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MECHANISM OF BLISTER FORMATION IN LEPROSY PATIENTS

S. N. CHATTERJEE, M.B., D.T.M. *(Calcutta)*

Lately of the Leprosy Research Department
School of Tropical Medicine, Calcutta

Many leprosy patients get blisters from time to time, due to burns or scalds. Burns are caused either by close proximity or direct contact with flame or heated solid bodies, and scalds by action of steam, boiling water, or other hot fluids. Blisters are more commonly found on anesthetic hands than on any other part of the body. In some cases the patient may tell of holding something hot with the anesthetic hand, the heat being sufficient to cause burn but because the hand was insensitive to heat it was not retracted, with the result that he burned himself unknowingly.

There are other instances, however, in which the heat is not unbearable and only part of one hand is anesthetic, or of the two hands exposed to the same heat only one is anesthetic, and blisters appear again and again on the anesthetic parts and not on the normal parts. Here, evidently, the heat is not enough to cause burns of normal parts, but still it produces blisters in anesthetic parts.

ILLUSTRATIVE CASES [1]

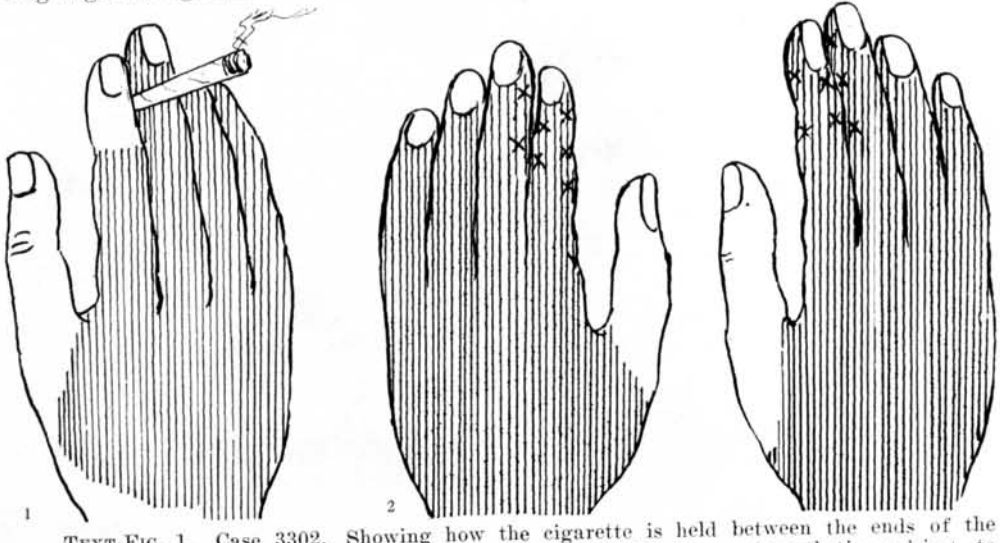
A. CIGARETTE SMOKING

CASE 3302 (P.G.H.). The patient occasionally gets blisters on the radial side of the distal part of his right middle finger, but none on any other finger. These are ascribed to the smoking of country-made cigarettes (*bidi*). The adjoining sides of the distal parts of the right index and middle fingers are subjected to the heat of the burning end of the cigarette. Blisters occur only on the medial side of the right middle finger, which is anesthetic; the distal part of the index finger is not anesthetic. The extent of anesthesia and how the cigarette is held are shown in Text-fig. 1. A photograph of the area of blistering is shown in Fig. 1.

[1] In the sketches used to illustrate these case reports, the anesthetic parts are shown by vertical lines. The locations of blisters are usually indicated by cross-marks.

Case 1362 (J.C.). This patient gives a similar history of blister formation on the right middle finger only, from smoking cigarettes held between the right index and middle fingers. There is an anesthetic area covering the right middle finger, proximal parts of the right index and ring fingers, and the adjoining part of the dorsum of the hand, but the distal part of the right index finger is not anesthetic.

Case 1547 (K.C.). This patient, a heavy smoker, is practically never free from blisters, which appear frequently on the index and middle fingers and occasionally on the ring and the little fingers of both hands but never on his thumbs. The cigarette is usually held between the index and middle fingers of either hand, but when it gets short he sometimes holds it between the thumb and index finger. Therefore, both sides of the index finger and the radial side of the middle one, and the thumbs of both hands, are exposed to the heat. As shown in Text-fig. 2, blisters occur on all of the contact areas except those of the thumbs, which are not anesthetic whereas the rest of the hands are anesthetic. Occasionally he gets blisters in other anesthetic parts due to accidental contact with the burning end of the cigarette. One such ulcer is seen at the tip of the left ring finger in Fig. 2, and two on the dorsum of the right middle finger.



Text-Fig. 1. Case 3302. Showing how the cigarette is held between the ends of the forefinger (not anesthetic, not blistered) and the middle finger (anesthetic, subject to blistering).

Text-Fig. 2. Case 1547. Blisters occur mainly on the index and middle fingers of both hands, not on the thumbs (not anesthetic).

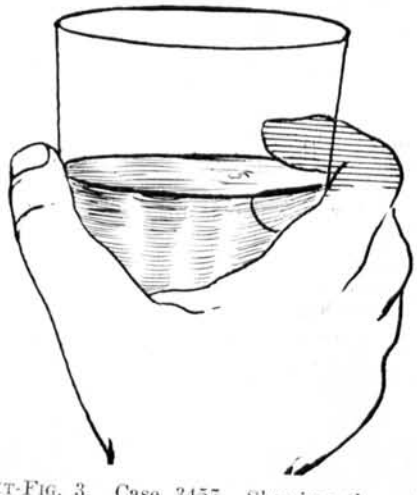
B. Tea Drinking

Case 3457 (L.B.). This patient sometimes gets blisters on her right index finger (Fig. 3) due to drinking hot tea from a glass. Text-fig. 3 shows the way she holds the glass with her right hand, and the extent of anesthesia of the index finger. All the fingers and part of the palm of the right hand come into contact with the glass and are therefore exposed to the same heat, yet blisters appear only on the anesthetic part of the index finger.

