

Poison Ivy, Oak, and Sumac Dermatitis: What Is Known and What Is New?

Yesul Kim, MD,* Alexandra Flamm, MD,* Mahmoud A. ElSohly, PhD,†‡ Daniel H. Kaplan, MD, PhD,§ Raymond J. Hage Jr, MBA,|| Curtis P. Hamann, MD,¶ and James G. Marks Jr, MD*

Poison ivy, poison oak, and poison sumac are the most common causes of clinically diagnosed allergic contact dermatitis in North America. Approximately 50% to 75% of the US adult population is clinically sensitive to poison ivy, oak, and sumac. We reviewed the botany and history of these plants; urushiol chemistry and pathophysiology, clinical features, and the prevalence of allergic contact dermatitis caused by these plants; and current postexposure treatment and preventive methods, including ongoing investigations in the development of a vaccine (immunotherapy). Although extensive efforts have been made to develop therapies that prevent and treat contact dermatitis to these plants, there lacks an entirely effective method, besides complete avoidance. There is a need for a better therapy to definitively prevent allergic contact dermatitis to these plants.

BOTANY

Poison ivy, poison oak, and poison sumac are members of the Anacardiaceae family of plants and in the genus *Toxicodendron*. The 2 species of poison ivy are *Toxicodendron rydbergii*, a nonclimbing, dwarf shrub found in northern and western United States, and *Toxicodendron radicans*, a climbing vine found in the eastern United States. The 2 species of poison oak are *Toxicodendron toxicarium* and *Toxicodendron diversilobum*. Poison ivy has 3 leaflets, and poison oak can have 3 to 5 leaflets (Fig. 1). Poison sumac, or *Toxicodendron vernix*, is a small shrub that grows in moist, swampy areas. It can be identified by its stem, which bears 7 to 13 smooth-edged, pointed leaves (Fig. 1).¹ Clusters of green fruit that grow in the angle between the twig and leaf are specific to all *Toxicodendron* species.²

History

The first written account of poison ivy was in 1624 by explorer John Smith, governor of Bermuda, who compared it with “English ivy, but being but touched, causeth rednesse, itchyng, and lastly blisters.”³ Over the centuries, botanists, physicians, and chemists curiously searched for possible positive applications of poison ivy.³

From the *Department of Dermatology, Penn State Hershey Medical Center, Hershey, PA; †National Center for Natural Products Research and Department of Pharmaceutics and Drug Delivery, University of Mississippi; ‡ElSohly Laboratories, Incorporated, Oxford, MS; §Department of Dermatology, University of Pittsburgh, PA; ||Hapten Sciences, Memphis, TN; and ¶Contact Dermatitis Institute, Phoenix, AZ.

Address reprint requests to: Yesul Kim, MD, 500 University Dr, PO Box 850, Hershey, PA 17033. E-mail: ykim4@pennstatehealth.psu.edu.

J.G.M. is a consultant to Hapten Sciences, Inc.

DOI: 10.1097/DER.0000000000000472

© 2019 American Contact Dermatitis Society. All Rights Reserved.

For instance, an 18th-century French physician and professor, Andre-Ignace-Joseph Dufresnoy, intrigued by how a sore on the wrist of a student completely vanished after exposure to poison ivy, created infusions and distillations derived from poison ivy.³ He claimed that these led to improvement in a variety of medical maladies, including skin conditions and leg paralysis. In addition, the *Toxicodendron* family has known applications outside of medicine, such as the lacquer of *Toxicodendron vernicifluum* (Japanese lacquer tree) being used to coat wooden and metal objects.

Prevalence

Toxicodendron dermatitis affects up to 10 to 50 million Americans per year.⁴ Approximately 50% to 75% of the US adult population is clinically sensitive to poison ivy, oak, and sumac.² It affects all ethnicities, skin types, and ages, and most geographical regions in the United States are at risk.⁵ *Toxicodendron* dermatitis is a major contributor to the 9 million office visits and 1.6 million hospital outpatient visits for contact dermatitis in the United States annually.^{6,7} According to the US Centers for Disease Control and Prevention, emergency department visits for poison ivy or skin rash rose from 472,000 in 2002 to 929,290 in 2012.⁸ Occupations with outdoor exposure, including construction workers, forestry workers, farm workers, landscapers, forest firefighters, and telephone line workers, are particularly affected, and *Toxicodendron* dermatitis is covered by workman's compensation in California.⁹ In 2011, the cost of treatment accounted for up to 1% of California's yearly workers' compensation budget, with the total budget in 2014 of approximately US \$11.4 billion.⁹ In a review of a 2016 data set consisting of commercially insured persons throughout the United States, most patients diagnosed with *Toxicodendron* dermatitis were evaluated and treated in the outpatient setting by family practice physicians, whereas dermatologists were the fourth most common providers

