

## Penicillin Skin Testing Is a Safe and Effective Tool for Evaluating Penicillin Allergy in the Pediatric Population

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**What is already known about this topic?** Penicillin skin testing is safe and effective in the evaluation of adult patients with a history of penicillin allergy but has not been validated in the pediatric population.

**What does this article add to our knowledge?** Penicillin skin testing was safe and effective in the evaluation of children with a history of penicillin allergy.

**How does this study impact current management guidelines?** Our study confirms the safety and validity of penicillin skin testing in the pediatric population and enables clinicians to have a robust discussion with the parents of pediatric patients with a history of penicillin allergy regarding penicillin skin testing.

**BACKGROUND:** Penicillin skin testing has been validated in the evaluation of adult patients with penicillin allergy. However, the commercially available benzylpenicilloyl polylysine (Pre-Pen) is not indicated in the pediatric population. Moreover, the safety and validity of penicillin skin testing in the pediatric population has not been well studied.

**OBJECTIVE:** We describe the safety and validity of penicillin skin testing in the evaluation of children with a history of penicillin allergy.

**METHODS:** Children (<18 years) with a history of penicillin allergy were evaluated with penicillin skin tests and were reviewed for basic demographics, penicillin skin test results, adverse drug reaction to penicillin after penicillin skin test, and adverse reaction to penicillin skin test. By using the  $\chi^2$  test, we compared the differences in the proportion of children and adults with a positive penicillin skin test. *P* value (<.05) was considered statistically significant. The institutional review board approved the study, and all the subjects signed written informed consents.

**RESULTS:** A total of 778 children underwent penicillin skin testing; 703 of 778 patients had a negative penicillin skin test (90.4%), 66 had a positive test (8.5%), and 9 had an equivocal test (1.1%). Children were more likely to have a positive penicillin skin test (*P* < .0001) compared with adults (64 of 1759 [3.6%]); 369 of 703 patients with negative penicillin skin test (52%) were challenged with penicillin, and 14 of 369 patients (3.8%) had an adverse drug reaction. No adverse reactions to penicillin skin testing were observed.

**CONCLUSION:** Penicillin skin testing was safe and effective in the evaluation of children with a history of penicillin allergy. © 2014 American Academy of Allergy, Asthma & Immunology (J Allergy Clin Immunol Pract 2014;2:439-44)

**Key words:** Adverse drug reaction; Penicillin allergy; Penicillin skin testing; Pediatric; Safe

The incidence of penicillin (PCN) allergy ranges from 1% to 10%. Many of these patients do not have evidence of an IgE-mediated reaction when evaluated with PCN skin testing (PST).<sup>1,2</sup> Many physicians on hearing of a patient's PCN allergy elect not to use PCN or other  $\beta$ -lactam antimicrobials when, in fact, PCN or other  $\beta$ -lactam antimicrobials may be the antibiotic of choice.<sup>3</sup> This may cause increased cost to the medical system and may expose the patient unnecessarily to broad-spectrum antibiotics. Many studies have examined PSTs in adults; however, few studies have been published that evaluated PST in the pediatric population. In fact, the prevalence of PCN allergy in children is unknown. Pre-Pen (AllerQuest, Plainville, Conn), benzylpenicilloyl polylysine, is approved for use in the adult population; however, Pre-Pen is not indicated in the pediatric population according to the package insert. It has been reported in the adult population that a patient with a negative PST to the major determinant (benzylpenicilloyl polylysine) and minor determinants (benzylpenicilloate, benzylpenilloate, benzylpenicillin [PCN G], or benzylpenicilloyl-N-propylamine) of PCN with a history of PCN allergy is at low risk for having an IgE-mediated reaction when rechallenged with a PCN drug (1%-3%).<sup>4-8</sup> In this article, we describe our clinical experience with PSTs in the pediatric population and the relevant outcomes.

### METHODS

#### Patients

Patients who underwent PST from July 8, 1993, to August 21, 2009, and who met the following inclusion criteria were enrolled into the study: the patient was administered PSTs, had a history of PCN and/or cephalosporin allergy, and was younger than 18 years of age.