Case 2149 (S.B.). This woman gets blisters on the palmar surface of the left middle and index fingers, but not on any other finger. She is accustomed in taking tea to hold the teacup between the thumb and the index and middle fingers of the left hand; the other fingers of that hand are bent, as shown in Text-fig. 4, and cannot be used for holding the cup. Blisters occur on the contact fingers, which are anesthetic, but not on the thumb, which is not anesthetic.

C. Cooking

Case 1758 (R.C.). This patient gets blisters on the ulnar side of her right hand. When cooking her food she uses tongs to lift hot utensils so that her hands may not come in contact with them, but the hands are exposed to heat when the cooking pot is placed



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Text-Fig. 3. Case 3457. Showing the extent of anesthesia (right index finger), and how the glass of hot tea is held.

Text-Fig. 4. Case 2149. Blisters occur only on the useful but anesthetic index and middle fingers from holding hot teacup.

over and taken off the fire. As a result she gets blisters on the anesthetic parts of her right hand, but not on the adjacent normal parts or on the left hand, which are non-anesthetic. Text-fig. 5 shows the extent of the anesthetic parts of the right hand, which are liable to blistering.

Case 1651 (S.B.). This woman has a similar history of getting burns on her right hand, excepting the right thumb, while cooking. Although she holds the rings of the cooking pan with pieces of cloth folded several times for protection, the cloth neverthe-

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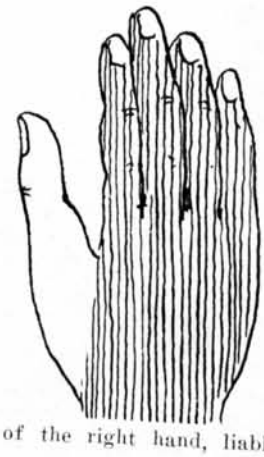


Text-Fig. 5. Case 1758. Showing the anesthetic parts of the right hand, liable to injury when cooking.

Text-Fig. 6. Case 1651. Showing the anesthesia of the right hand, which area alone is liable to burns while cooking.

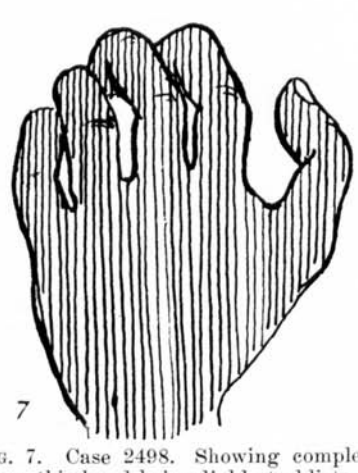
less becomes heated. The heat is not enough to cause burns on her right thumb or on any part of her left hand, but still it causes burns of the anesthetic fingers of her right hand. The extent of the anesthesia of that is shown in Text-fig. 6.

CASE 2498 (A.D.). Another case of burns due to cooking. Here the blisters appear on the left hand, which is anesthetic with contractures as shown in Text-fig. 7, but not on the right hand, which is nonanesthetic.

CASE 3249 (R.M.). This man, who cooks his own food, also gets occasional burns on different parts of his left hand only, which is anesthetic with contractures; his right hand is nonanesthetic. There are scars on the left little and middle fingers, and leucoderma on the latter, due to burns. (A drawing of this hand would be very similar to Text-fig. 7.)

D. CONTACT WITH HOT WATER

CASE 3288 (S.K.B.). The trouble in this case was caused by a compress of cotton soaked in hot water which the patient himself applied to his right hand. The whole of that hand was subjected to the same degree of heat, but it produced a blister on his right ring finger only, which alone was anesthetic, as shown in Text-fig. 8. No blister occurred on the other fingers or on the adjoining parts of the hand, although the hot cotton touched those parts also.



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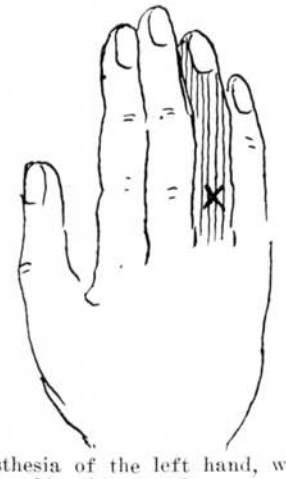

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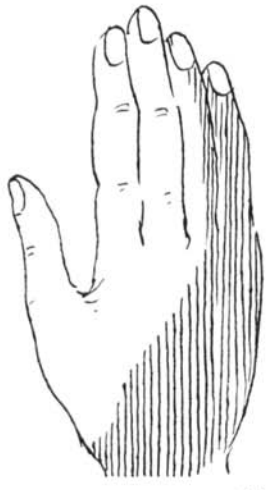
TEXT-FIG. 7. Case 2498. Showing complete anesthesia of the left hand, with contractures of fingers, this hand being liable to blisters when cooking but not the nonanesthetic right hand.

TEXT-FIG. 8. Case 3288. Blistering from a hot compass occurred only on the anesthetic ring finger, as indicated.

