

Skin Prick Test Versus Phadiatop as a Tool for Diagnosis of Allergic Rhinitis in Children

Sasiwimon Traian, MD¹, Wiparat Manuyakorn, MD, PhD¹ ,
Watcharoot Kanchongkittiphon, MD, PhD¹,
Cherapat Sasisakulporn, DipMedTech¹,
Wanlapa Jotikasthira, MSc¹, Potjanee Kiewngam, BNS¹,
Wasu Kamchaisatian, MD¹, and Suwat Benjaponpitak, MD¹

Abstract

Background: Skin prick test (SPT) or Phadiatop, a multi-allergen IgE screening test, was used as a tool for detecting aeroallergen sensitization.

Objective: To compare SPT and Phadiatop as a tool for diagnosis allergic rhinitis (AR) using the nasal provocation test (NPT) as a comparative standard.

Methods: Children aged 5–18 years with rhinitis symptoms more than 6 times in the past year were enrolled. SPT to 13 common aeroallergens, serum for Phadiatop, and NPT to *Dermatophagoides pteronyssinus* (Der p) were performed. NPT to mixed cockroach (CR) were performed in children who had CR sensitization and negative NPT to Der p. Children who had a disagreement between the result of SPT and Phadiatop or having negative results were evaluated for specific IgE (sIgE) to common aeroallergens.

Results: One hundred-forty children were enrolled with the mean age of 9.8 ± 3 years, 56% were male. Of 92 children (65.7%) with positive SPT to any aeroallergens, 88 children (95.6%) were sensitized to house dust mite (HDM). NPT showed positive results in 97 children (69.3%). Of 48 children who showed negative SPT, 4 children (8.3%) had sIgE to aeroallergens but NPT was positive in 1 child. Eighty-eight children (62.9%) had positive tests for Phadiatop and 4 (4.5%) of them had negative results for NPT to Der p. Among 52 children who had negative results for Phadiatop, 4 children (7.6%) had sIgE to aeroallergens but NPT was positive in 2 children (3.8%). SPT and Phadiatop showed 94.2% agreement: with Kappa 0.876, $p < 0.001$. Using NPT as a comparative standard for diagnosis for AR, SPT showed a sensitivity of 89.6% and specificity of 88.3% and Phadiatop provided the sensitivity of 88.6% and specificity of 95.3%.

Conclusions: SPT to aeroallergen and Phadiatop have good and comparable sensitivity and specificity for the diagnosis of AR in children.

Keywords

children, rhinitis, Phadiatop, skin prick test, nasal provocation test, dust mite, cockroach allergic, IgE, aeroallergen

Introduction

Allergic rhinitis (AR) is an increasingly common allergic disease that has a significant impact on the quality of life, sleep and school performance in children.^{1,2} Many non-allergic triggers such as infections can induce rhinitis symptoms mimicking allergic rhinitis.³ Preschool to school-age children can have rhinitis associated with acute infective rhinitis up to 6–8 times per year.^{4,5}

¹Division of Pediatrics Allergy and Immunology, Department of Pediatrics, Faculty of Medicine Ramathibodi Hospital, Mahidol University, Bangkok, Thailand

Corresponding Author:

Wiparat Manuyakorn, Division of Pediatrics Allergy and Immunology, Department of Pediatrics, Faculty of Medicine, Ramathibodi Hospital, Mahidol University, Rama VI Road, Ratchathewi, Bangkok 10400, Thailand.
Email: mwiparat@hotmail.com

Assessment of allergen sensitizations using allergen-specific IgE in the blood or skin prick test in children with frequent rhinitis helps in the diagnosis of AR and excludes from non-allergic rhinitis.^{3,6} The confirmatory diagnosis of AR from the evidence of sensitization may help in reducing the unnecessary prescription of intranasal steroid or antihistamine in rhinitis children.^{3,7} The negative predictive value of this allergen sensitization assessment is as high as 90–95%.⁸ However, some sensitized negative patients could have local nasal specific IgE production namely local allergic rhinitis (LAR) which is required a nasal provocation test for the diagnosis.^{3,6} Skin prick test (SPT) is a simplified and reproducible method to assess allergen sensitization for diagnosis of AR.^{3,7} However, performing and interpreting SPT requires adequate training. In the situation that SPT cannot be performed, assessment of allergen sensitization in the blood can be an alternative method. Phadiatop, multi-allergen immunoglobulin E screening assay, is a single qualitative assay detecting IgE antibodies to a well-balanced mixture of relevant allergens designed by the manufacturer, which are often implicated in causing allergic diseases in the blood. Phadiatop is proposed to use as a screening test for detecting atopy in the epidemiologic study in school children.⁹ Nevertheless, there is no previous study evaluating SPT and Phadiatop as a tool in the diagnosis of AR in children. Therefore, this study was aimed to compare Phadiatop to SPT in the detection of aeroallergen induced rhinitis in children using the nasal allergen-provocation test as a comparative standard for diagnosis of AR.

