

Neonatal skin care: Developments in care to maintain neonatal barrier function and prevention of diaper dermatitis

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Abstract

Background: Understanding the importance of the barrier function of the skin of preterm and term neonates is crucial in effective neonatal skin and diaper care. This literature search aimed to review the development of different practices in neonatal care to maintain skin barrier function, in turn preventing diaper dermatitis.

Methods: We performed two quantitative literature searches of English language studies: an initial literature search of studies published in the last 5 years was conducted using Cinahl, Medline, Embase, British Nursing Index, and DelphiS, followed by a second search of publications from 1990 to 2017 using the National Institute of Clinical Excellence Health Databases Advanced Search using key words, synonyms, and Boolean phrasing. Titles and abstracts were reviewed for relevance.

Results: One hundred ten studies were analyzed for the purpose of this review; however, data are of variable quality. Guidance can be drawn from the existing literature relating to best practice options for diaper area cleansing methods, diaper type selection, and use of barrier creams. More research is required into the benefit or otherwise of diaper-free time.

Conclusions: Super-absorbent diapers reduce moisture at skin level and reduce diaper dermatitis. Barrier creams carry benefit both in prevention and cure but do not provide a substitute for frequent diaper changes. The literature does not demonstrate superiority of one cleansing method over another, but neither the use of wipes nor water increases diaper dermatitis prevalence. Further studies are required to explore the potential benefit of diaper-free time, taking due consideration of the practicalities, particularly for vulnerable neonates within the Intensive Care setting.

KEY WORDS

contact dermatitis, diaper cleansing, diaper dermatitis, neonatal, skin barrier

1 | INTRODUCTION

Diaper dermatitis is a broad term used to describe inflammatory changes of variable severity in the skin of the diaper area, namely the lower abdomen, buttocks, perianal, and perineal areas.¹ Clinical studies generally assess the presence of diaper dermatitis, as distinct from other skin disorders potentially

affecting the same area, according to features of impacted skin integrity (ulceration, scaling), rash (papules, edema), and redness (spotty, continuous).² Methods used to evaluate the severity of diaper dermatitis include clinical evaluation using standardized scoring systems, and noninvasive measurements of stratum corneum hydration, skin surface pH, transepidermal water loss, and sebum levels.

The majority of diaper dermatitis is irritant contact dermatitis,³ with no single causative factor; rather, the skin is subject to a complex interplay of potentially damaging factors.^{1,4} Neonates with diaper dermatitis demonstrate behavioral changes such as increased crying, agitation, and changes in eating and sleeping patterns, which suggest emotional and physical distress.⁵ The negative impact can extend beyond the affected individual, with studies highlighting parental guilt in response to diaper dermatitis in their charges.⁵ This has prompted warning that health care providers educating parents on diaper care should not imply poor parenting, which might affect the emotional well-being of parents.⁶

Within the literature, there is considerable variation in reported frequency of diaper dermatitis, in part due to study methodology variation and differences in the age of studied cohorts. Estimations range from 25% of infants to the majority of children being affected to some degree before the age of 2 years.^{1,7,8,9,10} A US survey of 482 neonatal units looking at extremely low birthweight babies found that an average of 21% suffered skin breakdown during the first week of life. The authors also identified reduced rates in centers that had skin care protocols that limited adhesives and liberally used barrier cream.¹¹

Neonatal skin, especially in the diaper area, is subject to the stresses of urine, feces, friction, microbes, and chemicals that can contribute to compromised barrier function, leading to dermatitis, infection, and pain. Effective neonatal skin care for the diaper area therefore aims to maintain barrier function by cleansing the skin of physiologic irritants and reducing excess moisture, without causing physical injury, irritation, and potential allergic contact dermatitis in response to exogenous chemicals.⁹ The goal of this study was to determine the most appropriate practice for neonatal skin care in maintaining barrier function and preventing diaper dermatitis, through a comprehensive review of current literature.

2 | METHODOLOGY

Two independent literature searches were performed by two of the authors. An initial literature search of English language papers published in the last 5 years was conducted using Cinahl, Medline, Embase, British Nursing Index, and DelphiS, alongside a search of current clinical trials, gray literature, with title, abstracts, and reference lists reviewed. Search terms used included variations of "neonatal," "nappy care," and "barrier function." However, due to the limited number of papers found, the decision was made to perform a second literature search.

