Understanding of the structure and function of the epidermal barrier has expanded greatly over the course of the last two decades.1 Primary functions of the epidermal barrier are to protect against the entry of foreign substances (antigens, irritants, and microbes). In addition to these primarily defensive roles, the epidermis traps moisture and regulates hydration, and it synthesizes vitamin D.2 The epidermal barrier is not a passive structure. As keratinocytes mature to horny corneocytes, the epidermis is in a constantly active self-proliferating phase. In addition to physically blocking entry of most foreign substances, the barrier coordinates an immunologic defense against pathogens that manage to bypass the barrier.

The structure of the stratum corneum has been described as a bricks-and-mortar structure. The “bricks” are covalently bonded corneocytes arranged in compact, overlapping layers to hold moisture in while keeping allergens, pathogens, and environmental toxins (such as UV radiation) out. The “mortar” consists of ceramides, cholesterol, and lipids. Together, these elements form lipid bilayers that fill the spaces between the corneocytes. This extracellular matrix provides necessary permeability of moisture to the stratum corneum. A majority of research related to epidermal barrier function has focused on classic atopic dermatitis, which has come to be seen as the quintessential disease of barrier dysfunction. However, research continues to show that impaired barrier function contributes to a host of inflammatory dermatoses, including rosacea,3 acne,4 and psoriasis.5 The following provides a closer look at the diagnosis and management of two cutaneous conditions influenced by barrier dysfunction: juvenile plantar dermatitis or wet-to-dry foot syndrome, and head and neck dermatitis.

**Take-Home Tips.** Juvenile Plantar Dermatitis tends to be chronic; typical interventions may be palliative but not curative. The differential diagnosis includes keratolysis exfoliativa and tinea pedis. Topical corticosteroids are a standard treatment. An anti-inflammatory barrier repair therapy may represent a suitable option for primary or adjunctive treatment in children with JPD.

When a dermatitic presentation on the head and neck of a patient with a current or past history of AD does not respond well to standard therapies, consider the potential influence of *Malassezia*, for which antifungal therapy is beneficial. Airborne pattern AD simulates photodermatitis with subtle distinctions and responds to avoidance plus barrier repair therapy.
Epidermal Barrier Dysfunction

J uvenile plantar dermatosis (JPD), also known as wet-to-dry foot syndrome or sweaty socks syndrome, is a poorly understood and under-studied condition whose presentation may mimic that of numerous other common dermatoses. Due to a lack of published data on the condition, its prevalence is not well known. However, the condition may be somewhat common. There is some evidence that JPD may be a presentation of childhood atopic dermatitis and that it can persist into adulthood.

Clinical Presentation. Although juvenile plantar dermatosis was first described more than three decades ago, a literature search returns relatively few publications on the condition. Taken together, information from these few publications suggests that the condition tends to be chronic with an extended course of two to four years and that typical interventions may be palliative but not curative. JPD typically presents as an erythematous rash of the weight-bearing plantar aspects of the feet; the distal one-third of the plantar surface of the feet and toes tend to be involved more frequently. The postal two-thirds of the plantar surface are not involved. Areas of involvement generally are smooth and shiny with a high incidence of painful fissuring and cracking. In some cases, the skin of the affected areas desquamates. Although generally associated with hyperhidrosis, ironically, JPD may be associated with anhidrosis.

The desquamation of the skin can mimic keratolysis exfoliativa, but this typically presents initially as pin-size white dots that coalesce. Furthermore, keratolysis exfoliativa tends to affect the palms of the hands more often than the feet and is often asymptomatic.

The differential diagnosis of JPD also includes tinea pedis. However, tinea pedis typically involves the fourth and fifth toe web spaces, whereas JPD generally spares the toe webs. Although tinea pedis rarely affects small children, clinicians should not assume based on a patient’s younger age that a questionable presentation is JPD rather than tinea pedis. A potassium hydroxide (KOH) preparation can confirm or rule out tinea.

JPD may be misdiagnosed as classic atopic dermatitis (AD) of the foot, given the young age of affected individuals. While there is evidence of an association between JPD and AD, they are distinct diagnoses. In a 10-year follow-up of patients diagnosed with JPD, researchers found that 52 percent of JPD patients were atopic, and that JPD was often associated with hand eczema in adulthood.

Barrier Disease Beyond Eczema: Management of Juvenile Plantar Dermatitis with a Physiologic Barrier Repair Cream

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About 26 percent of individuals who had JPD as children experienced hand eczema as adults.6

**Pathogenesis.** The etiology and pathogenesis of JPD are not well understood, though it is generally accepted that excessive moisture of the feet contributes. There is no evidence for a fungal component to the disease. While there is no conclusive evidence implicating bacterial mediators, hypotheses suggest that bacterial colonization may be a factor in the pathogenesis.9 There is histopathological documentation of inflammation at the junctions of sweat-gland ducts and acrosyringia in affected individuals.9

Irritants/allergens are not shown to contribute to the etiology of JPD. In the case of recalcitrant JPD, patch testing may be indicated; data show that in one study population, half of patients diagnosed with non-atopic plantar dermatoses ultimately had positive patch reactions to at least one tested item.

The process of skin fissuring and desquamation in JPD is not fully understood, but it may be likened loosely to the formation of syneresis cracks in dried mud puddles (See Sidebar). As water evaporates out of the puddle, shrinkage occurs, leading to the formation of cracks and fissures in the mud crust.

