

The Use of Penicillin Skin Testing to Assess the Prevalence of Penicillin Allergy in an Emergency Department Setting

Ali S. Raja, MD, MBA
Christopher J. Lindsell, PhD
Jonathan A. Bernstein, MD
Christopher D. Codispoti, MD
Joseph J. Moellman, MD

From the Departments of Emergency Medicine (Raja, Lindsell, Moellman) and Internal Medicine, Division of Immunology/Allergy Section (Bernstein, Codispoti), University of Cincinnati, Cincinnati, OH.

Study objective: Patient-reported penicillin allergies are often unreliable and can result in unnecessary changes in antibiotic therapy. Although penicillin allergy skin testing is commonly performed in allergy clinics, it has not been used in emergency departments (EDs) to verify self-reported allergies. We hypothesize that ED-based testing is possible and that the false-positive rate of patients with self-reported penicillin allergy are greater than 90%.

Methods: This prospective observational cohort study enrolled a convenience sample of ED patients with a self-reported penicillin allergy. Patients were enrolled by one of 2 emergency physicians who performed skin prick and intracutaneous tests with penicillin major and minor determinants. The total testing time was 30 minutes. The proportion of false-positive self-reported allergies was computed with 95% confidence intervals (CIs) by using the score method.

Results: A total of 150 patients (mean age 42 years; SD 16 years; 46% men; 47% black) were enrolled. The false-positive rate for self-reported penicillin allergy was 137 of 150 (91.3%; 95% CI 85.3% to 95.1%). There were no adverse reactions associated with penicillin skin testing. Compared with patients with a false-positive penicillin allergy result (confirmed by negative penicillin skin testing result), patients reporting a true penicillin allergy confirmed by positive penicillin skin test results tended to be more frequently men (61.5% versus 44.5%; Δ 17.0%; 95% CI –13.5% to 42%), black (69.2% versus 44.5%; Δ 24.7%; 95% CI –6.9% to 46.8%), and have no family history of drug allergy (7.7% versus 17.5%; Δ 9.8%; 95% CI –20.9% to 20.4%), but self-reported other drug allergies more frequently (61.5% versus 38.7%; Δ 22.9%; 95% CI –7.7% to 47.5%).

Conclusion: Penicillin skin testing is feasible in the ED setting. A substantial number of patients who self-report a penicillin allergy do not exhibit immunoglobulin E-mediated sensitization to penicillin major and minor determinants. Penicillin testing in the ED may allow the use of more appropriate antibiotics for patients presenting with a history of penicillin allergy. [Ann Emerg Med. 2009;xx:xxx.]

0196-0644/\$-see front matter

Copyright © 2009 by the American College of Emergency Physicians.

doi:10.1016/j.annemergmed.2008.12.034

INTRODUCTION

Penicillin, the first antibiotic discovered,¹ remains extremely effective in several disease processes, and its derivatives are first-choice therapies for many patients in the emergency department (ED).^{2,3} The prevalence of patient self-reported penicillin allergy is reported to be as high as 20%.⁴⁻⁶ Unfortunately, it has been demonstrated that patient self-reported penicillin allergy history is unreliable,⁷ and many patients are unable to accurately recall the nature of the reaction they had to the drug.⁴ A history of penicillin allergy can pose a significant problem because many patients in the ED require antibiotics, and in the presence of a reported penicillin allergy, second-line antibiotics are often substituted.⁸ The use of these broad-spectrum drugs, combined

with the microbe-rich environment of the ED, is an ideal milieu for the growth of resistant bacterial organisms and the subsequent emergence of multidrug-resistant pathogens.⁹

Allergists and clinical immunologists have used penicillin skin testing for more than 50 years¹⁰ to determine whether patients exhibit an immunoglobulin E (IgE)-mediated reaction to this drug. This rapid (approximately 30 minutes) test has been demonstrated to be safe¹¹ and reliable,^{12,13} with only 2 documented cases of anaphylaxis resulting in death, both of which occurred more than 50 years ago with skin test reagents vastly different from those used today.^{14,15} Previous studies demonstrate that more than 85% of patients with a self-reported history of penicillin allergy have negative penicillin

Editor's Capsule Summary

What is already known on this topic

Many patients who report penicillin allergy are not truly allergic to penicillin, and this can limit antimicrobial choices.

