Hand Dermatitis: A Focus on Allergic Contact Dermatitis to Biocides

Lisa E. Maier, MD[a,b,*], Heather P. Lampel, MD, MPH[c], Tina Bhutani, MD[d], Sharon E. Jacob, MD[e,f]

KEYWORDS

• Hand dermatitis • Contact dermatitis • Contact allergy • Biocide • Preservative • Diagnosis

Hand dermatitis is a common affliction, affecting 2% to 10% of the general population.[1] It has multiple exogenous and endogenous causes, including allergic contact dermatitis (ACD), irritant dermatitis, atopic dermatitis, and dyshidrotic eczema.[1] Several studies have shown that irritant contact dermatitis (ICD) is the most common cause; however, ACD is not far behind.[2,3] Veien and colleagues[2] noted that 33% of 522 hand dermatitis patients had ICD, whereas 13% of male and 20% of female patients had ACD. Often, these 2 types of exogenous dermatitis can occur simultaneously in the same patient.[3]

Sufferers of chronic hand dermatitis experience a significantly decreased quality of life. They may feel shame, emotional upset, pain, pruritus, and decreased ability to perform activities of daily life.[4] Occupational hand dermatitis, 1 of the most common occupational diseases in many areas of the world,[5] may be devastating for workers and employers alike, because it is associated with job loss, lost work days, and decreased productivity.[6] Exposure to "wet work," which is defined as prolonged exposure to liquids, occlusive gloves, hand washing, and water-soluble irritants, increases the risk for developing hand dermatitis.[5,7] Those at risk include health care workers, janitors/cleaners, hairdressers, dental assistants, veterinarians, food preparation/service workers, and metalworkers.[1,6,8] Each of these careers have higher risks of developing contact dermatitis of the hands because of compromised skin barrier.[9,10]

Many of these "wet-work" jobs expose the worker to a variety of biocides, such as antimicrobials in scrubs, handwashes, cleaning fluids, and disinfectants,[11] and thus may result in allergic sensitization to these biocides. Identification of offending biocides in the workplace may be difficult because they may not be listed on material saftey data sheets (MSDSs). Biocides are important agents of ACD not only in occupational settings but also in nonoccupational settings.[12] These biocides are broadly used as preservatives in household products, including cosmetics, shampoos, moisturizers, topical medications, and home cleaning agents, allowing for exposure of a large portion of the population.[13] Despite their ability to cause sensitization, biocides are important in preventing decomposition and contamination of many household and occupational products by microorganisms, ultimately making

[a] Department of Dermatology, University of Michigan, 1910 A. Taubman Center 0314, 1500 East Medical Center Drive, Ann Arbor, MI 48109-0314, USA
[b] VA Ann Arbor Healthcare System, 2215 Fuller Road, Ann Arbor, MI 48105, USA
[c] Department of Dermatology, University of California, Irvine, 101 The City Drive South, Building 53 Room 302A, Ann Arbor, Orange, CA 92868, USA
[d] Department of Internal Medicine, University of California, San Diego, 200 West Arbor Drive, San Diego, CA 92103, USA
[e] Rady Children's Hospital, University of California, San Diego, 8010 Frost Street Suite 602, San Diego, CA, USA
[f] VA San Diego Healthcare System, 3350 La Jolla Village Drive, 111B San Diego, CA 92161, USA
* Corresponding author. Department of Dermatology, University of Michigan, 1910 A. Taubman Center 0314, 1500 E. Medical Center Drive, Ann Arbor, MI 48109-0314.
E-mail address: maierl@umich.edu (L.E. Maier).