CASE 3433 (N.C.S.). A similar case of blistering after a hot compress, applied by the patient to his right hand. The cotton touched normal parts also, but it produced a blister only on the ulnar side of the hand where there was anesthesia. The blistering was severe enough to cause a scar, shown in Fig. 4. Text-fig. 9 shows anesthesia over the dorsum of the hand and the little finger, and on the ulnar side of the ring finger.

CASE 3182 (G.G.). This patient applied a hot compress to his left arm because the ulnar nerve was painful. He wrung the excess of hot water from the cotton between the thumbs and the index fingers of the two hands. All these fingers were therefore exposed to the same heat, but blisters appeared only on the left index finger (Fig. 5), the only one which was anesthetic. There was no blistering of the thumbs or of the right index finger, which were nonanesthetic. Text-fig. 10 shows the anesthesia of the left index finger.

Case 2156 (S.B.D.). This patient spilled hot water all over her right hand, after which there occurred blisters on the right index finger and nowhere else. Text-fig. 11 shows the extent of the anesthesia, involving no other finger than the right index.



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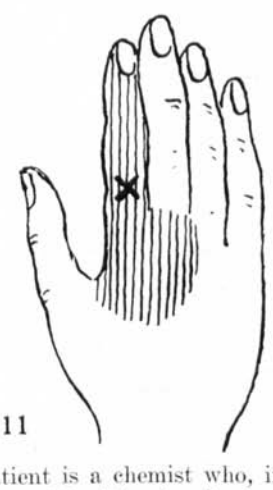
Text-Fig. 9. Case 3433. Extent of anesthesia of hand on the ulnar border of which a hot compress produced a blister.

Text-Fig. 10. Case 3182. Anesthesia of the left index finger, which blistered after preparing a hot compress.

E. Contact With Heated Solid Bodies

Case 2109 (B.D.). This patient got a blister on the palmar surface of the right ring finger after grasping the handle of a kettle containing hot water. Later he got a similar blister at the same site after ringing the bell of a temple with a stick in his right hand for about 15 minutes. There was no blister on any of the other fingers of that hand, which were nonanesthetic. Text-fig. 12 shows that the anesthesia was confined to the right ring finger. Fig. 6 shows scars on that finger due to blisters.



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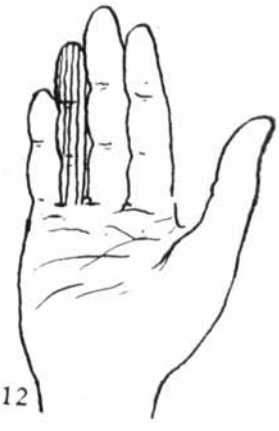

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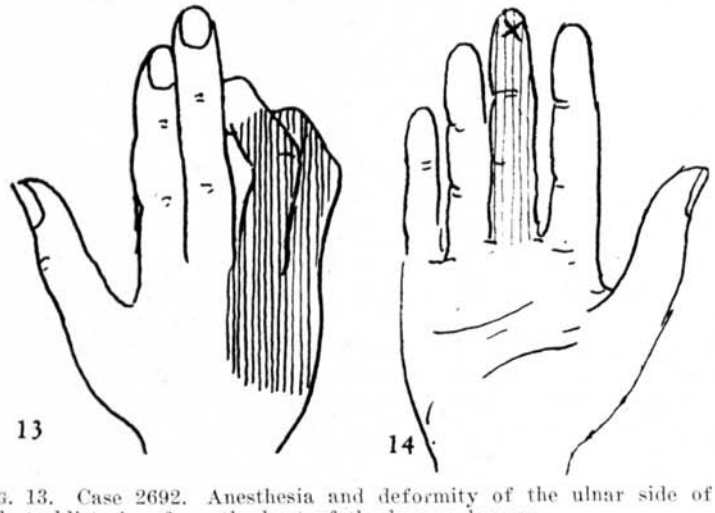
Text-Fig. 11. Case 2156. Anesthesia of right index finger, where blistering occurred after spilling of hot water.

Text-Fig. 12. Case 2109. Anesthesia of the right ring finger, which alone blistered after holding the handle of a hot-water kettle.

Case 2692 (B.B.G.). This patient is a chemist who, in his work, is likely to touch or approach a heated bunsen burner with either hand. Occasionally he gets blisters, but on the ulnar side of his right hand only. As shown in Text-fig. 13, that side of that hand is anesthetic, and the last two fingers are contracted; the left hand, which does not get burned, is not anesthetic.

Case 3057 (B.S.C.). This patient gets blisters on the tip of his right middle finger. He adjusts the wick of his hurricane lantern by grasping the key with his right thumb and the index and middle fingers. Thus the tips of all three fingers come into contact with

the hot chimney from time to time, but blisters occur only on the right middle finger, which alone is anesthetic, as shown in Text-fig. 14.



TEXT-FIG. 13. Case 2692. Anesthesia and deformity of the ulnar side of right hand, which is liable to blistering from the heat of the bunsen burner.

TEXT-FIG. 14. Case 3057. Anesthesia of right middle finger, which alone is liable to blister after contact with a hot lantern chimney.

In the cases cited the anesthetic parts and the adjoining or corresponding normal parts were subjected to the same temperatures, yet blisters appeared on anesthetic parts only. It is evident from this that a temperature which is of no consequence to normal parts may produce blisters on anesthetic parts. Why the effect of the same temperature on anesthetic and nonanesthetic parts should be so different was not known. Hence this matter has been investigated during the last four years.