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**Abbreviations used**

ADR- Adverse drug reaction

ENDA- European Network for Drug Allergy

PCN- Penicillin

PST- Penicillin skin testing

**Study design**

This was a retrospective cohort study in which medical records were reviewed for basic demographics (age and sex), type of adverse drug reaction (ADR) to PCN or cephalosporin, PST results, time from the original PCN ADR to testing, and ADRs to PCNs after a negative PST. All of the information was entered into a spreadsheet program (Microsoft Excel; Microsoft Corp, Redmond, Wash) and was then converted into a JMP file (JMP version 7.0; SAS Institute Inc, Cary, NC) (see "Statistical analysis" section) for statistical analysis. The Mayo Clinic Institutional Review Board approved the study, and all the participants signed written informed consent forms.

**PCN allergy testing**

PCN allergy testing was conducted by using benzylpenicilloyl polylysine (Pre-Pen; Hollister-Stier, Spokane, Wash), PCN G potassium (Pfizerpen; Pfizer, New York, NY), amoxicillin, and alkaline hydrolysis mix (penicilloate), as previously reported.<sup>9</sup> Patients from July 8, 1993, to October 31, 2004, were tested with Pre-Pen; however, when the Pre-Pen was not commercially available, patients, after October 31, 2004, were tested with benzylpenicilloyl polylysine prepared by our institution with the protocol developed by Levine.<sup>10</sup> The institutional benzylpenicilloyl polylysine was compared with the Pre-Pen and found to be comparable (data not shown). The penicilloate was produced by reacting PCN G with 1 N of sodium hydroxide at a pH of 11.5 for 90 minutes, after which the pH was adjusted to 7.4 by the addition of 1 N of hydrochloride. The penicilloate was lyophilized and stored at 4°C. The penicilloate was diluted with PBS solution to 0.01 mol/L and filtered through a 0.22- $\mu$ m membrane for sterility and done weekly to be used for PST. The aqueous penicilloate was stored at 4°C. The benzylpenicilloyl polylysine (Pre-Pen) was used according to the manufacturer's instructions, and the PCN G potassium was used in a concentration of 6000 U/mL in PBS solution. The amoxicillin was diluted with sterile water to 0.01 mol/L and was filtered through a 0.22- $\mu$ m membrane for sterility and done weekly to be used for PST. Histamine, 0.05 mg/mL, was used as the positive control, and the negative control was PBS solution.

Skin prick tests were performed on the volar surface of the forearm with the PCN reagents described above and with control reagents. The skin prick test was not done in duplicate. The skin prick test sites were examined at 15 minutes. A positive PST result was defined as a wheal at least 3  $\times$  3 mm larger than the negative control, with a surrounding zone of erythema to 1 or more PST reagents (Pre-Pen, PCN G, penicilloate, and amoxicillin).<sup>1</sup> Patients with negative or equivocal PCN skin prick test results underwent PCN intradermal testing. Intradermal skin tests were performed on the volar surface of the forearm. The test reagents were injected intradermally to produce an initial wheal of 2  $\times$  2 mm. The skin prick test sites were examined at 15 minutes. A positive intradermal test result was defined as a wheal at least 3  $\times$  3 mm larger than the negative control, with a surrounding zone of erythema.<sup>1</sup> Patients with a wheal but no flare

on PST (prick and intradermal) were considered to be equivocal. Allergy skin testing was performed where resuscitation was available in case of anaphylaxis.

**Statistical analysis**

Descriptive statistics were used to describe the age, sex, results of the PSTs, and the proportion of ADRs in patients with a history of PCN allergy and negative PSTs who were challenged with a PCN or a semisynthetic PCN (eg, amoxicillin). Patients with an equivocal PST result defined as a 2  $\times$  2-mm wheal and flare or  $\geq$  3  $\times$  3-mm wheal without a flare on skin prick or intradermal PST, or positive cefazolin skin test results but negative PST results were considered to have negative PST results in the statistical analysis.

