CE 3.0 HOURS Continuing Education

Extremely Preterm Infant Skin Care

A Transformation of Practice Aimed to Prevent Harm

Deanna E. Johnson, APRN, NNP-BC, CWON

ABSTRACT

Background: The skin of extremely preterm infants is underdeveloped and has poor barrier function. Skin maintenance interventions initiated in the neonatal intensive care unit (NICU) have immediate and lifelong implications when the potential for infection, allergen sensitization, and altered aesthetic outcomes are considered. In addition, the high-level medical needs of extremely preterm infants demand skin-level medical interventions that too often result in unintended skin harm.

Purpose: We describe the use of a harm prevention, or consequence-centered, approach to skin care, which facilitates safer practice for extremely premature infants.

Method: Neonatal and pediatric Advanced Practice Registered Nurses (APRN) came together for monthly meetings to review the evidence around best skin care practices for extremely preterm infants, with an emphasis on reduction of skin harm. Findings were focused on the population of interest and clinical implementation strategies.

Findings: Skin care for extremely preterm infants remains overlooked by current literature. However, clinical practice pearls were extracted and applied in a manner that promotes safer skin care practices in the NICU.

Implications for Practice: Gentle adhesives, such as silicone tapes and hydrogel-backed electrodes, can help to reduce medical adhesive-related skin injuries. Diaper wipes are not appropriate for use among extremely preterm infants, as many ingredients may contain potential allergens. Skin cleansers should be pH neutral to the skin and the prophylactic use of petrolatum-based emollients should be avoided.

Implications for Research: Further exploration and understanding of skin care practices that examine issues of true risk versus hypothetical risk of harm.

Key Words: anetoderma of prematurity, barrier function, harm prevention, medical adhesive-related skin injury, neonatal skin care, premature infant skin care

Understanding premature infant skin care under the umbrella of preventable harms requires a paradigm shift from examining how a product or regimen might be helpful, to how the intervention might cause unintended negative consequences. Our most premature and frail patients must be acknowledged as more than a premature infant, but also as the developing child, adolescent, and adult who we are aiming to support. Because of the unique properties of preterm infant skin, skin care and skin maintenance interventions initiated in the neonatal intensive care unit (NICU) may have immediate and lifelong implications when the potential for hospital-acquired infection, allergen sensitization, and altered aesthetic outcomes are considered. There are very few interventions in the NICU that are without risk, and skin care practices cannot be excluded from the potential to cause significant patient' harm.

Author Affiliation: *Children's Hospitals and Clinics of Minnesota, Minneapolis.*

The author declares no conflicts of interest.

Correspondence: *Deanna E. Johnson, APRN, NNP-BC, CWON, Children's Hospitals and Clinics of Minnesota, Mail Stop 32-3210, 2525 Chicago Ave, Minneapolis, MN 55404 (deanna.johnson@childrensmn.org).*

DOI: 10.1097/ANC.0000000000000335

NATURE AND SIGNIFICANCE OF THE PROBLEM

The skin structure of the preterm infant is immature and varies from that of term infant skin. The outermost layer of skin, the stratum corneum (SC), is constructed much like bricks and mortar (keratinocytes and lipid) and when mature is 10 to 20 layers thick, depending on body location. The SC provides barrier function by preventing transepidermal water loss (TEWL) and evaporative hypothermia, while at the same time offering protection from microbe invasion, allergen infiltration, and toxin absorption. Levels of TEWL increase with the decrease of barrier function. In extremely premature infants the SC is underdeveloped, with less than 2 to 3 layers, resulting in negligible barrier function. The decreased presence of the SC is visually notable by the overall ruddy and gelatinous appearance of premature infants in the days immediately after delivery.[1] Stimulated by exposure to the drier extrauterine environment, extremely premature infants undergo observable accelerated skin maturation and at about 14 days of life there is a visual development of suppleness and an appearance of increasing durability and robustness. This progression has been scientifically calculated and quantified using methods of measuring TEWL. The time line for this accelerated skin

maturation process is anywhere from 2 to 8 weeks, depending on gestational age at delivery,[1,2] with the more immature babies taking the longest amount of time to transition and attain barrier function.

