Standardized Trauma (Tape Stripping) in Human Vulvar and Forearm Skin

Effects on Transepidermal Water Loss, Capacitance and pH

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Mechanical trauma to genital skin may favor the transmission of sexually transmitted diseases. To study differences between vulvar and forearm skin in epidermal repair after standardized trauma, transepidermal water loss, capacitance and pH of forearm and vulvar skin in 10 healthy premenopausal women were monitored for 7 days after a standardized trauma induced by tape stripping to glistening. Vulvar and forearm skin showed similar responses immediately after tape stripping: a sudden increase in transepidermal water loss and capacitance. Forearm skin, however, reacted more intensely than vulvar skin; forearm skin readings remained significantly higher than normal values for 2 days after tape stripping, whereas vulvar skin readings were not significantly different from normal. Thus, vulvar skin did not respond as extensively as forearm skin, presumably because it is a less complete barrier against excess body water loss. On the other hand, vulvar skin seemed to recover faster from skin damage than forearm skin, probably because of its higher epidermal cell turnover. Key word: Skin surface pH.

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The stratum corneum is a major diffusion barrier against excess body water loss and percutaneous penetration of molecules and it protects the organism against physical trauma (1).

Previous studies on the forearm have shown that injury to the stratum corneum by stripping the skin with adhesive tape increases the transepidermal water loss (TEWL) due to the removal of this protective barrier (2-6).

Vulvar skin has been described as a model of specialized skin with the following characteristics:

1. a less complete barrier against water loss,
2. an increased basal cutaneous blood flow and
3. a high 'epidermal cell turnover'.

Since no data are available on the effect of traumaticizing the corneal layer of this specialized skin, we studied the effect of this standardized physical trauma on vulvar skin and compared the responses with the reaction of forearm skin in the same individual. Damage to the corneal layers of these two sites were monitored by TEWL, water content and skin surface pH. These results provide information which may help to understand vulvar physiology better.

MATERIAL AND METHODS

Study population

Ten healthy premenopausal women entered the study after signing a written consent form. The study had been approved by the UCSF Committee for Human Research. The women were between 28 and 45 years old.

Tape stripping

Before the stratum corneum of the volar side of the skin of one forearm and the medial part of one labium majus was stripped with adhesive tape (Scotch® Tape 800, 3M), hairs had been clipped off both labia majora. Sites were chosen using a randomization protocol. Skin was stripped until glistening (30-60 times), which indicated near complete removal of the stratum corneum (3).

Measurements

The measurements at the stripped and a symmetrical control site were performed 3 min after tape stripping (day 0), on day 1-4 and day 7. Before all measurements, volunteers had been physically inactive for at least 15 min. The temperature of the test room was 20°C and the relative humidity was 50-60%.

TEWL was measured with an evaporimeter (Servo Med Ep 1, Servo Med, Stockholm, Sweden). The readings expressed in g/m²/h were converted to values at a standard reference temperature of 30°C (8). Skin temperature was measured with a thermistor (tele thermometer, Yellow
Table I. Transepidermal water loss (TEWL), capacitance and pH of the forearm and vulvar skin before tape stripping (premenopausal women, n = 10)

<table>
<thead>
<tr>
<th></th>
<th>Vulva</th>
<th>Forearm</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>TEWL</td>
<td>14.9 ± 3.4</td>
<td>7.4 ± 1.8</td>
<td>&lt; 0.05</td>
</tr>
<tr>
<td>Capacitance</td>
<td>87.2 ± 2.5</td>
<td>85.1 ± 2.6</td>
<td>n.s.</td>
</tr>
<tr>
<td>pH</td>
<td>5.5 ± 0.5</td>
<td>5.3 ± 0.6</td>
<td>n.s.</td>
</tr>
</tbody>
</table>

Springs Instruments, Yellow Springs, Ohio) on the skin surface.

Capacitance of the skin, as an indicator of stratum corneum water content, was measured with a capacitance meter (cornometer CM 780, Photon Ltd., Cologne, West Germany). The cornometer probe was applied to the skin with a slight pressure for 3 s and its values were expressed digitally in arbitrary units.

Skin surface pH was measured with a pH meter (Skinner pH-Meter PH 900 PC, Courage and Khazaka, Cologne, West Germany). The measurements were performed with a glass electrode (Ingold Electrode 403, Electrolyte 9811).

The measured values of TEWL, capacitance and pH were digitized using an AD converter board (Metabyte DAS 16, Metabyte, Tauton, Mass.) installed in an IBM AT-compatible computer. The sampling rates for the TEWL were set at one measurement per second over a period of 30 s. TEWL was calculated by taking the average of the values in the final 10 s of the measuring interval.

Statistics

For TEWL and capacitance, values of the stripped site were compared with their symmetrical control and the ratios expressed in percent (relative TEWL, relative capacitance). Since the distribution of these values in this study population does not differ significantly from a normal distribution (Elser and Maibaum, unpublished data), the differences between mean of stripped sites and control sites can be compared, using Student's t-test for paired data (9).

Skin surface pH of stripped and untreated sites were compared and the differences checked for significance using Student's t-test. Statistics were computed on a personal computer (Macintosh SE, Apple Computer Inc., Cupertino, Calif.) with a statistical software package (Stat View 512+, Brain Power Inc., Calabasas, Calif.).

RESULTS

Table I shows the absolute TEWL values, capacitance and skin surface pH before tape stripping. Vulvar TEWL was significantly higher than forearm TEWL. Capacitance and skin surface pH did not differ significantly between vulvar and forearm skin.