The second literature search of English language papers published after 1990 was through the National Institute of Clinical Excellence Health Databases Advanced Search; this includes the PubMed, Medline, British Nursing Index, Health Management Information Consortium Exerpta Medical Database, Cumulative Index to Nursing Allied Health Literature, and Allied and Complementary Medicine databases. Search terms used included variations of

"diaper (nappy and napkin) dermatitis (rash)." Titles and abstracts were reviewed for relevance.

3 | RESULTS

One hundred ten papers were identified as relevant to our topic and analyzed. Included papers focused on diaper dermatitis as distinct from atopic or other forms of contact dermatitis, and on pediatric subjects. The selected papers included one Cochrane review, two other systematic reviews, eight randomized control trials, four nonrandomized comparative studies, and seven non-comparative, observational studies. The remaining papers comprised partial reviews, single expert opinion, or nonresearch-based educational pieces. The results are organized into relevant clinical categories: diaper types, wash products, barrier creams, and cleansing (wipes vs water).

4 | TYPES OF DIAPERS

The Cochrane review (2006) pointed to the paucity of evidence when looking specifically at types of diapers and their impact on diaper dermatitis incidence. Although the papers reviewed found increased diaper dermatitis rates within the populations of infants using cloth diapers versus disposable, absorbent diapers, the 28 studies identified were heterogeneous, methodologically flawed, and with low patient numbers. Therefore, though the data within the review were indicative of benefits of the higher absorbency product, the authors were unable to categorically conclude benefit.¹²

A number of studies, including those reviewed in the Cochrane process, do, however, indicate that super-absorbent diapers reduce the moisture at skin level and so reduce diaper rash when compared to cloth alternatives.

Monterosso et al¹³ compared neonates who were given cloth napkins with or without absorbent pads inside. They then measured the neonates' temperature and incubator temperatures required to maintain their core body temperatures. They found that the babies with absorbent pads had higher mean core temperatures and lower incubator temperatures. Although the clinical significance of the small change, 0.04°C, is arguable, this is in keeping with studies that have shown increased liquid uptake from absorbent diapers. Dutta et al¹⁴ compared cloth napkins to absorbent diaper pads for the measurement of urine output in neonates by pouring known volumes of liquid into the napkins. They found a 26% deficit with the absorbent pads compared to the 12.1% deficit of simple cloth napkins on their own.

Many of the studies looking at diaper types comprised partial reviews aimed at education and often single clinician opinions, published in low impact factor journals, often with the same authorship on multiple papers. Despite the low evidence level, however, they are very consistent. Almost all describe reduced rates of diaper dermatitis with strict cleaning regimes and frequent diaper changes.

Kamat and Malkani¹⁵ specifically reviewed papers looking at diaper use in a lower-income country setting. Although the studies involved were low quality, the results suggested increased spread of *Clostridium difficile* and other communicable pathogens around nurseries that used cloth diapers when compared to disposable diapers, which is of great importance in both low-income settings and neonatal units anywhere in the world where pathogens can spread very easily between vulnerable infants.

The inclusion of super-absorbent gels (reducing skin moisture), petrolatum-based lotions (improving skin integrity), and breathable outer layers (reducing local humidity) into thinner diapers with a better fit to the body's contour has seemingly led to a reduction in the presence of erythema and severity of diaper dermatitis.¹⁶ It is difficult to quantify precisely any declines in the incidence and severity of the condition, as the advent of modern diapers also maps with the development of newer cleansing products and their wider adoption into skincare regimens.⁶ Nonetheless, it is widely recognized that modern disposable diaper technology has successfully reduced some of the main negative impacts of overhydration, increased pH, friction, and other variables on skin integrity.³ However, while modern diapers undoubtedly meet the hygiene needs of infants, the occlusive nature of diaper wearing (regardless of type) concomitantly increases local humidity, hydration, and pH,¹⁷ factors implicated in diaper dermatitis.

5 | BARRIER CREAMS AND WASH PRODUCTS

The positive effects of barrier cream are reproduced for treatment as well as prevention. A nonrandomized study of 63 newborns separated into breast milk or barrier cream treatment groups found no difference in mean number of clinical improvement days but identified that the postlesion score of the barrier cream group was statistically significantly lower ($P = 0.002$), suggesting some improvements in infants receiving barrier cream.¹⁸ Although Rowe et al¹⁹ found limited research data in their systematic review, they concluded that barrier creams were an effective component of infant skin management.

