lyophilized food extracts were prepared in laminar flow hoods by adding 1 g of lyophilized cow's milk, egg white, egg yolk, wheat, soybean, or shrimp to 10 mL of Coca's solution (0.9% sodium chloride [5 g], 0.4% phenol [4 g], and sodium bicarbonate [2.5 g] in sterile water [1 L], pH 7.0). One drop (50 μ L) of each dissolved lyophilized food, local (Siriraj) mite allergen extracts (*D pteronyssinus* or *D farinae*) or commercial American cockroach allergen extract (ALK-Abello, Port Washington, New York) was placed into individual 12-mm aluminum test cups (Finn Chambers on Scan pore; Epitest Ltd Oy, Tuusula, Finland) containing filter paper. The cups were applied with adhesive tape to the unaffected skin of the individual's back. Isotonic saline solution was the negative control. The application period was 2 days; results were evaluated 20 minutes and 1 day after removal of the cups (day 2 and day 3 after application). Reactions were classified according to the European Task Force on Atopic Dermatitis⁹ as follows: negative, no

reaction; +/- doubtful reaction, only erythema, questionable; + weak reaction, erythema, infiltration; ++ moderate reaction, erythema, few papules; +++ strong reaction, erythema, many papules; and ++++ extreme reaction, erythema, vesicles. Erythema alone without infiltration was regarded as a negative reaction because it could be attributed to local irritation. Irritant or doubtful reactions, including sharply demarcated confluent erythema, or reactions confined to margins without infiltration were deemed negative. Patients were asked to report any delayed skin reactions that were noticed after testing.

Skin Prick Test

A simple blood lancet (Vitrex Medical A/S, Herlev, Denmark) was used for SPTs. Each child was tested with locally lyophilized allergen extracts of cow's milk, egg white, egg yolk, soy, wheat, and shrimp, as well as local mite allergen extracts (*D pteronyssinus* and *D farinae*) and commercial American cockroach allergen extracts. Histamine dihydrochloride (10 mg base/mL) and sterile 50% (vol/vol) glycerine were used as positive and negative controls, respectively. Wheals and flares induced by the allergens were recorded 15 minutes after testing; those induced by histamine solution were recorded 10 minutes after testing. The mean wheal diameter (longest diameter plus the perpendicular diameter divided by 2) was calculated. Reactions at least 3 mm larger than the negative control were considered positive.

Food Challenge Test

An open OFC was performed after 2 weeks of an elimination diet, one food at a time, starting with the foods to which the patient had negative SPT and APT results. The initial OFC was performed in the hospital, with administration of increasing doses of dried food up to 8 g to allow immediate treatment of serious acute adverse reactions. If there were no immediate reactions, then OFC continued for at least 2 weeks at home, with at least one serving of food intake daily. Parents observed and recorded symptoms. The OFC was discontinued when a clinical reaction was noticed. If any adverse reactions occurred, patients were instructed to call and visit the investigator as soon as possible. Patients were evaluated via telephone call on days 7, 14, and 21 of the challenge. If patients tolerated the food challenge, that food could be continued in ordinary meals.

Table 1
Demographic Data of the Study Population

Characteristic	No. (%) of patients (N = 53)
Sex	
Male	26 (49.1)
Female	27 (50.9)
Age group, y (median, 2.08 years; range, 0.42–13 years)	
<1	13 (24.5)
1–5	35 (66.0)
>5	5 (9.4)
Associated allergic diseases	
Allergic rhinitis	8 (15.1)
Asthma	6 (11.3)
No. of suspected causative foods	
1	6 (11.3)
2	6 (11.3)
>2	41 (77.4)
Atopic dermatitis severity	
Mild	20 (37.7)
Moderate	26 (49.1)
Severe	7 (13.2)