Materials and Methods

This study was conducted at the Pediatric Allergy and Immunology Unit, Faculty of Medicine Ramathibodi Hospital, Bangkok, Thailand, from November 2017 to November 2018. Ethical approval was provided by the Human Rights and Ethics Committee of the Faculty of Medicine, Ramathibodi Hospital, Mahidol University, Bangkok, Thailand (ID 10-60-34). Written informed consent was obtained for all participants and their parents. The current study was registered at the Thai Clinical Trials Registry (No. TCTR20190215002).

Participants

Children between 5–18 years old with frequent rhinitis defined by having rhinitis symptoms (sneezing, itching, nasal obstruction, rhinorrhea) more than 6 times in the past year and rhinitis symptoms occur for two or more consecutive days for more than 1 hour on most days were enrolled.¹ Children with chronic cardiovascular disease, liver disease, kidney disease, GI disease, autoimmune disease, uncontrolled asthma, or nasal/sinus

surgery were excluded. Baseline characteristics including age, sex, and allergic comorbidities were recorded. SPT to 13 common aeroallergens, the blood test for Phadiatop, and nasal provocation tests were performed on all participants. Some of the children who had disagreements between the result of SPT and Phadiatop were further evaluated for specific IgE (sIgE) to house dust mite, cockroach, Acacia, Careless weed, grass mixed (Bermuda, Rye, Timothy, Meadow, Johnson, Bahia grass), fungi mixed (Penicillium, Cladosporium, Aspergillus, Alternaria), and animal mixed (cat dander, dog dander, Guinea pig epithelium, rat, mouse).

Skin Prick Test (SPT)

SPT was performed using blood lancet (Feather Safety Razor, Osaka, Japan) on the volar aspect of the forearm with a positive control solution of 0.1% histamine, normal saline as a negative control and 13 commercial extracts of aeroallergens including Johnson grass, Bermuda grass, Careless weed, *Cladosporium Sphaerospermum*, Alternaria, *Aspergillus Fumigatus*, Curvularia, American cockroach, German cockroach, cat hair, dog pelt, *Dermatophagoides pteronyssinus* (Der p), and *Dermatophagoides farina* (Der f) (ALK-Abello Pharm., Inc USA). After 15 minutes, a wheal size was measured and mean of the longest diameter plus the perpendicular diameter designated as mean wheal diameter (MWD) was recorded. The size of 3 millimeters greater than the wheal size of the negative control was interpreted as positive.

Phadiatop and Specific Immunoglobulin E Measurement

Serum samples from all participants were sent for Phadiatop (Phadia, Uppsala, Sweden). Phadiatop level ≥ 0.35 PAU/L was defined as positive. Serum for specific IgE to Der p (d1), German cockroach (i6), Acacia (t19), Careless weed (w82), grass mixed (gx2) (Bermuda, Rye, Timothy, Meadow, Johnson, Bahia grass), mold mixed (mx1) (Penicillium, Cladosporium, Aspergillus, Alternaria), animal mixed (ex2) (cat dander, dog dander, Guinea pig epithelium, rat, mouse) using ImmunoCap (Phadia, Biomed diagnostics, Bangkok, Thailand) were sent in children who had the disagreements between the result of SPT and Phadiatop or negative SPT and Phadiatop.

HDM Nasal Provocation Test

NPT to Der p was performed on all participants. Before NPT, participants were asked to discontinue topical nasal corticosteroids for 2 weeks, antihistamine medication for a week, and oral or topical decongestants for a day. NPT protocol was modified using our previous

report¹⁰ and a recent study in children¹¹ as follows. Firstly, baseline nasal symptom scores were recorded, then nasal airway resistance (NAR) and nasal airflow patency were assessed using anterior rhinomanometry analyzes (Multifunctional Spirometer HI-801, Chest M. I, Inc., Tokyo, Japan) and peak nasal inspiratory flows (PNIF) (In-Check Nasal, Clement Clark, Harlow, UK). As a negative control, patients were initially tested with one puff of a saline solution (0.9% NaCl) nasal spray (150 µL) per each nostril. Then, one spray (150 µL) of a house dust mite solution at different concentrations of the Der p allergen extract (50, 200, 500, 2,000 AU/ml) per each nostril was applied to both nostrils at 15-minute intervals, in order to find the maximum tolerated dose. Total nasal symptom scores including sneezing (0–3), rhinorrhea (0–3), nasal blockage (0–3), and ocular symptom (0–1), PNIF, as well as NAR, were assessed after each provocation. NPTs were considered positive if one of the following criteria were met: 1) An increase in NAR by at least 20% of the baseline value with changes in the total nasal symptom scores from baseline value by at least 3 points, 2) a reduction of PNIF by at least 20% from the baseline with changes in the total nasal symptom scores from baseline value by at least 3 points, 3) An increase in NAR by at least 40% of the baseline value, regardless of total nasal symptom scores. Patients were closely monitored for 30 minutes after finishing NPT. Nasal irrigation, oral antihistamines, as well as oral decongestant would be given to patients with troublesome nasal symptoms.

Nasal Provocation Test to Mixed Cockroach

In the subgroup of enrolled children who had negative results to Der p NPT and had positive SPT or sIgE to cockroach were further evaluated by NPT to a mixed cockroach in the next visit at least 4 weeks from the last NPT. The mixed cockroach NPT was started with mixed American and German cockroach at the concentration of 1:5000 weight per volume (wt/v) and 1:1000 wt/v.¹² All the procedure for NPT was similar with Der p NPT.