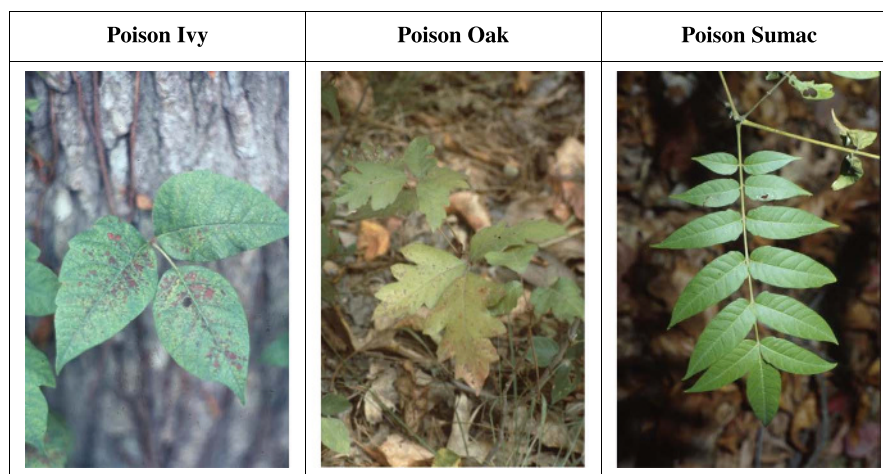


Figure 1. Botany of poison ivy, poison oak, and poison sumac.

involved in the diagnosis and treatment of this condition.¹⁰ When diagnosed, almost half of patients did not receive any treatment.¹⁰ The most common treatment received was oral steroids, which was approximately two-thirds the cost of high-potency topical corticosteroids.¹⁰ Cost of diagnosis in the emergency department is on average 5 times that in the outpatient setting.¹⁰ Interestingly, the increase in atmospheric carbon dioxide not only is potentially responsible for increased photosynthesis, water use efficiency, and growth and population biomass of poison ivy, but also produces a more allergenic form of urushiol.¹¹ Therefore, climate change and specifically the increase in atmospheric carbon dioxide concentrations can be expected to magnify the prevalence of urushiol dermatitis.

Urushiol Chemistry

The allergens responsible for *Toxicodendron* dermatitis are contained within the resinous sap material, termed urushiol, which is derived from the Japanese word for “sap.” Urushiol is found in the stems, roots, leaves, and skins of the fruits of these plants, which must be bruised to release allergens. Urushiol is composed of a mixture of catechols with a straight alk(en)yl side chain at the C3 position (Fig. 2).¹² Both the catecholic ring and aliphatic chain play important roles in the allergenicity of urushiol.¹³ The degree of saturation and length of side chains vary with different catechols.¹² For instance, poison ivy urushiol contains predominantly 3-*n*-pentadecylcatechols (PDCs, C15 side chain), whereas poison oak contains 3-*n*-heptadecylcatechols (HDCs, C17 side chain) (Fig. 2).¹² Because the urushiols in poison ivy, oak, and sumac differ only slightly in structure, a person sensitized to one will react to all plants, because of the phenomenon of cross-reactivity. Other plants that contain urushiol cross-reacting chemicals include the following: (a) *Anacardium occidentale*, the tropical cashew nut tree; (b) *Mangifera indica*, the tropical mango tree; (c) *Ginkgo biloba*, the ginkgo tree; (d) *Semecarpus anacardium*,

the Indian marking nut tree; and (e) *T. vernicifluum*, the Japanese lacquer tree.¹²

Urushiol Pathophysiology

The typical allergic contact dermatitis to poison ivy, oak, and sumac is a type IV hypersensitivity reaction to urushiol. Allergic contact dermatitis is initiated by contact with urushiol catechols, which avidly bind to and penetrate the skin, where they are oxidized to quinone intermediates and bind surface proteins on antigen-presenting cells, such as Langerhans cells (LCs) in the epidermis and dermis.² Langerhans cells are the only cells known to express langerin (CD207), a C-type lectin that is sufficient to induce formation of Birbeck granules.¹⁴ CD1a, a class I major histocompatibility complex molecule, found in Birbeck granules,¹⁵ in addition to langerin, is necessary for LCs to efficiently present nonpeptide antigens, such as urushiol, to T cells.¹⁶ It has been shown that poison ivy-induced skin inflammation is dominated by CD1a, a lipid-presenting molecule expressed on LCs in humans but not in mice. In CD1a-transgenic mice, urushiol triggers CD1a-dependent skin inflammation, driven by CD4⁺ T cells that produce interleukins 17 and 22, which are similar to cytokines in human subjects with poison ivy dermatitis.¹⁷ Langerhans cells internalize and process the urushiol self-hapten neoantigen, which is then presented to sensitized CD4⁺ T cells.¹ These lymphocytes expand and form circulating activated T-effector and ultimately T-memory lymphocytes.¹⁸ The linkage of the hapten and carrier protein by an amino nucleophile seems to lead to selective induction of T-effector cells, leading to allergic contact dermatitis, whereas the linkage of the hapten and carrier protein by a sulfhydryl bond seems to lead to selective induction of suppressor cells, leading to a reduced allergic contact dermatitis.¹⁹ After subsequent contact, these T-effector cells elicit a cell-mediated cytotoxic immune response that destroys epidermal cells and activates dermal vasculature.² The incidence and intensity of poison ivy sensitivity seem to decline proportionately with age in the