Changes in the relative TEWL over 7 days post stripping are demonstrated in Fig. 1. An immediate significant TEWL increase (p < 0.01) was observed for the forearm skin and not for the vulvar skin. One day post tape stripping, skin surface pH increased in the vulvar skin, whereas skin surface pH in the forearm skin remained almost unchanged. pH decreased on the day following the subsequent daily stripping (p < 0.01) and 3 (p < 0.05), and still significant for 7 days. These data showed almost unchanged capacitance for both sites, and the control site for both sites.

DISCUSSION

Vulvar skin has been recognized as specialized skin with increased transpirable water loss (TEWL), high epidermal and extracellular fluid content and increased basal cutaneous blood flow. We have shown that forearm skin, compared to vulvar skin, has more sebaceous glands, is more densely innervated and has increased basal cutaneous blood flow. In the present study, we have investigated the effect of stripping on the skin surface pH of the forearm and vulvar skin. The results of the present study suggest that the forearm skin has a higher baseline pH than the vulvar skin.

These findings may be due to the different types of skin present on the forearm and vulvar skin. The forearm skin contains a higher number of sebaceous glands and is more densely innervated, which may contribute to increased skin surface pH. In contrast, the vulvar skin has a lower number of sebaceous glands and is less densely innervated, which may contribute to increased skin surface pH changes after stripping.

The results of this study suggest that the forearm skin has a higher baseline pH than the vulvar skin. However, further studies are needed to determine the role of different factors, such as sebaceous glands, innervation, and blood flow, on the skin surface pH of the forearm and vulvar skin.
Standardized trauma in vulvar and forearm skin

**DISCUSSION**

Vulvar skin has been recognized as a model of specialized skin with increased transepidermal water loss (TEWL), high epidermal cell turnover and increased basal cutaneous blood flow (7). Recently, we have shown that forearm skin reacted more intensively to sodium lauryl sulfate exposure than did vulvar skin (10). After stripping the corneal layers of vulvar and forearm skin, we found a similar phenomenon: forearm skin responses to this trauma were stronger than vulvar skin reactions. Immediately after tape stripping, relative TEWL increased sharply for both sites, but relative TEWL readings of forearm skin were higher than those of vulvar skin. These findings may be explained by the physiologically decreased barrier function of vulvar skin. Further damage to the vulvar barrier results in relatively less TEWL increase than at the forearm.

TEWL increase of forearm skin returned slowly to normal baseline values. Four days after tape stripping, values were still increased. Vulvar skin TEWL, however, was significantly increased only directly post trauma and did not differ significantly from the control site from day 1 till the end of the study. We conclude that vulvar skin recovers more rapidly from this physical trauma than forearm skin does. This may be a result of the physiologically increased epidermal cell turnover of vulvar skin as demonstrated by the dnmot chloride technique, or of the relatively minor damage to barrier function in vulvar skin, since baseline barrier function of vulvar skin is physiologically decreased compared with that of forearm skin (7, 11).

Skin capacitance as an indicator of epidermal hydration increased significantly directly after tape stripping, on both vulvar and forearm skin. This increase was followed by capacitance decreases for the remainder of the study. Tape stripping removes most of the stratum corneum so that capacitance was measured almost directly from the viable epidermis which has a higher capacitance than the stratum corneum.

Two days after tape stripping, capacitance values of stripped skin were lower than at the control site. This reflects a drying effect, especially on forearm skin, which can be explained by a reactive hyperkeratosis. We observed this dry eczema with decreased capacitance readings on the forearm skin, but vulvar skin seemed to react differently after the trauma. Capacitance values at that site were almost unchanged 1 day post trauma.

The increased TEWL during these study days is another explanation for the drying effect. On the other hand, the lower capacitance values may reflect the beginning of a healing process described by other investigators (12): the inner layers of the epidermis show an increased mitotic activity after tape stripping with the attempt to regenerate the stratum corneum.

On the last study day, capacitance of vulvar skin was back to normal, indicating the regeneration of its corneal layers. Forearm skin capacitance values, however, remained decreased until the last day, showing that regeneration was delayed.

Skin surface pH decrease immediately after tape stripping. This confirms Szakall's observations dating back to the 1950s (13, 14) that a double pH gradient
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REFERENCES

Three different enzyme immunoassays (ELISA) and Western blotting of B. burgdorferi in sera from 100 patients with erythema migrans and from 100 controls were compared. The immunoassays were based on recombinant antigens (flagellum ELISA) and total cell antigen (capture ELISA) (12). The Western blot pattern was considered to be positive than either the IgM or IgG ELISA. The overall sensitivity of the ELISA and Western blot was 88% and 92%, respectively. The ELISA and Western blot pattern was positive in 84% and 94% of 100 patients with erythema migrans sera, but a fraction of false-positive results were seen in 10% of the controls sera. IgG Western blot was considered to be of high diagnostic value for the diagnosis of Lyme disease with a high occurrence of positive results in the positive sera.

Three different enzyme immunoassays, ELISA, and Western blotting of B. burgdorferi in sera from 100 patients with erythema migrans and from 100 controls were compared. The immunoassays were based on recombinant antigens (flagellum ELISA) and total cell antigen (capture ELISA) (12). The Western blot pattern was considered to be positive than either the IgM or IgG ELISA. The overall sensitivity of the ELISA and Western blot was 88% and 92%, respectively. The ELISA and Western blot pattern was positive in 84% and 94% of 100 patients with erythema migrans sera, but a fraction of false-positive results were seen in 10% of the controls sera. IgG Western blot was considered to be of high diagnostic value for the diagnosis of Lyme disease with a high occurrence of positive results in the positive sera.

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