An understanding of the underdeveloped junction between the dermal and epidermal skin layers is also important to preterm infant skin maintenance. These 2 layers of skin are linked together by fibrils; these connection points in preterm infants are weaker, fewer, and more widely spaced than those of mature skin.[1] Tissue edema, as a result of the decreased presence of collagen,[1] is common to preterm infants and further weakens the bond between the epidermis and dermis, as fluid collects between these layers. As a result, skin is less elastic and more likely to blister from friction.

At the time of birth, both preterm infants and term infants will undergo skin acidification. This acidification process results in an *acid mantle,* or kind of protective shroud against some invasive microorganisms.[1] The formation of this acid mantle is an endogenous process that occurs independent of gestational age and begins nearly immediately after delivery.[3,4] Skin pH is shown to range from greater than 6.0 to just over 7.0 after birth,[1] dropping to about 5.5 in the first week.[1,4] Further decline occurs over the next 3 weeks, finally attaining a pH of approximately 5.0.[1,3] Alkaline skin care products, such as soaps, temporarily increase skin pH, which may cause an escalation in the overall numbers of skin microbes and also generate a change in the bacterial species in attendance. In addition, alkaline pH shifts have been found to increase TEWL, further hindering skin barrier function.[1] Therefore, an acid skin surface allows for full barrier function and is therapeutic to infection prevention.

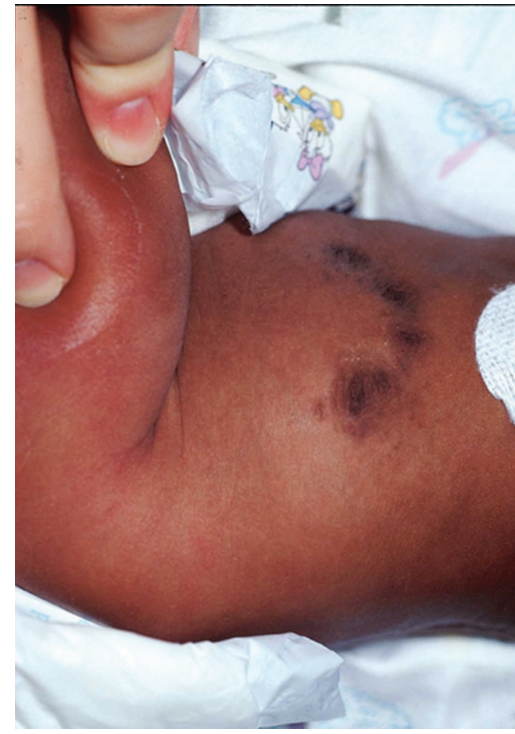
AVAILABLE KNOWLEDGE

Because of the anatomical and chemical skin differences discussed previously, neonatal skin maintenance plans for premature infants must go beyond basic recommendations for bathing and emollient use, to encompass subcategories of preventable harms. Special considerations for very low birthweight infants include chemical and adhesive-related skin breakdown, potential for allergen sensitization, and also absorption of potential toxins.

Medical adhesive-related skin injuries (MARSIs) include contact dermatitis, moisture maceration, and also mechanical skin injuries that occur when the epidermis is separated from the dermis. Mechanical injuries manifest as tension blisters, skin tears, and denudement caused by epidermal stripping. Epidermal stripping is the most common type of MARSI in the NICU and results when the bond between the adhesive and epidermis is stronger than the attachment between the epidermis and dermis.[5] The most fragile and extremely preterm babies often require the most monitoring equipment, which must be attached to the infants using medical adhesives.[5] Each device affixed to the infant requires consideration of the purpose and criticality, as the incidence and significance of these injuries can be improved with careful tape selection. Gentle adhesives, such as silicone tape and hydrogel adhesives, can be considered for nonlife lines and devices that require frequent site rotation, saving the more aggressive adhesives, such as silk, paper tapes, and clear film dressings, for critical tubes and lines, such as endotracheal tubes and central lines. Although common, MARSIs in the neonatal units are generally acute and resolve with relatively simple focused interventions.

