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Review Article

The Significance and Protection of the Skin Barrier in Newborn Care

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Abstract

The newborn skin barrier undergoes significant structural and functional changes during the transition from the intrauterine to extrauterine environment. This review examines the unique characteristics of neonatal skin, particularly in preterm infants, focusing on stratum corneum development, barrier function, and its implications for clinical care. We discuss the current evidence regarding routine emollient use in both term and preterm infants, analyzing various formulations and their effects on barrier integrity, infection risk, and potential neurodevelopmental outcomes. The emerging understanding of the skin-brain axis and microbiome interactions highlights the complexity of neonatal skin care beyond simple barrier protection. Based on the current evidence, we provide recommendations for evidence-based skin care practices that support natural barrier maturation while minimizing potential adverse effects.

Keywords: Newborn skin barrier, Stratum corneum, Emollients, preterm infants, Transepidermal water loss, Skin microbiome

Introduction

The newborn skin is a dynamic organ that undergoes continuous adaptation during the critical transition from a protected intrauterine environment to the external world. This transition requires rapid structural and functional maturation to establish an effective barrier against environmental challenges, while maintaining essential physiological functions.

Structural and Functional Characteristics of Newborn Skin

The skin of both term and preterm infants exhibited distinct differences from adult skin. The stratum corneum (SC), the outermost protective layer, is up to 30% thinner than that in adults, and this difference is particularly pronounced in preterm infants [1]. Corneocytes are smaller, with accelerated cell turnover, and the keratinization process remains incomplete. The dermal-epidermal junction shows reduced undulation, particularly in preterm infants, creating a vulnerability to mechanical trauma.

In infants born before 28 weeks of gestation, the SC may be extremely thin or absent, resulting in markedly elevated transepidermal water loss (TEWL). TEWL rates demonstrate clear gestational age dependency: approximately 75 g/m²/h at 23 weeks, 45 g/m²/h at 26 weeks, and 17 g/m²/h at 29 weeks, compared to 5-8 g/m²/h in term infants [2]. Complete SC development may require up to nine weeks postpartum in very preterm infants [3].

Vernix caseosa, comprising 80% water along with lipids and proteins, provides crucial protection at birth. This substance creates a hydrophobic barrier, exhibits antimicrobial properties, and facilitates acid-mantle formation. Its preservation is particularly important in preterm infants, who typically have reduced vernix coverage [4].

Barrier Integrity and Health Implications

The skin barrier serves multiple critical functions, including regulation of water loss, protection against mechanical trauma, prevention of pathogen entry, thermoregulation, and immunological surveillance. Compromised barrier integrity leads to serious complications, particularly in preterm infants, including dehydration, electrolyte imbalance, increased infection risk, and thermal instability. Sepsis is a major cause of morbidity and mortality in this population [5].

Postnatal Adaptation and Maturation

The immediate postnatal period involves rapid adaptation from a liquid to a gaseous microbe-rich environment. Skin surface pH transitions from near-neutral (6.0-7.5) at birth to acidic levels (5.0-5.5) within the first week, establishing the protective "acid mantle" [6]. This acidification process may be delayed in preterm infants, particularly under high humidity incubator conditions.

Barrier maturation exhibits distinct patterns. In term infants, TEWL stabilizes rapidly within days and remains stable during the first two years [7]. Stratum corneum hydration may exceed adult levels between 3-12 months, although the water retention capacity remains low [7,8]. Sebum production, which was initially high due to maternal hormonal influences, decreased dramatically after 3-6 months. Barrier lipids, including ceramides and free fatty acids, remain at lower levels than those in adults during infancy, similar to natural moisturizing factors (NMFs) [7-9].

The Skin-Brain Axis and Neurodevelopmental Interactions

Neonatal skin functions as a neurodevelopmental interface, equipped with sensory receptors and components of the hypothalamic-pituitary-adrenal (HPA) axis [10]. Growing evidence has linked skin barrier dysfunction with neurodevelopmental outcomes. Chronic inflammation and stress responses triggered by barrier disruption may influence neurodevelopmental trajectory. Epidemiological associations between atopic dermatitis and neurodevelopmental disorders, including ADHD and autism spectrum disorder, have broader implications for skin health [11].

The microbiota-gut-skin-brain axis represents a complex communication network that influences immune development and potentially neurodevelopmental processes [12-14]. Skin care practices affecting microbiome composition may have far-reaching consequences beyond the local barrier function.

Clinical Guidelines for Neonatal Skin Care

Current International Recommendations

Major health organizations, including the World Health Organization (WHO), Association of Women's Health, Obstetric and Neonatal Nurses (AWHONN), National Institute for Health and Care Excellence (NICE), and various national pediatric associations have published guidelines for neonatal skin care [15-17]. These emphasize preserving the natural barrier function while minimizing infection risk through appropriate cleansing and moisturizing practices.

Bathing and Cleansing Practices

The WHO recommends delaying the first bath for at least 24 h or a minimum of 6 h if earlier bathing is necessary [18]. The bathing frequency should be limited to several times weekly, with a brief duration (5-10 minutes) and water temperature of 35-37°C. When cleansers are used, they should be neutral to slightly acidic (5.5-7.0), fragrance-free, and without potential irritants [19-21].

Emollient Use in Healthy Term Infants

Recent large-scale randomized controlled trials and meta-analyses have contradicted earlier promising findings regarding the routine prophylactic emollient use for atopic dermatitis prevention. Current evidence demonstrates no preventive benefit and suggests a potential increased risk of skin infections and food allergies [22-24]. Therefore, routine prophylactic emollient use is not recommended in healthy term infants. Emollients should be reserved for treating specific conditions such as dryness or scaling.