A 2-tailed sample *t* test was used to determine if the mean elapsed time (months) between the original PCN allergic reaction and PST were equal in the PST positive and PST negative groups. Moreover, the mean elapsed time (months) between the original PCN allergic reaction and testing in children were compared with adults<sup>11</sup> by using the 2-tailed sample *t* test. By using a  $\chi^2$  test, we compared the differences in the proportion of children and adults with a positive PST. A software program (JMP version 7.0) was used to perform the statistical analyses. A *P* value (<.05) was considered statistically significant.

**RESULTS****Demographics**

Between July 8, 1993, and August 21, 2009, 778 children underwent PST and met the inclusion criteria. The overall mean  $\pm$  SD age of the study group was 5  $\pm$  3.5 years. Three hundred and sixty-seven were girls (47.1%) (Table I). None of the children had been previously included in other studies.

**Clinical characteristics of the PCN allergy and PST results**

Seven hundred and three children (90.4%) had negative PSTs, 66 patients had positive PSTs (8.5%), and 9 had equivocal PSTs (1.1%) (Figure 1). Children were more likely to have a positive PST compared with adults (66 children [8.5%] vs 64 of 1759 adults [3.6%]<sup>11</sup>; *P* < .0001). If a positive PST was defined by a wheal and flare of 5  $\times$  5 mm instead of 3  $\times$  3 mm larger than the negative control, then the children still demonstrated increased positive PSTs compared with adults, but the difference was no longer statistically significant (17 children [2.19%] vs 27 of 1759 adults [1.5%]<sup>11</sup>; *P* = .33).

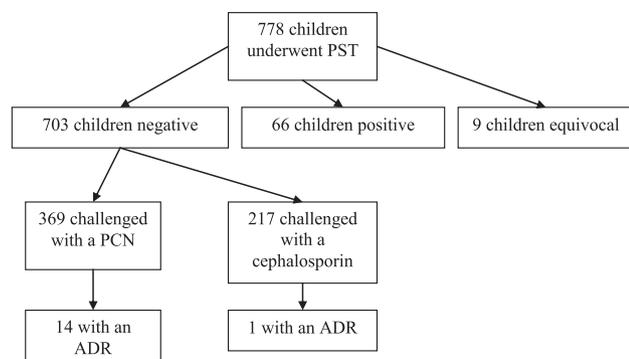
Within the positive PST group, 31 children (47%) were positive to the major determinant, 19 were positive to PCN G (29%), 23 were positive to benzylpenicilloate (35%), and 21 were positive to amoxicillin (34%) (Table II). It should be noted that 62 of the 66 children with positive PSTs were tested to amoxicillin. Only 3 of the 66 children with positive PST (4.5%) were tested with cefazolin, and 2 of these children were noted to be positive. The total percentage may exceed 100% because some patients had positive PSTs to more than 1 component (Table II).

The mean  $\pm$  SD time elapsed from the initial PCN allergic reaction to skin testing was 23  $\pm$  32 months (460 of 778 patients had information available [59%]). Patients with positive PSTs reported a shorter elapsed time between the PCN ADR and skin testing versus those with negative PSTs, but the difference was not statistically significant (mean  $\pm$  SD, 16  $\pm$  28 months vs 24  $\pm$  32 months; *P* = .15). When the time elapsed between the

**TABLE I.** Children demographics and PST results compared with adults\*

	Children (n = 778)	Adults (n = 1759)
Female patients, no. (%)	367 (47.1)	1027 (58.4)
Age (y), mean ± SD	5 ± 3.5	60 ± 15
Time since index reaction (mo), mean ± SD	24 ± 32	252 ± 180
Positive PST, no. (%)	66 (8.5)	64 (3.6)

\*The adult population data were previously published (see Ref 11).



