

Allergic Contact Dermatitis from Formaldehyde Textile Resins in Surgical Uniforms and Nonwoven Textile Masks

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Despite a trend for reduction in the concentration of free formaldehyde in textiles, formaldehyde textile resin (FTR) allergic contact dermatitis (ACD) remains an important clinical issue and is likely underdiagnosed. Patients with FTR ACD may react to formaldehyde released from the resin or to the resin itself. Screening with formaldehyde and ethyleneurea/melamine formaldehyde resin will uncover most cases. Patch testing with the suspected offending fabric most often leads to false-negative results. We present a case of a 49-year-old pediatrician who developed a severe widespread dermatitis caused by contact with FTRs from her hospital "greens" ("scrubs") and mask.

NATURAL AND SYNTHETIC UNTREATED FABRICS used in the manufacture of clothing rarely cause skin problems.¹ However, the chemicals and dyes that are added to the fibers during manufacturing may lead to irritant contact dermatitis or to allergic contact dermatitis (ACD). Formaldehyde-releasing permanent-press finishes or formaldehyde textile resins (FTRs) are such additives with the potential for skin irritation or allergy.

Natural fibers used to produce textiles are derived from cellulose or protein and include cotton, silk, wool, and linen. Man-made fibers can be made from cellulose (rayon) or from proteins such as casein or soybean protein.² Synthetic or noncellulose fibers are derived mainly from petrochemical processes and include polyester, acrylics, and nylon.²

The early use and history of FTRs was reviewed by Storrs.² The strength and wrinkle resistance of cellulose and rayon fibers are improved by acid formaldehyde treatment. Unfortunately, the early resins tended to produce a yellowing and weakening of the fabric upon absorption of chlorine from bleaches. Today, the textile industry has reduced its levels of formaldehyde release, mostly on account of purer resins and decreased overall use.³ The synthetic resins include urea formaldehyde resins (N-methylolurea and dimethylolurea), and melamine

formaldehyde resins (dimethylol melamine, tetramethylol melamine, and hexamethylol melamine), which react with formaldehyde to form cross-links between adjacent cellulose molecules. Cyclic urea derivatives (dimethylol ethyleneurea, dimethylol propyleneurea, dimethylol dihydroxyethyleneurea, and dimethoxymethyl dihydroxyethyleneurea) bind directly to the fibers.

Many garments are made by "blending" natural and synthetic fibers. In general, blended fabrics are more likely to be treated with FTRs than are unblended fabrics. Washing reduces the free formaldehyde content of these fabrics. For the patient allergic to an FTR but not to formaldehyde, washing will not help.

The clinical picture of textile dermatitis coincides with the places on the skin where garments fit most snugly. Dermatitis on the anterior and posterior axillary folds from dress or shirt fabrics is typical. Men may have significant neck dermatitis. Pants, nylons, and tights often result in dermatitis on the inner and anterior thighs. Allergy to finishes on bed linens or furniture fabric may produce dermatitis on the back, posterior legs, and other areas of prominent contact. Friction, warmth, and moisture from perspiration all increase the appearance of textile ACD.

We present a case of FTR ACD in a pediatrician that occurred toward the end of the severe acute respiratory syndrome (SARS) epidemic in Toronto, Canada.

Case Presentation

A 49-year-old pediatrician presented with a history of recurrent generalized dermatitis. The eruption started in April 2003, toward the end of the SARS epidemic in Toronto, Canada. She is a hospital-based pediatrician who works in a neonatal intensive care unit (ICU), a delivery

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Figure 1. Diffuse dermatitis caused by textile resin allergic contact dermatitis.

room, and an emergency room. She wore hospital “greens” (or “scrubs”) while performing her clinical duties. Precautions against SARS at that time required the additional use of an N95 mask (or a disposable surgical