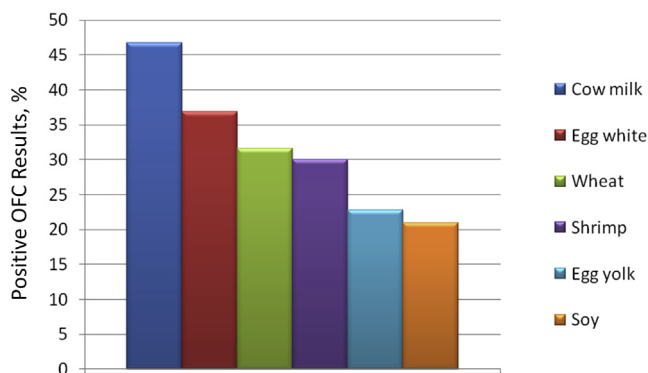


Figure 1. Positive oral food challenge (OFC) test results in children with atopic dermatitis.

Statistical Analysis

The data were analyzed using SPSS statistical software, version 18 (SPSS Inc, Chicago, Illinois). Characteristics data were presented by median (range) for continuous data or in number and percentage of categorical data. $P < .05$ was considered statistical significance. The negative predictive value (NPV), PPV, sensitivity, specificity, positive likelihood ratio (LR+) and negative likelihood ratio (LR-) were used to evaluate the association between the results of SPTs and APTs by using OFC result as the gold standard.

Results

Fifty-six patients with atopic dermatitis were enrolled in the study. Because APTs were not performed successfully in 3 patients, 53 patients were evaluated. The median age of the 53 participants was 2.08 years (range, 5 months to 13 years). Half of the patients (49.1%) were male. Ninety percent were 5 years or younger. Associated allergic diseases were found in 14 patients (26.4%). Half of the cases had moderate atopic dermatitis (49.1%) (Table 1). The age at onset of rashes was less than 1 year in all cases. More than 88% of parents suspected that at least 2 foods caused atopic dermatitis in their children. Most of the patients younger than 1 year were breastfed. Maternal diet restriction of at least 2 foods was found in 90% of cases. The most commonly restricted food was cow's milk, followed by egg white, seafood, soy, and wheat.

APT results were positive in 25.5% of all food allergen tests, and SPT results were positive in 22.6%. Some parents refused OFC for foods that might cause serious reactions, would be avoided anyway, or had never been eaten before by their children. The most common food for which parents refused OFC was shrimp, followed by egg white and wheat. There were 238 OFCs performed, of which 75 (31.5%) had positive results. OFC results were positive in 21 of 45 tests (46.7%) for cow's milk, 14 of 38 tests (36.8%) for egg white, 12

of 38 tests (31.6%) for wheat, 9 of 30 tests (30.0%) for shrimp, 10 of 44 tests (22.7%) for egg yolk, and 9 of 43 tests (20.9%) for soy (Fig 1).

Positive OFC results revealed atopic dermatitis symptoms (75 of 75 tests [100%]), urticaria (12 of 75 [16%]), perioral swelling (5 of 75 [6.7%]), and increased sputum (3 of 75 [4%]). Of the 75 positive OFC results, APT results were positive in 30 (40%), and SPT results were positive in 30 (40%). Positive APT results were found in 42.9% of OFC results positive for cow's milk, in 44.4% for soybean, in 50% for egg white, in 40% for egg yolk, in 22.2% for shrimp, and in 33.3% for wheat. Positive SPT results were found in 33.3% of positive OFC results for cow's milk, in 11.1% for soybean, in 64.3% for egg white, in 60% for egg yolk, in 11.1% for shrimp, and in 50% for wheat. APT and SPT results for each food according to OFC results are given in Tables 2 and 3. Among cases with negative OFC results, the percentage of negative APT and/or SPT results was high. None of the patients with negative OFC results had positive results on the APT and SPT.

The sensitivity, specificity, PPV, NPV, and positive and negative LR of APT for all foods in this study were 40%, 90.2%, 65.2%, 76.6%, 10.2, and 0.67, respectively. For SPTs, those values were 40%, 93.9%, 75%, 77.3%, 6.6, and 0.64, respectively (Table 4). When the APT result was positive in children with atopic dermatitis, the chance of allergy to that food was high (LR+ >10); when the SPT result was positive, the chance was moderate (LR+ = 6.6).