TEMPERATURE INVESTIGATIONS

These investigations, carried out with a thermocouple and light-trace galvanometer, comprised, first, a control series of tests of corresponding normal parts of the body, in 10 individuals. Temperature records were then made of anesthetic and nonanesthetic parts, before and after the application of heat. For the latter study there were avail-

DESCRIPTION OF PLATE

FIG. 1. Case 3302. Blister from cigarette smoking on the middle finger (anesthetic), not on the adjacent side of the forefinger (not anesthetic).

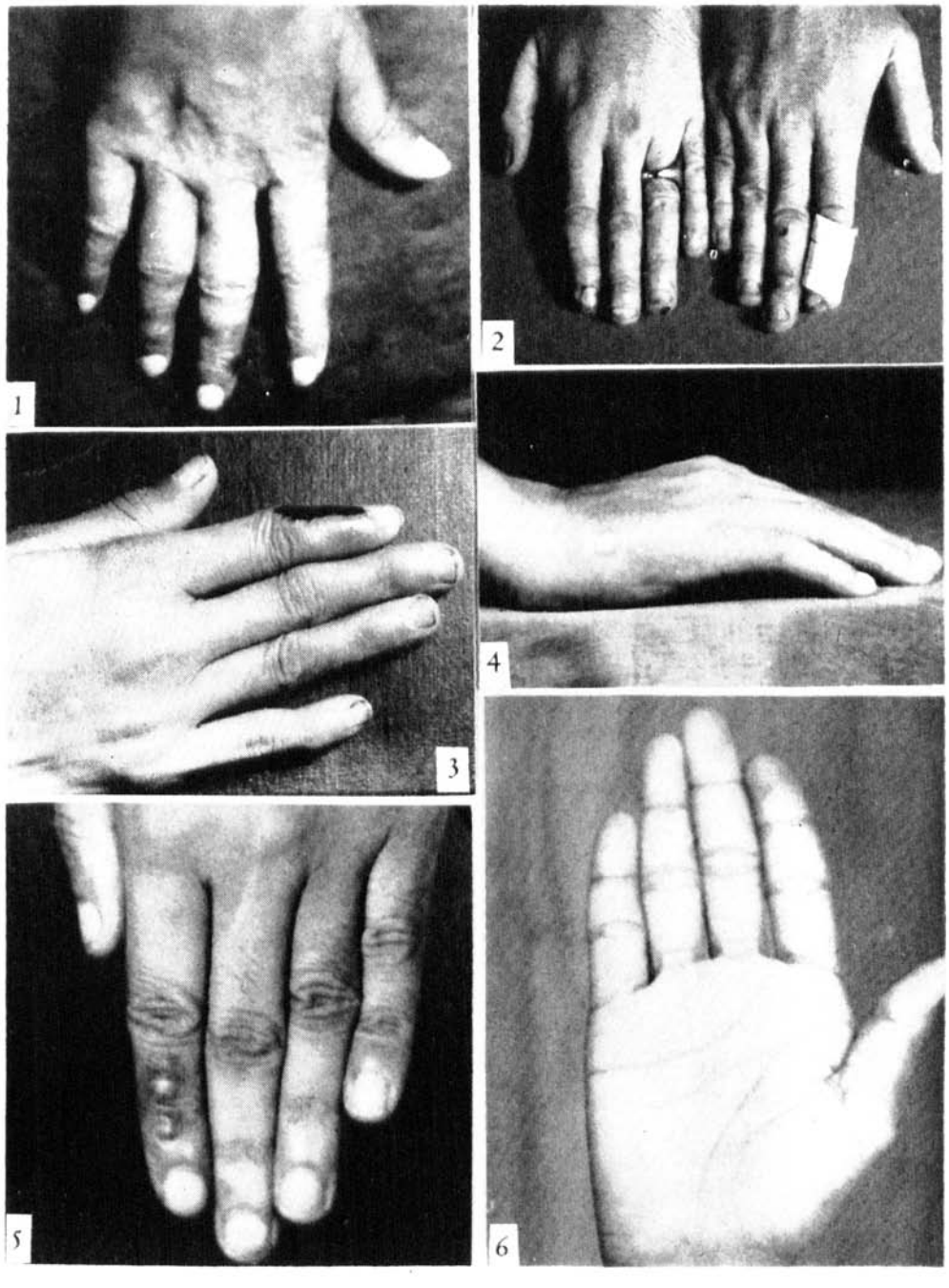
FIG. 2. Case 1547. Blisters from cigarette smoking on fingers, but not on the thumbs, which are not anesthetic.

FIG. 3. Case 3457. Blistering of right index finger, which alone is anesthetic, from holding a glass of hot tea.

FIG. 4. Case 3433. Scar on the ulnar side of the hand due to a blister from a hot compress.

FIG. 5. Case 3182. Blisters due to preparation of a hot compress, on the left index finger which alone was anesthetic.

FIG. 6. Case 2109. Scars on the palmar surface of the anesthetic right ring finger, due to repeated blistering.



able several of the patients who had experienced blistering of anesthetic parts recorded in the foregoing section of this report. These observations were extended on several other patients with anesthesia on one side but none on the opposite side.

Instrument.—The apparatus used consisted of a thermocouple and a light-trace galvanometer made by Hartmann and Braun, Frankfurt on Main, Germany, shown in Fig. 7.

The thermocouple is composed of two welded junctions of iron and constantan wires. The reference junction is encased in an insulated metal tube and immersed in water at any desired temperature, side by side with an accurately graduated standard mercury thermometer reading directly to 0.1°C. The measuring junction is in the form of a stirrup mounted on an insulated handle. The two junctions are connected to each other in series, and the two free ends are connected to a red and a black plug pin indicating positive and negative terminals, respectively.