Statistical Analysis

The sample size estimation of 140 subjects was calculated from the probability of expected sensitivity 0.9 and error 0.05. The sensitivity, specificity, predictive value (with 95% confidence interval), and likelihood ratio of SPT and Phadiatop were calculated. The relationship between the MWD of SPT and Phadiatop results were analyzed by Spearman's Rho correlation analysis. A receiver-operating characteristic (ROC) curve with area under the curve (AUC) was evaluated the diagnostic performance of HDM SPT and Phadiatop.

The agreement between SPT and Phadiatop was assessed by Kappa coefficient statistics. A two-tailed P value of 0.05 was considered to indicate statistically significant. The statistical analysis was conducted using the SPSS 18.0 software package (IBM, Chicago, IL, USA)

Results

One hundred-forty children were enrolled in the study with the mean age of 9.8 ± 3 years, 56% were male. SPT was positive in 92 (65.7%) children in which 88 (95.6%) children were sensitized to HDM. HDM including Der f and Der p was the most common aeroallergen followed by cockroach: 49/92 positive to only HMD, 20/92 positive to HMD and CR, 19/92 positive to HDM and others, 2/92 positive to CR only and 2/92 positive to CR and other allergens. NPT to Der p was positive in 94 (67.1%) children. Among 88 children with positive SPT to HDM, 4 of them (4.5%) had negative results for Der p NPT. NPT to mixed cockroach was performed in 6 cockroach sensitized children with negative NPT to Der p and only 3 out of 6 children had positive NPT to the mixed cockroach. Regarding Phadiatop, 88 children (62.9%) had positive results (Table 1 and Figure 1).

Agreement Between Phadiatop and Skin Prick Test

Of 88 children with positive Phadiatop, 86 children (97%) had positive SPT to at least one aeroallergen.

Table 1. Baseline Characteristics of the Enrolled Children.

Variables	Enrolled Patients (N = 140)
Age: year	9.8 ± 3
Sex: male	79 (56.4)
Allergic comorbidities	
Physician diagnosed	49 (35)
allergic conjunctivitis	
Food allergy	8 (5.7)
Atopic dermatitis	33 (23.6)
Passive smoking	35 (25)
Skin prick test positive	92 (65.7)
HDM only	49 (35)
HDM and CR	20 (14.3)
HDM and other	19 (13.6)
CR only	2 (1.4)
CR and other	2 (1.4)
Phadiatop positive	88 (62.9)
Positive result for nasal	97 (69.3)
provocation test (NPT)	
NPT positive HDM	94 (67.1)
NPT positive to CR	3 (2.1)

Data present as N (%) or mean ± sd. HDM = house dust mite, CR = cockroach.