In patients with positive APT results who underwent OFC, the OFC result was positive in 65.2% of tests (90% for cow's milk, 77.8% for egg white, 66.7% for shrimp, 66.7% for wheat, 50% for egg yolk, and 40% for soybean). The SPT result was positive in 32.6% of the cases with positive APT results. All 15 patients (100%) with both positive APT and SPT results also had positive OFC results. In cases with both negative APT and SPT results, the OFC result was negative in 74.2% for cow's milk, 84.4% for soybean, 90.9% for egg yolk, 90% for egg white, 76.69% for shrimp, and 76% for wheat. Reactions occurred within 2 hours of food intake in 40% of patients. In the group that reacted within 2 hours, 40% had positive APT results and 53.3% had positive SPT results. No significant difference was found in APT or SPT results for any foods in the group that reacted within 2 hours vs those who reacted after 2 hours.

Positive APT results were found in 33.9% of patients for *D farinae*, in 35.8% for *D pteronyssinus*, and in 21.8% for American cockroach (Table 5). The correlation between APT and SPT results was very low for these antigens ($\kappa = 0.049$ and 0.031 , respectively). We divided the children by age (<1 year, 1–5 years, and >5 years) and found that as patients age, the percentage of positive APT results to *D farinae* and *D pteronyssinus* decreased. In contrast, as age increased, the percentage of positive SPT results to *D farinae* and *D pteronyssinus* increased.

No significant correlation was found between the results of SPTs, APTs, and OFCs and severity of atopic dermatitis. There were no serious complications from APTs or SPTs. Three patients (5.4%) had an adverse reaction from the APT. Two of them had irritation from the adhesive tape, and 1 had a reaction to the aluminum chamber.

Table 2
APT and SPT Results in Children With Atopic Dermatitis and Positive OFC Results

Food	No. of patients with positive OFC results	No. (%) of patients				
		Positive APT results	Positive SPT results	Positive APT and SPT results	Positive APT or SPT results	Negative APT and SPT results
Cow's milk	21	9 (42.9)	7 (33.3)	3 (14.3)	13 (61.7)	8 (38.1)
Soy	9	4 (44.4)	1 (11.1)	1 (11.1)	4 (44.4)	5 (55.6)
Egg yolk	10	4 (40)	6 (60)	3 (30)	7 (70)	3 (30)
Egg white	14	7 (50)	9 (64.3)	4 (28.6)	12 (85.7)	2 (14.3)
Shrimp	9	2 (22.2)	1 (11.1)	0	3 (33.3)	6 (66.7)
Wheat	12	4 (33.3)	6 (50)	4 (33.3)	6 (50)	6 (50)

Abbreviations: APT, atopy patch test; OFC, oral food challenge; SPT, skin prick test.

Table 3

APT and SPT Results in Children With Atopic Dermatitis and Negative OFC Results

Food	No. of patients with negative OFC results	No. (%) of patients				
		Negative APT results	Negative SPT results	Negative APT and SPT results	Negative APT or SPT results	Positive APT and SPT
Cow's milk	24	23 (95.8)	24 (100)	23 (95.8)	24 (100)	0
Soy	34	28 (82.4)	33 (97.1)	27 (79.4)	34 (100)	0
Egg yolk	34	29 (85.3)	34 (100)	30 (88.2)	34 (100)	0
Egg white	24	22 (91.7)	20 (83.3)	18 (75)	24 (100)	0
Shrimp	21	20 (95.2)	21 (100)	20 (90.9)	21 (100)	0
Wheat	26	24 (92.3)	21 (80.8)	19 (73.1)	26 (100)	0

Abbreviations: APT, atopy patch test; OFC, oral food challenge; SPT, skin prick test.