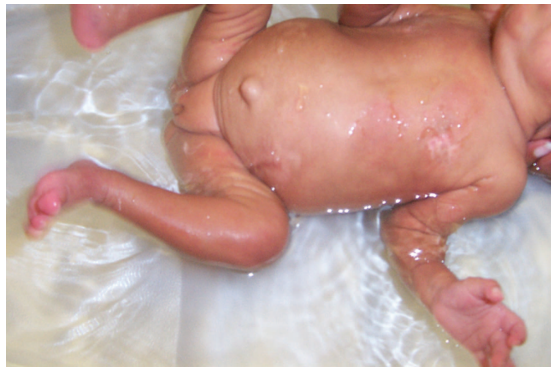
There is a unique iatrogenic consequence of medical adhesives, specific to very low and extremely low birth-weight infants, known as anetoderma of prematurity. Derived from the Greek word *anetos*, meaning relaxed or slackened, anetoderma of prematurity is a term used to describe permanent atrophic patches of skin that appear as areas of altered pigmentation and/or texture (Figure 1). These lesions may be flat, depressed, or emerge as an outpouching of skin. Sites of injury are always ventrally located, on body surface areas that have been subject to long-term medical

FIGURE 1



Anetoderma of prematurity. Skin shows hyperpigmentation and altered texture over the abdomen. Photograph compliments of Carolyn Lund, MS, RN, FAAN.

FIGURE 2



Anetoderma of prematurity. Atrophic patches of skin, with both areas of hyperpigmentation and hypopigmentation, scattered over the right and left anterior chest and also the left abdomen. Photograph compliments of Carolyn Lund, MS, RN, FAAN.

adhesives and devices, such as the chest and abdomen, where electrodes have been applied and lines affixed[6,7] (Figure 2). These types of lesions are not noted immediately after a specific skin injury, but rather appear between several weeks to 5 to 10 months of age.[5-7] There are some reports of focal areas of ecchymoses preceding the development of atrophic patches; however, in most cases anetoderma of prematurity is speculated to be caused by subclinical dermal injury due to long-term traction and pressure of the overlying attached device such as electrocardiographic monitoring patches and umbilical lines.[5-7] Although the exact mechanism of anetoderma of prematurity is not understood, given the location of the lesions, it is likely that subclinical iatrogenic dermal injury is the result of focal hypoxemia[7] and/or an inflammatory response, which alters the development and elasticity of the dermis.[5] Possible preventative measures include avoiding traction on affixed lines and wires, and by minimizing prolonged pressure by not allowing infants to lie on electrodes and also by using low-profile electrodes.[5] Also, when possible, position electrodes off areas of cosmetically sensitive areas, such as the breast area.[6] Hydrogel electrodes and silicone-backed adhesives may help to reduce both subclinical, and visible, skin injury, thereby reducing the potential for skin changes, which may have lifelong negative cosmetic implications.

