


Benefits of Using an Appropriately Formulated Wipe to Clean Diapered Skin of Preterm Infants

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Abstract

The skin of premature infants is underdeveloped rendering it more prone to break down and irritation. Therefore, special care is needed to protect premature skin and ensure it is not adversely affected. Many health care professionals advise using just water and cloth to clean diapered skin after a bowel movement despite evidence that shows improved infant skin health with the use of modern appropriately formulated baby wipes. This article describes the unique physiology of premature infant skin, reviews clinical evidence comparing use of baby wipes to water and cloth, and describes attributes of appropriately formulated baby wipes.

Keywords

infant skin, premature infant skin, diapered skin, skin irritation, diaper dermatitis, baby wipes, skin pH

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Human skin consists of 3 main layers: the epidermis, dermis, and underlying fat layer called the hypodermis. The dermis provides structural support for the epidermis and allows the skin to be resilient and absorb force.¹ The epidermis is the outer layer of the skin and can be further divided into multiple layers that serve different functions. Of particular interest is the outermost layer of the epidermis called the stratum corneum, or skin barrier, as it functions as the main barrier to the outside world. A healthy and functional stratum corneum is critical to health; it acts as a barrier to irritants and water loss, regulates heat and ion balance, prevents infection, resists mechanical trauma, and provides immune surveillance and tactile sensation.¹⁻⁴ There are a number of factors that can contribute to skin barrier damage and disrupt its function. In infants, the diaper environment puts skin at a higher risk for skin barrier disruption and irritation.

Maintaining Diapered Skin Health in Premature Infants

The skin of premature infants is underdeveloped and more fragile than full-term infants. The epidermis of premature infants is not as thick as full-term infants (20–30 μm at 26 weeks gestation vs 30–50 μm at 40 weeks

gestation).⁵ Skin barrier function is also compromised in premature infants as measured by the amount of water vapor that is lost through the skin or transepidermal water loss (TEWL). TEWL values of premature infants are inversely proportional to gestational age.⁶ Infants born at 23 to 29 weeks gestation have a compromised skin barrier with TEWL values reported to be as high as 60 to 70 $\text{g}/\text{m}^2/\text{h}$ in the first few days of life and dramatically decreased by 2 to 4 weeks postnatal age.^{2,7,8} By 30 weeks gestation, TEWL values were reported to be much lower, around 20 $\text{g}/\text{m}^2/\text{h}$, while term newborns had values around 6 to 8 $\text{g}/\text{m}^2/\text{h}$.^{6,9-11} One consequence of a poor barrier is increased permeability of molecules that can cause skin irritation and rash.^{5,9,12} One study showed that percutaneous absorption of phenylephrine was most pronounced in infants less than 30 weeks gestation as compared with more mature infants.¹³ By 2 weeks postnatal age, percutaneous absorption significantly decreased indicating rapid maturation of the skin

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Table 1. Review of Evidence Comparing Baby Wipes With Water and Cloth.

Paper	Method	Highlights
Ehretsmann et al ²³	Study A: Investigator-blinded, parallel study comparing 102 full-term infants cleaned with baby wipes versus water and cloth/implement.	Study A: Statistical decrease in severity of diaper rash in the intertriginous folds with the baby wipes group.
Lavender et al ²⁶	Study B: Clinical safety test for tolerance of baby wipes on 53 infants diagnosed with atopic dermatitis. 280 full-term healthy newborn infants randomized to have the diaper area cleaned with baby wipes or cotton wool and water.	Study B: No cutaneous intolerance to the baby wipe was observed. No difference between cotton wool and water and baby wipes with regard to skin pH, TEWL, hydration, and erythema scores.
Adam et al ²⁷	Study A: 32 full-term infants diagnosed with atopic dermatitis. Baby wipes were used on all infants. Study B: 15 full-term infants randomized to cleaning diaper area with baby wipe or washcloth and water for 14 days.	Study A: No clinical signs of cutaneous intolerance were observed by the parents or the dermatologist. Study B: Buttocks skin pH of infants cleaned with baby wipes was not statistically different than control site. Buttocks skin pH of infants cleaned with water and cloth was significantly higher than control site.
Visscher et al ²¹	130 NICU infants (born at 29 weeks gestation or later) randomized to have their diapered area cleaned by a baby wipe or water and gauze	Diaper area erythema, water loss, and skin pH were significantly lower in infants cleaned with one of the baby wipes tested.
Odio et al ²⁴	82 subjects randomized to have their diaper area cleaned by baby wipes or water and washcloth for 8 days.	Erythema scores were statistically lower in the perianal region of subjects cleaned with baby wipes. No differences in skin water loss were observed.