Discussion

Atopic dermatitis is a common chronic disease in children. Although atopic dermatitis symptoms can be caused by allergens, it can be challenging to determine which allergens are responsible, especially for non-IgE-mediated reactions. In this study, 77% of the parents of the patients with atopic dermatitis were already restricting more than 2 suspected foods; 90% of breastfeeding mothers restricted more than 2 foods from their own diets. Parents were reluctant to introduce suspected foods, even if they were able to control any atopic dermatitis symptoms that arose in their children; thus, children were unable to start new diets. Determining which foods trigger atopic dermatitis symptoms allows patients and their breastfeeding mothers to avoid triggering foods without unnecessarily restricting foods that do not cause reactions. OFC is the standard procedure to identify causative agents. However, it is difficult to perform and interpret OFC results in non-IgE-mediated reactions. Some parents do not want their children to have atopic dermatitis symptoms, so they refuse OFCs. A test that does not require children to eat suspected foods is needed to screen for suspected food allergies. Therefore, studies are needed to evaluate various tests to determine whether specific IgE tests, SPTs, or APTs are helpful in pinpointing triggering foods in children with atopic dermatitis.

Currently, the usefulness of APTs is controversial. A previous study found that although the predictive capacity of APT improved when combined with serum specific IgE measurements, OFCs became superfluous in only 0.5% to 14% of studied patients.²⁸ Another study found that the APT was a reliable, safe, and useful diagnostic tool for food allergy in children with atopic dermatitis.⁶ Several commercial freeze-dried food extracts are now available, but their diagnostic accuracy is still largely undefined. This is the first study to describe the use of the APT with lyophilized food allergen extracts to evaluate potential food antigens as causes of atopic dermatitis in children. The lyophilized food allergen extracts were tested for sterility, reproducibility, and efficacy in the SPT and APT¹⁹ without false-positive results or irritating effects.¹⁸ A previous study found that APTs using fresh foods had a higher diagnostic accuracy than APTs using commercial extracts.¹⁹ In our pilot study, the results of fresh food and lyophilized food extract tests were comparable, but preparing the fresh food every time APTs were performed was inconvenient. If the lyophilized extracts cannot be prepared, fresh food can be used as substitution. The commercial food extract test gives less sensitivity but more specificity and can be used if no fresh food or lyophilized food extracts are available.¹⁹

In this study, the APT had an overall sensitivity of 40%, a specificity of 90.2%, a PPV of 65.2%, and an NPV of 76.6%, when performed with lyophilized food. The APT for cow's milk had a sensitivity of 42.9%, specificity of 95.8%, and PPV of 90%. Previous studies with different APT methods have reported an overall sensitivity of 18% to 93%, specificity of 41% to 97%, and positive predictive value of 40% to 96%, with 40% to 60% specificity, 90% to

95% sensitivity, and 71% to 97% PPV for cow's milk.^{7–16} Those studies used fresh foods (prick-to-prick with native food), which yielded better results than commercial extracts. However, the use of fresh foods may limit testing for certain seasonal foods.

The present study found that APTs and SPTs, considered together, were the best diagnostic predictors of a positive OFC result. All patients who tested positive on both APTs and SPTs also had positive OFC results. If patients test negative on both APTs and SPTs, an OFC was needed to determine whether the patient could safely eat the food. The PPV of the APT in predicting which patients will develop dermatitis with an OFC was 40% to 90%, depending on the type of food. The positive OFC results were consistent with the fact that the most common causative foods were cow's milk, egg white, seafood, soy, and wheat.