What question this study addressed

Can emergency department (ED) skin testing of patients who report penicillin allergy identify a group who do not have a true allergy?

What this study adds to our knowledge

In 150 patients reporting penicillin allergy, a 30-minute skin prick and intracutaneous test performed in the ED found that 91% did not have a true immunoglobulin E-mediated penicillin allergy.

How this might change clinical practice

Skin testing for penicillin allergy can feasibly be done in the ED by emergency physicians after brief training, which may allow more appropriate antibiotic selection in certain cases.



Figure. Penicillin skin testing.

skin test results.¹⁶⁻²⁰ Penicillin skin testing is routinely performed in outpatient allergy clinics and has been evaluated in the ICU²¹ and in nonallergy outpatient clinics.²² However, to our knowledge, there have been no studies investigating the feasibility of using penicillin skin testing in the ED or whether such testing could alter the treatment decisions for these patients.

This study was designed to investigate whether ED-based penicillin skin testing was feasible and to determine the rate of false-positive self-reported penicillin allergy in our patient population. We hypothesized that ED-based testing is possible and that the false-positive rate of patients with self-reported penicillin allergy would be greater than 90%. Potential direct antibiotic cost savings if penicillin skin test results were known were also estimated.

MATERIALS AND METHODS

Study Design and Setting

This was a prospective observational cohort study of penicillin skin testing at an urban, academic ED. The study was approved by the local institutional review board, and written consent was obtained from all participants. All enrolled participants were offered follow-up at an affiliated allergy and immunology clinic for further evaluation of their history of penicillin allergy.

Selection of Participants

Participants were enrolled between April 2007 and October 2007 by one of 2 emergency physicians. Participants were

serially enrolled when the investigators were available in the ED, resulting in a convenience sample of patients. Eligible patients were those who were older than 18 years and who self-reported a penicillin allergy during triage. Patients previously enrolled in the study, who were known to be pregnant, or who were unable to consent were excluded.

Methods of Measurement

All patients were skin prick tested by one of 2 emergency physicians (A.S.R. or J.J.M.), who had each been trained to perform the skin test by an allergy and immunology specialist (J.A.B. or C.D.C.). The 30-minute training involved both the administration and interpretation of penicillin skin prick and intracutaneous tests. Competency was assessed by evaluating the emergency physicians' abilities to discern positive and negative test results at the end of the session. Testing was conducted on the volar surface of either forearm, with both major determinant and minor determinant mixture reagents, in conjunction with a normal saline solution negative control and a positive histamine hydrochloride control. If the penicillin skin prick test results were negative at 15 minutes, intracutaneous tests were conducted with 0.02 mL of the major determinant and minor determinant mixture, along with a saline solution control, and evaluated after an additional 15 minutes. Positioning of the tests is shown in the [Figure](#).

Skin prick and intracutaneous test results were measured with calipers and were considered positive if either the major determinant or the minor determinant mixture resulted in a wheal diameter greater than or equal to 3 mm larger than the negative control with a flare. The patient's treating physicians were blinded to the results of skin testing. They were also asked which antibiotics they would have used if the patient had not reported a penicillin allergy, and the actual antibiotics prescribed were recorded. Standard Red Book²³ average wholesale drug costs were obtained for all prescribed and first-choice antibiotics. All results were recorded on standardized case

Table 1. Characteristics of patients (No. (%) unless otherwise indicated).

Characteristics	No Penicillin Allergy on Testing, N=137	Penicillin Allergy on Testing, N=13	Total, N=150
Age, y, mean (SD)	41.9 (15.5)	41.6 (16.5)	41.9 (15.6)
Female	76 (55.5)	5 (38.5)	81 (54.0)
Black	61 (44.5)	9 (69.2)	70 (46.7)
Hispanic	1 (0.7)	0 (0.0)	1 (0.7)
Asian	2 (1.5)	0 (0.0)	2 (1.3)
White	73 (53.3)	4 (30.8)	77 (51.3)
Family history of drug allergy	24 (17.5)	1 (7.7)	25 (16.7)
Patient reported allergies to other drugs	53 (38.7)	8 (61.5)	61 (40.7)

Table 2. Patient self-reported allergy histories, No. (%).