EPICUTANEOUS SENSITIZATION

Percutaneous allergen sensitization likely precedes upper and lower airway sensitization.[8,9] Once an infant or child is sensitized to an allergen, the antibody can circulate through the bloodstream and migrate to other areas of the body, including nasal and lung mucosa.[8] TEWL is a quantification of evaporative water loss through the skin and is considered a well-established indicator of skin barrier function. Boralevi et al[8] demonstrated in children with atopic dermatitis (AD) that the higher the rate of TEWL, the higher the rate of allergen infiltration and sensitization to allergens, as demonstrated by a higher frequency of positive atopy patch test. In cases of AD, it is speculated that there is an intrinsic epidermal barrier weakness allowing for allergen penetration, leading to AD and later allergic rhinitis and asthma.[9] Although intrinsic susceptibility to allergic diseases in infants with AD is different from the physiologic underdeveloped SC in the preterm infant, the propensity for allergen infiltration may be arguably quite similar. Chang and Nakrani[10] released a case report in 2013 of 6 children with allergic contact dermatitis over perioral and perianal areas. These children were initially misdiagnosed as having eczema, impetigo, or psoriasis and were actually found to have allergic contact dermatitis caused by methylisothiazolinone, a common preservative found in both wet wipes and baby wipes. In all cases the rash resolved upon stopping usage of the wipes. Preterm infants may be at especially high risk for sensitization due to the near absence of barrier function that protects older infants and children from the invasion of potential allergens and toxins. In keeping with this knowledge, all skin care product labels in the NICU, including diaper wipes, must be closely reviewed for potential allergens. Products with very few ingredients may be preferable.

INFECTION PREVENTION

Skin care practices in the NICU have a particularly heavy encumbrance of risk versus risk, especially when infection prevention is considered. An example of a risk-versus-risk scenario is when an antiseptic skin preparation is undoubtedly needed to reduce the risk of bloodstream infections before central line placement, but this practice may place the infant at risk for chemical dermatitis and/or absorption of potential toxins. Likewise, routinely applied skin emollients may enhance barrier function, thereby decreasing TEWL, but may also increase the chances of a hospital-acquired infection. In other words, risk versus risk means that we are placed between a metaphoric rock and hard place.

Central line-related bloodstream infections (CLABSIs) in the NICU carry a 25% mortality risk,[11] as well as increased morbidities, including poor neurodevelopmental outcomes. One of the main risk factors for line-related sepsis is the concentration of skin flora at the insertion site; therefore, effective skin antisepsis before a central line insertion is paramount in preventing CLABSI.[12] The Centers for Disease Control and Prevention (CDC) recommends

cleansing the skin with chlorhexidine gluconate (CHG) before placement of central venous lines, as CHG has been shown to have reduced infection rates when compared with iodine-based solutions.[13] There is sufficient safety data for older children and adults, demonstrating that CHG exposure is generally well tolerated; however, the CDC's recommendations for CHG usage do not include infants younger than 2 months, as the safety and efficacy cannot be proven due to the lack of data.[13] Chapman et al[12] demonstrated that preterm infants do absorb CHG into their bloodstream after a single exposure to aqueous CHG before central line placement, and that serum levels peak at 2 to 3 days after exposure. The long-term effects of CHG exposure have not been tested, and there is concern that preterm infants may be more vulnerable to possible toxic effects relative to their increased potential for absorption, and also immature organ function resulting in a decreased ability to clear the CHG.[12] Although alcohol skin preparations alone can cause skin breakdown in preterm neonates, significant contact dermatitis has been reported with aqueous and alcohol CHG preparations.[14] Chemical erosions (burns) have been reported in infants less than 26 weeks' gestational age, most frequently noted on the abdomen after umbilical line placement.[14] It is suggested that preterm infants may be at the highest risk for CHG absorption and chemical erosions in the first 2 weeks of life, when skin barrier function is markedly decreased.[14]

A commonly used alternative to CHG in the NICU is povidone-iodine. In addition to having poor barrier function, preterm infants are at higher risk for iodine overload due to decreased renal clearance and the inability to regulate the uptake of iodine into the thyroid.[15] The ability to control the uptake of iodine matures at about 36 to 40 weeks' gestational age, leaving preterm infants at risk for transient hypothyroidism, goiter, and possibly altered neurodevelopmental outcomes.[15] A systematic review of thyroid dysfunction in preterm infants by Aitken and Williams[14] showed that the risk of thyroid dysfunction in preterm neonates after topical iodine exposure ranged from 12 to 33 per 100 infants, versus 0 in the nonexposed group. This article summarizes by advocating for the use of alternatives to iodine-containing skin antiseptics, such as CHG, due to the potential for altered neurodevelopmental outcomes related to thyroid dysfunction. However, it is also noted in this summary that the extent of thyroid dysfunction is unknown and that none of the studies included in the review evaluated neurodevelopmental outcomes in exposed infants. Again, further study is indicated.