Abbreviations: TEWL, transepidermal water loss; NICU, neonatal intensive care unit.

barrier during the first 14 days of life.¹³ In vitro studies that investigated the permeability of cadaver infant skin at different gestational ages showed preterm skin was 3 to 50 times more permeable to alcohol and 100 to 1000 times more permeable to salicylate than full-term skin.^{14,15} In addition, the dermis of premature infants contains fewer structural proteins, which weakens the skin and puts them at higher risk of skin damage due to mechanical action.^{1,16}

The compromised barrier, increased permeability, and immature dermis of premature skin is especially problematic in the diapered area as it is continually challenged by excess moisture from urine and irritants from feces. While there is not one single cause of diaper dermatitis, there are a number of factors in the diapered area that are known to be involved in skin break down and irritation, which include skin overhydration, exposure to irritants found in feces, increase in skin pH, mechanical abrasion, diet, loose/watery stool, and certain medications.¹⁷ One of the primary causes of diaper rash is the interaction of skin with enzymes found in feces. Feces contains digestive enzymes that break down fat and protein consumed by the infant. Once these enzymes are excreted, they contact the outer layer of the skin and continue to digest the fat and proteins of the skin barrier. This leads to break down of the skin barrier,

allowing irritants from feces and urine to more readily penetrate through the stratum corneum into the living layers of the epidermis resulting in inflammation and the onset of diaper dermatitis.¹⁷⁻²⁰ Therefore, it is of utmost importance to thoroughly clean diapered skin to prevent damage caused by digestive enzymes and other irritants present in feces. Since the skin of premature infants is more fragile than full-term infants, it is also important to thoroughly clean the diapered area using a method that applies the least amount of abrasion to the skin.

Formulated Baby Wipes Are a Gentle and Effective Way to Clean the Delicate Skin of Premature Infants

Clinical studies over the past 15 years have demonstrated the safety and efficacy of using formulated baby wipes on diapered infant skin. A summary of these studies is shown in Table 1. Baby wipes were found to be superior to water and cloth in 4 out of 5 published studies comparing cleaning with water and cloth to cleaning with formulated baby wipes. None of the studies found baby wipes to be inferior to water and cloth. A study published in 2009 demonstrated that, compared with water and gauze, use of baby wipes on premature infants