**FIGURE 1.** Outcomes of children undergoing PST.

initial PCN ADR and skin testing in adults<sup>11</sup> who had positive PSTs were compared with children with positive PSTs, the difference was statistically significant (mean ± SD, 252 ± 180 months vs 24 ± 32 months;  $P < .0001$ ) (Table I).

Most children (from a history given by the parent) reported a history of ADR to amoxicillin (537/778 [69.0%]) before PST. Among the 66 children who demonstrated positive PSTs, 49 (74.2%) reported a history of ADR to amoxicillin. The antibiotics listed before skin testing in the allergy profile of children with positive PST are shown in Table III. Among the children with positive PSTs, rash was the most common ADR reported before skin testing (56/66 [84.8%]). The ADR was unknown in 9 of the 66 children with a positive PST (13.6%). One child with a positive PST (1.5%) reported anaphylaxis before the PST. In the children with a negative or equivocal PST, 587 of 721 ADRs were reported to be rash (81%), 127 unknown (17.6%), 8 erythema multiforme (1.1%), 7 swelling (1%), 7 respiratory difficulty (1%), 3 serum sickness (0.4%), and 3 anaphylaxis (0.4%) (some patients fit more than 1 category).

### Oral challenges with PCN after PST

Three-hundred and sixty-nine of the 703 patients with a negative PST were challenged with a PCN medication. Fourteen children (3.8%) had an ADR. The characteristics of these children are described in Table IV. The mean ± SD age of the children was 5.28 ± 3 years. Ten of the 14 children were girls (71.4%). All the children (from a history given by the parent) reported a rash as their ADR before skin testing. Two of the 14 children (14.3%) (from a history given by the parent) reported PCN as the antibiotic to which they had an ADR before testing. Most children who experienced an ADR after a negative PST (10/14 [71.4%]) reported amoxicillin or amoxicillin clavulanate as the antibiotic to which they had experienced an ADR before skin prick testing.

**TABLE II.** Positive PST determinants

Determinant	Children positive, no. (%) (n = 66)*
Major determinant	31 (47)
PCN G	19 (29)
Benzylpenicilloate	23 (35)
Amoxicillin†	21 (34)
Cefazolin‡	2 (3.5)
Major determinant only positive to that specific penicillin skin test	19 (29)
PCN G solely	6 (9)
Benzylpenicilloate only positive to that specific penicillin skin test	7 (11)
Amoxicillin only positive to that specific penicillin skin test†	10 (16)

\*Children could test positive to more than 1 reagent.

†Only 62 of the 66 children with a positive PST were tested with amoxicillin.

‡Only 3 of the 66 children with a positive PST were tested with cefazolin.

**TABLE III.** Antibiotics that caused ADR before PST

Antibiotic	Positive PST, no. patients (%) (n = 66)	Negative PST, no. patients (%) (n = 712)
Amoxicillin	49 (74.2)	488 (68.5)
PCN	8 (12.2)	96 (13.5)
Amoxicillin clavulanate	5 (7.6)	75 (10.5)
Ampicillin	1 (1.5)	4 (0.1)
Cephalexin	1 (1.5)	13 (1.8)
Unknown	2 (3.0)	36 (5.1)

One child in the group that reported an ADR to a PCN antibiotic after a negative PST experienced an ADR with PCN (1/14 [7.1%]). The remaining 13 children (92.9%) experienced an ADR with amoxicillin or amoxicillin clavulanate. Ten of the 14 children (71.4%) (from a history given by the parent) reported rash as the ADR. Rash was only described as urticaria in 1 chart; otherwise, the rash was not well characterized. Two children (14.3%) (from a history given by the parent) reported serum sickness, 1 child reported itching (7.1%), and 1 child (7.1%) was diagnosed with erythema multiforme.

### DISCUSSION

The Joint Task Force on Practice Parameters<sup>1</sup> and the European Network for Drug Allergy (ENDA)<sup>2</sup> both advocate the use of PSTs in the evaluation of PCN allergy. However, they do not address the safety or the efficacy of PST in the pediatric population despite Pre-Pen not being indicated in the pediatric population. Our study supports the safety and efficacy of using PST (benzylpenicilloyl polylysine, PCN G, penicilloate, and amoxicillin skin tests) in the evaluation of pediatric patients with a history of PCN allergy.