The light-trace galvanometer, the measuring instrument, consists of a suspended-coil mirror galvanometer and a fine slit illuminated by a lamp, the sharp linear image of which is focused by the concave mirror and moves over a graduated translucent scale. The reading of the lower scale is from 15° to 45°C.

When a difference of temperature is created at the two junctions of the thermocouple, an electromotive force (e.m.f.) is generated. This current, flowing through the galvanometer, causes a deflection of its coil which is magnified by the lamp-mirror and scale arrangement.

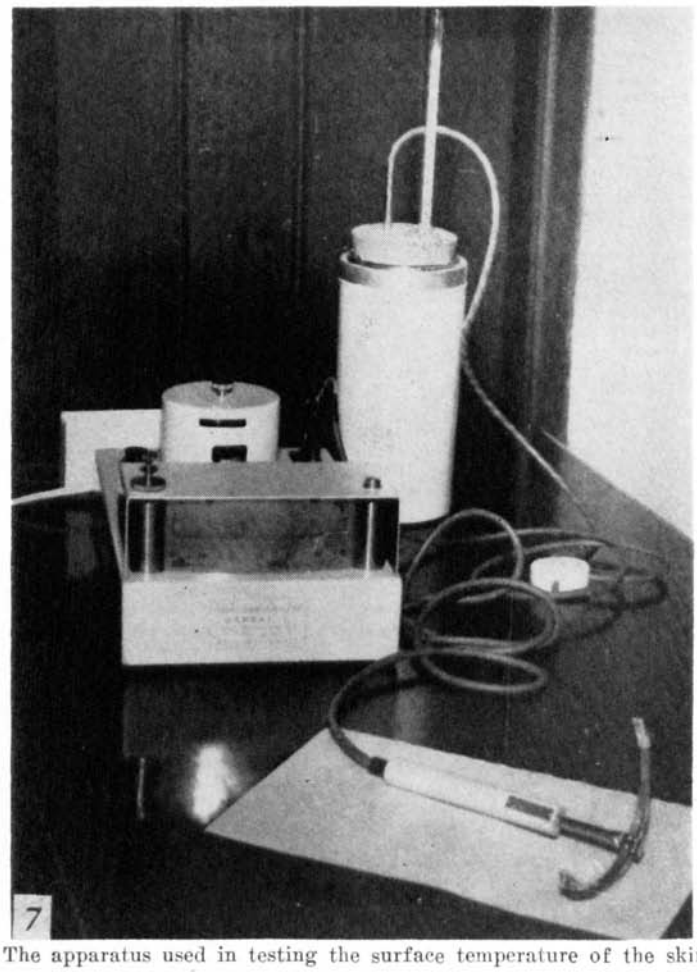


FIG. 7. The apparatus used in testing the surface temperature of the skin.

In using the instrument, the object of which the temperature is to be measured is touched by the center of the thermocouple wire mounted on the stirrup handle. The reading of the deflection of the light spot on the lower scale gives the temperature of the object touched in degrees centigrade.

General precautions.—To obtain uniform results, as far as possible, all the examinations of a particular patient were done at the same time. Before examination the patient was asked to rest, and not to rub or scratch the parts to be tested. Doors and windows were closed, and the fans were stopped to avoid draught. The patient was told to turn his head away from the parts to be tested. Exactly the same points on either side were tested, to avoid normal variations due to dissimilarity of parts. The winter months were found to be the best time for the examination, when the differences of temperature between anesthetic and nonanesthetic parts were more marked, the temperature of normal parts were not affected by sweating, and the patient and the examiner suffered no discomfort from the closing of the room and the stopping of the fans. The parts to be tested were examined carefully to make sure there was no complicating factor, such as some other skin disease or some inflammatory condition, which might influence the reading.

I. TESTS OF CORRESPONDING NORMAL PARTS

For purposes of control, the temperatures of normal parts of the body on the opposite sides were compared in 10 individuals. First the reference temperature and the room temperature were noted. After that the thermocouple was applied to the areas to be tested, one after the other, and the readings recorded. The findings are given in Table 1.

RESULTS

In a great majority of the comparisons of areas with normal sensation—48 out of 76—the readings were identical. Of the 28 comparisons in which they were different, the differences were only 0.1° in 11 instances, 0.2° in 12, and 0.3° in 3, with no local condition evident to explain them. In 2 instances the difference was 0.5°, and in both cases there was an evident abnormality on the warmer side.

In one case there was a seborrhoeic patch on one side of the face causing anidrosis and dryness, while the opposite side was cooler due to sweating. In the other case the similar variation was due to itch on the right thigh, which gave rise to irritation and an increase of skin temperature.

II. COMPARISON OF ANESTHETIC AND NONANESTHETIC PARTS BEFORE AND AFTER APPLICATION OF HEAT

In this study the temperatures of an anesthetic part and of the corresponding nonanesthetic part were first measured, under the same general conditions as in the comparison of normal parts. After that,

TABLE 1.—*Temperatures of corresponding normal parts of body, 10 subjects, in degrees centigrade.*