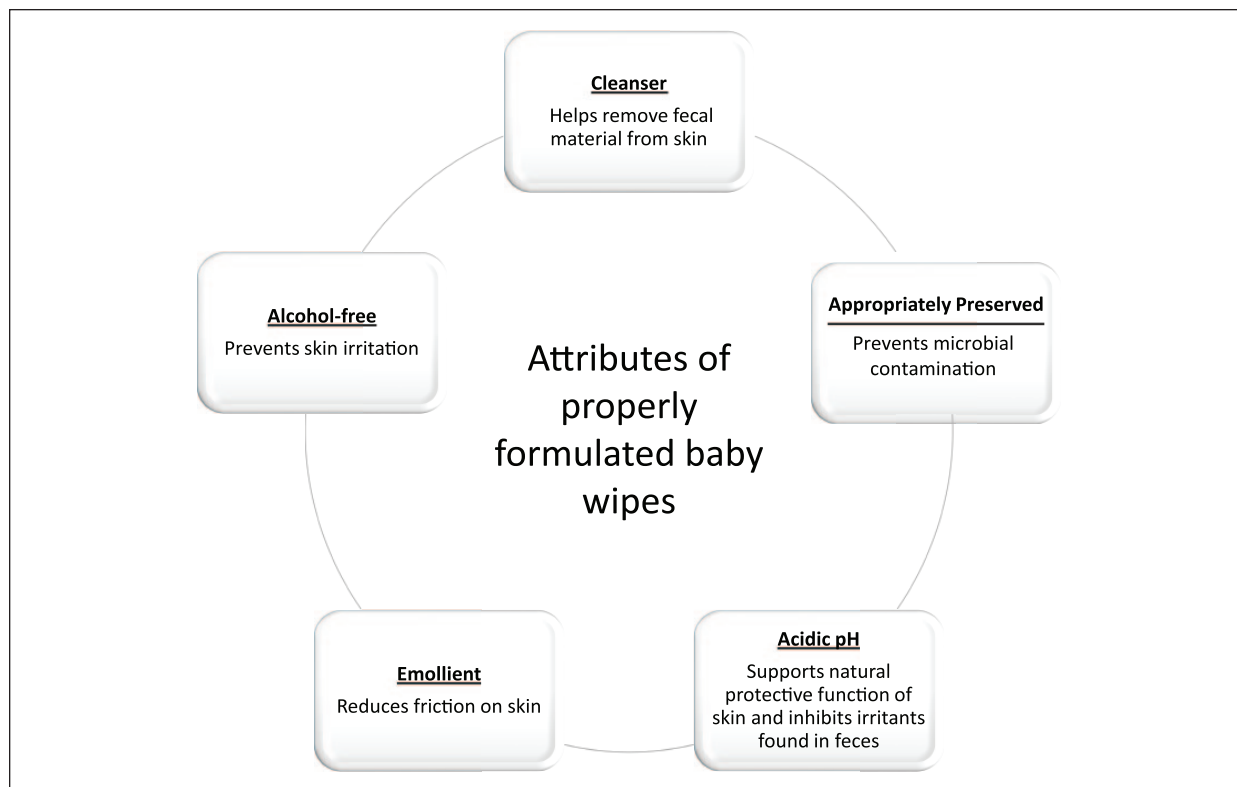


Figure 1. Attributes of a properly formulated baby wipe.

29 weeks gestation and older resulted in better skin barrier properties including lower TEWL values, pH, and erythema scores.²¹ Two separate studies highlighted that even infants diagnosed with atopic dermatitis, a condition that renders the skin more sensitive to allergens,²² demonstrated excellent tolerance to cleaning with baby wipes.^{23,24} Together these data demonstrate that baby wipes are mild and safe to thoroughly and gently clean infant skin even sensitive skin.

Concerning premature infants, a published study demonstrated baby wipes were safe and gentle in premature infants born after 29 weeks gestation.²¹ However, special consideration may be needed for infants less than 29 weeks gestation because there are no published studies that systematically evaluate the tolerability of baby wipes in these infants. Clinical studies in very premature infants are difficult to perform due to their fragile state; however, there are some inferences that can be made based on available skin characterization data. One major concern associated with using any skincare products on very preterm infants is the potential percutaneous absorption of ingredients found in the products.²⁵ As described above, infants 25 to 29 weeks gestation have a highly compromised skin barrier and therefore are particularly prone to absorption of molecules through the

skin. However, after the first 2 weeks of life, percutaneous absorption decreased dramatically and was similar to mature skin.¹³ This dramatic decrease was associated with an increase in barrier function as measured by low TEWL values.^{12,13} These data indicate absorption through the skin was greatly hindered in infants with a functional barrier. After 2 to 4 weeks postnatal age, infants 23 to 29 weeks gestational age showed rapid maturation of the skin barrier.^{2,7,8,12} Therefore, special consideration must be taken when cleaning the skin of very premature infants, especially during the first 2 weeks of life while the skin barrier is undergoing rapid maturation. An evidence-based skin care protocol for extremely preterm infants should be developed and documented by health care professionals caring for this patient population.

Attributes of a Properly Formulated Baby Wipe

Many modern baby wipes are formulated with infant skin health in mind. Based on the biology of premature skin, there are 5 main attributes of a formulated baby wipe to consider to support skin health of premature infants (Figure 1).