Allergy History	No Penicillin Allergy on Testing, N=137	Penicillin Allergy on Testing, N=13
Told by family only	49 (35.8)	5 (38.5)
Told by physician only	6 (4.4)	0 (0)
Adverse reaction only	62 (45.3)	6 (46.2)
Told by physician and family	3 (2.2)	1 (7.7)
Adverse reaction and told by family	9 (6.6)	0 (0)
Adverse reaction and told by physician	8 (5.8)	1 (7.7)
Known of allergy for <1 y	2 (1.5)	1 (7.7)
Known of allergy for 1–5 y	8 (5.8)	2 (15.4)
Known of allergy for >5 y	107 (78.1)	9 (69.2)
Known of allergy for unknown time	20 (14.6)	1 (7.7)
No known previous skin test for penicillin allergy	137 (100)	11 (84.6)
Previous skin test for penicillin allergy	0 (0)	2 (15.4)

report forms, which were also used to record anonymous demographic information and patient-report allergy histories for both the patient and the family.

Primary Data Analysis

The primary outcome measure was the result of the penicillin skin test. The proportion of false-positive self-reported penicillin allergies was computed, as were 95% confidence intervals (CIs), by using the score method with continuity correction. Our hypothesized false-positive penicillin allergy rate of 90% was used to determine that a sample size of at least 139 patients would be needed for the 95% CIs to extend $\pm 5.0\%$ from our observed false-positive rate. Analyses used SPSS version 15.0 (SPSS Inc., Chicago, IL) or Microsoft Excel (Microsoft Corporation, Redmond, WA).

RESULTS

There were 168 patients approached, of whom 150 consented to testing. The characteristics of the enrolled patients and the results of skin testing are summarized in Table 1. The mean age was 42 years (SD 16 years), 46% were men, and 47% were black. There were no adverse reactions associated with penicillin skin testing, and our hypothesis that penicillin skin testing would be feasible in the ED was borne out.

The penicillin skin test result was negative in 137 of the 150 cases. This false-positive rate for self-reported penicillin allergy of 91.3% (95% CI 85.3% to 95.1%) supports our hypothesis that the rate would be greater than 90%. Compared with

patients with negative penicillin skin test results and patient-reported allergy, patients with positive skin test results tended to be more frequently men (61.5% versus 44.5%; Δ 17.0%; 95% CI -13.5% to 42%), black (69.2% versus 44.5%; Δ 24.7%; 95% CI -6.9% to 46.8%), and had no family history of drug allergy (7.7% versus 17.5%; Δ 9.8%; 95% CI -20.9% to 20.4%), but self-reported other drug allergies more frequently (61.5% versus 38.7%; Δ 22.9%, 95% CI -7.7% to 47.5%).

The sources from whom the patients found out about their reported penicillin allergies are summarized in Table 2. Among the 79 patients who reported at least 1 adverse reaction and were found to have a negative skin test result, the adverse reactions included a rash in 63 cases, shortness of breath in 26, facial swelling in 26, and some other reaction in 9 cases. For the 7 patients who reported at least 1 adverse reaction to penicillin and who had positive skin test results, 4 reported a rash, 1 reported shortness of breath, 2 reported facial swelling, and 2 reported some other reaction. There was a tendency for those with a positive skin test result to have known about their allergy for less time than those without a positive skin test result; 23.1% of those with a positive skin test result had known for 5 years or fewer compared with 7.3% of those with a negative test result (Δ 15.8%; 95% CI -2.2% to 46.9%). Patients with a positive skin test result were also more likely to have had previous penicillin skin testing than those without a positive test result (15.4% versus 0%; Δ 15.4%; 95% CI 2.3% to 46.3%).

Of the 13 patients with a positive penicillin skin test result, 8 tested positive to the major determinant (6 skin prick and 2

Table 3. Physician antibiotic changes for patients prescribed antibiotics.