Multiple studies in the adult population have shown that the prevalence of ADR after negative PSTs is low.<sup>4,7,12</sup> Macy et al<sup>12</sup> followed up patients (ages, 0.2-86.1 years) for an average of 4 years after negative PSTs. They reported 3.2% of reactions in a total of 2236 PCN courses. No serious reactions were reported. Repeated PSTs were done in 33 patients older than 18 years old, and 1 had a positive PST. Sogn et al<sup>7</sup> challenged 566 patients (ages 21-97 years) with positive PCN allergy history but negative PSTs and found only 7 of patients (1.2%) had reactions that

**TABLE IV.** Characteristics of patients who tested negative with PST who had ADR after rechallenge with a PCN antibiotic

Patient no.	Age (y)	Sex	Time from reaction to test (y)	Previous ADR	Antibiotic that caused ADR before PST	Time from testing to rechallenge	Antibiotic used for rechallenge	ADR after rechallenge
1	6	F	2	Rash	Amoxicillin clavulanate	2 y	Amoxicillin	Itching
2	9	F	Unknown	Rash	Unknown	8 y	Amoxicillin	Rash*
3	8	F	Unknown	Rash	Amoxicillin	2 y	PCN	Rash
4	13	F	1	Rash	PCN	3 y	Amoxicillin	Rash*
5	7	F	2	Rash	Amoxicillin	2 y	Amoxicillin clavulanate	Urticaria
6	4	M	Unknown	Rash	Unknown	12 y	Amoxicillin	Rash
7	4	F	3	Rash	Amoxicillin	2 y	Amoxicillin	Rash*
8	4	F	Unknown	Rash	PCN	1 mo	Amoxicillin	Rash
9	3	M	1	Rash	Amoxicillin	3 mo	Amoxicillin	Erythema multiforme
10	3	F	2	Rash	Amoxicillin	4 y	Amoxicillin	Rash*
11	5	F	4	Rash	Amoxicillin	1 y	Amoxicillin	Serum sickness
12	3	F	3	Rash	Amoxicillin clavulanate	2 y	Amoxicillin clavulanate	Rash
13	4	M	3	Rash	Amoxicillin	3 y	Amoxicillin	Serum sickness
14	1	F	Unknown	Rash	Amoxicillin	1 mo	Amoxicillin clavulanate	Rash

\*After a negative PST, the patients received more than 1 course of PCN and/or amoxicillin and experienced ADR only with their last known exposure of PCN/amoxicillin.

were possibly IgE mediated. No reactions were life threatening or fatal. In a study performed by Gadde et al,<sup>4</sup> 649 patients (ages 20-80 years) with a positive PCN allergy history and negative PSTs were given PCN. The patients were followed-up for 72 hours. Fifty-four patients (9.1%) reported adverse reactions, with only 17 (2.9%) being probable IgE-mediated reactions. Anaphylaxis that consisted of urticaria, angioedema, and breathing difficulty occurred in 2 patients. Both of these patients had received parenteral PCN G procaine. These studies confirm the usefulness of PSTs in the evaluation of PCN allergy in the adult population.

However, in comparison with adults, few studies have been done in children to investigate the utility of PSTs in the evaluation of PCN allergy. In our pediatric population, 8.5% of the children with a history of PCN allergy had a positive PST. Jost et al<sup>13</sup> performed a retrospective and prospective study with 921 children and found that 177 children were positive on PST (19%). The children were tested with the major determinant, PCN G, and with penicilloate. Jost et al<sup>13</sup> collected data retrospectively from January 1, 1979, until December 31, 1992. In this group, they found that 154 of 562 children had positive test results (27%). However, in the group that was prospectively evaluated (January 1, 1993, to May 31, 2003), only 23 of 359 children had positive results (6%). The prevalence of positivity in the latter group is similar to our prevalence of 8.5% but much different than the prevalence of 27% seen in data collected before 1993. The difference in prevalence of positive PSTs between this study and our study could be due to the dates of collection. Our prevalence of positive PST is supported further by a study performed by Mendelson et al.<sup>14</sup> In this study, 240 children with a history of ADR to a PCN drug were tested with the major determinant, PCN G, penicilloate and penicillate. They found that 21 children had 1 or more positive skin tests (8.75%). Hence, our results are consistent with much of the pediatric literature.