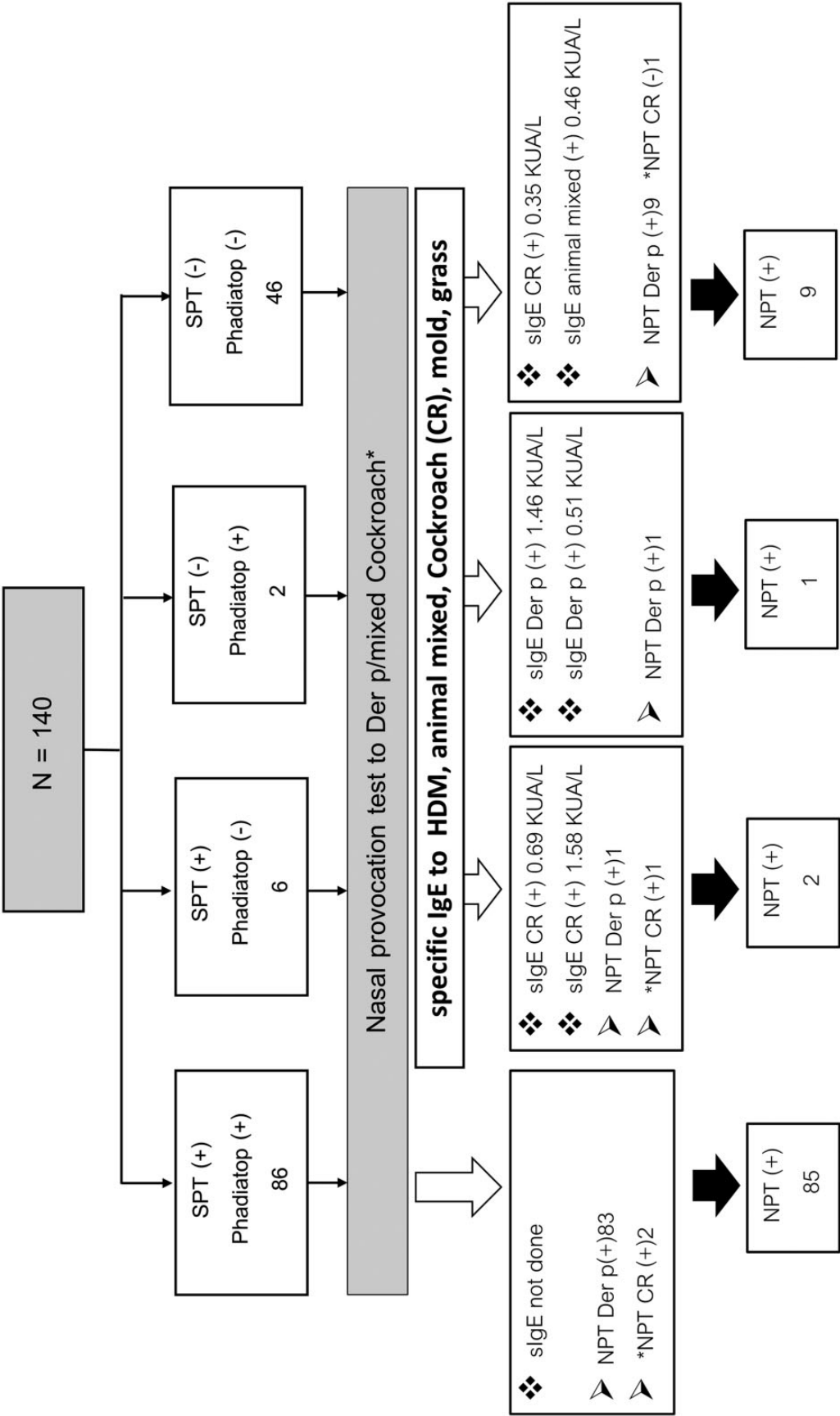


Figure 1. The diagram of the results of skin prick test (SPT), Phadiatop, specific immunoglobulin E (sIgE), and nasal provocation test (NPT). *NPT to mixed cockroach (NPT CR) was further performed in children who had negative results for Der p NPT and having evidence of cockroach sensitization.

Table 2. Skin Prick Test (SPT) and Phadiatop in Detecting Allergic Rhinitis Based on Nasal Provocation Test.

Test	Sensitivity % (95% CI)	Specificity % (95% CI)	PPV % (95% CI)	NPV % (95% CI)	LR+ (95% CI)	LR- (95% CI)	Kappa	Agreement (%)
SPT	89.6 (81.4–94.6)	88.3 (74.1–95.6)	94.5 (87.1–97.9)	79.1 (64.5–89.0)	7.7 (3.3–17.6)	0.1 (0.06–0.2)	0.756	89.2
Phadiatop	88.6 (80.2–93.9)	95.3 (82.9–99.1)	97.7 (91.2–99.6)	78.8 (64.9–88.4)	19.0 (4.9–73.9)	0.1 (0.06–0.2)	0.794	90.7
SPT plus Phadiatop	87.6 (79.0–93.1)	97.6 (86.2–99.8)	98.8 (92.7–99.9)	77.7 (64.0–87.5)	37.6 (5.4–261)	0.12 (0.07–0.2)	0.796	90.7
SPT or Phadiatop	90.7 (82.6–95.4)	90.6 (76.9–96.9)	95.6 (88.6–98.5)	81.2 (66.8–90.5)	9.7 (3.8–24.8)	0.1 (0.05–0.1)	0.789	90.7

PPV=positive predictive value, NPV=negative predictive value, LR+=positive likelihood ratio, LR-=negative likelihood ratio, 95% CI =95% confident interval and SPT=skin prick test.

Table 3. Accuracy of Skin Prick Test (SPT) to HDM and Phadiatop in Detecting Allergic Rhinitis Based on Nasal Provocation Test to HDM.

Test	Sensitivity % (95% CI)	Specificity % (95% CI)	PPV % (95% CI)	NPV % (95% CI)	LR+ (95% CI)	LR- (95% CI)	Kappa	Agreement (%)
SPT HDM	89.3 (80.8–94.5)	91.3 (78.3–97.1)	95.4 (88.1–98.5)	80.7 (67.0–89.9)	10.2 (4.0–26.2)	0.1 (0.06–0.2)	0.781	90
Phadiatop	89.3 (80.8–94.5)	91.3 (78.3–97.1)	95.4 (88.1–98.5)	80.7 (67.0–89.9)	10.2 (4.0–26.2)	0.1 (0.06–0.2)	0.781	90
SPT plus Phadiatop	88.2 (79.6–93.7)	93.4 (81–98.3)	96.5 (89.4–99.0)	79.6 (66–88.9)	13.5 (4.5–40)	0.12 (0.07–0.2)	0.783	90
SPT or Phadiatop	90.4 (82.1–95.2)	84.7 (70.5–93.1)	92.3 (84.4–96.6)	81.2 (66.8–90.5)	5.9 (2.9–11.7)	0.11 (0.06–0.2)	0.744	88.5

PPV=positive predictive value, NPV=negative predictive value, LR+=positive likelihood ratio, LR-=negative likelihood ratio, 95% CI =95% confident interval, SPT=skin prick test, and HDM= house dust mite.

Regarding SPT, of 92 children had positive tests to at least one aeroallergen, 86 of them (93.5%) had positive tests for Phadiatop. The Kappa agreement between Phadiatop and SPT was 0.876, $p < 0.001$. Subgroup analysis in 88 children with positive SPT to HDM, Phadiatop demonstrated positive results in 84 children (95.5%) with the Kappa agreement of 0.88, $p < 0.001$. Spearman's Rho correlation between results of Phadiatop level and MWDs for each allergen showed statistically significant correlation only with MWDs of HDM in Der f and Der p with r of 0.857, $p < 0.001$ and 0.838, $p < 0.001$, respectively.