Emollient Use in Preterm Infants

However, evidence regarding emollient use in preterm infants remains inconclusive. Studies in low- and middle-income countries suggest potential benefits, including reduced infection and mortality rates, particularly with plant-based oils [25]. However, studies in high-income settings have not demonstrated clear benefits and suggest a possible increased risk of infection in extremely low birth weight infants [10,15,25,27]. The WHO provides conditional recommendations for emollient use in preterm infants, emphasizing the need for individualized assessment and further research.

Emollient Formulations: Scientific Evidence

Formulation Types and Mechanisms

Emollients function through different mechanisms: occlusives create physical barriers that reduce TEWL, humectants draw water to increase hydration, and emollients soften the skin through lipid integration [28-32]. Ointments provide maximum occlusion, but may feel greasy. Creams and lotions offer improved cosmetic acceptability, but require preservatives that may cause irritation.

Specific Ingredients and Their Effects

Physiological Lipids: Ceramides, cholesterol, and free fatty acids are essential barrier components. While theoretically beneficial, high-quality evidence supporting the routine use of ceramide-containing products in healthy newborns re-

mains limited [33-35].

Petrolatum and mineral oils provide effective occlusion with minimal allergenic potential. White petrolatum remains a recommended and affordable option despite theoretical infection concerns in preterm infants [36].

Plant-Based Oils: Efficacy varies significantly with fatty acid composition.

- Sunflower seed oil (high linoleic acid) shows promise in reducing TEWL and infection risk, particularly in resource-limited settings [37-39].
- Coconut oil demonstrates antimicrobial properties and potential growth benefits [40].
- Olive oil (high oleic acid) may disrupt barrier function and is not recommended [38,39].
- Mustard oil causes irritation and should be avoided [41].

Additional Ingredients: Fragrances, harsh preservatives, alkaline soaps, and alcohols should be avoided. Even "natural" plant extracts may cause sensitization [42-48].

The alt text for a table containing skincare recommendations for newborns could be: "Table 1 summarizes the recommended skincare practices for newborns, including the types of cleansers and frequencies of bathing for optimal skin health.

Area	Recommendation	Details and rationale
1. Cleansing:	Gentle cleansers	Use gentle, soap free/sulfate free, fragrance free, hypoallergenic cleansers formulated near physiological pH (~ 5.5).
	Avoid harsh soaps	Avoid harsh soaps/detergents that strip surface lipids, precipitate xerosis, and irritant dermatitis.
2. Bathing:	Frequency	Limit to 2–3 times per week unless visibly soiled. Prefer lukewarm water; keep baths brief (5–10 min) and pat skin dry afterward.
3. Moisturization	Emollients	Apply bland emollients immediately after bathing (the "3 minute rule"). Favor fragrance-free, hypoallergenic products containing ceramides, hyaluronic acid, or glycerin, a thin layer of petrolatum/ lanolin, can reinforce the barrier. Use at least once daily, more frequently with dryness.
4. Diaper area care	Frequent cloth changes.	Diapers are changed frequently to minimize exposure to moisture and irritants. For each change, a thin barrier layer (e.g., zinc oxide or petrolatum) was applied. Cleanse with alcohol and fragrance-free wipes or warm water and cotton.
5. Clothing	Soft, breathable fabrics.	Dress infants in soft, breathable fabrics (e.g., cotton) to reduce friction/irritation. Avoid overdressing; use light layers appropriate to ambient temperature to prevent sweating and overheating.
6. Environmental control	Humidity	Maintain moderate indoor humidity (~40–60%) to mitigate skin dryness, maintain room temperature within a comfortable range, and avoid thermal extremes that compromise the barrier integrity.
7. Sun protection	Shadow and clothing	Prioritize shade and protective clothing. For infants ≥6 months, use broad spectrum, water resistant sunscreen SPF ≥30 with mineral filters (zinc oxide/titanium dioxide); apply 15–20 minutes before exposure and reapply every 2 hours or after water/sweating. For <6 months, rely on shade/clothing; if necessary, use minimal amounts of mineral sunscreen on limited exposed areas with clinician guidance.
8. Special considerations	Atopic tendency, prematurity	In infants with atopic predisposition or prematurity, adopt gentler cleansing and consistent emollient therapy and seek dermatology input for suspected eczema flares.

Table 1: Practical recommendations for newborn and infant skin care.

Efficacy and safety evaluation

Barrier Function Effects

Emollients generally reduce TEWL and increase hydration, although their effects vary by formulation. Evidence suggests that certain skincare regimens may interfere with natural postnatal barrier maturation [18,21].

Safety Considerations

Irritation and Sensitization: Newborn skin shows increased sensitivity to chemicals. The selection of products without fragrances, alcohols, or harsh preservatives is critical [43].

Infection Risk: Evidence remains conflicting, particularly for preterm infants. The benefits observed in resource-limited settings contrast with neutral or negative findings in high-resource NICU [3,15,37,49].

Microbiome Effects: Emollients influence microbial colonization patterns through modification of pH, moisture, and lipid content. The long-term implications remain under investigation [46,50-52].

Conclusions and Recommendations

The neonatal skin barrier is a complex and dynamic system that requires careful consideration in clinical care. Current evidence supports the following:

1. Minimal intervention for healthy term infants, avoiding routine prophylactic emollient use
2. Individualized assessment for preterm infants, considering gestational age, clinical condition, and care setting
3. When emollients are indicated, selection of simple, well-tolerated formulations (petrolatum, appropriate plant oils)
4. Avoidance of products containing fragrances, harsh preservatives, or potentially sensitizing ingredients
5. Recognition that skin care practices may influence not only barrier function but also microbiome development and potentially neurodevelopmental outcomes

Future research should focus on optimizing care strategies that support natural barrier maturation, while minimizing adverse effects, particularly in vulnerable preterm populations.

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