Interestingly, Jost et al,<sup>13</sup> Mendelson et al,<sup>14</sup> and our prevalence of positive PSTs (6%, 8.75%, and 8.5%, respectively) are higher than in our adult population (3.6%).<sup>11</sup> When we compared our pediatric positive PST prevalence with the adult population in our institution, children were more likely to have had a positive PST than were adults (66 children [8.5%] vs 64

adults [3.6%]<sup>11</sup>;  $P < .0001$ ). A similar finding was noted by Macy et al,<sup>15</sup> who divided the subjects into quartiles (<30 years vs 30-50 years vs 51-65 years vs >65 years) and showed that 11.3% vs 9.1% vs 5.2% vs 3.8%, respectively, demonstrated positive PSTs. The higher rates of a positive PST may be due, in part, to the time from initial ADR to PST. The loss of PST positive response with time has been demonstrated in several studies.<sup>16,17</sup> Patients with a distant history of PCN allergy compared with those with a more recent history are more likely to lose their PCN sensitivity with time. Another explanation for the difference in the positive PST prevalence between children and adults in our institution may be due to the patient selection. However, our positive PST results in the pediatric population is comparable with adults described at other institutions (eg, 7.1% by Gadde et al<sup>4</sup>). Thus, PST in the pediatric population appears to be at least as sensitive as PSTs in the adult population in the detection of a PCN allergy mediated by IgE.

The criterion standard test to determine PCN tolerance of patients with a history of  $\beta$ -lactam allergy is oral challenge.<sup>18</sup> We also found that children with negative PST when rechallenged with a PCN had a low rate of ADR. A study performed by Ponvert et al<sup>19</sup> followed up 93 children who had a negative PST and subsequently had been treated with  $\beta$ -lactam antibiotics. Seven reported suspected allergic reactions (7.5%). Skin tests were performed with PCN G, amoxicillin, ampicillin, cefazolin, and ceftriaxone. If negative, oral challenge was performed with the suspected drug. Two of the 93 children had an ADR (2.1%). Mendelson et al<sup>14</sup> tested 240 children and found 21 patients to have positive skin tests (8.75%). Among the 219 patients with negative PSTs who were challenged with PCN, 3 had an ADR to PCN (1.4%). Caubet et al<sup>20</sup> prospectively challenged children who presented to the pediatric emergency department for a possible  $\beta$ -lactam allergy with the implicated  $\beta$ -lactam antibiotic. Six of 88 children had positive oral challenge (6.8%). Among the children with a negative skin test, 2 of 77 had a positive oral challenge (2.6%) compared with 4 of 11 positive oral challenges among the children with a positive skin test (36%). In our study, 3.8% of children with a negative PST had a positive oral challenge compared with 2.6% in the Caubet et al<sup>20</sup> study. We did not challenge our patients who were PST positive. Macy and

Ngor<sup>21</sup> also reported low positive oral challenge rates with amoxicillin among children with a negative PST (only using penicilloyl-polylysine, PCN G, and amoxicillin) (2 of 124 [1.6%]). Among adult patients with a history of PCN allergy and a negative PST who were challenged with PCN, the ADR rates also were low (1.2% by Sogn et al<sup>7</sup> and 2.9% by Gadde et al<sup>4</sup>). The low rate of ADR to PCN after a negative PST in our study (3.8%) is consistent with the pediatric and adult literature, and confirms the usefulness of PST in the evaluation of PCN allergy in the pediatric population.