The Ability of SPT and Phadiatop in the Diagnosis of Allergic Rhinitis Using NPT as a Comparative Standard

Using the result of NPT to Der p or CR as a comparative standard for diagnosis of AR, sensitivity, specificity, positive predictive value, and negative predictive value of SPT is 89.6%, 88.3%, 94.5%, and 79.1% compared to those of Phadiatop 88.6%, 95.3%, 97.7%, and 78.8%, respectively. The Kappa agreements of SPT and Phadiatop with NPT are 0.756 and 0.794 (Table 2). Subgroup analysis using NPT positive result to Der p as a comparative standard for diagnosis of HDM

induced AR, SPT to HDM, and Phadiatop provides the comparable sensitivity, specificity, PPV, NPV, and Kappa agreement (Table 3).

Cut Off Values for MWD of HDM Skin Prick Test and the Level of Phadiatop in Detecting HDM Induce Allergic Rhinitis

The cutoff values for the MWD of HDM SPT (Der p and Der f) for predicting of 99% predictive value of positive NPT to Der p are 6.0 mm for Der p and 6.6 mm for Der f (Figure 2(A) and (B)). The ROC curve analysis between MWD and Der p/Der f was demonstrated in Figure 2(D). Der p and Der f allergen were demonstrated similarly high accuracy value of AUC 0.92, $p < 0.001$ with 95% CI ranging from 0.87 to 0.96. The cutoff values of the level of Phadiatop for predicting of 99% predictive value of positive NPT to Der p is 12.2 PAU/L (Figure 2(C)).

Serum Specific IgE in Children With the Disagreement of Phadiatop and Skin Prick Test or Having the Negative Result of SPT and Phadiatop

Serum specific IgE to common aeroallergens was measured in 54 children including 6 children who