Although a double-blind, placebo-controlled food challenge is the gold standard for diagnosing allergy, open OFCs were performed in our study because the skin lesions observed in patients with atopic dermatitis with OFCs are objective. Skin lesions observed in patients with atopic dermatitis with OFC was mostly eczematous. However, all kinds of skin lesions, including urticarial, and also other possible symptoms should be observed. Usually the symptoms of OFC are the same as the presenting symptoms. The most common foods for which parents refused OFC were shrimp, followed by egg white and wheat. The reasons for refusal were concern about serious reactions and that parents would avoid those foods, whether the OFC results were positive or not. All patients with positive OFC results developed atopic dermatitis symptoms on the test. Additional urticaria, perioral swelling, and increased

Table 4

Sensitivity, Specificity, PPV, NPV, and LRs of Atopy Patch Test and Skin Prick Test for Foods in Children With Atopic Dermatitis

	Sensitivity, %	Specificity, %	PPV, %	NPV, %	LR+	LR–
APS						
All foods	40	90.2	65.2	76.6	10.2	0.67
Cow's milk	42.9	95.8	90.0	65.7	10.8	0.6
Soybean	44.4	82.4	40.0	84.8	2.4	0.7
Egg yolk	40	88.2	50.0	83.3	3.3	0.7
Egg white	50.0	91.7	77.8	75.9	6.3	0.5
Shrimp	22.2	95.2	66.7	75.0	4.4	0.8
Wheat	33.3	92.3	66.7	75.0	4.7	0.8
SPTs						
All foods	40	93.9	75.0	77.3	6.6	0.64
Cow's milk	33.3	100.0	100.0	63.2	Infinity	0.8
Soybean	11.1	97.1	50.0	80.5	3.7	0.9
Egg yolk	60	100	100.0	89.5	Infinity	0.4
Egg white	64.3	83.3	69.2	80.0	3.7	0.4
Shrimp	11.1	100.0	100.0	72.4	Infinity	0.9
Wheat	50.0	80.8	54.5	77.8	2.5	0.6

Abbreviations: APT, atopy patch test; LR–, negative likelihood ratio; LR+, positive likelihood ratio; NPV, negative predictive value; PPV, positive predictive value; SPT, skin prick test.

Table 5

Atopy Patch Test and Skin Prick Test Results for *Dermatophagoides pteronyssinus*, *Dermatophagoides farinae*, and American Cockroach in 53 Children With Atopic Dermatitis

Aeroallergen	No. (%) of patients				κ
	Positive APT result	Positive SPT result	Positive APT and SPT result	Positive APT or SPT result	
<i>Dermatophagoides farinae</i>	18 (33.9)	15 (28.3)	6 (11.3)	28 (52.1)	0.049
<i>Dermatophagoides pteronyssinus</i>	19 (35.8)	13 (24.5)	5 (9.4)	27 (50.9)	0.031
American cockroach	11 (20.8)	5 (9.4)	2 (3.8)	13 (24.6)	0.175

Abbreviations: APT, atopy patch test; SPT, skin prick test.

sputum were found in 16%, 6.7%, and 4% of the tests, respectively. Both the APT and SPT results were positive in approximately 40% of cases with a positive OFC result. None of the negative OFC results had positive results on both the APT and SPT. When APT and SPT results were both negative, the OFC result was negative in 74.2% to 90.9% of cases. Most of the cases with immediate-type reaction to OFCs had positive SPT results. When an OFC is performed in the case of positive SPT results to that food, an immediate-type reaction should be closely observed for. We suggest that OFCs performed, although SPT and/or APT results are negative. When both SPT and APT results are negative, we can convince the parents that their children are less likely to have serious immediate-type reaction and OFCs should be safely performed.

The specificity of APTs and SPTs for all foods in children with atopic dermatitis was 90.2% and 93.9%, respectively. Using the OFC as the gold standard, we found that the chance of milk allergy was high (PPV, 90%; LR+, 10.8) if the APT result to cow's milk was positive. In cases with positive SPT results to cow's milk, egg yolk, and shrimp, the chance of that food allergy was very high (PPV, 100%; LR+, infinity).

This study found that in 40% of cases, reactions occurred within 2 hours after food intake. In this group, 40% had positive APT results, and 53.3% had positive SPT results. A previous study of children with suspected food allergy (median age, 2.1 years) found that in OFC-positive cases, specific IgE test, SPT, and APT results were positive in 86%, 83%, and 55%, respectively.⁶ We found no significant difference in APT or SPT results for any food between the group that reacted within 2 hours vs the group reacting after 2 hours. In contrast, another study⁶ found that immediate-type reactions (within 2 hours) were associated with positive SPT results, and that late-phase clinical reactions (after 2 hours) were associated with positive APT results (sensitivity, 76%; specificity, 95%).

