

Ph value of infant's skin is higher on diaper area compared to nondiaper area

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Abstract

Prolonged use of diaper may alter skin barrier function due to exposure to irritants from feces and urine, concurrent mechanical friction and occlusion, thus render the skin prone to inflammation and infection. Measurement of skin pH value may be used to document skin barrier function, especially in tropical countries such as Indonesia, and to expose the difference between diapered and non-diapered skin. The purpose of this study is to compare the pH value between baby's diapered and non-diapered skin. In this cross-sectional study, the skin pH of 43 healthy babies aged 6 to 12 months were measured using pH-meter on diaper and non-diaper area of the skin. pH values were documented and compared. The mean pH value of diaper area was $6,11 \pm 0,72$ g/m²/h (95% CI, 4,88 – 8,02) and non-diaper area was $5,91 \pm 0,69$ g/m²/h (95% CI, 4,53 – 7,69), with significant difference ($p=0,005$). pH values increased significantly on diaper area compared to non-diaper area, revealing impaired barrier function on diapered skin, despite no pathological skin changes.

Introduction

The use of diaper has become a necessity in infant care, and is an important factor influencing skin barrier function. In the Asia Pacific, the market for disposable diapers in 2013 is over 60%.¹ Prolonged use of diaper may cause increased pH value due to occlusion by urine and feces. An acidic skin is necessary to maintain normal skin microbiomes and to protect against pathogenic bacteria and fungi.² Lack of skin acidity promotes the activity of fecal enzymes such as protease and lipase, which may irritate the skin. An increase in pH value may demonstrate disruption in skin barrier function, leading to various pathologic skin conditions, most commonly irritant diaper dermatitis.³ The effect of diaper use towards skin barrier function measured by pH has

not yet been studied in a tropical country such as Indonesia, that has different humidity and temperature range compared to other non-tropical countries. A study to compare the pH values between diaper and non-diaper area is necessary to strengthen the pathophysiology of skin barrier changes due to diaper use, especially in a tropical country.

Materials and Methods

The purpose of this study is to compare the difference of pH value between infant's diapered and non-diapered skin. This cross-sectional study was performed in the Department of Dermatology and Venereology, Dr. Soetomo Hospital, Surabaya. Consecutive sampling was done since December 2016, and 43 healthy babies who met inclusion criteria were selected. The inclusion criteria are infants aged 6-12 months, using specific disposable diapers daily, and parents consenting to the study. Samples were excluded if history of topical use of moisturizer, corticosteroids, antibacterial, or antifungal within 24 hours of examination were found; and if there were skin lesions on the examination area.

After signing informed consent, identity taking and anamnesis were done towards each sample. Skin examination was done at the buttocks, representing diaper area, and at the outer thigh, representing non-diaper area. The skin was dried with tissue paper, then each sample was acclimatized for 15 minutes before pH measurement. The measurement was performed using pH-meter 3 times at each area, 5 seconds each time with 5 seconds interval, by one doctor, in a room with no direct air movement and no direct sunlight. The pH values were noted and analyzed statistically by SPSS for Windows.

Results

This study was performed in 43 healthy infants, with 53,5% male and 46,5% female, and 23,3% of the sample was 6 months old. Anamnesis revealed that 51,2% of the sample usually have their diaper changed less than 6 times per day, and 48,8% more than 6 times per day. As for daily skin care routine before diaper change, most parents (53,5%) cleaned the diaper area using baby wipes alternating with soap, 18,6% used only baby wipes, 16,3% used only soap, and 11,6% used water. Therefore, from 43 samples, 69,8% used soap to clean diaper area. The type of soap used most frequently was liquid baby soap (70,0%), 26,7% used bar baby soap,

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Key words: pH, infant's skin, diaper area, nondiaper area.

Contributions: All authors contributed equally.

Conflict of interest: The authors declare no potential conflict of interest.

Funding: none.

Received for publication: 1 February 2019. Accepted for publication: 13 February 2019.