Part tested	G.K.	A.K.	B.S.	S.S.	N.R.	S.D.	A.K. B.	A.B.	G.M.	S.M.
Ear, right	33.2	—	34.5	33.4	33.5	34.7	33.5	35.0	36.9	36.5
Do, left	33.2	—	34.5	33.4	33.4	34.5	33.5	35.0	36.9	36.5
Cheek, right	35.0	33.5	34.5	35.0	34.2	35.0	34.5	35.9	36.6	36.0
Do, left	35.0	34.0[a]	34.5	35.0	34.2	35.0	34.4	35.9	36.6	36.1
Arm, right	33.5	32.7	34.5	35.1	33.8	34.3	34.5	35.7	36.0	36.5
Do, left	33.5	32.7	34.5	35.1	34.0	34.0	34.7	35.7	36.0	36.5
Forearm, right	—	33.5	34.6	34.0	34.7	34.3	34.5	35.3	36.2	35.8
Do, left	—	33.5	34.6	34.1	34.7	34.3	34.5	35.5	36.0	36.0
Dorsum, right	—	—	34.6	33.9	34.8	34.1	33.7	35.1	36.1	35.7
Do, left	—	—	34.6	33.9	34.5	34.1	33.7	35.1	36.1	35.7
Palm, right	—	34.5	—	—	—	34.7	35.0	35.0	—	—
Do, left	—	34.6	—	—	—	34.9	35.0	35.0	—	—
Chest, right	33.2	—	35.0	34.1	33.4	33.7	34.4	35.5	36.0	36.3
Do, left	33.2	—	35.0	34.0	33.2	33.5	34.4	35.5	36.1	36.3
Thigh, right	33.9	—	34.4	34.3	34.2	34.0	34.0	35.5	36.0	36.5[b]
Do, left	34.0	—	34.2	34.0	34.2	33.9	34.0	35.5	36.0	36.0
Leg, right	—	—	34.0	33.4	33.5	33.2	33.5	35.0	35.7	36.0
Do, left	—	—	34.0	33.2	33.4	33.1	33.5	35.0	35.9	36.0

[a] Seborrhoea
[b] Itch

the effects of the application of heat were determined, to see if either of those areas would accumulate more heat than the other.

Heating was done with a glass of hot water carefully maintained at 52°C, applied for 5 minutes, and the temperature was determined immediately thereafter. After one side had been tested, the other corresponding part was tested at once. When the test was of a palmar surface, the patient was caused to hold the glass of hot water tightly for the time stated; when it was of a dorsal area, the glass was applied firmly against the surface. When the hypothenar eminence was to be tested and there were wasting of muscle and hollowing of it, particular care was taken in determining the effect of heating that the glass containing hot water should make proper contact.

The results of these tests in 22 cases are given in Table 2. The 9 cases included in the first part of the table are from the group of illustrative cases described in the first part of this report, they being the ones available when the temperature-testing work was done. The number being small, 13 other cases with unilateral anesthesias but no his-

tory of blistering were tested similarly, to see if the results would be the same.

RESULTS

Before heating.—The results given in Table 2 show that, before the application of heat, the anesthetic parts usually have lower temperatures than the corresponding normal parts on the opposite side of the body. This is in agreement with the findings of Stein (2), and certain other authors mentioned by him, and also my own previous findings (1). Out of the 22 cases, the anesthetic area was the cooler in 19 cases. It was lower by 1.0° or more in 12 cases, and by less than that amount in the other 7. The least difference in these cases was 0.3° (2 cases), and the greatest difference was 4.7° (1 case); the average difference was 1.4°.

Contrary to the usual findings, higher temperatures were recorded in the anesthetic parts in 3 cases, and there was an evident explanation in each instance. In one case (No. 5) the difference was 1.0°, and this was due to sweating of the normal part which caused a lowering of the temperature; the anesthetic part was dry and hot due to anidrosis. In the 2 other cases (Nos. 12 and 17) the temperatures of the anesthetic parts were the higher because of inflammatory conditions, once due to sepsis after injury (0.6° difference) and once due to an injection of oil given a few days before the test was made (0.5° difference).

After heating.—After the application of heat by the method described, the anesthetic part was in every instance warmer than the corresponding nonanesthetic part. The differences in the increases of temperature of the two parts were 2.0° or more in 15 of the 22 cases. The range of differences was between 0.6° (No. 17) and 5.0° (No. 21); the average was 2.3°.

If on a graph one were to draw lines between the original temperatures before heating and those recorded after heating of the two areas compared, the two lines would obviously cross in all cases but the 3 in which the original temperature of the anesthetic areas was the greater.

DISCUSSION

Normal skin can stand a certain amount of heating without blistering. Skin can stand more heat when the temperature is raised gradually than when the same temperature is applied suddenly, because in the latter case the blood vessels do not have time to dilate sufficiently to adjust to it. In the heating experiment reported the 52°C temperature, though applied suddenly and maintained for five minutes, did not produce blisters in either the normal or the anesthetic parts.

Evidently those patients who had had blisters had exposed themselves to higher temperatures than 52°C. The significant thing is that in all cases it was the same for anesthetic and nonanesthetic parts, yet

TABLE 2.—*Comparison of temperatures of anesthetic and corresponding nonanesthetic parts, before and after heating, in degrees centigrade.*

Case No.	Area tested [a]	Temperature/heating		
		Before	After	Increase
(*a*) *Patients with history of blistering* (9)				
1. (3302)	Hypothenar, rt, Sa +	35.4	38.5	3.1
	Do, lt, Sa—	35.8	38.0	2.2
2. (3457)	Index, rt, palmar, Sa +	29.2	39.2	10.0
	Do, lt, Sa—	30.3	38.5	8.2
3. (2498)	Hypothenar, lt, Sa +	32.4	39.4	7.0
	Do, lt, Sa—	33.5	37.8	4.3
4. (3433)	Hypothenar, rt, Sa +	34.8	39.5	4.7
	Do, lt, Sa—	36.0	38.7	2.7
5. (3182)	Index, lt, dorsum, Sa +	32.2	40.0	7.8
	Do, lt, Sa—	31.2	38.0	6.8
6. (2156)	Index rt, dorsum, Sa +	29.0	34.5	5.5
	Do, lt, Sa—	30.7	34.0	3.3
7. (2109)	Ring, rt, palmar, Sa +	33.5	40.8	7.3
	Do, lt, Sa—	34.4	39.5	5.1
8. (2692)	Hypothenar, rt, Sa +	30.2	39.5	9.3
	Do, lt, Sa—	31.2	38.0	6.8
9. (3057)	Middle, rt, dorsum, Sa +	34.2	41.0	6.8
	Do, lt, Sa—	34.8	40.0	5.2

