Diaper Dermatitis and Fecal pH: The Role of the Infant Gut Microbiome

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Introduction

Diaper dermatitis (DD) is a common occurrence in the NICU, with an estimated 29% of infants in the Neonatal Intensive Care Unit (NICU) affected during their hospitalization.[1,2] The function of the skin plays a role in the development of DD among infants, along with internal factors such as fecal pH and the composition of the infant gut microbiome. The prevalence of DD among infants in the NICU is variable in the literature. The lack of consistent management methods, inconsistent assessment tools, and variability due to the subjective nature of assessment lead to a lack of reliability among published studies.[3] Additionally, DD may be associated with the care complexity of the infant during their hospitalization. Factors such as time to full feeds, type of feeds, stooling frequency, antibiotic usage, and characteristics of severity of illness have been described in DD literature related to assessment and management.[4] Emerging data suggest that DD may be an early indicator of gut dysbiosis, or an overgrowth of pathogenic bacteria in the infant gastrointestinal (GI) system. Gut dysbiosis has been linked to many negative health outcomes in preterm infants, including increased risk of late onset sepsis, necrotizing enterocolitis, and diminished growth.[5,6,7] Recognition of DD as a symptom of this condition provides early and effective intervention during the window of immune development during the first few months of life.

Underlying Factors of Diaper Dermatitis

Diaper dermatitis is an inflammatory skin condition that occurs as a result of overhydration and the interaction of stool enzymes and the condition of the skin.[8] In addition to exposure of skin to urine and feces, pH plays a key role in the development of DD. Infant skin has a higher pH initially and continues to mature over the course of weeks to months depending on the prematurity of the infant at birth.[9] Hoeger, et. al. described a significant change in skin pH among non-hospitalized infants between 30 to 90 days of age.[10] The non-hospitalized infant is fed without complication in comparison to the infant in the NICU that has additional implications for the change in skin pH.

Additionally, prolonged exposure of the perianal region to urine and feces leads to a more alkaline skin pH, increasing the risk for diaper rash.[11,12]

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Fecal pH also plays a significant role in the development of diaper dermatitis, in that fecal enzymes, which are activated at elevated pH, have a direct irritant effect on the skin. Indeed, human breastmilk contains specific carbohydrates, called human milk oligosaccharides (HMO), which promote the growth of *Bifidobacterium longum* subsp. *infantis (B. infantis*) in the infant gut. *B. infantis* is an infant-adapted gut bacterium that efficiently converts HMO from human milk into acidic byproducts, lactate and acetate, creating a fecal pH of ~5.0.[13] In the absence of *B. infantis*, the production of these acidic byproducts is limited, causing fecal pH to rise to ~6.0 or higher. Unfortunately, due to modern medical practices in the US over the past century, most infants no longer maintain appreciable levels of *B. infantis* in their gut microbiome during infancy, and recent studies show that most infants in the US today have an elevated fecal pH.[14]

Prevention of Diaper Dermatitis

Currently, prevention is the key to decreasing DD among infants. Preventative methods in the literature promote the use of emollients and barrier products. The maintenance of skin integrity with topical administration of emollients and other DD products may provide mitigation of symptoms, but lack complete elimination. Additional approaches to promoting skin health from an internal perspective can be more intuitive to the elimination of DD. Proper nutrition is essential to the normal function of body systems demonstrating the importance of GI health. Infants in the NICU are often fed small amounts initially with extended length of time until full enteral feeds are established. Premature infants require the fortification of human milk with nutritional additives to promote adequate nutrition.[15] The addition of fortification, such as human milk fortifier in liquid form, can contribute to changes in pH of the GI system that may contribute to DD.[16] In addition to prioritizing a human milk diet, the infant gut microbiome should be considered in this fragile population. As mentioned, the presence of *B. infantis* in the infant converts HMOs in human milk to acidic end products, lowering fecal pH to the skin-protective range.

Safe and effective colonization of *B. infantis* in the infant GI system has now been demonstrated through feeding the probiotic strain *B. infantis* EVC001 to term, breastfed infants.[14,17,18] Furthermore, infants in this study who received *B. infantis* EVC001 had a significant reduction in the number of loose, watery stools per day compared to controls, along with a reduction in average fecal pH (5.97 to 5.15).[17] In addition to the significantly lower in pH and improvement in stool consistency,

infants who received *B. infantis* EVC001 also showed an 80% reduction in GI pathogens associated with autoimmune and allergic conditions later in life. Based on this growing body of evidence, LabCorp national diagnostic lab has recently updated the infant stool pH reference range to pH 4.5-5.5, corresponding to the observed benefits within this range.

Conclusion

Skin care for the vulnerable infant in the NICU should be based on a holistic examination of the NICU environment. This examination should include optimization of extrinsic and intrinsic modalities to promote skin health among this fragile population. Restoration of the infant gut microbiome with *B. infantis* EVC001, and subsequent reduction in both frequency and pH of the stool, may be an effective way to address the underlying gut dysbiosis and manage the biochemical factors that precede the onset of DD, rather than waiting to treat the skin topically once signs and symptoms have been identified.

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