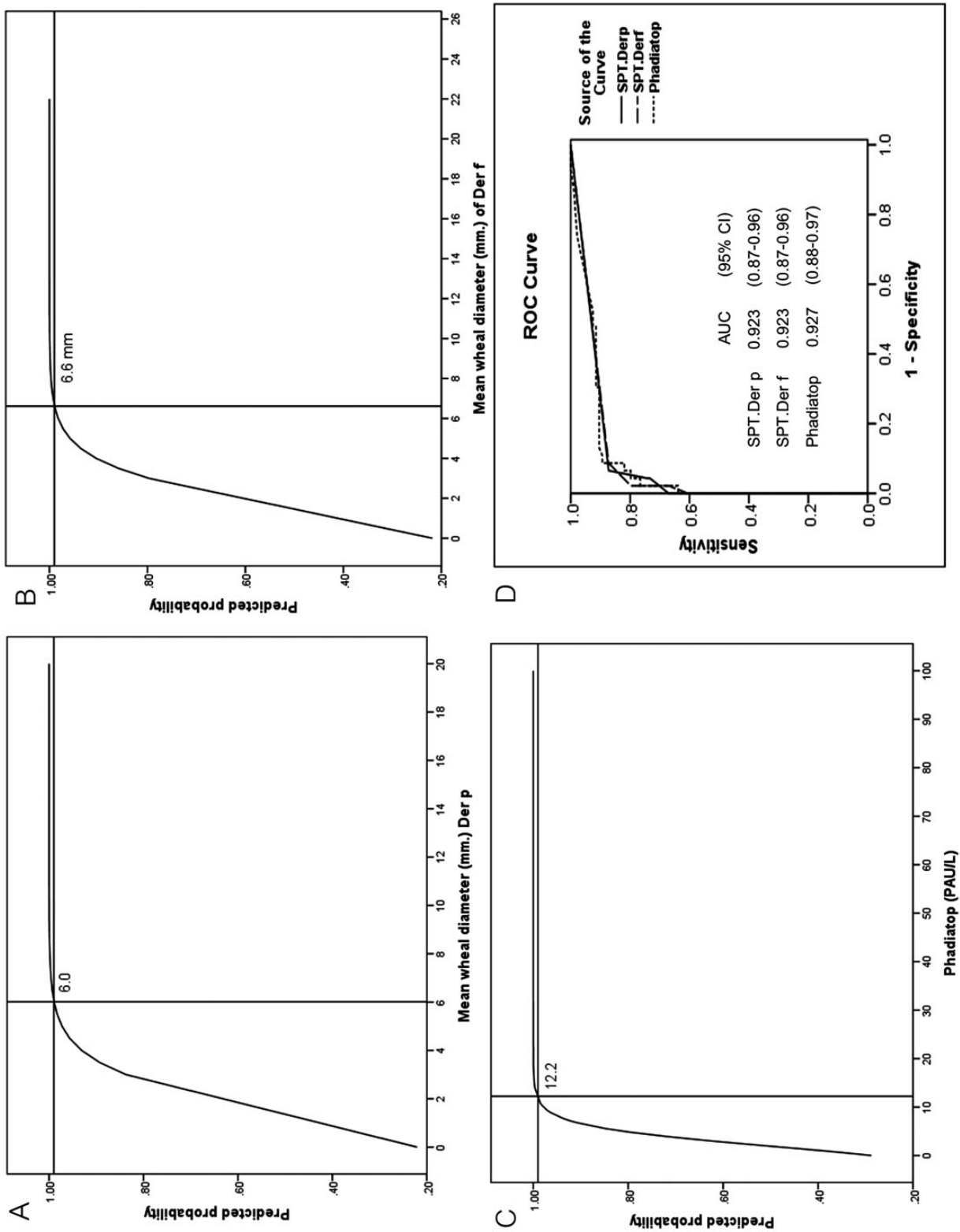


Figure 2. Cut-off value for the MWD for Der p (A), Der f (B) and the level of Phadiatop (C) for 99% predicted probability for positive NPT to Der p. ROC curve of SPT to Derp, Der f, and Phadiatop for the positive result of NPT to Der p (D).

had negative results of Phadiatop but had positive SPT, 2 children who had negative results of SPT but had positive Phadiatop, and 46 children with negative results of Phadiatop and SPT (Figure 1). From these 54 children, serum specific IgE was positive only in 6 children (11%). Of 52 children with negative Phadiatop, serum specific IgE was positive in 4 cases (7.6%) and half of them had positive NPT. Of 48 cases of children with negative SPT, serum specific IgE was positive in 4 cases (8.3%) and only one child had positive NPT (Figure 3).

The Result of NPT, SPT, and Phadiatop

Of 86 children who had positive results of SPT and Phadiatop, only 1 child (1.1%) had negative NPT (Figure 1). Eight children had a discrepancy between SPT and Phadiatop test in which 5 of them (62.5%) had negative NPT. Of 48 children with negative SPT, only 1 child had positive NPT (Figure 3). In addition, NPT was positive only in 2 children out of 52 children whose negative Phadiatop (Figure 3). One child with negative SPT, Phadiatop, and NPT had specific IgE to animal mixed at a very low level at 0.46 KUA/L suggested being non-clinically significant.

Discussions

In this study, we have investigated the ability of SPT and Phadiatop in detecting aeroallergen induced rhinitis in children using NPT as a comparative standard. SPT and Phadiatop provide a very strong correlation with the Kappa of 0.88. Additionally, both tests provide good sensitivity, specificity, PPV, and NPV ranging from 78.8% to 97.7% for the diagnosis of aeroallergen induced AR. Further investigation for specific IgE to aeroallergen in rhinitis children who had negative results for SPT or Phadiatop detected only 7-8% more cases of allergen sensitization in which 50% of this group had true allergen-induced AR (Figure 3).

The sensitivity of Phadiatop in detecting allergic sensitization in children with asthma and/or rhinitis has been reported ranging from 87%¹³ to 98%.¹⁴ Differences in the sensitivity might be explained from the differences in the prevalence of allergic disease and most importantly, the investigation used for the diagnosis of allergic diseases. Previous studies used serum specific IgE or skin test as a standard for diagnosis of the allergic disorder.¹⁵ None of them used NPT as a comparative standard for the diagnosis of AR. In our study, all participants were nasally challenged with HDM and CR to confirm the diagnosis of allergen-induced AR.

Since we used NPT as a comparative standard for diagnosis of allergen-induced AR, then we could identify the diagnosis of LAR in children who had no evidence of sensitizations. Otherwise, this group of children would have been classified as non-allergic rhinitis if either SPT or specific IgE tests were used, leading to the false-negative result when calculated for the test accuracy. This reason would explain why our study demonstrated lower sensitivity than the previous study.¹⁴

We also have purposed the cut-off value for the MWD of HDM SPT for the diagnosis of children with HDM induced AR based on HDM NPT result. MWD of Der p at 6 mm and Der f at 6.6 mm provide the 99% predicted probability of having HDM induced AR. A previous retrospective study has shown that 80% of adults suspected HDM allergy who had MWD of Der p more than 5 mm, would have positive NPT.¹⁶ Additionally, we have purposed the cut-off value for Phadiatop at 12.2 PAU/L for the 99% predicted probability of having HDM induced AR. Another recent study in the adult with allergic rhinitis symptoms has demonstrated the level of specific IgE to Der p of 0.7 IU/ml for detecting adult AR based on the result of SPT to Der p with the sensitivity of 92.1%, the specificity of 94%.¹⁷ Up to our knowledge, this is the first study to demonstrate the cut-off value for the MWD of HDM SPT and the level of Phadiatop for detecting HDM induced AR based on the result of Der p NPT.

We have shown that among 88 children with positive SPT to HDM, 4 of them (4.5%) had negative results for Der p NPT which represent the silent HDM sensitization or local allergic responses. Besides, further investigation for serum specific IgE to aeroallergen in children having negative results for either Phadiatop or SPT showed positive results in 8% of cases, and less than half of them were proven to have allergen-induced rhinitis by NPT. Based on our study, most of the confirmed allergic rhinitis can be detected by SPT or Phadiatop. As a workup for specific IgE to each allergen is costly, therefore, we would not suggest routinely further investigation for specific IgE to aeroallergen in rhinitis children with negative SPT or negative Phadiatop unless that allergen is highly suspicious to be a causative allergen for AR. However, the cost and other non-direct medical costs of each test for diagnosis allergic rhinitis in children were not evaluated in the current study. A further well designed study should be done to recommend the cost-effectiveness for each test.