Increased liquid removal from the skin also removes irritants, such as the ammonia in the urine, and so reduces dermatitis and improves skin function. Two comparative studies on infant diaper dermatitis rates measured transepidermal water loss (TEWL), skin hydration, and pH and found significantly worse results in skin affected by diaper dermatitis.^{20,21} One study randomized 89, 9-month-old infants into three groups: plain wash cloths only, wash cloths with diaper cream, and wet wipes (baby wipes) with diaper cream. Although dermatitis rates were the same across the three groups, the actual TEWL and pH were improved, in the presence of diaper dermatitis, with the diaper barrier creams.²⁰ Though the age group involved in this study would not be categorized as neonates, there is an absence of comparable evidence relating to infants in the first weeks of life. Furthermore, incidence of diaper dermatitis

peaks at around the age of 9–12 months,²⁰ therefore, findings in this age group may help guide our understanding of the condition more generally.

A similar randomized study by the same group attempted to establish the ideal washing regimen for preservation of skin function. Sixty-four term neonates, under 48 hours old, were divided according to parent preference into bathing with washing gel; bathing and barrier cream; bathing, washing gel, and cream; and washing with water only. The patients that received barrier cream or washing gel with the basic wash twice weekly had significantly lower TEWL on the front, abdomen, and upper leg as well as higher stratum corneum hydration and significantly lower skin pH when compared to water-only care.²¹

6 | DIAPER AREA CLEANSING PRACTICES

The majority of the evidence around diaper skin care relates to the comparative effects of cleansing skin with cotton wool/cloth and water, versus commercially available wipes (also known as wet wipes or diaper wipes). Earlier generations of wipes contained ingredients linked to skin irritation, such as high levels of alcohol, certain fragrances, and (now limited) preservatives.^{4,22} Most modern wipes constitute manmade fibers and include water, synthetic detergents, emollients, pH stabilizers/adjusters, and preservatives, and many are alcohol and fragrance-free.⁶ However, there is variation between brands. Disposable wipes differ from one another in terms of the actual structure of the wipe (usually soft cloth substrates) and also the added constituents, which may include skin conditioning ingredients, such as dimethicone and glycerin and preservatives to prevent microbial growth. pH values of the different brands of wipes can vary.

Lavender et al²² compared 280 term infants, who were randomly assigned to diaper area care either with wipes, or with cotton wool and water, from age 48 hours to 4 weeks. Wipes were shown to be equivalent to water and cotton wool in terms of skin hydration, transepidermal water loss (TEWL, $\text{g}/\text{m}^2/\text{h}$; mean 17.8 vs 19.0, $P = 0.49$, 95% CI –3.9 to 1.2), skin surface pH (5.93 vs 5.65) and erythema, and presence of microbial skin contaminants/irritants. Maternal-reported diaper dermatitis during the course of the 4 weeks was higher in the water group, but this was not reflected in midwife-reported diaper dermatitis at 4 weeks. The authors concluded that wipes had an equivalent effect on skin hydration when compared to cotton wool and water.

In a study of infants by Garcia-Bartels et al, also in the first 4 weeks postpartum, 44 healthy, full-term neonates were again randomly assigned to skin care with wipes or water-moistened wash-cloth at each diaper change, equivalent to approximately eight times in every 24 hours.¹⁷ In addition to the measurement of TEWL, skin hydration, and skin pH assessed in the Lavender study,²² levels of the pro-inflammatory cytokine interleukin-1α (IL-1α, suggested to influence fetal skin barrier maturation) were measured on days 2, 14, and 28 postpartum. Microbiological

colonization was evaluated at baseline and on day 28. All children used the same diapers. Bathing was standardized with regard to frequency, and no additional skin care or wash products were used. The wipes group had significantly lower TEWL values on the buttock (median 9.60) compared to the water group (11.15) on day 28, potentially indicating a more advanced barrier function in the wipes group in the diaper area (higher TEWL values may be indicative of compromised skin barrier function). TEWL remained stable on nondiapered areas of skin in both groups. There was no increase in diaper dermatitis in either group. Skin pH, hydration, and microbiological colonization were comparable in both groups. IL-1a levels were higher in diapered skin compared to nondiapered skin areas but were comparable for both the wipes and water groups. These findings suggest that the skin barrier matures at different rates according to body site but is not influenced by diaper cleansing technique. The authors therefore conclude that neither option harms skin barrier maturation.¹⁷