Positive PCN Skin Test Result	First Antibiotic Choice	Cost for Dosing Regimen (\$)	Alternative Antibiotic Choice	Cost for Dosing Regimen (\$)
No	Penicillin V potassium	16.80	Erythromycin	7.56
No	Amoxicillin	25.20	Azithromycin	47.00
No	Benzathine penicillin G	5.90	Azithromycin	47.00
No	Ampicillin/sulbactam	323.68	Ciprofloxacin/metronidazole	463.68
No	Ceftriaxone	101.20	Vancomycin	117.60
No	Penicillin V potassium	24.00	Clindamycin	148.80
No	Cephalexin+trimethoprim/sulfamethoxazole	47.60	Trimethoprim/sulfamethoxazole	5.60
No	Cephalexin+trimethoprim/sulfamethoxazole	68.00	Trimethoprim/sulfamethoxazole	8.00
No	Amoxicillin	12.60	Azithromycin	47.00
No	Benzathine penicillin G	5.90	Clindamycin	104.16
No	Cephalexin+trimethoprim/sulfamethoxazole	47.60	Trimethoprim/sulfamethoxazole	5.60
No	Benzathine penicillin G	5.90	Clindamycin	104.16
No	Cephalexin+/trimethoprim/sulfamethoxazole	47.60	Clindamycin+trimethoprim/sulfamethoxazole	109.76
No	Piperacillin/tazobactam	402.64	Imipenem/cilastatin	932.96
No	Ceftriaxone	2.23	Ciprofloxacin	6.42
No	Penicillin V potassium	24.00	Clindamycin	148.80
No	Cephalexin+trimethoprim/sulfamethoxazole	47.60	Trimethoprim/sulfamethoxazole	8.00
No	Ceftriaxone	70.84	Moxifloxacin	306.25
No	Benzathine penicillin G	5.90	Clindamycin	104.16
No	Ceftriaxone	30.36	Moxifloxacin	131.25
No	Cephalexin+trimethoprim/sulfamethoxazole	47.60	Clindamycin+trimethoprim/sulfamethoxazole	109.76
Yes	Ceftriaxone	30.36	Moxifloxacin	131.25
Yes	Cephalexin+trimethoprim/sulfamethoxazole	47.60	Clindamycin+trimethoprim/sulfamethoxazole	109.76
Yes	Cephalexin+trimethoprim/sulfamethoxazole	68.00	Clindamycin+trimethoprim/sulfamethoxazole	156.80
Yes	Benzathine penicillin G	5.90	Clindamycin	104.16
Yes	Penicillin V potassium	24.00	Azithromycin	47.00
Yes	Ceftriaxone	2.23	Ciprofloxacin	6.42
Yes	Cephalexin+trimethoprim/sulfamethoxazole	68.00	Clindamycin+trimethoprim/sulfamethoxazole	156.80

PCN, Penicillin.

intracutaneous), 3 tested positive to the minor determinant mixture (2 skin prick and 1 intracutaneous), and 2 tested positive to both the major determinant and the minor determinant mixture skin prick testings.

In 33 of the 137 cases in which a false-positive penicillin allergy was reported, the physician prescribed an antibiotic (24.1%; 95% CI 17.4% to 32.3%). In 23 of 33 cases (69.7%; 95% CI 51.1% to 83.8%), the first choice of a penicillin or penicillin-derivative antibiotic was contraindicated by the self-reported history of penicillin allergy. However, in 2 of these cases, the physician disregarded this history and continued to use a penicillin-derivative antibiotic. Among the 13 true-positive reports of penicillin allergy confirmed by penicillin skin testing, the treating physician prescribed antibiotics in 8 cases (61.5%; 95% CI 32.3% to 84.9%). The first choice of a penicillin or penicillin-derivative antibiotic was contraindicated by the self-reported history of penicillin allergy in 7 of 8 cases (87.5%; 95% CI 46.7% to 99.3%). The individual antibiotic changes required because of a history of penicillin allergy are summarized in Table 3.

Among those patients with a false-positive penicillin allergy according to penicillin skin testing and for whom the first choice of a penicillin or penicillin-derivative antibiotic was not prescribed (n=21), the median antibiotic cost between the first

choice and prescribed antibiotics increased from \$30.36 to \$104.16 (difference between medians of \$73.80; 95% CI \$17.17 to \$130.43). Among those patients with a true-positive penicillin allergy history for whom the first-choice antibiotic would have been a penicillin or penicillin derivative (n=7), the median antibiotic cost between the first choice and prescribed antibiotics increased from \$30.36 to \$109.76 (a difference between medians of \$79.40; 95% CI \$12.88 to \$145.92).