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Dermatology Reports 2019; 11(s1):8056
doi:10.4081/dr.2019.8056

and 3,3% used bar antiseptic soap. Moisturizer was applied in 25,6% sample after each diaper change, and the type most frequently used was cream based (54,5%). The application of talc or powder was performed in 18,6% sample after their daily diaper change. 46,5% of the sample was formula-fed, 37,2% was breastfed, and 16,3% was both breast and formula-fed. 95,3% sample was aterm (37-40 gestational weeks). History of diaper rash was denied in 48,8% sample. As much as 44,2% of the sample had history of atopy, with the most frequent manifestation being atopic dermatitis (62,8%).

The measurement revealed mean pH value of diaper area was $6,11 \pm 0,72$ (95% CI, 4,88 - 8,02) and mean pH value of nondiaper area was $5,91 \pm 0,69$ (95% CI, 4,53 - 7,69). There is significant difference between pH value of diaper area and nondiaper area ($p=0,005$), shown in Table 1.

We also analyzed the pH values between diaper and non-diaper area against each variable in sex groups, age groups, frequency of diaper change, daily skin care routine, type of soap used, the use of moisturizer, powder, feeding history, birth gestational age, previous history of diaper rash, and atopy. It was revealed that the difference in pH values between diaper and non-diaper area against the different sex and age groups are not significant. There was no significant difference in pH values between diaper and non-diaper area against frequen-

cy of diaper change ≥ 6 times daily, but there was significant difference in frequency of diaper change < 6 times daily ($6,36 \pm 0,36$ vs $5,97 \pm 0,76$, CI 95% $p < 0,05$). In daily skin-care routine before diaper change, the use of soap or soap alternating with baby wipes increased the pH value of diaper area (soap $6,07 \pm 0,52$ vs $5,78 \pm 0,58$, CI 95% $p = 0,03$) (soap alternating with baby wipes $6,18 \pm 0,78$ vs $5,89 \pm 0,64$, CI 95% $p = 0,005$). The use of only baby wipes and only water did not make significant difference in pH values, nor did the different types of soaps that were used. The use of moisturizer or powder after diaper change did not cause significant difference in pH value in diaper and non-diaper area. Being formula-fed increased pH value of diaper area significantly ($6,03 \pm 0,71$ vs $5,88 \pm 0,66$, CI 95% $p = 0,04$), whereas being breastfed or combination of breast- and formula feeding did not cause significant difference in pH values. History of atopy increased pH value of diaper area ($6,30 \pm 0,86$ vs $6,06 \pm 0,77$, CI 95% $p = 0,03$), whereas birth gestational age and previous history of diaper rash did not cause significant difference in pH values between diaper and non-diaper area.

Discussion

The samples in this study were healthy infants aged 6-12 months old. There was no significant difference in pH value of diaper and non-diaper area against the different sex or age group, in concordance with previous study by Giusti F et al.⁴ This shows that skin barrier function is not influenced by sex, and there is no significant difference in skin barrier function within the age of 6 to 12 months. With diaper change less than 6 times daily, pH value of diaper area was significantly higher than non-diaper area ($6,36 \pm 0,36$ vs $5,97 \pm 0,76$, CI 95% $p < 0,05$). Li CH et al. revealed that infants with diaper change less than 6 times daily had a higher risk towards diaper rash compared to infants with daily diaper change 6 times or more.⁵ This is in concordance with our data analysis, that the frequency of diaper change had a significant role in diaper area skin barrier function. Diaper change in infants should be done every 4 hours, or 6 times or more daily.⁶ Prolonged occlusion in diaper area may increase pH value due to prolonged exposure of urine and feces. Ammonia from urine increases pH value,

thus increasing the proteolytic activity of fecal enzymes, which further disrupt skin barrier function.

