

Corneometric, sebumetric and TEWL measurements following the cleaning of atopic skin with a urea emulsion versus a detergent cleanser

REIMAR RUDOLPH¹ AND ECKHARD KOWNATZKI²

¹Nordseeklinik, Norderney, and ²Experimentelle Dermatologie, Universitäts-Hautklinik, Freiburg, Germany

A non-detergent urea emulsion cleanser and a detergent cleanser with added moisturizers were compared for their effects on stratum corneum moisture, surface lipids and transepidermal water loss (TEWL) of atopic skin. Following a single wash with either cleanser, low corneometry and sebumetry values increased and elevated TEWL values decreased. Over the course of more than 6 h, all induced changes gradually returned to their starting points. In all instances, the changes induced by the urea emulsion lasted significantly longer than those caused by the detergent cleanser. The sebumetry increase after a wash with the lipid-free detergent cleanser indicated that this method recognized not only true lipids but also the lipid-derived and skin lipid-depleting detergents. The transient TEWL normalization with either cleanser could not be attributed to a passing barrier restoration nor to an occlusion. It is speculated that the TEWL changes were related to stratum corneum water binding capacity.

Key words: atopic dermatitis; corneometry; detergent cleaning; emulsion cleaning; sebumetry; skin barrier; skin lipids; skin moisture; tewametry; urea. © Blackwell Munksgaard, 2004.

Accepted for publication 27 April 2002

Detergents are widely used for cleaning the human skin. The cleaning action is based on their lipid-emulsifying potential. Emulsified lipids can be washed off with water together with any adhering dirt. Detergents do not distinguish between foreign lipids contaminating the skin and natural skin lipids. They remove both. The depletion of stratum corneum barrier lipids leads to a loss of natural moisturizers and the intrusion of micro-organisms, irritants and allergens. The results are skin dryness and skin inflammation (1, 2).

Detergent-induced skin problems are particularly frequent in individuals with skin lipid deficiencies, such as patients with atopic dermatitis (3–5). They are also common in those whose skin is frequently exposed to detergents or who combine wet work and detergent skin cleaning, such as health care providers, hairdressers and employees in the food industry (6, 7).

In order to reduce detergent-induced skin problems, lipids or moisturizers are added to detergent cleansers. Other attempts try to stay away from detergents altogether. Switching from a detergent to a non-detergent emulsion cleanser (8) was shown to reduce the incidence of dry

skin and eczema on the hands of hospital staff (9). We recently proposed an emulsion cleanser that exploits the dissociating properties of urea (10) for cleaning purposes (11). Also this urea emulsion cleanser was found to prevent detergent-induced skin problems (12).

We compared the effects of a single wash with the urea emulsion cleanser and a detergent cleanser with moisturizers on stratum corneum properties reflecting intracorneal moisture, skin surface lipids and transepidermal water loss (TEWL), in patients with atopic dermatitis. We here report that abnormal values of all 3 skin properties improved for over 6 h following the wash with either cleanser but that such improvements lasted significantly longer with the urea emulsion.

Patients and Methods

Measurements were performed on 24 patients with atopic dermatitis admitted to the Nordseeklinik, Norderney, Germany, for rehabilitation treatment. There were 16 women and 8 men. Their age range was 25–49 years. Their scoring

index of atopic dermatitis (SCORAD) (13) at the time of admission was 57 ± 5 (mean $\pm$ SD). None was in a phase of acute exacerbation. They received bland skin care treatment supplemented if necessary with non-steroidal anti-inflammatory creams containing bufexamac, astringents and tar extracts. The skin of the forearms at the measurement site showed the typical dryness of atopic skin, but there were no fresh inflammatory lesions or cracks.