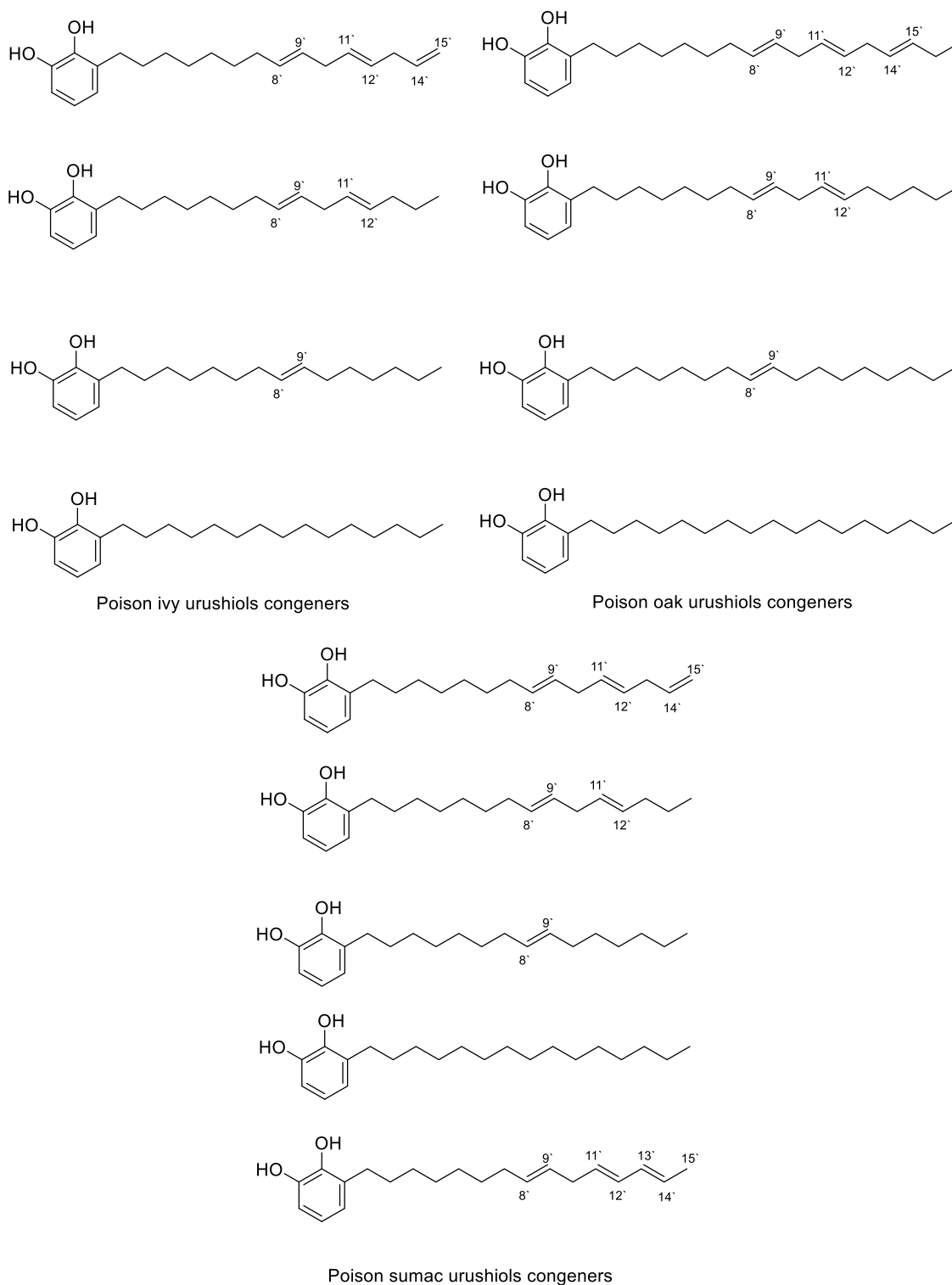


Figure 2. Chemical structures of urushiol in poison ivy, oak, and sumac.

absence of continued exposure.²⁰ In contrast to classical immune responses in which booster doses generally produce a rapid, elevated, and sustained rise in circulating antibodies, allergic contact

dermatitis does not characteristically have booster effects for antibody response.²¹ Furthermore, there is no evidence that one can spontaneously acquire immunity.²⁰

