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Contact Thermography for Assessment of Skin Damage Due to Experimental Irritants

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Irritant dermatitis after application of experimental irritants was studied by means of contact thermography. Sixteen healthy persons were patch-tested, using the following irritants: Sodium lauryl sulphate, benzalkonium chloride, nonanoic acid, hydrochloric acid, croton oil, sapo kalinus and sodium hydroxide. A main finding was that croton oil after 24 h caused a warm skin lesion, and sodium lauryl sulphate after 96 h caused a cold skin lesion. This study emphasizes the differences in the skin reactions to different irritants. *Key words: Patch testing; Irritant dermatitis; Non-invasive technique.* (Received May 20, 1987.)

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Skin temperature measurement by contact thermography has made it possible to image temperature differences of larger skin areas (1, 2). In clinical dermatology, contact thermography has been emphasized to facilitate the interpretation of patch tests in dark-skinned persons, and to be an important aid to detect weak positive patch test reactions (3, 4). Stüttgen et al. (5) studied allergic patch test reactions using indirect thermography, and found after 24–48 h an increase in skin temperature in the test area, and a thermographic picture in the form of dots, representing allergic papulovesicular eczema. Mustakallio (6) studied the irritant skin reaction of dithranol by contact thermography, and found increased skin temperature after 24 h.

The purpose of this study was to achieve a better characterization of irritant skin reactions and to understand their kinetics by using contact thermography.

MATERIAL AND METHODS

Sixteen healthy Caucasian persons volunteered for the study. Informed consent was obtained, and the study was approved by the local ethical committee.

Closed patch tests with experimental irritants were applied to both arms (anterolateral surface of the upper arm), using large Finn® chambers (diameter 12 mm, Epitest, Helsinki, Finland) on Scanpor® tape (7). The primary irritants used were as follows: sodium lauryl sulphate 10% in distilled water, benzalkonium chloride 3% in distilled water, nonanoic acid 20% in propanol, hydrochloric acid 4% in distilled water, croton oil 1% in petrolatum, sapo kalinus 50% in petrolatum, sodium hydroxide 2% in distilled water. Distilled water, propanol, petrolatum and empty chamber were used as controls. The patches were removed 24 h after application, except for the sodium hydroxide patch, which was removed after 60 min at the most, or earlier if the person complained of any feeling or pain from the test site. Reading was performed 24 and 96 h after application. The degree of inflammation was scored visually according to a modification of a method described by Fregert (8): 0, no reaction; 1, weak positive reaction (erythema, possibly slight infiltration); 2, moderate positive reaction (advanced erythema, infiltration, possibly vesicles and slight crustation); 3, strong positive reaction (advanced erythema, infiltration, possibly vesicles, bullae, pustules and/or pronounced crustation). All patch tests were read by one of the authors.

Contact thermography

A membrane consisting of cholesteric liquid crystals on a black light-absorbent material with high thermal conductivity was used to depict the temperature distribution over the test area (Flexitherm® contact-thermographic equipment) (2). The crystals are in a state between liquid and solid phase, and the colour of the crystals depends on the given temperature; i.e. the crystals reflect brown light at low temperatures and blue light at high temperatures in the temperature range 23.5–29.1°C. The thermography membrane is mounted in a frame with a window. The frame can be insufflated to aid contouring with the skin surface. Changes in colour can indicate temperature differences of 0.6°C.

The Flexitherm equipment includes a Polaroid® camera for colour photography and documentation. 24 and 96 h after application of the irritants, thermography was performed in daylight and at room temperature (21°C). The thermographic presentation of patch test sites was registered 10 s after the membrane was brought into contact with the skin. The colour reading was performed by one of the authors by comparison with a standard scale, and in some instances photographs were made for illustration.

Colour differences indicating a difference of 1.2°C between the patch test area and the immediately surrounding skin were classified into 'warm' and 'cold' lesions. Colour differences indicating difference in temperature less than 1.2°C were recorded as 'equal'.

Statistics

The sign test based on the binomial distribution was used when testing differences in thermographic response between the different irritants.

RESULTS

The different skin responses after application of irritants as seen by contact thermography are illustrated in Fig. 1. The distribution of cold and warm lesions as compared to the irritant applied is demonstrated in Table I. Visual reading (median score) for each irritant is demonstrated in Table II.

Twenty-four hours after application of the irritants 13 out of 16 croton oil patch test areas showed a warm, homogeneous discoid spot (Fig. 1), which was significantly more frequent than any other irritant ($p<0.01$). The three patch test areas which did not show a warm lesion were visually scored as 2 (moderately positive reaction). The elevated skin temperature was not limited to the test area, but extended several millimetres into the surrounding skin. Also sodium lauryl sulphate, hydrochloric acid and sapo kalinus in a few

Table I. *Numbers of patients with 'cold', 'warm' or 'equal' lesions 24 and 96 h after application of experimental irritants (n=16)*

	Number of 'cold', 'warm' or 'equal' lesions					
	24 hours			96 hours		
Irritant	Cold	Warm	Equal	Cold	Warm	Equal
Sodium lauryl sulphate	2	4	10	14	0	2
Benzalkonium chloride	0	1	15	1	0	15
Nonanoic acid	0	1	15	0	0	16
Hydrochloric acid	0	5	11	4	0	12
Croton oil	0	13	3	2	0	14
Sapo kalinus	0	2	14	1	0	15
Sodium hydroxide	3	0	13	8	0	8
Propanol	0	0	16	0	0	16
Petrolatum	0	0	16	0	0	16
Empty chamber	0	0	16	0	0	16
Sterile water	0	0	16	0	0	16