The International Nomenclature Cosmetic Ingredient (INCI) declaration of the urea emulsion (Veladerm® Duschlotion, LavaDerma Kosmetik GmbH & Co KG, Freiburg, Germany) was: aqua, urea, glycerine, paraffin, petrolatum, cetearyl alcohol, sodium cetearyl sulfate. The total amount of lipids and emulsifiers combined was below 20%, and the concentration of the emulsifiers below 5%. The INCI declaration of the detergent cleanser (Eucerin® Trockene Haut 5% Waschfluid, Beiersdorf AG, Hamburg, Germany) was: aqua, sorbitol, glycerine, sodium myreth sulfate, sodium lactate, urea, sodium cocoamphoacetate, lauryl glucoside, polyethylene glycol-40 hydrogenated castor oil, lactic acid, sodium benzoate, sodium salicylate, polyquaternium-10.

The patients were asked to wash the flexor surface of the forearms with lukewarm water and a pea-size amount of a cleanser, one on the right arm and the other on the left. After 1–2 min on the skin, the cleanser was rinsed off with water. Measurements were made in an area 3 cm in diameter at the following time points: 2 h, 1 h and immediately before, and 1, 2, 3, 4 and 6 h after, the wash. On the following day the entire procedure was repeated with the respective cleanser switched to the other arm. The value 2 h before the wash on the 2nd day was also used as 22-h time point of the 1st day.

Corneometry determining the capacitance of the stratum corneum and reflecting the relative stratum corneum moisture was measured with a corneometer CM 820 of Courage & Khazaka, Köln, Germany. 4 measurements were made per area. The results are reported in corneometry units. Sebumetry was performed with the instrument SM 810 of the same company. The lipids of one measurement per area are expressed in g/cm^2 . TEWL was determined with the Tewameter TM 210 of Courage & Khazaka. One measurement per area was made and expressed in g/hm^2 .

Values obtained from all 24 individuals with one cleanser at a given time point before and after treatment were combined and means $\pm$ SD were calculated. After it was ascertained by statistical analysis (Wilcoxon test for paired variables) that the data obtained with a given

cleanser on day 1 did not differ significantly from those of day 2, the results of consecutive days were combined. The Wilcoxon test for paired variables was also used to examine differences between the urea emulsion and the detergent cleanser for significance.

Results

Starting with constant low corneometry levels, all patients responded with an increase in stratum corneum moisture following the wash with either cleanser (Fig. 1). Over the following hours, the values gradually decreased and in all instances had reached starting levels after 22 h. The pattern was similar with the 2 cleansers, however, the elevated corneometry values lasted longer after a wash with the urea emulsion. From the time point 2 h after the wash, differences between the urea emulsion and the detergent cleanser were highly significant, with $P < 0.001$.

Skin surface lipids as determined by sebumetry increased in all instances as well (Fig. 2). The variation between patients was larger during the first hours, which could well reflect a more or less thorough rinsing at the end of the wash. Again, the response to the 2 cleansers was similar, with the effect lasting longer with the urea emulsion. Statistical evaluation showed the same significance level at the time points 2–6 h after the wash. After 22 h, the effect had worn off in all instances with either cleanser.

Before the wash the TEWL was elevated in 23 of the 24 patients (Fig. 3) as compared with our

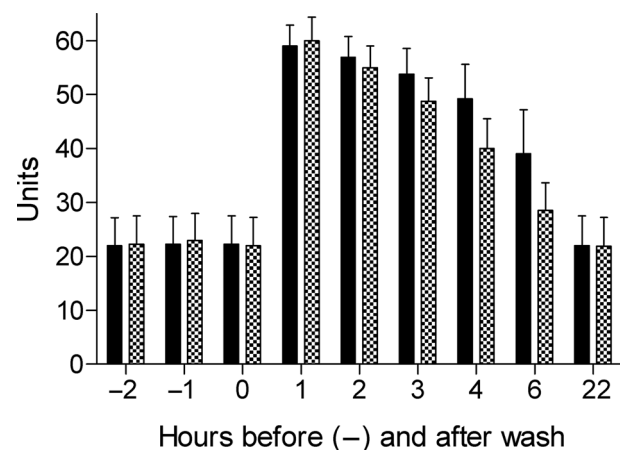


Fig. 1. Corneometry performed on the flexor surface of the forearms of 24 patients with atopic dermatitis at various time points from 2 h before till 22 h after a wash with a urea emulsion cleanser (black columns) and a detergent cleanser (shaded columns). Values represent means and SD of 2×24 measurements, for time point 22 h only once 24 measurements and are expressed in units.