Clinical Features

Classically, allergic contact dermatitis from poison ivy, oak, and sumac is an acute pruritic eczematous eruption characterized by streaks of erythematous papules and vesicles where the plant has brushed the skin (Fig. 3).¹ The areas of involvement frequently have sharp margins, geographic outlines, and linear configurations.¹ Interestingly, the fluid content of vesicles and bullae present in poison ivy, oak, and sumac dermatitis is not antigenic.⁵ A sensitized person typically develops the eruption within 24 to 48 hours after contact with the plant but onset can range from 4 hours to 4 days, with peak reaction severity occurring 1 to 14 days later.²¹ If left untreated, the eruption can last up to 3 weeks, with significant impact on patient quality of life. Furthermore, urushiol can be aerosolized in smoke and cause respiratory tract inflammation and generalized dermatitis in wildland firefighters.² Long-term complications are uncommon in most and are generally limited to transient postinflammatory hyperpigmentation or secondary infection, typically polymicrobial, with *Staphylococcus aureus*, group A β -hemolytic streptococcus, *Prevotella*, *Porphyromonas*, and *Fusobacterium* being the most common isolates.²² An uncommon but classic clinical presentation of urushiol allergic contact dermatitis is “black dot dermatitis,” where concentrated urushiol dries on the skin, producing black dots surrounded by acute dermatitis. This can sometimes be confused with vasculitis. Histologic changes found in a skin biopsy for *Toxicodendron* dermatitis are the same as those for other eczematous dermatoses, specifically epidermal spongiosis and a superficial perivascular lymphocytic infiltrate in the dermis with some exocytosis noted (Fig. 4).¹ Eosinophils and epidermal collections of LCs are often seen but not present in all cases. For “black dot dermatitis,”



Figure 3. Allergic contact dermatitis. Clinical representation.

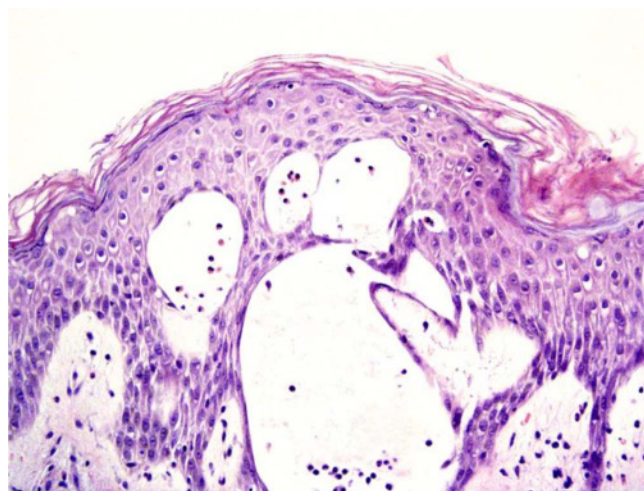


Figure 4. Histopathology of *Toxicodendron* dermatitis (hematoxylin-eosin stain, original magnification $\times 20$).

typically there is an amorphous yellow material on the stratum corneum and necrosis of the epidermis and superficial dermis (Figs. 4, 5).²³

Treatment

Treatment and prevention therapies have not significantly changed for many years. Postexposure treatment primarily aims to provide symptomatic relief of pruritus. Topical symptomatic therapies include calamine lotion, which may contain menthol and phenol, and astringents, such as aluminum acetate or aluminum sulfate that may be useful to dry weeping lesions.^{24,25} Although antihistamines may improve symptoms by sedation, they do not significantly improve pruritus because pruritus in poison ivy dermatitis is not primarily histamine mediated.^{26,27} High-potency topical corticosteroids, such as clobetasol, are most helpful early in allergic contact dermatitis.

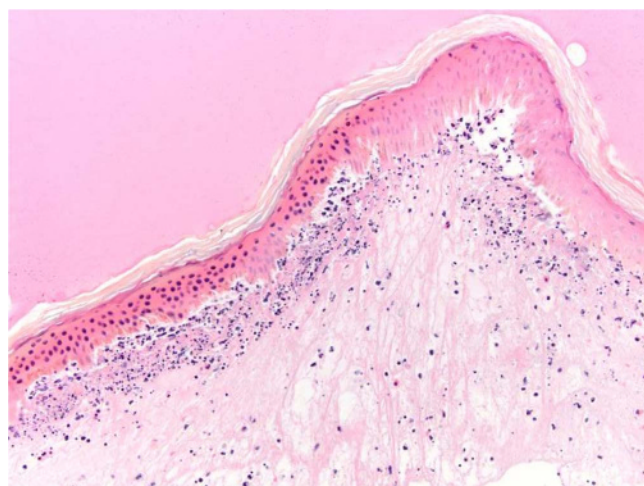


Figure 5. Histopathology of “black dot dermatitis” (hematoxylin-eosin stain, original magnification $\times 20$).

