Measurement of Transepidermal Water Loss Using an Evaporimeter to Follow the Restitution of the Barrier Layer of Human Epidermis after Stripping the Stratum corneum

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The rate of evaporation after stripping a test area with adhesive tape was followed in 10 women over a period of 15 days. The much increased transepidermal water loss after stripping diminished rapidly on the first 3 days. It then decreased more slowly, approaching but not fully reaching the normal rate by the end of test period. This can be taken to reflect the repair process of the damaged barrier layer. The instrument used makes possible instantaneous reading of the rate of evaporation, and is highly suited for assessing the function of the barrier layer. (Received July 4, 1984.)

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The stratum corneum acts as a barrier for water (1). By damaging this barrier, for example by stripping the skin with adhesive tape, the water loss increases greatly (2, 3, 4). Measurement of water loss could therefore be used for assessing the function of the barrier layer.

Evaporation from normal skin comprises sweating and transepidermal diffusion. Envi-

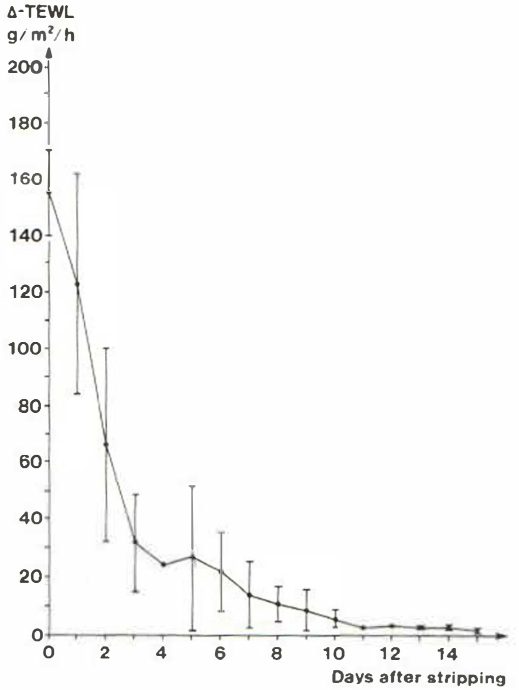

Fig. 1. Increase in TEWL after stripping. Δ-TEWL = difference between TEWL over test and control areas, measured on the same occasion. Mean value and standard deviation are indicated when two or more persons were measured.

ronmental factors such as relative humidity and temperature influence the transepidermal water loss (TEWL) (5, 6, 7, 8, 9).

By avoiding areas where sweating is markedly influenced by emotional stress, and by keeping ambient temperature and humidity fairly constant, any significant change in the rate of evaporation can be taken to reflect a change in the function of the barrier layer.

Various methods of determining the rate of evaporation from the skin have been described, including the use of a ventilated or unventilated chamber and measurement of evaporated water by gravimetry or electrohygrometry or infrared absorption (2, 5, 7, 9).

A highly ingenious instrument for this purpose is the evaporimeter we have employed.[1] The present investigation was done to evaluate its usefulness in assessing the function of the epidermal barrier.

MATERIAL

10 women volunteered to take part in the study. Their mean age was 30 years (range 19 to 50), and all were apparently healthy.

METHODS

The rate of evaporation was measured with an evaporimeter designed and constructed by Gert Nilsson, Department of Medical Engineering, University of Linköping.*

The probe, through which gas can flow freely, is placed on the skin. Temperature and relative humidity are measured at two levels, 3 and 9 mm above the skin surface, by means of two sets of thermistor and capacitive thin-film transducer. From the data obtained the partial water vapour

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[1] A modification of this prototype is now commercially available from Servo Med AB, Box 110, S-162 12 Stockholm, Sweden.

pressures at the two levels are automatically calculated. TEWL is derived from this pressure gradient expressed in g/m²/h, and is shown on a digital display or is continuously recorded on a pen recorder (10).

All measurements were made in May and June 1978, with the person lying prone.

Two symmetrical paravertebral mid-thoracic areas measuring 2×2 cm were mapped out, and the rate of evaporation was measured. Before each measurement the skin was gently dried with a cellulose swab.

One of the two areas was then stripped 10 times with transparent adhesive tape. After measuring, the stripping procedure was repeated until the increase in rate of evaporation exceeded 120 g/m²/h (30–70 strippings). A glistening area could then be seen, indicating the complete removal of the corneal layer. The contralateral area was used as control. 2 hours after the last stripping measurements were repeated as a rule once daily. Owing to practical considerations compliance proved unreliable, and the number of participants on any one day therefore varied from 1 to 10. The women took part in altogether 88 sessions during the test period of 15 days.

The difference in rate of evaporation between stripped and control areas on the same occasion is recorded as "evaporation difference" (Δ-TEWL).

RESULTS

The evaporation from normal human dorsal skin during the 15-day test period showed an interindividual variation ranging from 4 to 16 g/m²/h. The intraindividual variation (difference between maximum and minimum values) under the same conditions was 4–9 g/m²/h (mean 5.9 g/m²/h).

With the removal of the corneal layer, the rate of evaporation increased rapidly to a mean of 180 g/m²/h (range 146–205 g/m²/h) after the last stripping.

Fig. 1 shows the mean evaporation difference (Δ-TEWL) with standard deviation for the stripped area, with start point 2 hours after the last stripping (day 0). Δ-TEWL rapidly diminished during the first 3 days after stripping, indicating rapid repair of the barrier function. The rate of healing then gradually slowed down, and restitution approached asymptotically the normal state, which was almost but not fully reached after 15 days.

DISCUSSION

The evaporimeter used here proved to be a reliable and convenient means of estimating the rate of evaporation from a unit area. It can thus be used for almost instantaneous estimation of transepidermal water loss from the skin.

The change in TEWL, which reflects the repair of a damaged barrier after stripping the corneal layer as determined with the evaporimeter over a period of 2 weeks, tallies with results of other methods (2, 3, 4). The reproducibility is excellent. Individual fluctuations in TEWL were small in the control areas, ranging from 4 to 9 g/m²/h, which may probably be explained by environmental factors such as temperature and relative humidity which were not checked, but also by skin temperature, which showed some variation. The absolute TEWL under these conditions is small in comparison with values recorded over the stripped areas (range 146–205 g/m²/h). The initial Δ-TEWL value is therefore not significantly influenced by individual basal variations. Δ-TEWL is derived from two measurements made almost simultaneously, which should reduce any influence of change in environmental factors.

It has been contended that evaporimetry using this instrument underestimates the true TEWL when this is in the region of 75 g/m²/h or more (11). This opinion, however, is based on comparison with a method employing a dry gas as carrying medium. It may be argued that the dry gas itself will produce an artificial, abnormally high water vapour pressure gradient, and will thus bring about a maximum TEWL value. Our evaporimeter value probably reflects a more physiological situation.

This evaporimeter can be envisaged as a monitor in preventive occupational dermatology, to permit work causing skin trauma only as long as the barrier layer remains intact. Patients with dermatitis should be kept off work not only until the condition looks clinically healed but also until the barrier function has fully recovered. The instrument could also prove useful both for screening skin-care products before marketing and in the study of penetration-enhancing vehicles for pharmacutical purposes. Another obvious application would be the objective assessment of the effect of treatment of conditions in which the keratinization process is disordered, such as psoriasis. Here the barrier function is impaired, and we have noted a nice agreement between evaporimeter readings and the stage of clinical healing during the course of PUVA-treatment in psoriasis. In fact, the use of the evaporimeter in this application has already been reported (12).

We consider that the evaporimeter allows quick and elegant testing of the state of the epidermal barrier layer on any chosen occasion.

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