LIMITATIONS

The results of this study should be interpreted with consideration to several limitations inherent in its design. First, skin testing was conducted by emergency physicians trained by an allergy specialist; whether this is generalizable to contemporary ED practice outside of our study conditions is unknown. Also, the convenience sample may limit generalizability, although we do not expect there to have been bias introduced by our approach. The crude calculations of cost savings are provided as examples only and, because costs were gathered from the 2006 Red Book,²³ may have changed since then. A formal cost-effectiveness analysis is currently under way but is beyond the scope of this article.

A practical limitation of the generalizability of this study is the unavailability of commercial penicillin skin test reagents.

The Food and Drug Administration removed penicillin skin test reagents from the market in 2004 because they were reclassified as penicillin products and the manufacturer at that time was not approved to produce such products.^{24,25} Since then, penicillin skin testing has been confined to large academic institutions with the facilities to produce their own reagents according to well-published protocols.²⁶ This is likely to change in the near future because at least 2 manufacturers are in the process of developing commercially available penicillin skin test kits.²⁷⁻²⁹

Although not direct limitations of the study design, certain caveats of penicillin skin testing itself are important for both the treating physician and patient to understand. Penicillin major and minor determinants are useful only for excluding IgE-mediated penicillin drug reactions. Patients presenting with penicillin allergy may still have had a reaction that was due to other non-IgE-mediated immune responses or other nonimmunologic mechanisms. Furthermore, patients with a remote penicillin allergy may have diminished specific IgE antibody levels over time, so negative penicillin testing results do not completely exclude the potential for developing IgE-mediated responses in the future.⁴ This would be due to reactivation of memory T and B cells and could lead to a specific IgE-mediated penicillin response.

DISCUSSION

Our results are supportive of the feasibility of conducting penicillin skin testing in the ED and demonstrate the potential influence of conducting skin testing in the ED. The rate of false-positive reports of penicillin allergy in our patient population was high: more than 90% of patients reporting a penicillin allergy did not have a positive skin test result. These findings are consistent with previous reports from other non-ED patient populations, which also found high false-positive rates (>85%) of self-reported penicillin allergy.¹⁶⁻²⁰

The ED, in contrast to other clinical locations, presents potential challenges to allergy testing because of the multiple parallel clinical processes occurring simultaneously during the treatment of a patient population with diverse complaints. According to our experience, if performed early in the patient's treatment course, penicillin skin testing should not increase patients' length of stay and should provide useful information on which to base treatment decisions. Recently revised guidelines for allergy testing recommend that penicillin skin testing be performed only by "personnel skilled in the application and interpretation of this skin testing, with preparedness to treat potential anaphylaxis."³⁰

Current evidence suggests that patients with positive penicillin skin test reactions should be prescribed an alternative class of antibiotics, whereas those with a negative skin test result have the potential for being treated with penicillin or a penicillin derivative; reports from previous studies in other outpatient settings have found no adverse events among patients who have negative penicillin skin testing results and are administered penicillin.^{21,22} However, our study was not designed to support the safety of this approach, and until this

has been demonstrated, oral penicillin challenges should be performed under the supervision of an experienced allergy specialist. It is essential that clinicians continue to follow published guideline recommendations for the evaluation and treatment of patients with drug allergy until specific drug skin test reagents that will allow experts to rethink currently accepted treatment algorithms³¹ become available again.

The introduction of penicillin skin testing to the ED environment could help decrease the overuse of broad-spectrum antibiotics in the ED, a practice that is thought to contribute to the development of antibiotic resistance.^{8,32,33} Use of broad-spectrum antibiotics often occurs in patients presenting with a reported allergy to penicillin.^{8,18} The referral of patients to an experienced allergist who can perform appropriate diagnostic testing to determine whether or not they can tolerate a penicillin or penicillin derivative, when possible, is recommended.³⁴ However, patients presenting to the ED are often critically ill and need antibiotics urgently. Further, although all enrolled patients were offered a follow-up appointment in an allergy clinic, none followed up on our recommendation, which is in keeping with previous studies of the poor follow-up rates of ED patients.^{35,36} Incorporation of a 30-minute penicillin skin test protocol as a standard procedure for patients presenting with a self-reported penicillin allergy could provide emergency physicians with alternative options for treating these patients.