However, a limitation of clobetasol and other high-potency topical corticosteroids is the high cost compared with midpotency topical corticosteroids, such as triamcinolone. A randomized placebo-controlled study demonstrated that 1% pimecrolimus cream, which inhibits calcineurin and therefore T-cell activation in the skin, is ineffective at treating poison ivy allergic contact dermatitis.²⁸ The use of systemic corticosteroids is usually reserved for severe cases, variably described as either involving more than 20% of body surface area, presence of severe blistering or itching, or involvement of the face, hands, or genital area.^{29,30} Although there is a lack of well-designed studies that examine the proper dose and course of systemic corticosteroids for poison ivy dermatitis, there is extensive clinical experience that suggests too short a course of systemic corticosteroids results in rebound dermatitis.³¹ Oral prednisone, started at 1 mg/kg per day, with a maximum initial dose of 60 mg/d and a taper for 2 or 3 weeks, can be beneficial for patients with severe *Toxicodendron* dermatitis. For both oral and topical steroids, one must consider patient compliance. An alternative to prednisone is intramuscular injection of triamcinolone acetonide (40–80 mg). Benefits to intramuscular triamcinolone over topical corticosteroids include high compliance and duration of effect, which is approximately 3 weeks, the typical course of allergic contact dermatitis. However, the risk with intramuscular triamcinolone includes not only local adverse effects, such as skin atrophy, but also systemic adverse effects, such as infection, hyperglycemia, hypertension, adrenal suppression, and psychiatric disturbances, which are uncommon in the authors' experiences.

Prevention

Urushiol oil can be removed if washed off immediately before it is absorbed. It is known that 50% can be removed at 10 minutes, 25% at 15 minutes, and 10% at 30 minutes.² After 30 minutes, sufficient penetration of urushiol has occurred.² Avoidance is the best prevention method but may not be practical.

Medical approaches to prevent dermatitis aim at either inactivating the antigen before its absorption into the skin or by immunologic manipulation resulting in hyposensitization or tolerance, resulting in diminished clinical symptoms (Table 1). A study that compared Tecnu, a chemical inactivator intended to prevent poison ivy; Goop, an oil-removing compound; and Dial Ultra dishwashing soap found that all 3 products significantly reduced dermatitis without significant difference in efficacy of the 3 preparations.³² One small study showed that Zanf, a soap mixture, improved erythema, induration, and vesiculation.³³ A recent study showed that the method of washing rather than the type of wash is what matters.⁴⁵ They advise that forceful unidirectional washing with a damp washcloth and liquid dishwashing soap within 1 to 2 hours will successfully prevent *Toxicodendron* dermatitis.⁴⁵ The plant jewelweed (*Impatiens biflora*) was first used by Native Americans because it allegedly treated poison ivy dermatitis; however, there is conflicting evidence on its efficacy in current literature.^{34,35}

The utilization of barrier creams, which are topical preparations applied before exposure to a contact allergen, to prevent contact dermatitis is controversial. The ideal barrier should be safe, substantial, cheap, and readily available and should actively bind or retard urushiol penetration into the skin.⁴⁶ Topical quarternium-18 bentonite, a US Food and Drug Administration–approved organoclay compound marketed as Ivy Block, could prevent or reduce poison ivy and oak dermatitis by presumably interfering with absorption of the allergen.³⁶ Those pretreated with quarternium-18 bentonite lotion had absent or significantly reduced reactions to the urushiol compared with untreated control sites.³⁶ However, it leaves a residue on the skin, and it must be reapplied every 4 hours. Other topical barrier preparations include linoleic acid,⁴⁷ which must be rinsed off within 8 to 12 hours and reapplied after 4 to 8 hours, and occlusive barrier ointments such as Hollister Moisture Barrier and Hydropel.⁴⁸ A randomized, double-blind study of 7 different commercially available barrier creams found 3 products, Stokogard, Hollister Moisture Barrier, and Hydropel, offered statistically significant reduction in dermatitis severity.⁴⁸ From all of these products, Tecnu, Zanf, jewelweed soap, Ivy Block, and Dial Ultra dishwashing soap are commercially available.

In 1829, Dakin reported that the ingestion of *Rhus* leaves, a common practice among Native Americans, reduced the incidence and severity of skin lesions on subsequent contact with poison ivy.⁴⁹ Ingestion or parenteral administration of extracts of poison ivy or poison oak leaves was proposed more than 100 years ago as a protective method from these plants.^{38,50} Epstein et al⁵¹ showed that large amounts of urushiol ingestion taken for a period of 3 or more months are effective for hyposensitization, but not for desensitization. Over-the-counter homeopathic poison ivy, manufactured by preparing an alcohol extract from poison ivy leaves, is widely used in alternative medicine to prevent allergic contact dermatitis from poison ivy.³⁹ First studying this in 1958, Gross⁴⁰ found that 76.9% of subjects either were free of ivy dermatitis or experienced milder attacks. Later, Stein and Parsons⁴¹ demonstrated that 48% of patients had less severe or fewer episodes of poison ivy dermatitis. A recent study with a small sample size showed that most patients treated with homeopathic poison ivy experienced partial or complete protection from poison ivy dermatitis.³⁹ Hyposensitization has been demonstrated after exposure to cashew nut shell oil, which contains an antigen that is structurally similar to urushiol of poison ivy.⁵² However, Marks et al⁴² showed that oral ingestion of 1:1 mixture of *Rhus* antigens PDC and HDC diacetate did not induce a statistically significant hyposensitivity to urushiol in humans, although it appeared to be effective in animal models. The lack of activity of administered urushiol in the free form may be secondary to the high reactivity of catechol moiety of the urushiols with plasma proteins, which causes them to become “deactivated.”⁵³ Because large amounts of the antigen delivered orally are required to induce hyposensitization,^{1,46} there is an increased risk of mucocutaneous adverse effects. Systemic oral ingestion or injection of prepared extracts can also have adverse effects such as pruritus ani, generalized pruritus, and urticaria.²