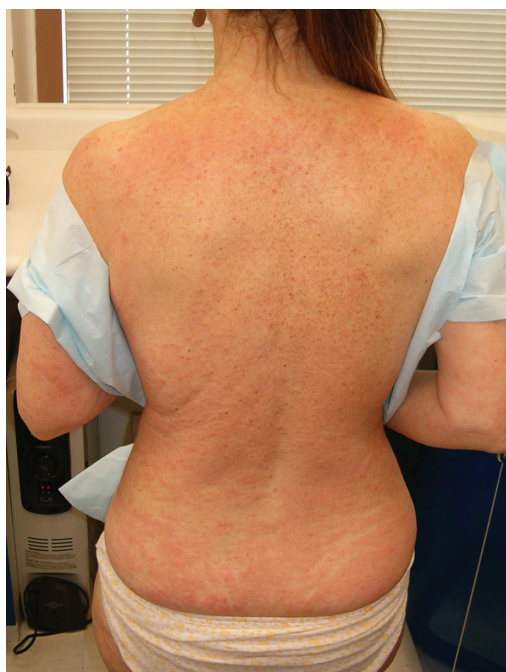


Figure 2. Diffuse dermatitis caused by textile resin allergic contact dermatitis.



Figure 3. Facial dermatitis caused by N 95 respirator.

mask) and a disposable paper gown. She reported frequently feeling warm in these additional layers. The patient developed a pruritic eruption, involving the face, neck, flexures, trunk, and legs (Figs 1 and 2), that worsened following a night of hospital call. The distribution of the facial eruption corresponded to the site of the N95 mask (Figs 3 and 4). In addition, the patient progressively developed financial difficulties due to her inability to perform hospital-based work.



Figure 4. N95 respirator manufactured by 3M.

The patient was evaluated by several dermatologists and allergists. A skin biopsy specimen showed a lymphoeosinophilic infiltrate in the dermis. She was also found to have cold urticaria and dermatographism and was treated with high-dose antihistamines. Results of prick testing with latex were negative. Although the patient initially responded to topical corticosteroids, high-dose oral prednisone was ultimately required for improvement.

The patient initially underwent patch testing elsewhere while taking 10 mg of prednisone daily and 120 mg of fexofenadine (Allegra, Aventis Pharmaceuticals, Bridgewater, NJ) twice daily. She had been stable on these dosages for 2 months and was reluctant to decrease the doses. The patient was patch-tested with the North American standard series, triclosan, chlorhexidine, bisphenol A, the strap of her N95 particulate respirator (3M Canada, London, Ontario, Canada), and a piece of her yellow disposable sterile gown. Her 96-hour patch-test results revealed only a mild reaction to quaternium-15.

In the following months, she was patch-tested again, while on 8 mg of prednisone, to the Chemotechnique textile series, fragrance series, and plant series (Chemotechnique Diagnostics, Malmö, Sweden); the greens she wore while working (Standard Textiles, Cincinnati, OH) 50% cotton/50% polyester); the yellow gowns used when she examined infants; and several of her nylons. Patch tests were read at 48 hours and at 120 hours. The textile samples were cut into 1-inch pieces, wetted with saline, applied under Scanpor tape (Norgesplaster A/S, Venesla, Norway), and then left for the full 120 hours. Her 120-hour results revealed a very strong reaction to melamine formaldehyde 7% and milder reactions to urea formaldehyde 10% and ethyleneurea/melamine formaldehyde 5% (Fig 5). She also had a mild reaction to

her scrubs or greens at 48 hours; this cleared at 120 hours. These positive reactions were considered significant because of her very strong reaction to melamine formaldehyde while she was on prednisone at a dose of 8 mg.

The patient's skin remained clear in the few months during which time she avoided hospital work and followed the general precautions recommended for patients diagnosed with a textile resin ACD. At the patient's request, she was patch-tested again, while off prednisone, with the North American standard series; the Chemotechnique textile series; and her own mask, yellow disposable gown, and greens/scrubs, in the manner described above. Patch tests were read at 48 hours and at 120 hours. This testing showed a very strong ++ reaction to melamine formaldehyde, a + reaction to urea formaldehyde, a + reaction to ethyleneurea/melamine formaldehyde mix, a ++ reaction to quaternium-15, a + reaction to Kathon CG (Rohm and Haas Company, Philadelphia, PA), a minor + reaction to toluene sulfonamide formaldehyde resin, a minor + reaction to imidazolidinylurea, and a + reaction to 1% formaldehyde. Results of patch tests with the N95 mask, surgical greens, and yellow double gowning cover were negative at 120 hours. To evaluate for free formaldehyde in the greens, mask, and gown, acetonitrile extractions were performed.⁴ The presence of formaldehyde was confirmed in the patient's N95 mask and scrubs/greens but not in the yellow gown.

