BESTPRACTICES:

The Emerging Science of the Developing Infant Skin Microbiome

Introduction: The Skin Microbiome

The skin harbors a large, diverse community of microorganisms referred to as the skin microbiome. A typical square centimeter of skin is estimated to contain from 10,000 to one billion bacteria, depending on the mode of sampling.[1] The bacterial diversity of the skin microbiome varies by area of the body; differences in skin ecology such as temperature, texture, thickness, humidity and chemistry help determine which kinds of microbes live in which skin locations.[2] However, mRNA sequencing results have shown that intrapersonal variation is less than the variation typically seen among individuals.[2]

The microbiome lives in a relatively acidic skin environment at a pH of approximately 5, a pH that inhibits the growth of many, but not all, pathogenic bacteria.[2] Normal skin microbiome includes beneficial and harmful bacteria in coexistence.[2]

This article shares the latest research on the development of the skin microbiome in infancy, including the neonatal period, and informs on the essential role of a healthy skin microbiome while providing practical advice for patients.

An Infant's Skin Microbiome and Its Development Over Time

An infant experiences the first major exposure to microbes at birth, and the types of bacteria present on the newborn's skin varies by delivery mode.[3] Babies delivered vaginally had an initial microbiome that was more similar to their mother's own vaginal microbiota than to that of other babies born vaginally to other mothers.[3] The skin bacteria of most C-section infants did not closely resemble their mothers' vaginal bacteria, but resembled adult skin bacterial communities suggesting exposure both from mother and influence from environmental exposure in the hospital.[3]

The initial microbial populations evolve over time, adapting to characteristics of each body site. In a study of infants age 1 to 12 months, differences in skin microbiome between infants born vaginally and by C-section are no longer apparent by 1 month, and the skin microbiome continued to evolve during at least the first year of life.[4] While the most abundant classes of bacteria were Bacilli, Clostridia, and Actinobacteria at all sites sampled and all ages, relative amounts differed as a function of age and site.[4] This contrasts with adult skin, where the microbiome is reasonably constant over time.[4] The infant skin microbiome may, therefore, be at greater risk to support the growth of harmful or infectious microbes during this transition period, especially if something interferes with normal establishment of commensal bacteria.[4]

The Neonatal Skin Microbiome

Changes in the skin microbiota throughout the neonatal period (first month) have not been well described and may provide insights into the links between establishment of skin microbiota in early life and disease. In particular, products such as soaps and moisturizers applied to skin may potentially impact the development of the skin microbiome.[2]

We recently completed a study of longitudinal changes in the neonatal skin microbiota comparing two skin care regimens in newborn infants with healthy skin.[5] The treatment group included a prescribed skincare regimen of baby wash, shampoo and lotion, while the control group continued the use of their existing products.[5]

Physicians and caregiver assessments of tolerance and noninvasive measures of skin pH and skin microbiome were made at baseline (newborn) and treatment weeks 1 and 3, and infants were monitored for adverse events throughout.[5]

Two important characteristics of the skin microbiome are richness and diversity of the species of microorganisms present. Richness refers to estimates of the total number of species present in a microbiome community. For example, greater richness means more variety in the types of microorganisms. Diversity, on the other hand, provides additional information about the relative amounts of the species that are present. Calculations of diversity include the relative abundances of different species as well as the number of those different types of species. Both richness and diversity were measured at baseline and weeks 1 and 3.

The use of the specified skin care regimen was well tolerated. Microbial richness was lower in babies delivered vaginally than by C-section at baseline, but the skin microbiota in all babies evolved to an infant skin microbial profile within the first week of life.[5] Infant skin was initially dominated by *Staphylococcus* and *Streptococcus* species but these decreased to about half of skin microbiota species in infants older than 1 month.[5] Overall microbial diversity on infant skin continued to increase during the 1 to 3 week study period and was affected by the type of skin care routine.[5]

The Impact of the Skin Microbiome on Skin Health

In addition to hosting the microbiome, the skin itself is an important immunological barrier. A healthy, intact skin barrier protects from external aggressors such as allergens, germs, dirt, chemicals and ultraviolet radiation. A healthy skin microbiome can help prevent pathogen colonization and many members of the skin microbiome are directly inhibitory to pathogens.[6] For example, commensal bacteria (ie, *S. epidermidis*) on the skin amplify the skin's innate immune response to pathogens.[2] Both diversity and richness have been linked to several human diseases, and new research suggests that some disease states may be linked to the absence of commensal bacteria and not simply the presence of a pathogen.[7,8]