In conclusion, our results suggest that penicillin allergy testing is feasible in the ED setting. The high false-positive rate of penicillin allergies, more than 90%, is consistent with that of reports from other settings and further supports the need for a rapid test for penicillin allergies in the ED patient population.

Supervising editor: Gregory J. Moran, MD

Author contributions: ASR, CJL, JAB, CDC, and JJM conceived the study and designed the trial. ASR and JJM obtained research funding and conducted the trial and data collection. CDL provided statistical advice on study design and analyzed the data. ASR and JJM drafted the article, and all authors contributed substantially to its revision. JJM takes responsibility for the paper as a whole.

Funding and support: By *Annals* policy, all authors are required to disclose any and all commercial, financial, and other relationships in any way related to the subject of this article that might create any potential conflict of interest. See the Manuscript Submission Agreement in this issue for examples of specific conflicts covered by this statement. Supported by a Resident Research Grant from the University of Cincinnati Department of Emergency Medicine.

Publication dates: Received for publication November 6, 2008. Revision received December 11, 2008. Accepted for publication December 30, 2008.

Presented at the Society for Academic Emergency Medicine annual meeting, May 2008, Washington, DC.

Reprints not available from the authors.

Address for correspondence: Joseph Moellman, MD, University of Cincinnati, Department of Emergency Medicine, Cincinnati, OH 45221-0769; 513-558-5281, Fax 513-558-5791; E-mail joseph.moellman@uc.edu.