Discussion

Patients with textile resin ACD may be allergic to formaldehyde released by the textile resin or (less commonly) to the resin itself.⁵ Although patch testing with 1% aqueous formaldehyde identifies about 70% of individuals with FTR allergy, some patients will be missed if testing with formaldehyde resins is omitted.^{6,7} In addition, many patients with FTR ACD do not react to the formaldehyde on patch tests, and many patients who do react do not develop positive reactions until the fifth or seventh day.^{8,9}

The pediatrician discussed here was severely affected by a long history of recurrent generalized dermatitis that worsened after nights on hospital call. She had positive patch-test reactions to the formaldehyde resins melamine formaldehyde and urea formaldehyde and had a weaker reaction to formaldehyde. Our patient reacted positively to the formaldehyde releasers quaternium-15 and imidazolidinylurea. Approximately one half of formaldehyde-sensitive patients react to one or more formaldehyde-releasing preservatives; reactions to quaternium-15 are the most common.⁷ Further analyses confirmed the presence

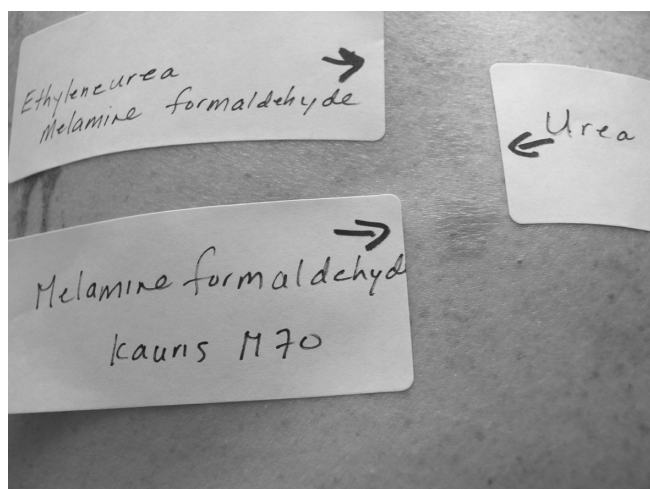


Figure 5. Positive patch-test reactions to melamine formaldehyde.

of formaldehyde in the patient's greens and face mask, corresponding to the areas of her dermatitis.

Ethyleneurea melamine/formaldehyde resin is recommended as a screening agent by the North American Contact Dermatitis Group, but all resins should be tested if FTR ACD is strongly suspected. Owing to the limited ability of patch testing to recreate conditions of friction and perspiration, the results of patch testing with the textile itself are often falsely negative.^{1,9} Our patient had negative results at 120 hours for all textiles.

The patient was unable to return to work because the hospital's uniforms were 50% cotton and 50% polyester (Fig 6). The N95 mask made by 3M was required for all hospital personnel during the SARS epidemic. The mask contains polyester and rayon fibers as well as other ingredients (as supplied by 3M) (Table 1). Our analysis confirmed the presence of formaldehyde in the mask despite the absence of formaldehyde or associated resins in the published list of ingredients. Discussions with 3M revealed no use of FTRs, but it was acknowledged that trace impurities of free formaldehyde were possible. These impurities would occur as a by-product of the degradation of polypropylene. Polypropylene is melted in the early steps in the production of the nonwoven textile. Usually, there is an off-gassing of formaldehyde during the manufacturing, but it is not 100% efficient, and trace levels of formaldehyde may remain in the mask. Polyester-based masks might offer a benefit to a patient with FTR sensitivity as there is no off-gassing of formaldehyde in the melting process.

It is important to draw attention to the possibility of the presence of free formaldehyde and FTR in nonwoven textile products. The N95 mask and the paper gown are disposable



Figure 6. Label on hospital greens, indicating a blend of 50% cotton and 50% polyester.