Of particular interest to physicians caring for infants and children, is that the diversity and richness of skin microbiome are decreased in patients with atopic dermatitis (AD).[9] Up to 20% of children in westernized countries are affected by AD.[10] The focus of much of the AD research has been on skin colonization by *S. aureus*.[10] AD lesions are linked to an increase in *S. aureus* in the presence of low diversity of other species,[9] and colonization by *S. aureus* has been proven to exacerbate the disease and precedes flares.[10] *S. aureus* also increases during AD flares.[9] Research suggests that improving the overall diversity of the skin's microbiome can improve the severity of AD.[9]

Practical Advice

While the skin microbiome is initially formed at birth, it continues to change and evolve during infancy and childhood. Maintaining a healthy skin microbiome appears to be important to limiting certain skin diseases such as AD. Recommendations to parents should include the proper care of skin to limit disruptions of the microbiome. This would include using gentle cleansers and skin care products with, for example, the appropriate pH so as not to disrupt the delicate balance of the skin microbiome. Harsh cleansers may not support babies' uniquely different and developing skin barrier, and therefore may potentially disrupt the balance of the skin microbiome. Skin barrier disruption characterized by an imbalance of bacteria colonization in the skin microbiome can lead to adverse skin conditions.[6]

Summary

The skin microbiome is an essential aspect of an infant's immune system and is a first line of defense against pathogens. The skin microbiome is first established at birth by birth route but becomes more skin-like, and significantly more diverse during the first 30 days of life.

The skin microbiome in infancy and early childhood is not a stable ecosystem like we see in adults, and as such it may require special care to protect the evolving microbiome and prevent the development of skin issues.

Kimberly A. Capone, PhD

Head, Microbiome Platform
Emerging Science & Innovation,
Research & Development
Johnson & Johnson Consumer Inc.
Skillman, NJ USA

A review of a Product Theater presentation by Dr. Capone.

This supplement is sponsored by Johnson & Johnson Consumer Inc.

Dr. Capone discloses that she is an employee of Johnson & Johnson Consumer Inc.

References

1. Grice EA, Kong HH, Renaud G, et al. A diversity profile of the human skin microbiota. *Genome Res*. 2008;18(7):1043-1050.
2. Grice EA, Segre JA. The skin microbiome. *Nat Rev Microbiol*. 2011;9(4):244-253.
3. Dominguez-Bello MG, Costello E, Contreras M, et al. Delivery mode shapes the acquisition and structure of the initial microbiota across multiple body habitats in newborns. *Proc Natl Acad Sci USA* 2010;107:11971-11975.
4. Capone KA, Dowd SE, Stamatas GN, Nikolovski J. Diversity of the human skin microbiome early in life. *J Invest Dermatol.* 2011;131:2026-2032.
5. Capone K, Tierney N, Smith H, Tian S, Horowitz P. Longitudinal Development of the Skin Microbiome During the Neonatal Period. Abstract. American Academy of Dermatology - 75th Annual Meeting. Orlando, FL. March 3-7, 2017.
6. Egert M, Simmering R, Riedel CU. The association of the skin microbiota with health, immunity, and disease. *Clin Pharmacol Ther*. 2017;102(1):62-69.
7. Tlaskalov-Hogenová H, Štepánková R, Hudcovic T, et al. Commensal bacteria (normal microflora), mucosal immunity and chronic inflammatory and autoimmune diseases. *Immunol. Lett*. 2004;93:97–108.
8. Cogen AL, NizetV, Gallo RL. Skin microbiota: a source of disease or defence? *Br J Dermatol.* 2008;158(3):442-455.
9. Kong HH, Oh J, Deming C, et al. Temporal shifts in the skin microbiome associated with disease flares and treatment in children with atopic dermatitis. *Genome Res.* 2012;22(5):850-859.
10. Brandwein M, Steinberg D, Meshner S. Microbial biofilms and the human skin microbiome. *npj Biofilms Microbiomes* 2016;2:3. doi:10.1038/s41522-016-0004-z

Prepared by the Custom Products division of Frontline Medical Communications, publishers of *Pediatric News* and *Dermatology News*. The editorial staff was not involved with the writing or review of this material.