The finding that a smaller percentage of children older than 5 years had positive APT results could indicate that food is not the main factor inducing atopic dermatitis in this age group. It is also possible that the study population in this age group was too small to be representative.

Dust mites and cockroaches are the most common aeroallergens causing respiratory allergy in Thai children and are reported to cause atopic dermatitis exacerbation.^{20–26} Patients can develop symptoms from touch, inhalation, or ingestion of these aeroallergens.²⁶ Reported results of APTs for aeroallergens are variable,^{23,24} and there is no gold standard for diagnosis. The use of APTs to diagnose dust mite and cockroach allergy in this study was also limited because the role of these allergens as the cause of atopic dermatitis could not be confirmed. Most parents in this study were more concerned about food allergens than about dust mite or cockroach allergies. Our study found that approximately one-third of APT results were positive for *D pteronyssinus* and *D farinae*, and

approximately one-fourth of SPT results were positive for *D pteronyssinus* and *D farinae*. More than half of the patients had positive APT or SPT results to at least one antigen (*D pteronyssinus*, *D farinae*, or American cockroach). A previous study from Singapore compared APT results for dust mites, cat dander, Bermuda grass, and German cockroach in patients with atopic dermatitis vs controls.²⁴ They reported that APT results were significantly different between the groups only for dust mites. The difference between that study and ours was the different species of cockroach used. We used American cockroach extract in APTs because Thai patients are usually more sensitized to American cockroach than German cockroach. If aeroallergens can be avoided, atopic dermatitis symptoms can improve, and progression to airway allergy may be prevented. Interestingly, the percentage of positive APT results for *D pteronyssinus* and *D farinae* decreased as patient age increased, whereas positive SPT results for *D pteronyssinus* and *D farinae* increased with increasing age. Our study found no significant correlation between the results of SPTs, APTs, and OFCs and severity of atopic dermatitis, which was supported by the previous study.²⁰ The severity of atopic dermatitis may decrease at the study time because most patients had been treated for some time and had experienced improvement in their skin condition.

Parents usually avoid only suspected food, but mites or cockroaches might worsen of skin lesion in atopic dermatitis. Avoiding mites and cockroaches may be helpful in preventing further aeroallergen sensitization.

In our experience, more than half of parents of patients with atopic dermatitis deny giving their children the suspected foods after negative SPT results. To convince them to try the foods, we performed APTs, and if the results were also negative, OFCs were recommended before the patients eat those foods again. If the APT results were strongly positive and parents felt that such food had strong correlation with the symptoms, we recommended that the food be avoided for a while. Then the food should be reevaluated because the symptoms were likely to occur after the patients restarting eating or had contact with that food. If the SPT result was negative and the APT result was not strongly positive, we discussed with parents the advantage of an OFC. After a negative SPT result, 70% to 80% of the parents accepted giving their children the suspected foods again when the APT result was also negative. However, approximately 20% to 30% of the parents still avoid all the suspected foods because they do not want their child to have any symptoms at all. A limitation of this study was that some parents refused OFCs for safety reasons, especially in young infants.

APTs with locally prepared lyophilized allergen extracts were safe and had high specificity and median positive predictive value for evaluation of suspected food allergy in children with atopic dermatitis, especially for patients with late-phase clinical reactions. APTs may help to prevent unnecessarily restrictive diets, which may be the consequence of misjudging late reactions based on clinical assessment alone. The value of APTs in evaluating food allergy in atopic dermatitis needs more studies and meta-analysis.

APTs with locally prepared lyophilized allergen extracts were safe and had high specificity, median PPV, and low sensitivity for evaluation of suspected food allergy in children with atopic dermatitis.

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