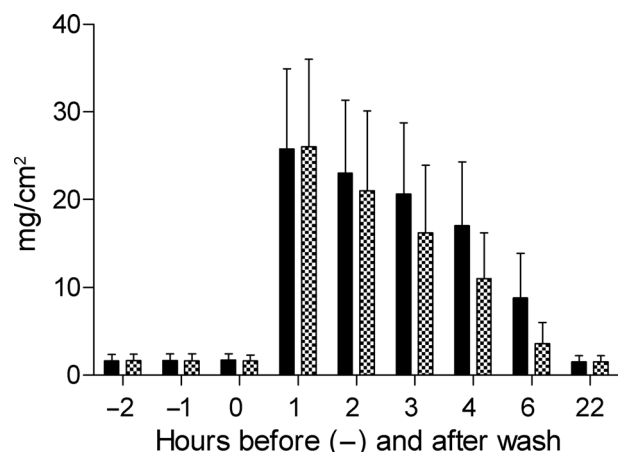


Fig. 2. Sebumetry performed on the flexor surface of the forearms of 24 patients with atopic dermatitis at various time points from 2 h before till 22 h after a wash with a urea emulsion cleanser (black columns) and a detergent cleanser (shaded columns). Values represent means and SD of 2×24 measurements, for time point 22 h only once 24 measurements and are expressed in $\mu\text{g}/\text{cm}^2$.

normal values ranging from 13 to $17 \text{ g}/\text{hm}^2$. Immediately after the wash, the elevated TEWL values reached levels close to normal. They increased again during the following hours and had returned to initial values after 22 h. Again, both cleansers showed this course. The effect of the urea emulsion lasted longer than the detergent cleanser, the differences between the 2 being significant ($P < 0.001$) at the times of measurement between 2 and 6 h. There was no change in the TEWL of 1 patient starting off in the normal range.

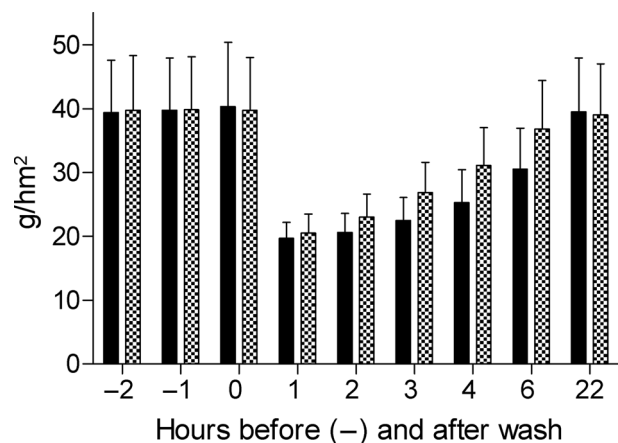


Fig. 3. Tewametry performed on the flexor surface of the forearms of 24 patients with atopic dermatitis at various time points from 2 h before till 22 h after a wash with a urea emulsion cleanser (black columns) and a detergent cleanser (shaded columns). Values represent means and SD of 2×24 measurements, for time point 22 h only once 24 measurements and are expressed in g/hm^2 .

Discussion

The skin of patients with atopic dermatitis lacks moisture and lipids (14, 15). It has been suggested that an abnormal composition of the barrier lipids and the resulting barrier leakage are the basic problem of this disease (16). Barrier leaks facilitate penetration in both directions. Loss of moisturizers and water causes the typical skin dryness. The intrusion of foreign material eliciting immunologic and non-immunologic skin responses causes allergic and irritant inflammatory reactions.

The results presented here indicate that abnormal values for water content, surface lipids and TEWL in the atopic patients approached normal figures following a wash with either a non-detergent urea-based emulsion cleanser or a detergent cleanser containing moisturizers. The effect was transient and gradually returned to starting values over the course of hours. The wash with either cleanser had no measurable effect on the response of the skin to the same or the other cleanser on the following day.