REFERENCES

- Grossman CM. The first use of penicillin in the United States. *Ann Intern Med*. 2008;149:135-136.
- Gilbert D, Moellering RC, et al. *The Sanford Guide to Antimicrobial Therapy*. 36th ed. Sperryville, VA: Antimicrobial Therapy, Inc; 2006.
- Warnke PH, Becker ST, Springer IN, et al. "Grandmother penicillin"—not in vogue, but clinically still effective. *J Antimicrob Chemother*. 2008;61:960-962.
- Mendelson L. Adverse reactions to β -lactam antibiotics. *Immunol Allergy Clin North Am*. 1998;18:745-756.
- Nicklas R, Bernstein IL, Li JT, et al. β -Lactam antibiotics: the diagnosis and management of anaphylaxis. *J Allergy Clin Immunol*. 1999;101:S498-S501.
- Surtees S, Stockton MG, Gietzen TW. Allergy to penicillin: fable or fact? *BMJ*. 1991;302:1051-1052.
- Sogn DD, Evans R 3rd, Shepherd GM, et al. Results of the National Institute of Allergy and Infectious Diseases Collaborative Clinical Trial to test the predictive value of skin testing with major and minor penicillin derivatives in hospitalized adults. *Arch Intern Med*. 1992;152:1025-1032.
- Yates AB. Management of patients with a history of allergy to beta-lactam antibiotics. *Am J Med*. 2008;121:572-576.
- File T Jr. Overview of resistance in the 1990's. *Chest*. 1999;115:3S-8S.
- De Weck A, Blum G. A new skin test for the detection of penicillin allergy. *Praxis*. 1963;52:67-70.
- Valyasevi M, Van Dellen R. Frequency of systematic reactions to penicillin skin tests. *Ann Allergy Asthma Immunol*. 2000;85:363-365.
- Sarti W. Routine use of skin testing for immediate penicillin allergy to 6,764 patients in an outpatient clinic. *Ann Allergy*. 1985;55:157-161.
- Yeager LB, Kvinge VE. Penicillin skin test procedure and prevention of penicillin reactions. *Lancet*. 1965;85:126-128.
- Drägin GB. Anaphylactic shock with fatal outcome following an intradermal test for sensitivity to penicillin. *Ter Arkh*. 1966;38:118-119.
- Pawlowski K, Balasz W. Sudden death after a test for sensitivity to penicillin. *Pol Tyg Lek*. 1966;21:1940-1941.
- Gadde J, Spence, M, Wheeler B, et al. Clinical experience with penicillin skin testing in a large inner-city STD clinic. *JAMA*. 1993;270:2456-2463.
- Lin R. A perspective on penicillin allergy. *Arch Intern Med*. 1992;152:930-937.
- del Real GA, Rose ME, Ramirez-Atamoros MT, et al. Penicillin skin testing in patients with a history of beta-lactam allergy. *Ann Allergy Asthma Immunol*. 2007;98:355-359.
- Stember RH. Prevalence of skin test reactivity in patients with convincing, vague, and unacceptable histories of penicillin allergy. *Allergy Asthma Proc*. 2005;26:59-64.
- Whitmore SE. How predictive is a history of penicillin allergy? *JAMA*. 2001;286:1174-1175.
- Arroliga ME, Wagner W, Bobek MB, et al. A pilot study of penicillin skin testing in patients with a history of penicillin allergy admitted to a medical ICU. *Chest*. 2000;118:1106-1108.
- Borch JE, Andersen KE, Bindslev-Jensen C. The prevalence of suspected and challenge-verified penicillin allergy in a university hospital population. *Basic Clin Pharmacol Toxicol*. 2006;98:357-362.
- Fleming T. *2006 Red Book: Pharmacy's Fundamental Reference*. Montvale, NJ: Thompson PDR; 2006.
- Blanca M, Romano A, Torres MJ, et al. Continued need of appropriate betalactam-derived skin test reagents for the management of allergy to betalactams. *Clin Exp Allergy*. 2007;37:166-173.
- Schafer JA, Mateo N, Parlier GL, et al. Penicillin allergy skin testing: what do we do now? *Pharmacotherapy*. 2007;27:542-545.
- Parker C. Conjugation of penicillin and its derivatives. In: Chase R, Williams C, eds. *Methods in Immunology and Immunochemistry*. New York, NY: Academic Press; 1967:133-143.
- Matheu V, Perez E, Gonzalez R, et al. Assessment of a new brand of determinants for skin testing in a large group of patients with suspected beta-lactam allergy. *J Invest Allergol Clin Immunol*. 2007;17:257-260.
- Romano A, Viola M, Bousquet PJ, et al. A comparison of the performance of two penicillin reagent kits in the diagnosis of beta-lactam hypersensitivity. *Allergy*. 2007;62:53-58.
- Treudler R, Simon JC. PPL and MDM skin test: new test kit is helpful in detecting immediate-type allergy to beta-lactams. *J Dtsch Dermatol Ges*. 2007;5:286-292.
- Bernstein IL, Li JT, Bernstein DI, et al. Allergy diagnostic testing: an updated practice parameter. *Ann Allergy Asthma Immunol*. 2008;100(3 suppl 3):S1-148.
- Executive summary of disease management of drug hypersensitivity: a practice parameter. Joint Task Force on Practice Parameters, the American Academy of Allergy, Asthma and Immunology, the American Academy of Allergy, Asthma and Immunology, and the Joint Council of Allergy, Asthma and Immunology. *Ann Allergy Asthma Immunol*. 1999;83(6 pt 3):665-700.
- Vanderweil SG, Tsai CL, Pelletier AJ, et al. Inappropriate use of antibiotics for acute asthma in United States emergency departments. *Acad Emerg Med*. 2008;15:736-743.
- Ryan RJ, Lindsell C, Sheehan P. Fluoroquinolone resistance during 2000-2005: an observational study. *BMC Infect Dis*. 2008;8:71.
- Bernstein JA. Allergic drug reactions. How to minimize the risks. *Postgrad Med*. 1995;98:159-160, 163-166.
- Vukmir RB, Kremen R, Dehart DA, et al. Compliance with emergency department patient referral. *Am J Emerg Med*. 1992;10:413-417.
- Vinker S, Kitai E, Or Y, et al. Primary care follow up of patients discharged from the emergency department: a retrospective study. *BMC Fam Pract*. 2004;5:16.

Editor's Capsule Summary: What is already known on this

topic: Many patients who report penicillin allergy are not truly allergic to penicillin, and this can limit antimicrobial choices.

What question this study addressed: Can emergency department (ED) skin testing of patients who report penicillin allergy identify a group who do not have a true allergy? What this study

adds to our knowledge: In 150 patients reporting penicillin allergy, a 30-minute skin prick and intradermal test performed in the ED found that 91% did not have a true immunoglobulin E-mediated penicillin allergy. *How this might change clinical practice:* Skin testing for penicillin allergy can feasibly be done in the ED by emergency physicians after brief training, which may allow more appropriate antibiotic selection in certain cases.