We have also shown that NPT in children was safe and feasible. No complication from NPT was detected in this study. The age of children who had positive NPT was not significant differences from that of children with negative NPT (data not shown). As a result, NPT could be the alternative further investigation in rhinitis children who are highly suspicious of allergic rhinitis but

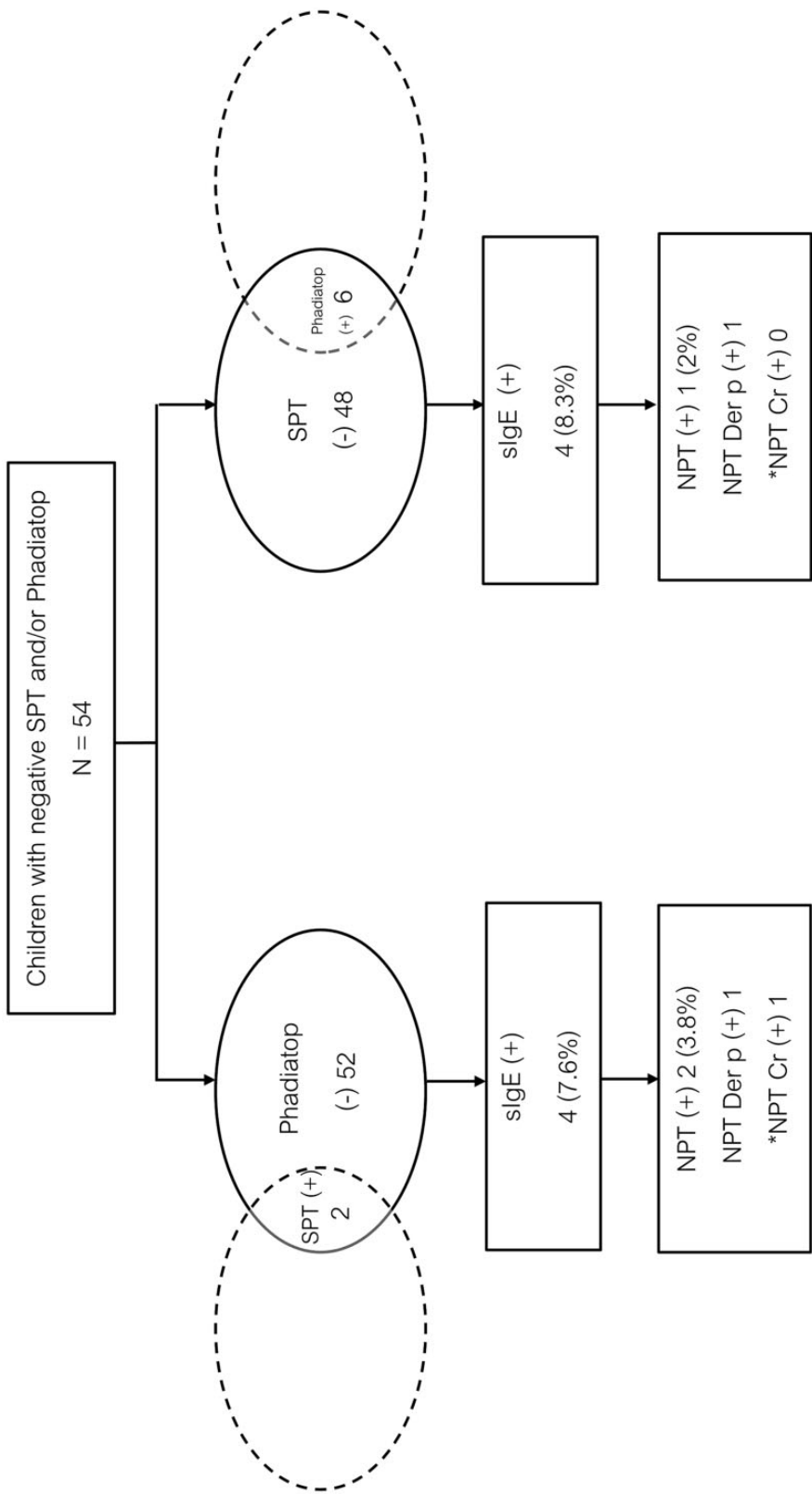


Figure 3. Diagram of children with negative results of SPT and/or Phadiatop and the result of specific IgE (sigE) and NPT. *2 children had positive results for SPT. #6 children had positive results for Phadiatop.

the screening test of SPT or Phadiatop is negative. However, NPT should not be used as a screening tool for the diagnosis of allergic rhinitis in primary care setting since NPT needs to be done by a trained technician from its complicated procedure. The strengths of our study are all rhinitis children were thoroughly evaluated for allergen sensitization as following: SPT, the blood test for Phadiatop, NPT to Der p. Moreover, children with AR in our study were confirmed by NPT which differs from previous reports that used only the history of rhinitis symptoms and evidence of IgE sensitization by SPT or Phadiatop or specific IgE. Nevertheless, our study has some limitations. We had performed NPT to Der p and, in selected cases, to CR which are the two most common causative allergen-induced allergic symptoms in South East Asian countries including Thailand.¹⁸ Therefore, the NPT outcome might not represent all aeroallergen induced AR. However, all of our enrolled subjects with positive SPT had either HDM or CR sensitization. We may have missed very few children with another allergen-induced rhinitis. As a result, our study would apply to the countries that have HDM as the most common aeroallergen sensitization for AR.