A proper stratum corneum hydration requires the presence of low molecular weight hygroscopic molecules. Water applied to the skin without such moisturizers will evaporate within minutes (17). The increase of hydration sustained over more than 6 h reported here was presumably due to the moisturizers provided by the cleansers. The urea emulsion contained urea and glycerine, both known to improve the moisture of dry skin (18). The moisturizers in the detergent cleanser were glycerine, urea and lactic acid. In order to be effective, the moisturizers did not have to remain on the skin as is customary with moisturizing creams and lotions. Moisturizing wash-off cleansers may even be superior to leave-on skin care products, as hygroscopic molecules remaining on the skin surface can extract water from the stratum corneum.

Lipids of mineral or plant origin may partially substitute for skin lipids and improve both the feel and function of a lipid-depleted skin. Whereas the customary detergent cleaning removes lipids, both cleansers increased skin surface lipids as assessed by sebumetry. The urea cleanser contained the mineral-oil-derived lipid mixtures petrolatum and paraffin with marginal amounts of emulsifier, while the detergent cleanser contained no lipids that were not detergents. This indicates that sebumetry recognized not only non-detergent lipid molecules but also the lipid-derived detergents with their fatty acid side chains. High sebumetry values due to detergents may add to lipid barrier destruction and should not be considered advantageous.

Both cleansers reduced the TEWL of the 23 patients in whom it was found to be elevated at the start. This effect of the detergent cleanser was surprising, as detergents would rather be expected to eliminate lipids, increase barrier leakage and raise the TEWL.

As TEWL increases are associated with barrier insufficiency, the reduction of an increased TEWL is generally interpreted as barrier repair (19). For several reasons, this was not a likely explanation for the effects of the 2 cleansers. True barrier repair requires days and not minutes as reported here (20). A well-functioning barrier that is not exposed to lipid-dissolving agents should last for days and not just for a few hours as reported here. For a barrier to be functional, a particular composition of the lipids and their arrangement in a membrane-like network around and between the corneocytes are crucial (20–22). Neither cleanser contained such lipids, and if they had been present they would not have been expected to adopt this pattern.

Also occlusion is not a likely explanation for the transient TEWL reduction (23). The small amounts of lipids remaining on the skin after the wash with the urea emulsion would probably not suffice to curb evaporation, and the detergent cleanser did not even contain any non-detergent lipids. Occlusion would also be expected to reduce both an elevated and a normal TEWL, but the TEWL of the single patient who was normal at the start did not change. The same observation was made in atopic children (Schöne and Kownatzki, unpublished observation).

Although TEWL increases follow a barrier damage, TEWL reductions need not necessarily be associated with barrier repair. It is conceivable that TEWL increases are not caused by barrier damage directly but are mediated by another consequence of the barrier insufficiency. TEWL reductions could be expected if such consequence is influenced independently of barrier restoration. Stratum corneum moisture and its restitution appear to be a good candidate, for several reasons.

A reduction of stratum corneum moisture invariably follows barrier damage (15). In the findings reported here, a restoration of stratum corneum moisture by either cleanser closely paralleled the TEWL reduction and vice versa. An inverse relationship between stratum corneum hydration and TEWL was previously reported by Tagami and Yoshikuni (24). The authors concluded that the inability to bind water caused an increased water passage. We follow their line of thought and suggest that TEWL rises after barrier perturbation in general come about via a

reduction of the stratum corneum water-binding capacity and that TEWL normalization can be achieved by improvement of the stratum corneum water content even while barrier defects persist.

Atopic patients who used the 2 products for cleaning their skin reported favourable effects on the subjective skin feeling. As observed in the experiments this wore off during the following hours but lasted longer with the urea emulsion. There is no information yet whether these objective and subjective improvements were associated with a better protection of the barrier-compromised skin against penetrating irritants and allergens. Although no residues of the improvements were discernible on the following day, it needs to be studied whether the repeated use of moisturizing cleansers has beneficial effects on the long-term course of the disease.

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Address:

Dr Eckhard Kownatzki
Postfach 5704
79025 Freiburg
Germany
Tel: +49 761 881 7596
Fax: +49 761 881 7596
e-mail: e.kownatzki@gmx.de