Gentle Cleanser

Preterm infants have a compromised and a more permeable skin barrier,^{2,7,8,12,14,15} thus they are at increased risk for irritation on exposure to irritants found in feces and urine.^{1,20,28,29} Infant feces consists of both fat- and water-soluble components. Cleansing practices that only include water may not adequately remove fat-soluble fecal material. Even very small amounts of fecal proteases can cause skin barrier damage in mice and full-term skin models.^{18,30} Since premature skin is thinner, it is expected that fecal-derived proteases would illicit more skin damage as compared with full-term skin, further justifying the importance of thoroughly cleaning skin of feces. The efficient removal of the fatty portion of feces requires surfactants to emulsify and trap them in droplets so they can be effectively removed.³¹ Thus, almost all contemporary baby wipes contain low concentrations of mild surfactants to accomplish this important task. It is important to note that most baby wipes contain less than 0.3% of a mild surfactant; in contrast, bottled baby products contain 5% to 20% surfactant.³² One study done in premature infants born at 29 weeks gestation or later showed use of wipes with a mild surfactant was well-tolerated and resulted in better skin health outcomes as compared with water and cloth.²¹

Appropriately Preserved

At birth, preterm infant skin does not have all the necessary defenses to protect against pathogens; thus, it is of utmost importance to keep contaminants off of the skin. Since microbial growth is enhanced in moist environments, baby wipes are at risk for microbial growth.³³ Therefore, baby wipes should contain an approved preservation system to ensure a fresh product before and during use. Not surprisingly, many clinical and scientific experts recommend using baby wipes that contain a well-tolerated preservative as endorsed by agencies such as the US Cosmetic Ingredient Review or the European Union Cosmetics Directive.³⁴ One could postulate that preservatives might transfer to the skin and inhibit skin microbiota. To date, there is no evidence that the concentration of preservatives that inertly reach the skin have an impact on the microbiota. A published clinical study with 173 infants observed no impact on periurethral flora after use of a preserved baby wipes as compared with the use of water and napkins.³⁵

Acidic pH

Within a few days of birth, the pH of preterm and full-term infant skin becomes slightly acidic.^{4,11,36} The acidification process is vital to support maturation of the skin barrier,

protect from pathogens, and inhibit activity of digestive enzymes in feces that break down skin.^{1,19,29,37} Fecal enzymes have the highest activity at neutral to basic pH.^{18,30,38,39} The pH of tap water has been reported to be as high as 8.5, and the pH of distilled water can range from pH 6.5 to 7.0, which does not match the acidic nature of skin and are optimum for fecal enzyme activity.^{40,41} In contrast, most baby wipes are formulated to a slightly acidic pH to support healthy infant skin. Several clinical studies have demonstrated a lower skin pH is associated with use of acidic baby wipes as compared with water, in both premature and full-term infants.^{21,27} Different than water, a pH buffered formula also helps neutralize irritants found in stool.^{30,38,39}

Emollient

When wiping the skin, it is important to apply as little friction to the skin as possible to avoid mechanical damage to infant skin. This is especially true for premature infants because their skin has decreased structural support due to the underdeveloped dermis and immature stratum corneum.^{1,16} Emollients have been shown lower the coefficient of friction between skin and a substrate in an aqueous solution⁴² and are therefore added to some baby wipes to provide more glide across the skin than water alone. The increased glide is thought to decrease the risk of mechanical damage to fragile premature skin. It is important to note that emollient creams have been tested on preterm infants as young as 25 weeks gestation and their use was associated with improved skin health outcomes.⁴³⁻⁴⁵

Alcohol Free

Most modern baby wipes are free of alcohol that can irritate the skin. It is important to note that only certain types of alcohols are damaging to skin, such as ethyl alcohol. For a product to comply with the "alcohol-free" standard set by US Food and Drug Administration a product must be free of ethyl alcohol.⁴⁶

Author Contributions

All authors participated in reviewing literature and writing the manuscript.

Ethical Approval

Ethics approval was not needed for this study because no research was performed. All the information in the article was from previously published articles and referenced appropriately.

Declaration of Conflicting Interests

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