blisters appeared only on the anesthetic parts. Therefore there must be some factor in the anesthetic parts which was responsible for this difference. In the experiments reported there were two findings in the anesthetic parts which were significant. These were, (*a*) a lower temperature record—usually—before the application of heat, and (*b*) a higher temperature record—always—after the application of heat, in comparison with the temperature records of the corresponding normal parts.

The question arises why the temperature was the higher in the anesthetic parts after application of heat. Heat is transmitted or transferred to other parts by radiation, conduction and convection. Heat applied to the skin is dissipated partly by radiation through the air, partly by conduction through the solid tissues of the skin, and mainly by convection through cutaneous blood vessels. In the cases in our experiment the loss of heat by radiation from the anesthetic and the nonanesthetic parts must have been the same, the temperature of the hot water and the room temperature being constant in each instance. The conduction of heat from the heated parts to the adjoining parts of the skin was also same, the temperature of the water, time of exposure, and the tissue conducting the heat (i.e., the skin of the corresponding

TABLE 2.—*(Continued)*

(b) Patients without history of blistering (13)

10. (2716)	Hypothenar, rt, Sa +	33.7	40.0	6.3
	Do, lt, Sa—	34.3	38.0	3.7
11. (3359)	Hypothenar, lt, Sa +	33.0	39.0	6.0
	Do, rt, Sa—	34.3	37.0	2.7
12. (2260)	Middle, lt, dorsum, Sa +	35.6	43.5	7.9
	Do, rt, Sa—	35.0	41.6	6.6
13. (3031)	Hypothenar, rt, Sa +	32.0	40.6	8.6
	Do, lt, Sa—	35.0	39.5	4.5
14. (3417)	Hypothenar, rt, Sa +	29.5	40.5	11.0
	Do, lt, Sa—	30.8	39.0	8.2
15. (3021)	Hypothenar, rt, Sa +	34.7	40.5	5.8
	Do, lt, Sa—	35.2	39.0	3.8
16. (1432)	Hypothenar, lt, Sa +	31.0	39.5	8.5
	Do, rt Sa—	34.6	38.5	3.9
17. (3328)	Hypothenar, rt, Sa +	34.0	39.6	5.6
	Do, lt, Sa—	33.5	38.5	5.0
18. (1079)	Hypothenar, rt, Sa +	30.6	36.0	5.4
	Do, lt, Sa—	31.6	35.0	3.4
19. (3573)	Hypothenar, rt, Sa +	33.7	42.0	8.3
	Do, lt, Sa—	34.0	40.0	6.0
20. (2857)	Hypothenar, lt, Sa +	35.7	41.5	5.8
	Do, rt, Sa—	37.2	41.0	3.8
21. (3432)	Middle, lt, palmar, Sa +	30.0	41.0	11.0
	Do, rt, Sa—	34.7	40.7	6.0
22. (3022)	Hypothenar, rt, Sa +	36.4	40.5	4.1
	Do, lt, Sa—	36.7	39.6	2.9

[a] The words "area" and "finger" are omitted, the meaning being clear without them. Sa+ = anesthetic to light touch; Sa— = nonanesthetic.

parts of the same patient) being the same. Therefore there must be some difference between the convection of heat from the normal and the anesthetic parts. Had the convection been same after application of heat the temperature record would have been same on either side. A higher temperature record in the anesthetic parts is indicative of less convection of heat from these parts causing more accumulation of heat.

Dissipation of heat in the skin depends upon vascular dilatation, causing increased circulation of blood. Less than normal dissipation of heat from the anesthetic parts is indicative of less dilatation of the blood vessels of those parts than of those of the normal parts. This is suggestive of capillary contraction in the anesthetic parts.

That there is capillary contraction in anesthetic parts is also evident from the fact that, before the application of heat, anesthetic parts are usually somewhat cooler than the corresponding normal parts. The

lower temperature is indicative of less circulation of blood, and that—other things being normal—is due to capillary contraction.

Two factors are involved in the matter of heating. (*a*) The initial temperature of the anesthetic parts being lower than that of the normal parts before the application of heat, these parts have to adjust to a higher difference of temperature after exposure to heat. (*b*) The blood vessels of the anesthetic parts do not dilate after exposure to heat to the same extent as those of the normal parts, and consequently there is less dissipation, but rather an accumulation, of heat. These two factors may be responsible for the production of blisters, when a temperature insufficient to cause blistering of normal parts proves to be sufficient to cause blisters in the anesthetic parts.