Dermatol Clin 27 (2009) 251–264
doi:10.1016/j.det.2009.05.007
0733-8635/09/$ – see front matter. Published by Elsevier Inc.

products safer (from a microbial standpoint) and more efficacious.[14] Biocides also increase the longevity of many products.[14] These low–molecular weight chemicals are able to penetrate microbial cell surfaces and act intracellularly by different mechanisms.[11] It is this property of permeability that allows the same chemicals to potentially penetrate through the stratum corneum and cause allergenicity by conjugating with autologous proteins in the skin, forming tertiary structures that can be recognized by Langerhan cells.[15] As a consequence, preservatives and biocides are considered skin-sensitizing allergens that commonly cause contact dermatitis.[16]

In 2007, Warshaw and colleagues[12] published patch test data from the North American Contact Dermatitis Group (between 1994 and 2004) regarding ACD of the hands. They concluded that the most relevant allergens associated with hand-only ACD were preservatives, metals, rubber accelerators, fragrances, and topical antibiotics. Quaternium 15, a formaldehyde-releasing preservative was found to be the most common allergen accounting for 16.5% of clinically relevant positive patch test results in patients with hand-only ACD. Quaternium 15 was found to be responsible for more hand-only ACD than even nickel, a known strong sensitizer. This article attempts to provide more information and detail about some of the common biocides and preservatives known to cause ACD of the hands and briefly discusses the potential for these chemicals to cause other patterns of contact dermatitis. Some of the most common biocides causing ACD and potential sources of exposure are listed in **Table 1**.

FORMALDEHYDE

Formaldehyde is a widely used chemical substance found in a multitude of products and used for a variety of applications. It has been manufactured and marketed as a biologic preservative since the late 1800s.[17] It is often found in skin and hair care products, cosmetics, permanent press textiles, certain cleaning products, disinfectants, paper, and topical medications.[17] Metal working fluids,[18] paints and lacquers, construction material, and printing ink[19] may also contain formaldehyde or a formaldehyde releaser. Occupations that are associated with formaldehyde allergy include machinists, health care workers, painters, janitorial staff, and cosmetologists.[20] Because formaldehyde is present in many products encountered on a daily basis, allergy to this substance is quite common. The data from the North American Contact Dermatitis Group (NACDG), year 2003 to 2004, showed that formaldehyde was positive in 8.7% of patients patch tested.[21] This prevalence of allergy has been stable during the previous decade.[21] Formaldehyde is also an important allergen inducing hand dermatitis. In analyzed data from 1994 to 2004 NACDG results on allergic contact *hand* dermatitis, formaldehyde ranked as the second most common allergen (trumped only by the formaldehyde releaser Quaternium 15) and accounted for 13% of positive patch test results.[12] It is an important cause of occupational hand dermatitis,[20] particularly affecting workers exposed to metalworking fluids and creams.[20]

Formaldehyde is patch tested as 1% in water or in the thin-layer rapid use epicutaneous (TRUE) test as 0.18 mg/cm^2 *N*-hydroxymethyl succinimide in polyvidone, which releases formaldehyde when in contact with the skin.[17] Formaldehyde patch tests must be interpreted carefully for several reasons. First, Formaldehyde is a notable irritant, so false-positive results may occur.[22] Clinical relevance determination may be difficult, because formaldehyde is nearly ubiquitous in everyday products. It may not be listed on ingredient labels, may be present as an impurity or may even be contained in the materials used to coat containers of various products.[23] Furthermore, many labeled products contain such small amounts that they may not cause dermatitis.[24] Lack of complete dose-response data makes predicting the allergic potential of these products difficult. Reported threshold responses are varied and range from 30 to 300 ppm.[24]

Patients with formaldehyde allergy commonly present with chronic hand and/or generalized dermatitis.[25,26] For these formaldehyde-allergic patients, slow recovery is to be expected, even with the strictest plan to avoid the allergen because patients may be unaware of, or unable to discontinue all potential sources of this chemical.[26]

FORMALDEHYDE-RELEASING PRESERVATIVES

Formaldehyde releasers are a group of chemicals that contain a small, detachable formaldehyde moiety.[23] The 5 most commonly used chemicals in this category are Quaternium 15, dimethyloldimethyl (DMDM) hydantoin, imidazolidinyl urea (IMID), diazolidinyl urea, and 2-bromo-2-nitropropane-1,3-diol (bronopol).[14] There are multiple formaldehyde releasers used specifically in industry, especially in cutting fluids that may cause allergic contact dermatitis of the hands.[27] These are not discussed in detail in this article, but the reader is directed to Schnuch and colleagues[27] for more information. Patients who are allergic to