Although preterm infants are largely overlooked in the available literature for best practice regarding skin antisepsis, careful application technique of iodine or CHG-based products is essential to protect preterm infants from skin breakdown. Gentle, nonaggressive application can be done to decrease friction-related breakdown. Not allowing product to pool on skin surfaces, especially skin creases, may decrease the risk of chemical burns.[11] Also, in effort to reduce the risk of harm, some recommendations include using sterile water or saline to clear the skin of residual product. With the latter practice, there is concern that this may counteract the very property of CHG that increases the efficacy of the product over iodine.[11]

Petrolatum-based emollients are commonly used in wound healing for superficial injuries and burns, and it seems perfectly reasonable that the practice of using petrolatum-based products may facilitate a similar therapeutic healing environment for the skin of preterm neonates. The topical application of emollients has demonstrated improved neonatal skin condition[16]; however, prophylactically applied topical emollients in the NICU have been associated with an increased risk for hospital-acquired infection.[17] A 2009 Cochrane Review[17] found that the prophylactic application of topical emollients increased the relative risk for coagulase-negative staphylococcal infection by 31%. There was also a noted relative risk increased by 20% for all hospital-acquired infections, encompassing bacterial and fungal organisms. The mechanism of increased infection is not fully understood, but may be by way of cross-contamination during application and/or by facilitating a skin surface environment that is complementary to bacterial growth.[17] It was concluded in this review that the potential benefits of prophylactic topical application did not outweigh the potential for infection. This Cochrane Review was updated in 2016,[18] and in comparing topical ointment and cream to routine skin care, there was "borderline significant higher risk of infection with coagulase-negative staphylococci but no statistically significant effects on infection with other bacteria or fungi."[16(p12)]

Routine bathing is often thought of as beneficial to reducing the overall number of microbes and also necessary for the removal of physiologic skin debris. However, bathing premature infants may provoke detrimental physiologic effects if timing and skin care products are not carefully considered.[1] Allowing for the physiologic acidification of skin after birth is crucial to barrier function and infection prevention.[4] Alkaline pH shifts support the growth of *Staphylococcus aureus* and *Candida albicans*[4]; therefore, skin cleansers should be pH balanced to the skin as a way to protect premature infants from infection. Extremely premature infants, during the first 2 weeks life, should be cleaned with only sterile water.[1] Just as important are the nonskin risks of bathing, including hypothermia and worsening respiratory distress. As such, bathing premature infants should be approached with

caution and should only be done 2 to 3 times per week and while the infant is demonstrating relative clinical stability.[1]

RATIONAL/ASSUMPTIONS

The skin of premature infants is, in essence, wounded. The decreased presence of, or in extreme cases near-complete lack of, SC can be compared with a superficial partial-thickness wound, as seen in denudement or epidermal stripping from medical adhesives. Based on this foundation, skin care for premature infants born less than 28 weeks' gestation should therefore be similar to wound cares until adequate time is allowed for the infant to develop barrier function.

SPECIFIC AIMS

The focus of this project was harm reduction, both actual and potential, to support the preterm infant both in the NICU and as a developing child and adult for tomorrow.