That, it seems evident, is what happened in our patients who had had blisters. In the case of cigarette smoking, for example, the burning end gradually approaches the two fingers holding the cigarette. When one of these fingers is not anesthetic, it is self-evident that the patient will not allow the burning end to come so near to the skin as to be unbearable to that finger. Therefore the temperature which was bearable to the normal finger, due to normal dissipation of heat, caused blisters in the adjoining anesthetic finger because of less dissipation of heat. The situation was similar in the case of blistering from drinking hot tea. In the case of cooking, it was not that a particular hand or a particular finger was especially susceptible to heat or was more exposed to heat every time. But in spite of proper and equal precautions for both hands, blisters appeared on the anesthetic hand or on the anesthetic parts of the same hand, where there must have been somewhat more accumulation of heat In the case of hot compresses usually both hands come in contact with the same temperature during the process of wringing and pressing the wet cotton, but blisters appear on the anesthetic part. There must have been some accumulation of heat in this part, greater than elsewhere because the heat was not as quickly dissipated as in the normal parts. The same principle was involved, it must be concluded, in the other cases of selective blistering which have been cited. Presumably it was accumulation of the heat produced by friction due to ringing the bell with a stick which had the same effect on the anesthetic finger of the patient who blistered after that exercise.

SUMMARY AND CONCLUSIONS

1. Leprosy patients frequently get burns of their anesthetic hands, because the lack of sensation prevents them from realizing when the heat to which they are exposed is excessive and harmful. Hence they get burned unknowingly.

2. There are instances, however, in which the heat is not excessive for normal skin, but a part of one hand or one or more of the fingers are anesthetic. In that event blisters will appear only on the anesthetic

parts, and not on the adjacent or on the corresponding normal parts. In these cases, evidently, the heat is not unbearable, or so great as to cause burns of normal parts.

3. To find out why the effect of the same temperature should be so different in the anesthetic and in the nonanesthetic parts, an investigation was carried out on 22 patients during the last four years with the use of a thermocouple and light-trace galvanometer. The temperatures of the anesthetic and of the corresponding normal parts were recorded, before the application of heat (52°C for 5 minutes) and also immediately afterward.

4. Before the application of heat the anesthetic parts usually showed a lower temperature than the corresponding normal parts. This is held to be indicative of less active blood circulation in the anesthetic parts, due to contraction of the blood vessels.

5. After the application of heat the anesthetic parts always showed a higher temperature than the normal parts, indicative of less dissipation of heat. This is ascribed to insufficient dilatation of the blood vessels causing more accumulation of heat in the anesthetic parts than in the corresponding normal parts.

6. It is concluded that there are two factors in selective blistering. (*a*) The initial temperature of an anesthetic part being lower than that of the corresponding normal part, that part has to adjust to a greater difference of temperature after application of heat. (*b*) There is more accumulation of heat and more rise of temperature in an anesthetic part than in the corresponding normal part. These two factors appear to be responsible for the production of blisters in the anesthetic parts. A temperature which is just insufficient to produce blisters in a normal part may be just sufficient to produce blisters in an anesthetic part.

7. The experiment reported further confirms my previous observation that the neural signs in leprosy are closely associated with capillary contraction, causing diminution of blood supply in the skin of anesthetic parts. The study also confirms previous findings that the temperature of the anesthetic parts is lower than that of the nonanesthetic parts.

8. This study has opened up a new and fruitful line of study.

RESUMEN Y CONCLUSIONES

1. Los leprosos reciben frecuentemente quemaduras en sus manos anestesiadas, porque la falta de sensibilidad impide que se den cuenta de que el calor al que se exponen es excesivo y nocivo, y de ahí que se quemen sin saberlo.

2. Sin embargo, hay casos en que el calor no es excesivo para la piel normal, pero en que una porción de una mano o uno o más dedos están insensibilizados. En ese caso, no aparecerán ampollas más que en las

partes anestesiadas, y no en las normales adyacentes o correspondientes. En esos casos, manifiestamente, el calor no es intolerable o tan intenso que produzca quemaduras en tejidos normales.

3. A fin de descubrir por qué el efecto de la misma temperatura resultaba tan distinto en las partes anestesiadas y en las inanestesiadas, se ha llevado a cabo una investigación en 22 enfermos durante los últimos cuatro años, usando en ella una pila termoeléctrica y un galvanómetro de percepción delicada. Se registraron las temperaturas de las partes anestesiadas y de las normales correspondientes, antes de la aplicación del calor (52° C. por 5 minutos) y además inmediatamente después.

4. Antes de la aplicación del calor, las partes anestesiadas revelaron por lo general una temperatura más baja que las normales correspondientes. Se considera esto como indicativo de menor actividad de la circulación sanguínea en las partes insensibilizadas, debido a contracción de los vasos sanguíneos.

5. Después de la aplicación del calor, las partes anestesiadas revelaron siempre una temperatura más alta que las normales, indicativo esto de menos disipación del calor. Esto se atribuye a insuficiente dilatación de los vasos sanguíneos, que ocasiona más acumulación del calor en las partes anestesiadas que en las normales correspondientes.

6. Se deduce que figuran dos factores en la vesiculación selectiva: (*a*) Siendo la temperatura inicial de una parte anestesiada más baja que la de la parte normal correspondiente, dicha parte tiene que ajustarse a una diferencia mayor de temperatura después de la aplicación del calor. (*b*) Hay más acumulación del calor y más aumento de temperatura en una parte anestesiada que en la normal correspondiente. Estos dos factores parecen ser los causantes de la formación de ampollas en las partes anestesiadas. Una temperatura que es apenas insuficiente para producir ampollas en una parte normal puede resultar apenas suficiente para producir ampollas en una anestesiada.

7. El experimento descrito confirma nuevamente la observación anterior del A., en el sentido de que los signos neurales en la lepra se hallan íntimamente asociados con la contracción capilar, ocasionando disminución del riego sanguíneo en la piel de las partes anestesiadas. El estudio confirma además hallazgos anteriores, al efecto de que la temperatura de las partes anestesiadas es más baja que la de las otras.

8. Este estudio inaugura una senda nueva y fructífera de investigación.

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