TABLE 1. Preventive Therapies

	Mechanism of Action	Efficacy	Limitations	Commercially Available
Tecnu poison ivy wash	Chemical inactivator of urushiol antigen	Significantly reduces dermatitis; no significant difference among 3 products (Stibich et al ³²)	Must be used within 2 h of exposure More expensive compared with Dial and Goop	Yes
Goop	Oil-removing compound		Must be used within 2 h of exposure	No
Dial Ultra dishwashing soap	Topical surfactant		Must be used within 2 h of exposure	Yes
Zanfel	Soap mixture of fatty acid, ethoxylate, and lauroyl sarcosinate (surfactant)	Significantly reduces dermatitis (Davila et al ³³)	Expensive, must be used soon after exposure	Yes
Jewelweed (<i>I. biflora</i>)	Plant with saponins	Conflicting evidence on efficacy; efficacy may be related to presence of saponin (Long et al ³⁴ ; Motz, 2012; Motz et al ³⁵)	Must be used soon after exposure Dish soap (Dawn) is more effective (Motz, 2012 ⁴³)	Yes (soap with jewelweed)
Ivy Block (5% quaternium-18 bentonite)	Organoclay compound that interferes with absorption of allergen by physical blocking	Significantly reduces dermatitis (Marks et al ³⁶)	Must be preemptively applied and reapplied every 4 h, leaves clay residue on skin	Yes
Salts of linoleic acid dimer	Decrease absorption of oils	Significantly prevents dermatitis (Orchard, 1986 ³⁷)	Must be preemptively applied and rinsed off within 8–12 h	No
Hollister Moisture Barrier	Water repellant	Significantly reduces dermatitis severity; no significant difference among 3 products (Grevelink et al ³⁸)	Must be preemptively applied	No, discontinued
Hydropel				No
Stokogard				No
Oral poison ivy/oak leaves extract	Hyposensitization	Conflicting evidence on efficacy (Epstein, Signore ³⁹ ; Gross ⁴⁰ ; Stein and Parsons ⁴¹)	Adverse effects from oral administration Large amounts of ingestion required (Epstein ⁴⁴)	Yes homeopathic poison ivy
Oral <i>Rhus</i> antigens (PDC, HDC)	Hyposensitization	Does not significantly induce hyposensitivity to urushiol (Marks et al ⁴²)	Ineffective	No
Vaccine	Hyposensitization	Ongoing investigation	Ongoing investigation	No

Therefore, despite supportive testimonials, hyposensitization with extracts of poison ivy, oak, or sumac remains controversial.

What Is New?

Despite the wide prevalence of poison ivy, oak, and sumac dermatitis and the vast burden that it inflicts, there is still lack of any definitive preventive therapy besides complete avoidance. Recently, there was a study in guinea pigs of intramuscular administration of water-soluble derivative of the saturated congener on the poison oak urushiol, 3-*n*-HDC-4-(4-aminophenyl)-butyrate, which resulted in almost complete desensitization to urushiol.⁴² One product currently in development to prevent contact dermatitis

caused by exposure to urushiol in poison ivy, oak, and sumac is a vaccine (immunotherapy), PDC-APB (3-pentadecyl-1,2-phenylene bis (4-(4-aminophenyl)butanoate)) (Fig. 6). In nonclinical studies,

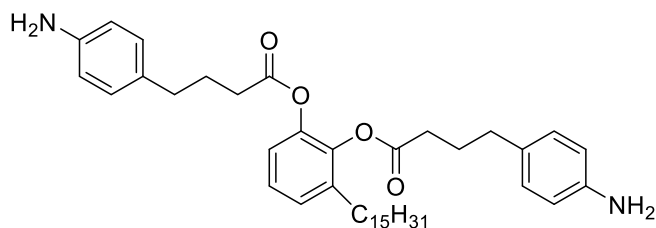


Figure 6. Structure of PDC-APB.

PDC-APB was shown to effectively induce both tolerance and desensitization to urushiol.⁵³ A double-blind, placebo-controlled phase I study of 40 healthy adults with a history of exposure to poison ivy was completed in the United States in 2017. PDC-APB was generally well tolerated, and results supported further clinical investigation. A second clinical study is underway in healthy subjects with proven sensitivity to urushiol to be tested at baseline for degrees of sensitivity, dosed, and retested for measures of sensitivity. The study is designed to provide additional safety data and a signal of biological activity. To appropriately evaluate the efficacy of the vaccine, a patch test based on the hydrogel delivery system of the Thin-layer Rapid Use Epicutaneous (T.R.U.E.) patch test was developed (SmartPractice, Phoenix, Ariz). All doses of urushiol included in the patches for the study elicited a local reaction and severity of the reactions correlated with the dosage of urushiol used.⁵⁴

In summary, poison ivy, oak, and sumac cause allergic contact dermatitis in millions of Americans annually. Treatment is mainly symptomatic. Presently, definitive prevention of this affliction is by avoidance. A new urushiol patch test was developed to evaluate a new vaccine (immunotherapy), which is now in clinical trials.