METHODS

A collaborative team of clinical experts was brought together for monthly meetings. We set out to create a simplified, streamlined, and standardized approach to premature infant skin care, which focuses on the reduction of harms by supporting the infant's current fragile state and future potential as a developing and healthy individual. The group was led by a Neonatal Skin Integrity Nurse Practitioner. Group members included 3 additional neonatal nurse practitioners, a skin integrity pediatric clinical nurse specialist, and a dermatology and wound, ostomy, and continence-certified pediatric nurse practitioner. A topic-based literature review on bathing, emollients use, skin antiseptic preparations, MARSI prevention, and allergen sensitization was completed by the group. When focused skin care interventions were considered for implementation, other clinical leaders, such as the neonatal clinical nurse specialist, as well as experts from various departments, including respiratory therapy, laboratory, nursing informatics, and infection prevention and control were consulted. The financial implications for interventions were also discussed with the hospital purchasing and value analysis department.

Interventions

A preterm skin maintenance guideline was created based on best practices found in the literature review, as well as innovative practices based on clinical understanding of products and expert opinion. Focused nursing education was done by way of topic-based articles that were added to the neonatal community nursing monthly newsletter. Also, these articles, along with skin integrity poster boards, were placed in highly visible areas such as break rooms.

Meetings with the nursing informatics department were held and an electronic chart flag to the Skin Integrity team was created to alert the team to high-risk premature infants. The Skin Integrity team now receives an electronic chart flag for babies admitted to the neonatal community who were born less than 29 weeks' gestation. This electronic chart flag prompts a Skin Integrity team member to perform an initial full skin assessment, including a review of the pregnancy and birth history. The Skin Integrity team then continues to clinically follow until the infant's skin has successfully transitioned to extrauterine life. Routine physical examinations and progress notes are preformed and placed in the medical record, similar to other consulting services. The length of time the Skin Integrity team continues to follow the infant is highly variable and determined by each infant's unique need.

A standardized provider neonatal skin maintenance electronic order-set was created for this special subgroup of NICU admissions. The order-set was created for the purpose of ensuring a unified language for interventions and can be ordered by the admitting provider or by the Skin Integrity team upon receiving the electronic chart flag.

Context and Interventions (Getting Buy-in)

Bedside nurses are the clinical gatekeepers of routine skin care in the NICU. Nursing must come to know the interventions as convenient and also harmonious with developmentally appropriate cares. Possible interventions were scrutinized for issues surrounding usability and current bedside trends. For instance, we found that diaper wipes were valued because they were conveniently kept in the warm isolate; a practice that kept the wipes within reach and also warm for the small babies. As such, multiuse prepackage diaper wipes, without preservatives, may became a mode of transmission for infection. However, the preservatives and other added ingredients in prepackaged diaper wipes may contain potentially sensitizing ingredients. For these reasons, we opted to implement the use of prepackaged single-use sterile saline towelettes for routine diaper area cleansing, for the first 2 weeks of life—while barrier function is most inadequate. Similarly, bottles of sterile water for bathing can be conveniently and safely warmed in the bedside milk warmers.

It is also important to acknowledge that NICUs are often located within larger pediatric facilities or as a unit within an adult hospital. Most skin care products are nonprescription and are stocked on unit shelves or available through the hospital central supply. This

ease of accessibility can lead to a "trickling down" of skin care products and/or techniques from other care communities. The end result of this trend was a wide diversity in bedside skin care practices, many not suitable for the neonatal population, especially premature infants. Routine Skin Integrity team bedside follow-up during the postnatal skin transitional period has opened up opportunities for focused nursing education when an inappropriate skin care product or technique is noted to have been used.

The availability of important neonatal skin maintenance products was reviewed. We found that silicone adhesives were not being routinely used as they were not readily available at the bedside. As such, we worked together with unit leadership to ensure that the bedside supply carts were stocked with silicone adhesives. In addition, the NICU unit stock rooms were collaboratively reviewed and several modifications were made to make certain that all essential skin maintenance products are available. Items that are generally inappropriate for neonatal use have been removed from unit stock.