The aforementioned, subsequent study of older infants (9 months ± 8 weeks)²⁰ saw the addition of barrier cream application twice daily to the wipes group and a third group in which diaper cream was applied twice daily after cleansing with water-moistened washcloths (plain wash cloths only, wash cloths with diaper cream, and wet wipes with diaper cream).²⁰ This time, on diapered skin, TEWL values were reduced in the water and diaper cream group only but remained stable in the wipes and barrier cream group and the water only group. However, interestingly, in the same group TEWL was lower in nondiapered skin also but again remained stable in the two other groups, for unexplained reasons. Although dermatitis rates were the same across the three groups, the actual TEWL and pH were improved, in the presence of diaper rash, with the diaper barrier creams.²⁰ Importantly, the incidence of diaper dermatitis was comparable in all groups. TEWL was higher in areas of skin affected by diaper dermatitis than in unaffected skin, indicating that higher TEWL is indeed a marker of compromised barrier function. No correlation was found between bacterial and mycologic colonization and diaper care regimen. This study confirms previous findings that cleansing with wipes or water does not influence diaper dermatitis occurrence, and though this study is in older infants, it is worthy of note as it reflects the aforementioned findings in neonates and suggests that these findings extend beyond the first few weeks of life.

It may be argued that guidelines for diaper care of preterm infants in neonatal intensive care unit (NICU) environments are particularly imperative to minimize risk of diaper dermatitis and barrier disruption in this already vulnerable group. However, a study into this group, outlined below, showed similar results to those in term neonates, with regard to a comparable or even favorable effect on TEWL values and skin condition from wipes compared to water and washcloths/cotton wool.

In the one study identified in our search of cotton wool versus wipes among NICU patients, 130 infants (gestational age 23–41 weeks, at enrollment 30–51 weeks) were randomly assigned to be diaper cleansed using either wipes with pH of 4, wipes with pH

of 5.5, or a rayon and polyester cloth and water, which was the standard mode of cleansing at the time of the study within the NICU. Measurements of skin condition including skin erythema, skin rash (diaper dermatitis), TEWL, and pH within the diaper area and at control sites were determined daily for up to 14 days. Perineal erythema and TEWL were significantly lower for both types of wipes compared to the cloth and water method. The lower pH wipe produced a significantly lower skin pH than the higher pH wipe and the cloth and water method. The authors concluded that both wipes are appropriate for use on medically stable NICU patients, including both full and preterm infants, and provide more normalized skin condition and barrier function versus the cloth and water standard. Lower pH wipes may facilitate acid mantle development and therefore assist in colonization, infection control, and barrier repair.²³

Recommendations from a European Roundtable Meeting on Best Practice Healthy Infant Skin Care, published in 2009 and reviewed in 2016, recommend that wipes should contain pH buffers to maintain slight acidity of the skin and should be free of potential irritants such as alcohol, fragrance, essential oils, soap, and harsh detergents (eg, sodium lauryl sulfate) and they should contain well-tolerated preservatives. Drying can be achieved through air-drying or gentle patting with a dry towel or dry cotton balls to avoid scrubbing that can cause barrier disruption.⁴

7 | DISCUSSION

Diaper rash is a potentially severe and ongoing problem despite modern diaper technology, with reported incidence ranging from 25% within the first 4 weeks of life to as much as 100% at some point in infancy.^{1,4,6,8,24} The results demonstrate that any practice that keeps urine and feces away from the skin and that reduces the abrasion will reduce the incidence of diaper dermatitis. The best way of doing this has to be put into the context of what is practical within the social circumstances of the family.

Super-absorbent diapers have been shown to reduce the moisture at skin level and so reduce diaper rash when compared to cloth alternatives.^{14,21} In alignment with the more recent research, super-absorbent disposable diapers or pads are therefore recommended where logically or financially available.

A survey of practice of the care of over 1800 infants in the United States showed lower rates of diaper dermatitis with higher frequency of diaper changes and longer diaper-free time.²⁵ In the context of community care of a newborn, diaper-free time is not often practical. In the neonatal care of an intensive care premature child with highly immature skin, this may be the best mode of management, although our search did not identify a study comparing diaper use to diaper free time in the care of such children. While data regarding TEWL vary according to study and age group, no adverse effects of using modern wipes versus water for diaper area cleansing, in terms of increased diaper dermatitis, have been demonstrated in the literature. However, longer observation periods and a broader

cross section of ages would allow for greater insight into the pathophysiology of diaper dermatitis.

8 | CONCLUSION

Diaper dermatitis is best managed by prevention. Current evidence suggests that super-absorbent diapers and barrier creams are effective for prevention and treatment of diaper dermatitis. There is a lack of data supporting the superiority of wipes over water, or vice versa, in terms of cleaning practices, but neither method seems to be associated with higher incidence of diaper dermatitis.^{17,20,22,23} Modern disposable diaper technology has successfully reduced some of the main negative impacts of overhydration, increased pH, friction, and other variables on skin integrity.

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