In conclusion, skin prick test to common aeroallergen and blood for Phadiatop provide a comparable in sensitivity and specificity in detecting aeroallergen induced AR based on nasal provocation test. Blood for the Phadiatop test may be an alternative test for the diagnosis of AR in children if the skin prick test is unavailable.

Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding

The author(s) disclosed receipt of the following financial support for the research, authorship, and/or publication of this article: : This study was supported by Research Fund, Faculty of Medicine, Ramathibodi Hospital, Mahidol University.

ORCID iD

Wiparat Manuyakorn  <https://orcid.org/0000-0003-4278-1186>

References

1. Bousquet J, Khaltaev N, Cruz AA, et al. Allergic Rhinitis and its Impact on Asthma (ARIA) 2008 update (in collaboration with the World Health Organization, GA(2)LEN and AllerGen). *Allergy*. 2008;63(Suppl 86):8–160.
2. Meltzer EO, Blaiss MS, Derebery MJ, et al. Burden of allergic rhinitis: results from the pediatric allergies in America survey. *J Allergy Clin Immunol*. 2009;124:S43–S70.
3. Roberts G, Xatzipsalti M, Borrego LM, et al. Paediatric rhinitis: position paper of the European Academy of Allergy and Clinical Immunology. *Allergy*. 2013;68:1102–1116.
4. Heikkinen T, Jarvinen A. The common cold. *Lancet*. 2003;361:51–59.
5. Gruber C, Keil T, Kulig M, Roll S, Wahn U, Wahn V. History of respiratory infections in the first 12 yr among children from a birth cohort. *Pediatr Allergy Immunol*. 2008;19:505–512.
6. Campo P, Eguiluz-Gracia I, Bogas G, et al. Local allergic rhinitis: implications for management. *Clin Exp Allergy*. 2019;49:6–16.
7. Bousquet J, Heinzerling L, Bachert C, et al. Practical guide to skin prick tests in allergy to aeroallergens. *Allergy*. 2012;67:18–24.
8. King MJ, Tamulis T, Lockey RF. Prick puncture skin tests and serum specific IgE as predictors of nasal challenge response to dermatophagoides pteronyssinus in older adults. *Ann Allergy Asthma Immunol*. 2008;101:12–17.
9. Garcia-Marcos L, Sanchez-Solis M, Martinez-Torres AE, Moreno JML, Sastre VH. Phadiatop compared to skin-prick test as a tool for diagnosing atopy in epidemiological studies in schoolchildren. *Pediatr Allergy Immunol*. 2007;18:240–244.
10. Manuyakorn W, Klangkalya N, Kamchaisatian W, Benjaponpitak S, Sasisakulporn C, Jotikasthira W. Efficacy of nasal cellulose powder in the symptomatic treatment of allergic rhinitis: a randomized, double-blind, placebo-controlled trial. *Allergy Asthma Immunol Res*. 2017;9:446–452.
11. Buntarickpornpan P, Veskitkul J, Pacharn P, et al. The proportion of local allergic rhinitis to *Dermatophagoides pteronyssinus* in children. *Pediatr Allergy Immunol*. 2016;27:574–579.
12. Phothijindakul N, Chusakul S, Aeumjaturapat S, et al. Nasal cytology as a diagnostic tool for local allergic rhinitis. *Am J Rhinol Allergy*. 2019;33:540–544.
13. Cantani A, Ferrara M, Barbieri C, Monteleone A, Businco L. Evaluation of new test (Phadiatop) for the screening of respiratory allergic disorders in children. *Ann Allergy*. 1990;64:158–161.
14. Williams PB, Siegel C, Portnoy J. Efficacy of a single diagnostic test for sensitization to common inhalant allergens. *Ann Allergy Asthma Immunol*. 2001;86:196–202.
15. Vidal C, Gude F, Boquete O, et al. Evaluation of the phadiatop test in the diagnosis of allergic sensitization in a general adult population. *J Invest Allergol Clin Immunol*. 2005;15:124–130.
16. Haxel BR, Huppertz T, Boessert P, Bast F, Fruth K. Correlation of skin test results and specific immunoglobulin E blood levels with nasal provocation testing for house-dust mite allergies. *Am J Rhinol Allergy*. 2016;30:60–64.
17. Hong SD, Ryu G, Seo MY, et al. Optimal cutoff values of allergen-specific immunoglobulin E to house dust mites and animal dander based on skin-prick test results: analysis in 16,209 patients with allergic rhinitis. *Am J Rhinol Allergy*. 2018;32:23–26.
18. Tham EH, Lee AJ and Bever HV. Aeroallergen sensitization and allergic disease phenotypes in Asia. *Asian Pac J Allergy Immunol*. 2016;34:181–189. 2016/08/21. DOI: 10.12932/AP0770.