REFERENCES

- Marks JG. Poison ivy and poison oak allergic contact dermatitis. *J Allergy Clin Immunol* 1989;9:497–506.
- Gladman AC. *Toxicodendron* dermatitis: poison ivy, oak, and sumac. *Wilderness Environ Med* 2006;17:120–128.
- Boyd JE, Rucker J. A poisoned reputation. Chemical Heritage: Summer 2013. Available at: <https://www.sciencehistory.org/distillations/magazine/no-ill-nature-the-surprising-history-and-science-of-poison-ivy-and-its>.
- Pariser DM, Ceilley RI, Lefkovits AM, et al. Poison ivy, oak and sumac. *Derm Insights* 2003;4:26–28.
- Fisher AA. Poison ivy/oak/sumac. Part II: specific features. *Cutis* 1996;58:22–24.
- Scappert SM, Burt CW. Ambulatory care visits to physician offices, hospital outpatient departments, and emergency departments: United States, 2001–02. *Vital Health Stat* 13 2006;159:1–66.
- Lewin Group. Burden of skin diseases. Society for Investigative Dermatology and American Academy of Dermatology Association, Cleveland 2005, 105 pp.
- Fretwell S. Poison ivy cases on the rise. The State; 2017. Available at: <https://www.thestate.com/news/local/article150403932.html>.
- Protecting workers from poisonous plants. Monthly safety unlimited newsletter. September 2014. Available at: <http://www.safetyunlimited.com/blog/2014/09/default.aspx>. Accessed January 3, 2019.
- Flamm A, Zomorodi N, Maczunga S, et al. Characteristics of *Toxicodendron* Dermatitis in the United States. Poster presented at the American Contact Dermatitis Annual Meeting; 2019; Washington, DC.
- Mohan JE, Ziska LH, Schlesinger WH, et al. Biomass and toxicity responses of poison ivy (*Toxicodendron radicans*) to elevated atmospheric CO₂. *PNAS* 2006;103:9086–9089.
- Marks JG, Anderson BE, DeLeo VA. *Contact and Occupational Dermatology*. New Delhi, India: Jaypee Brothers Medical Publishers (P) Ltd; 2016.
- Dawson CR. The chemistry of poison ivy. *Trans N Y Acad Sci* 1956;18:427–443.
- Valladeau J, Ravel O, Dezutter-Dambuyant C, et al. Langerin, a novel C-type lectin specific to Langerhans cells, is an endocytic receptor that induces the formation of Birbeck granules. *Immunity* 2000;12:71–81.
- Hanau D, Fabre M, Schmitt DA, et al. Human epidermal Langerhans cells cointernalize by receptor-mediated endocytosis “non-classical” major histocompatibility complex class I molecules (T6 antigens) and class II molecules (HLA-DR antigens). *Proc Natl Acad Sci U S A* 1987;84:2901–2905.
- Hunger RE, Sieling PA, Ochoa MT, et al. Langerhans cells utilize CD1a and langerin to efficiently present nonpeptide antigens to T cells. *J Clin Invest* 2004;113:701–708.
- Kim JH, Hu Y, Yongqing T, et al. CD1a on Langerhans cells controls inflammatory skin diseases. *Nat Immunol* 2016;17(10):1159–1166.
- Gayer KD, Burnett JW. *Toxicodendron* dermatitis. *Cutis* 1988;42(2):99–100.
- Dunn IS, Liberato DJ, Castagnoli N, et al. Contact sensitivity to urushiol: role of covalent bond formation. *Cell Immunol* 1982;74(2):220–233.
- Kligman AM. Poison ivy (*Rhus*) dermatitis. *AMA Arch Derm* 1958;77:149–180.
- Williams JV, Light J, Marks JG. Individual variations in allergic contact dermatitis from urushiol. *Arch Dermatol* 1999;135:1002–1003.
- Brook I, Frazier EH, Yeager JK. Microbiology of infected poison ivy dermatitis. *Br J Dermatol* 2000;142:943–946.
- Hurwitz RM, Rivera HP, Guin JD. Black-spot poison ivy dermatitis. *Am J Dermatopathol* 1984;6(4):319–322.
- Baer RL. Poison ivy dermatitis. *Cutis* 1990;46:34.
- Wilford PM, Sheretz EF. Poison ivy dermatitis. Nuances in treatment. *Arch Fam Med* 1995;3:184.
- Munday J, Bloomfield R, Goldman M, et al. Chlorpheniramine is no more effective than placebo in relieving the symptoms of childhood atopic dermatitis with a nocturnal itching and scratching component. *Dermatology* 2002;205:40.
- Yospovitch G, Fleischer A. Itch associated with skin disease: advances in pathophysiology and emerging therapies. *Am J Clin Dermatol* 2003;4:617.
- Amrol D, Keitel D, Hagaman D, et al. Topical pimecrolimus in the treatment of human allergic contact dermatitis. *Ann Allergy Asthma Immunol* 2003;91(6):563–566.
- Li LY, Cruz PD Jr. Allergic contact dermatitis: pathophysiology applied to future therapy. *Dermatol Ther* 2004;17:219–223.
- Craig K, Meadows SE. What is the best duration of steroid therapy for contact dermatitis (*Rhus*)? *J Fam Pract* 2006;55:166–167.
- Brodell RT, Williams L. Taking the itch out of poison ivy. Are you prescribing the right medication? *Postgrad Med* 1999;106:69.
- Stibich AS, Yagan M, Sharma V, et al. Cost-effective post-exposure prevention of poison ivy dermatitis. *Int J Dermatol* 2000;39:515–518.
- Davila A, Lucas J, Laurora M, et al. A new topical agent, Zanafel, ameliorates urushiol-induced *Toxicodendron* allergic contact dermatitis [abstract 364]. *Ann Emerg Med* 2003;42(Suppl 4):s98.
- Long D, Ballentine NH, Marks JG. Treatment of poison ivy/oak allergic contact dermatitis with an extract of jewelweed. *Am J Contact Dermat* 1997;8(3):150–153.
- Motz VA, Bowers CP, Kneubehl AR, et al. Efficacy of the saponin component of *Impatiens capensis* Meerb. In preventing urushiol-induced contact dermatitis. *J Ethnopharmacol* 2015;162:163–167.
- Marks JG Jr, Fowler JF Jr, Sheretz EF, et al. Prevention of poison ivy and poison oak allergic contact dermatitis by quaternium-18 bentonite. *J Am Acad Dermatol* 1995;33:212–216.
- Orchard S, Fellman JH, Storrs FJ. Poison ivy/oak dermatitis. Use of polyamine salts of a linoleic acid dimer for topical prophylaxis. *Arch Dermatol* 1986;122:783–789.
- Grevelink SA, Murrell DF, Olsen EA. Effectiveness of various barrier preparations in preventing and/or ameliorating experimentally produced *Toxicodendron* dermatitis. *J Am Acad Dermatol* 1992;27:182–188.
- Signore RJ. Prevention of poison ivy dermatitis with oral homeopathic *Rhus Toxicodendron*. *Dermatology Online J* 2017;23:17.