Also, parents and family must see the intervention as beneficial, or in the very least nontraumatic and nonharmful, to obtain buy-in. For this reason, the rounding Skin Integrity team member is attentive to parent education needs in regard to skin maintenance. Skin care products and adhesives, such as no-sting barrier film and silicone adhesives, are first placed on the backside of the parents' hand (or in the case of silicone adhesives, on a hairy forearm), so that they can first-hand experience the product before using it on their child.

Our group's experience with the implementation was positive, and interventions were well received by nursing and patient families. We found that nursing was seeking a streamlined process for skin care in the NICU, and that the large number of available products and varied practices was anxiety provoking for both nursing and families. We also recognized that many family members are quite savvy in regard to baby skin care product ingredients and that they favor this minimalistic approach. For these reasons, the interventions were quickly adopted into the unit culture and have been largely self-sustaining (see Table 1).

CONCLUSION

In many ways extremely preterm infants remain orphaned by current literature; however, clinical practice pearls can be extracted and applied in a

TABLE 1. Interventions for 22-28 Weeks Corrected Gestational Age

	Interventions
Bathing	Use warm sterile water Bathe 2 times per week, or every 4 d Okay to use mild pH-neutral cleanser after 2 wk of age
Emollient use	Use scent-free moisturizers/emollients that contain minimal ingredients Use 6% dimethicone cream sparingly over areas that are visibly dry/cracked Do not "double-dip" into tubs of emollients If using the same product for perineal protection, have 2 tubes at the bedside, clearly labeled for application site
Perineal cleansing	Warm sterile saline wipe for first 2 wk of life After 2 wk of age, use warm tap or sterile water and soft disposable cloth To avoid potentially sensitizing ingredients, defer the use of prepackaged diaper wipes until 37-wk corrected gestational age
Perineal protection	6% dimethicone cream (very light protection) Petrolatum-based clear barrier ointment (light protection) Zinc oxide-based paste (thick protection)
Medical adhesives	Hydrogel EKG leads Thoughtful tape selection. Use silicone adhesives for non life lines. Use silicone as a contact layer or "landing pad" under more aggressive adhesive when appropriate.
Aseptic skin preparation	For infants born <26-wk gestation, use 10% povidone-iodine for the first 2 wk of life After 2 wk of age, use 3.15% CHG in 70% isopropyl alcohol For infants born at ≥26-wk gestation, use 3.15% CHG in 70% isopropyl alcohol Do not allow preparations to pool in skin folds Always remove preparations with sterile saline or sterile water after the procedure

Abbreviations: CHG, chlorhexidine gluconate; EKG, electrocardiograph.

Summary of Recommendations for Practice and Research	
What we know:	• Underdeveloped extremely preterm infant skin results in an increased propensity for chemical-related skin breakdown, allergen sensitization, and absorption of potential toxins. • Postnatal skin maturation takes 2 to 8 weeks, depending on gestational age at delivery, with the more premature infants taking the longest. • Epidermal stripping and anetoderma of prematurity have both short-term and lifelong consequences. • Percutaneous allergen sensitization likely precedes, and can induce a systemic allergen response.
What needs to be studied:	• Incidence of anetoderma of prematurity and exploration of prevention strategies. • The relationship between prematurity and allergic diseases. • Toxicology data for the use of CHG in preterm infants, especially neurotoxicity. • Safe emollient usage in the NICU.
What we can do today:	• Asses every product that comes in contact with extremely premature infant skin for safety. • Limit or forego the use of skin care products that may have potential allergens. • Thoughtful medical adhesive usage and the use of silicone and hydrogel adhesives when appropriate. • Use gentle application technique for topical antisepsis and clear skin of residual product with sterile saline or sterile water following the recommended dry time. • Focal use only of topical emollients over areas of dry, cracked, or flaking skin. • Use mild cleansers that are pH-neutral to the skin.

manner that promotes safer skin care practices in the NICU. A harm reduction approach to neonatal skin care may facilitate a safer practice, even if the safest practice has not yet been established by current literature.

Acknowledgments

Special thanks to my friends and colleagues, Sandra Oehlke, APRN, and Mary Jaeger, APRN.