In daily skincare routine before diaper change, the use of soap or soap alternating with baby wipes for cleansing increased the pH value of diaper area. The use of water and washcloth are often regarded as the golden standard for cleansing. However, the polar nature of water limits its ability to remove lipophilic substances from the skin and does not have any pH buffering action.⁷ Soaps usually have high pH value, especially bar soaps. Gfatter et al. found that regular liquid soap (pH 9,5) causes a higher pH value on infants' skin compared to pH-buffered liquid soap (pH 5,5) and pH buffered bar soap (pH5,5).⁸ Lavender T et al. reveals no significant difference in infants' skin pH value with the use of baby wipes compared to water and cloth for 4 weeks.⁹ The result of this study corresponds with previous studies, that prolonged use of soap causes higher pH value in diaper area. Different types of soap did not cause significant difference in pH value. However further study with a larger sample size is needed to determine the correlation between soap types and pH value, because only one sample used antiseptic soap in this study thus it could not be analyzed. Only 25,6% sample in this study used moisturizer before each diaper change, and 54,5% of which used cream-based moisturizer. The use of moisturizer and the different types of moisturizer did not cause a difference in pH values on diaper and non-diaper area. Theoretically, cream-based moisturizers have protective effects on stratum corneum, enhancing maturation of skin barrier function, whereas lotions are less protective.⁶ Further studies with more controlled variables and a larger sample size is needed to determine the significance of moisturizer on skin pH value. Only 18,6% of the sample used talc before diaper change, with no significant difference on skin pH. Talc is often used in baby skin care but does not protect the skin from urine and feces exposure, and the granules may further cause friction on irritated skin.⁷

In 46,5% of the sample that was formula fed, the mean pH value on diaper area was significantly higher than non-diaper area ($6,03 \pm 0,71$ vs $5,88 \pm 0,66$, CI 95% $p = 0,04$). There is higher amount of protease and bile acid in the feces of formula-fed infants compared to breastfed infants,¹⁰ therefore, the pH of feces and diaper area of formula-fed infants are higher. From gestational age, there is no significant difference in pH values between diaper and non-diaper areas. The epidermis is fully formed in 34 weeks of gestation, therefore premature infants have less developed skin barrier compared to term infants.¹¹ Preterm infants

need longer time to complete postnatal adaptation and to reach term infants' skin barrier function, which may take around 4 weeks, depending on the gestational age at birth.¹² In this study, gestational age did not cause any difference in the pH value at diaper and non-diaper area, because skin maturation occurs in the first month of life, whereas the samples of this study were 6-12 months old. No significant difference was found on diaper and non-diaper area against history or different frequency of diaper rash. Adalat S et al. shows that previous recurrent episodes of diaper rash do not predispose to current diaper rash.¹³ This supports our finding that no difference in pH value was found, which might be due to the complete healing of the skin after each episode of diaper rash.

In infants with history of atopy, pH value of diaper area is higher than non-diaper area ($6,30 \pm 0,86$ vs $6,06 \pm 0,77$, CI 95% $p = 0,03$). In atopic skin, there is decreased filaggrin, which is the precursor of amino acids for maintaining acidic pH on the skin. The secretion of sweat high in lactic acids is also reduced in atopic patients, leading to higher skin pH.¹⁴ In this study, history of atopy may further disrupt skin barrier function in diaper area, due to the decreased filaggrin and lactic acid. The measurement revealed that the mean pH value of diaper area was $6,11 \pm 0,72$ (95% CI, 4,88 – 8,02) which is significantly higher than the mean pH value of non-diaper area which was $5,91 \pm 0,69$ (95% CI, 4,53 - 7,69), $p = 0,005$. The normal pH value of the skin is 4,5-6.¹⁴ Bartels NG et al. demonstrated higher pH in diaper area compared to nondiaper area in healthy infants aged 9 months ($5,5 \pm 0,7$ vs $5,1 \pm 0,5$, CI 95% $p < 0,001$).¹⁵ Giusti F et al revealed that the pH value in infants aged 8-12 months old diaper area is higher than on volar area ($6,06 \pm 0,54$, vs $5,45 \pm 0,71$, CI 95% $p < 0,05$).⁴ These support our findings that pH value on diaper area is higher than non-diaper area, even though there is no visible skin lesion. Diaper area may have increased pH due to exposure of the accumulation of urine and feces. Ammonia from urine increases pH value, and the activity of proteolytic fecal enzymes, which may irritate the skin and decreases skin acidity.

Conclusions

The pH value of healthy infants age 6-12 months in diaper area is $6,11 \pm 0,72$ (95% CI, 4,88- 8,02) and in non-diaper area is $5,91 \pm 0,69$ (95% CI, 4,53-7,69). The pH value in diaper area is significantly higher than non-diaper area.

Table 1. pH value analysis.

| Group | Mean | P |
|--------------------|-----------------|-------|
| pH diaper area | $6,11 \pm 0,72$ | 0,005 |
| pH non-diaper area | $5,91 \pm 0,69$ | |

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