40. Gross ER. An oral antigen preparation in the prevention of poison ivy dermatitis; results in 455 cases of ivy sensitivity. *Ind Med Surg* 1958;27(3):142–144.
41. Stein MF, Parsons E. Effectiveness in oral *Rhus* tox solution for poison ivy prevention. *Int J Pharm Compd* 2003;7(4):272–275.
42. Marks JG Jr, Trautlein JJ, Epstein WL, et al. Oral hyposensitization to poison ivy and poison oak. *Arch Dermatol* 1987;123:476–478.
43. Motz VA, Bowers CP, Young LM, et al. The effectiveness of jewelweed, *Impatiens capensis*, the related cultivar *I. balsamina* and the component, lawsone in preventing post poison ivy exposure contact dermatitis. *J Ethnopharmacol* 2012;143:314–318.
44. Epstein WL, Baer H, Dawson CR, et al. Poison oak hyposensitization. Evaluation of purified urushiol. *Arch Dermatol* 1974;109:356–360.
45. Neill BC, Neill JA, Brauker J, et al. Post-exposure prevention of *Toxicodendron* dermatitis with early forceful unidirectional washing. *J Am Acad Dermatol* 2018. doi: 10.1016/j.jaad.2017.12.081.
46. Epstein WL. *Rhus* dermatitis. *Ped Clinics of North Am* 1959;843–852.
47. Orchard S, Fellman JH, Storrs FJ. Poison ivy/oak dermatitis. Use of polyamine salts of a linoleic acid dimer for topical prophylaxis. *Arch Dermatol* 1986;122:783–789.
48. Grevelink SA, Murrell DF, Olsen EA. Effectiveness of various barrier preparations in preventing and/or ameliorating experimentally produced *Toxicodendron* dermatitis. *J Am Acad Dermatol* 1992;27:182.
49. Dakin R. Remarks on a cutaneous affection produced by certain poisonous vegetables. *Am J M sc.* 1829;4:98–100.
50. Duncan CH. Autotherapy in ivy poisoning. *NY Med J* 1916;104:901.
51. Epstein WL, Baer H, Dawson CR, et al. Poison oak hyposensitization. *Arch Dermatol* 1974;109:356–360.
52. Reginella RF, Fairfield JC, Marks JG Jr. Hyposensitization to poison ivy after working in a cashew nut shell oil processing factory. *Contact Dermatitis* 1989; 20:274–279.
53. ElSohly MA, Gul W, Abdel-Bakky MS, et al. Compositions for prevention/prophylactic treatment of poison ivy dermatitis. *J Sci Med Central* 2018;6:1115.
54. Kim Y, Longenecker A, ElSohly MA, et al. Urushiol patch test using the T.R. U.E. test system. *Dermatitis* 2018;29:127–131.