References

1. Lund C, Kuller J, Lane A, Lott JW, Raines D. Neonatal skin care: the scientific basis for practice. *J Obstet Gynecol Neonatal Nurs.* 1999;28:241-254.
2. Kalia Y, Nonato L, Lund C, Guy R. Development of skin barrier function in preterm infants. *J Invest Dermatol.* 1998:111;320-326.
3. Fluhr JW, Darlenski R, Taieb A, et al. Functional skin adaptation in infancy—almost complete but not fully complete. *Exp Dermatol.* 2010;19:483-492.
4. Fluhr JW, Darlenski R, Lachmann N, et al. Infant epidermal skin physiology: adaptation after birth. *Br J Dermatol.* 2012;166:483-490.
5. Lund C. Medical adhesives in the NICU. *Newborn Infant Nurs Rev.* 2014;14:160-165.
6. Goujon E, Beer F, Gay S, Sandre D, Gouyon J-B, Vabres P. Anetoderma of prematurity: an iatrogenic consequences of neonatal intensive care. *Arch Dermatol.* 2010;5:565-567.
7. Maffeis L, Pugni L, Pietrasanta C, et al. Iatrogenic anetoderma of prematurity: a case report and review of the literature. *Case Rep Dermatol Med. 2014;2014:*781493.
8. Boralevi F, Hubiche T, Leaute-Labreze C, et al. Epicutaneous aeroallergen sensitization in atopic dermatitis infants—determining the role of epidermal barrier impairment. *Allergy.* 2008;63:205-210.
9. Spergel J, Paller A. Atopic dermatitis and the atopic march. *J Allery Clin Immunol.* 2003;112:S118-S127.
10. Chang M, Nakrani R. Six children with allergic contact dermatitis to methylisothiazolinone in wet wipes (baby wipes). *Pediatrics.* 2014;133(2):e434-e438.
11. Ponnusamy V, Venkatesh V, Clarke P. Skin antisepsis in the neonate: what should we use? *Curr Opin Infect Dis.* 2014;27:244-250.
12. Chapman A, Aucott S, Gilmore M, Advani S, Clarke W, Milstone A. Absorption and tolerability of aqueous chlorhexidine gluconate used for skin antisepsis prior to catheter insertion in preterm neonates. *J Perinatol.* 2013;33(10):768-771.
13. O'Grady NP, Alexander M, Burns LA, et al. Guidelines for the prevention of intravascular catheter-related infections. Healthcare Infection Control Practices Advisory Committee. http://www.cdc.gov/hicpac/pdf/guidelines/bsi-guidelines-2011.pdf. Published 2011. Accessed July 7, 2016.
14. Chapman A, Aucutt S, Milstone A. Safety of chlorhexidine gluconate used for skin antisepsis in the preterm infant. *J Pernitol.* 2012;32:4-9.
15. Aitken J, Williams F. A systematic review of thyroid dysfunction in preterm neonates exposed to topical iodine. *Arch Dis Child Fetal Neontal Ed.* 2014;99:F21-F28.
16. Kiechl-Kohlendorfer U, Berger C, Inzinger R. The effect of daily treatment with an olive oil/lanolin emollient on skin integrity in preterm infants: a randomized controlled trial. *Pediatr Dermatol.* 2008;25(2):174-178.
17. Connor JM, Soll R, Edwards WH. Topical ointment for preventing infection in preterm infants. *Cochrane Database Syst Rev.* 2009;(3):CD001150.
18. Cleminson J, McGuire W. Topical emollient for preventing infection in the preterm infant. *Cochrane Database Syst Rev.* 2016;(1):CD001150.`

This continuing education activity is offered free of charge to NANN members and nonmembers thanks to an educational grant from Kimberly-Clark. It is available online only at the journal website, advancesinneonatalcare.org and the test can be taken online at NursingCenter.com/CE/ANC