In JPD, when the foot is exposed to moisture over extended periods of time (either through hyperhidrosis occlusion of the foot via footwear made of non-breathable synthetic materials), high levels of surface moisture develop. However, it is well established that exposure to water does not induce skin hydration; in fact, persistent water exposure is shown to disrupt epidermal barrier function.11 Furthermore, there is recent evidence that TEWL increases as temperature increases,12 a finding that may be relevant because non-breathable footwear may be associated with higher foot temperatures.

As the disrupted barrier permits excessive evaporation of subcutaneous moisture (transepidermal water loss or TEWL) beyond normal evaporation of moisture on the surface of the skin (skin surface water loss, SSWL), a cycle of further degradation and dysfunction ensues. With lack of hydration, desiccated corneocytes on the epidermal layer shrink. It is likely that in the presence of depleted lipids and epidermal proteins, corneocyte adhesion is diminished, and fissures develop.

Another theory posits that in the hot, humid environment of the shoe, sweat becomes “trapped” in the skin, producing corneocyte edema and exaggerated shearing stress.7

**Treatment Strategies.** There is no specific treat-
Epidermal Barrier Dysfunction

Head and neck dermatitis can be a treatment challenge for both patients and clinicians. Importantly, variants of the condition have been identified. Familiarity with these variants can aid diagnosis and treatment. Malassezia-exacerbated. When a dermatitic presentation on the head and neck of a patient with a current or past history of atopic dermatitis...
Epidermal Barrier Dysfunction

does not respond well to standard therapies, consider the potential influence of Malassezia, which is known to exacerbate AD. Adolescent and adult patients with a history of typical flexural atopic dermatitis—and often a history of mucosal allergies, as well—seem to be at increased risk for head and neck dermatitis. As sebum production increases in adolescence, Malassezia populations increase. At any time after that, even into the 30s or 40s, the patient can become IgE +/- CD4 sensitized to Malassezia, and the presence of the yeast will lead to new onset of atopic dermatitis on the face, neck, and upper chest, where sebum production and Malassezia counts are highest.

Malassezia-exacerbated head and neck dermatitis tends to be extremely recalcitrant to standard AD therapies. However, itraconazole 100mg twice-daily for two months generally yields clearance. When the acute flare is resolved after the initial two months of therapy, a maintenance regimen of itraconazole 100mg once- or twice-daily on two days per week may be continued indefinitely.

It is essential to recognize that patients have underlying atopic dermatitis and require treatment beyond targeting Malassezia. Standard topical therapies for AD in other areas, including a physiologic moisturizer, are indicated.

Airborne Pattern. Another variant of AD is airborne pattern atopic dermatitis, which simulates photodermatitis with subtle distinctions. Airborne pattern AD tends to flare during the height of mucosal allergen seasons, unless dust mites—which are ubiquitously present—are involved. Data indicate that certain recognized allergens have proteolytic effects on the stratum corneum, activating Protease-activated receptor-2 (PAR-2). Activated PAR-2 directly causes itch and causes inflammatory cytokine release from keratinocytes. Potentially causative airborne proteins so far identified include dust mite (the allergen most frequently associated with such reactions), cockroach, ragweed, birch, cedar, cypress, and juniper. Potentially causative airborne proteins so far identified include dust mite (the allergen most frequently associated with such reactions), cockroach, ragweed, birch, cedar, cypress, and juniper. It is extremely important to remember that this variant of AD is not related to the allergic effects of these proteins, and therefore, antihistamines and immunotherapy are usually not helpful. In susceptible patients, the proteins induce barrier dysfunction and itch independent of IgE binding.

Mite avoidance is simple, cheap, and often helpful. Mite-preventing mattress and pillow covers, when used properly, can be helpful. High quality covers cost around $100 and can be found on the Internet. Less expensive (and less comfortable) covers cost around $30 and can be found at Target or Walmart. These covers encase the mattress and pillowcase, and the normal sheets and pillowcases go over them. Frequently changing bed linens is recommended. Weekly vacuuming of the home, and especially the bedroom, is the only other intervention shown to be helpful.

Patients should be instructed to shower twice daily to remove proteins from the skin. Immediately following the shower, patients should apply a physiologic moisturizer. Showering before bedtime may be especially helpful; patients should dress in freshly laundered nightclothes before getting into bed (re-wearing protein laden pajamas defeats the purpose of bathing). Allergen-specific immunotherapy may be helpful in some patients, but as noted above, is often not effective.

Treatment consists of regular use of a physiologic moisturizer, CeraVe (Coria Laboratories) or EpiCeram (Promius), whose mechanism—increasing production of endogenous stratum corneum lipids—is completely unrelated to traditional moisturizers and likely leads to decreased penetration of these airborne proteases. Topical corticosteroid therapy is indicated to manage acute flares. One of the most effective and relatively inexpensive treatment options is a 50mL bottle of clobetasol solution compounded into a 16oz jar of CeraVe cream. This has been found to be extremely safe, highly effective, and much better accepted by patients than traditional topical steroids.

Keys to Success

For successful management of any form of face and neck dermatitis or atypical atopic dermatitis, several principles guide patient care and support long-term efficacy. First and foremost is compliance:
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