The package insert for Pre-Pen defines a positive PST as a 5-mm or larger wheal compared with The Joint Task Force on Practice Parameters<sup>1</sup> recommendation of wheal with erythema at least 3 mm larger than the negative control. Our practice has been evaluating patients with PSTs since the 1960s<sup>22</sup> and has used the definition of a positive PST as wheal with erythema at least 3 mm larger than the negative control, consistent with The Joint Task Force on Practice Parameters.<sup>1</sup> However, Macy and Ngor<sup>21</sup> showed that using a 5-mm or larger wheal with erythema as the definition of a positive PST is safe. Several other studies also showed that using a larger wheal size to define a positive PST with patients with negative tests challenged orally is associated with a low risk of systemic reaction.<sup>4,7</sup> Using the definition of a 3-mm or larger wheal with erythema would result in more false positives and may result in fewer ADRs during oral challenges. One could argue that this would be safer for the patient. However, a recent study reported that patients with a history of PCN allergy are associated with increased hospital days and infections, for example, *Clostridium difficile*.<sup>23</sup> Hence, the definition of a positive PST as 3-mm or larger wheal with erythema may not be inconsequential and should be reconsidered because it may reduce the number of currently patients who are not allergic and who receive PCN.

PST has generally been considered to be safe, with a low incidence of systemic reactions. The incidence of systemic reactions is considered to be less than 1% in patients who undergo stepwise prick or intradermal PST.<sup>19,24-30</sup> However, fatalities have been reported with PST. From 1973 to 1983, 1 death after PSTs was reported in a survey of practicing allergists sponsored by the American Academy of Allergy and Immunology.<sup>31</sup> The patient had undergone intradermal testing with PCN without performing skin prick testing. None of the patients in our study experienced an ADR during skin testing, which led us to conclude that PST is relatively safe if properly performed in the pediatric population.

There are several limitations to this study. Not all patients had been challenged with PCN after a negative PST, which may have resulted in a selection bias. The 3.8% of ADRs to PCN after a negative PST is similar to previous literature,<sup>4,7,14</sup> hence, selection bias seems less likely. Because this is a retrospective chart review, it is possible that patients with a history of anaphylaxis may not have undergone PST; thus, the prevalence of positive PSTs and/or ADRs to PCN after negative PSTs may be underrepresented by our study. Another limitation of the study is a lack of penilloate used in the PST reagents, which may have led to false-negative PSTs. However, the prevalence of positive PSTs is similar to the literature,<sup>13,14</sup> which suggests the effect of not including penilloate may be minimal.

The Joint Task Force on Practice Parameters<sup>1</sup> and the ENDA<sup>2</sup> recommend the use of PST in the evaluation of patients with a history of PCN allergy. If PST is negative, then the

ENDA recommends oral challenge with PCN to confirm the PST results. The Joint Task Force on Practice Parameters<sup>1</sup> recommends that, if PST is done with benzylpenicilloyl polylysine and PCN G but without the mixed minor determinants, then PCN challenge should be considered in patients with negative PSTs because some patients with a PCN allergy may be missed without the MDM. We find that, without the penicilloate skin test, 10% of patients with PCN allergy may have been missed. Moreover, without an amoxicillin skin test, 16% of patients with PCN allergy may be missed. Thus, ideally, PST should include benzylpenicilloyl polylysine, PCN G, amoxicillin, and MDM. However, in clinical practice, the MDM is not available commercially; hence, our results confirm the recommendation by The Joint Task Force on Practice Parameters<sup>1</sup> and the ENDA<sup>2</sup> to consider PCN or amoxicillin oral challenge in the clinician's office to exclude an IgE-mediated reaction to PCN after a negative PST with benzylpenicilloyl polylysine, PCN G, and amoxicillin.

## CONCLUSION

PST is effective in evaluating children with a history of PCN allergy. Children with a negative PST are at low risk of ADR to PCN. Moreover, PST seems to be a safe procedure in that children with a history of PCN allergy are at low risk of ADR when undergoing PST.

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