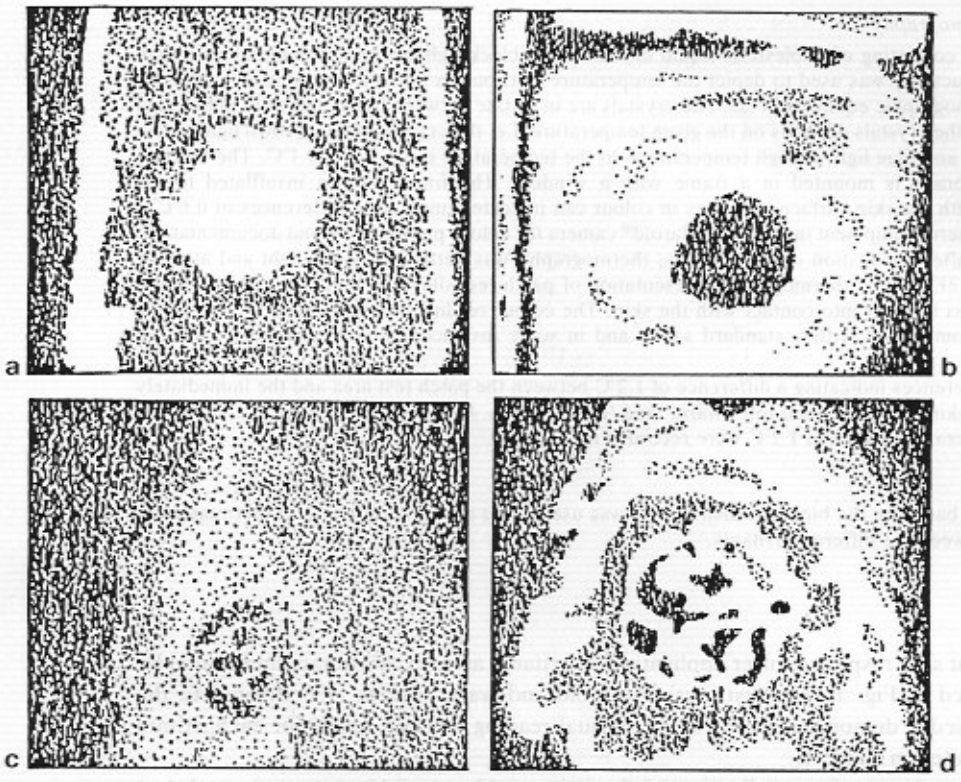

Fig. 1. Black/white drawings after colour thermograms. (*a*) Warm lesion (croton oil, 24 h); (*b*) cold, homogeneous lesion (sodium lauryl sulphate, 96 h); (*c*) cold, non-homogeneous lesion (sodium hydroxide, 96 h); (*d*) a thermographic picture of an allergic reaction to nickel sulphate according to previous experience (10); shown for the purpose of comparison. Paper colour photographs are available on request to the authors.

instances caused warm reactions. In some instances, sodium hydroxide and sodium lauryl sulphate after 24 h caused cold reactions.

After 96 h, 14 out of 16 sodium lauryl sulphate patch test areas showed a homogeneous, discoid, demarcated cold spot (Fig. 1). This finding was significantly more common with sodium lauryl sulphate than for any other irritant ($p<0.05$). The two patch test areas which did not show a cold lesion were visually scored as 0 (no reaction) and 1 (weak positive reaction). In 8 out of 16 of the test areas sodium hydroxide caused a cold reaction but, converse to the above-mentioned, the lowered temperature was here limited to punctuate areas within the test site, and the reaction was not homogeneous (Fig. 1). These punctuate areas were easy to see, but difficult to record by Polaroid® photography, which has a limited resolution. Likewise, inhomogeneous cold reactions were in few instances caused by hydrochloric acid and croton oil. At no time were warm or cold reactions seen after application of solvents or the empty chamber.

DISCUSSION

A main finding was that croton oil, after 24 h, caused a warm skin lesion, while after 96 h, sodium lauryl sulphate caused a cold lesion. The difference in thermographic response of

Table II. *Median visual score 24 and 96 h after application of experimental irritants*
0 = no reaction, 1 = weak positive reaction, 2 = moderate positive reaction, 3 = strong positive reaction

Irritant	Visual score, median (range)	
	24 hours	96 hours
Sodium lauryl sulphate	2 (0–3)	2 (0–3)
Benzalkonium chloride	1.5 (0–3)	0 (0–3)
Nonanoic acid	2 (0–3)	1 (0–2)
Hydrochloric acid	1 (0–3)	0 (0–3)
Croton oil	3 (2–3)	2 (1–3)
Sapo kalinus	2 (1–3)	1 (0–2)
Sodium hydroxide	1 (0–3)	1 (0–3)
Propanol	0 (0–1)	0 (0–0)
Petrolatum	0 (0–0)	0 (0–0)
Empty chamber	0 (0–0)	0 (0–0)
Sterile water	0 (0–0)	0 (0–0)

the skin to different irritants constitutes evidence of the variable nature of skin reactions to different experimental irritants. This supports the findings in our previous study on skin surface replica and irritancy, where croton oil and sodium lauryl sulphate were demonstrated to cause essentially different skin surface patterns (papular/non-papular) (9).

Weak reactions to croton oil and sodium lauryl sulphate could not be demonstrated by contact thermography, and we could not confirm the previously found high sensitivity of the method (3, 4).

Since the changes in skin temperature are specific for the irritant applied, and not only a question of intensity, thermography is mainly useful for pictorial characterization of irritant skin reactions, and not for the purpose of quantitation.

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