Table 1. Ingredients of 3M 8210 N95 Particulate Respirator

<i>Ingredient</i>	<i>CAS No.</i>	<i>% by Weight</i>
Polyester	Unknown	15–40
Polypropylene	Unknown	10–30
Thermoplastic elastomer	Unknown	10–30
Aluminum	Unknown	10–30
Acrylic emulsion	Unknown	1–5
Yellow pigment	Unknown	1–5
Rayon	Unknown	1–5
Polyester/polyurethane foam	Unknown	1–5
Isooctyl acrylate/acrylic acid copolymer	Unknown	0.1–1
Ethylene/acrylic acid copolymer	Unknown	0.1–1
Silicone emulsion	Unknown	0.1–1

CAS = Chemical Abstracts Service.

products made from nonwoven textiles. Nonwoven fabric is made without weaving; typically, a plasticlike material such as polypropylene, polyester, or rayon is bound together mechanically, thermally, or chemically, rather than by traditional weaving.^{10,11} Table 2 lists some familiar products made with nonwoven textiles.

Although there is little in the published literature about the presence of FTRs in nonwoven textiles, an Internet search revealed that melamine formaldehyde may be present in some paper products (to which it is added to provide wet strength). Formaldehyde and melamine formaldehyde are

Table 2. Products Made with Nonwoven Fabric

Disposable diapers
Sanitary napkins and tampons
Sterile wraps, caps, gowns, masks, and drapings used in the medical field
Household and personal wipes
Laundry aids (fabric dryer sheets)
Apparel interlining
Carpeting and upholstery fabrics, padding, and backing
Wall covering
Agricultural coverings and seed strips
Automotive headliners and upholstery
Filters
Envelopes
Tags
Labels
Insulation
House wraps
Roofing products
Civil engineering fabrics/geotextiles

Adapted from Association of the Nonwoven Fabric Industry (INDA). Available at: http://www.inda.org/category/nwn_index.html (accessed Jan 13, 2007).

also added to improve paper products' resistance to shrinkage and perspiration. Furthermore, information obtained on the Association of the Nonwoven Fabrics Industry Web site (<www.inda.org>) revealed a "Standards Development Forum" (published in the *International Nonwovens Journal*) discussing the need to review available methods for the measurement of formaldehyde in nonwoven textiles. The standards committee identified three areas of formaldehyde measurement related to the nonwoven manufacturing process: (1) binders (water-based emulsions, phenol formaldehyde resins, melamine formaldehyde resins, and urea formaldehyde resins), (2) stack emissions (from ducts, ventilation systems, and venting stacks), and (3) nonwoven products (formaldehyde content, evolution from disposable to durable, and industrial nonwoven products).¹² One needs to consider the possibility of an FTR system in nonwoven textile products when a patient presents with possible textile dermatitis.

FTR ACD has been recognized for over half a century. Marcussen reported on 26 patients with formaldehyde textile allergy in Denmark between 1934 and 1958.¹³ There seems to have been an increase in these reactions. Fowler and colleagues diagnosed 17 cases in a period of 28 months among 1,022 patients tested; only 12 reacted to formaldehyde.⁶ Despite the general trend in the North American textile industry toward fabrics with lower levels of free formaldehyde, an increasing trend toward the use of imported textiles may account for an increased incidence of FTR ACD. It is also possible that there is increased awareness of FTR ACD among physicians and that previous cases of generalized dermatitis simply went unrecognized. As with all ACD cases, lack of suspicion leads to the withholding of patch testing or to inadequate patch testing. In our case, textile dermatitis was suspected, but testing was done with only the standard series and the offending paper fabrics, rather than with all the FTRs.

The association between the Toronto SARS epidemic and the patient's development of FTR ACD is interesting. Many precautions were implemented during this time, including the routine wearing of masks and gowns. It is possible that the increased use of these products contributed to the patient's sensitization to FTRs. Although the patient's everyday clothes and bed linens may have played a part, the repeated severe flaring

following hospital call points to occupational exposure. It is unlikely that the patient will be able to return to hospital call or ICU work because of the difficulty of obtaining 100% cotton greens, gowns, and masks.

Summary

This case illustrates the potential for textile resin allergic contact dermatitis to severely affect a patient from an occupational viewpoint. Our patient's sensitivity to formaldehyde textile resins will have long-term consequences and will limit her ability to perform all of her duties as a pediatrician. In addition, this case illustrates the need to consider nonwoven disposable textiles among the agents contributing to FTR ACD.

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