STUDIES ON PRICKLY HEAT 1,2,3

II. EXPERIMENTAL AND HISTOLOGIC FINDINGS

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It is universally recognized that eruptions of prickly heat are initiated and aggravated by long-continued exposures to heat and high humidity and by the associated profuse sweating and wetting of the skin's surface. The mechanism by which the sweating contributes to the production of the dermatosis is as yet unclear. While the following studies leave many fundamental points still in doubt, it is hoped that they will help to clarify certain aspects of the pathogenesis of the disease.

CLINICAL OBSERVATIONS

In view of the fact that profuse sweating plays so important a role in the production of prickly heat, we had expected that any quantitative aberration of sweating which might exist in the affected areas would be in the direction of the appearance of excessive amounts of sweat on the surface of the skin.

We were, therefore, astonished to note the following: Two patients with well-defined, fairly large patches of prickly heat were examined immediately after they had engaged in a brief period of moderate exercise on a hot, humid day. In strong side-lighting, regularly spaced, pin-point, glistening droplets could be seen exuding from the pores of the normal skin. But in the patches occupied by prickly heat lesions no such droplets appeared. Moreover, the affected areas felt warm and dry to the touch as contrasted with the moist, cooler feeling, normal areas of skin. This was the first intimation that areas of prickly heat evidenced a reduction or absence of sweating instead of increased sweating as was previously thought to be the case.

The following studies were carried out in order to study and enlarge upon the above described findings.

PATIENTS STUDIED

On Guam, Marianas, during the month of August, 1945, we were able to select over 20 subjects suitable for study. They were all otherwise healthy white males who presented one or several relatively large, fairly sharply cir-

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circumscribed patches of typical prickly heat composed of closely set papules (fig. 1).

**MATERIALS AND METHODS**

Each subject was brought into a cool, dry room, usually an air-conditioned laboratory, and the areas of skin to be examined were dried by patting gently with a towel. Either Minor's starch-iodine reagents, or a mixture consisting of 2% powdered iodine in soluble starch, were applied to the patches of prickly heat and to the surrounding areas of normal skin. The powders were dusted on as evenly as possible so as to form a very thin and uniform coating. When the reagents were in place, the subject was taken into a room having a temperature ranging from 80°F. to 90°F. and a relative humidity of between 70% and 80%. This transfer to a hot, humid environment was generally sufficient to cause immediately the secretion and exudation of droplets of sweat. The exudation of sweat was brought into evidence by the appearance of pinpoint-sized, blue dots in a regular pattern determined by the development of the starch-iodine reaction at the orifices of the functioning sweat glands and ducts. In the few instances in which the sweat reaction was not sufficiently prompt, light exercises always brought on an immediate and clearly visible response in the normal skin.

**RESULTS OF STARCH-IODINE TESTS**

A total of more than 40 tests were carried out on the selected subjects. The results were uniform and demonstrated in unequivocal fashion that exudation of sweat was either absent or significantly reduced in the areas occupied by the lesions of prickly heat (figs. 1, 2).

The location of the patches of prickly heat seemed to be of no significance as far as inhibition of sweating was concerned. Sweating was inhibited equally in patches at different sites such as the back, neck, chest, abdomen, forearms, dorsa of hands, and thighs. The age of the lesions at the time of examination ranged from 2 to 3 days to 3 or more weeks. Sweating was inhibited regardless of the age of the lesions examined.

**DURATION OF INHIBITION OF SWEATING**

In several instances, we were able to follow the patients a while after the gross inflammatory lesions had disappeared and after the subjective disturbances had completely abated. In other words, at various times after apparent clinical healing of the process, we tested the sweat response of areas of skin previously occupied by the dermatosis. In all cases the inhibition of sweating persisted after the disappearance of active inflammatory lesions and abatement of symptoms.

Several areas examined 7 to 10 days and one area examined 30 days.

*Minor's method consists of painting the skin area with a solution containing iodine (C.P.) 1.8 grams; castor oil 10.0 cc.; and absolute alcohol q.s. Ad. 100.00 cc. After the solution has dried, the surface is dusted with soluble starch powder.*
FIG. 1. SUBJECT, H. A. D., PRESENTING PATCH OF CLOSELY-SET, TYPICAL PRICKLY-HEAT PAPULES ON LOWER BACK

This patch is a good example of the type of lesions selected for study.

All photomicrographs are at a magnification of 100 diameters.

FIG. 2. SUBJECT, H. A. D., 8 DAYS LATER, 10 MINUTES AFTER APPLICATION OF STARCH IODINE POWDER AND COMMENCEMENT OF SWEATING

Note absence of sweating as demonstrated by absence of starch-iodine reaction in area roughly conforming to the prickly heat patch in shape and location, but already significantly larger than the active patch shown in fig. 1.
Fig. 3. Focal Hyperkeratosis Obstructing Duct of Sweat-Gland
Paraductal lymphocytic inflammatory reaction.
after clinical recovery had not yet recovered their capacity to sweat. Indeed, in some instances the zone of inhibited sweating had extended and had become significantly larger than the site originally covered by visible lesions (figs. 1, 2).

HISTOLOGIC FINDINGS

Skin biopsies were made on six of the subjects; all of them were suffering from typical ordinary prickly heat and not one presented the picture of tropical anidrotic asthenia. The sites for biopsies were chosen to include areas occupied by moderately inflamed lesions as well as those with more severe inflammatory reactions. Care was exercised in each instance to obtain zones with typical lesions. The most recent lesions, i.e. the youngest, excised were said to have appeared two days before the excision; the oldest lesions excised were perhaps 10 to 20 days old when removed. The tissue was fixed in Bouin's solution and imbedded in paraffin; serial sections were cut. Hematoxylin and eosin were employed in staining.

The microscopic appearance of the lesions was remarkably uniform, there being differences only in degrees of severity of the changes. The findings were on the whole confirmatory of those described by Pollitzer in 1893 (1). At the sites of the individual papules, quite frequently there were semilunar plaques of hyperkeratosis and occasionally parakeratosis, invariably situated at the orifices of the ducts of sweat glands (fig. 3). These apparently served as lids or covers for the orifices, since the normally collapsed ducts were, when thus covered, obviously patent and often even considerably dilated. A minor variation of the keratin plaque was the whorled mass of squamous epithelial cells which had the appearance of an "epithelial pearl" and which, too, effectively occluded the orifice of the duct to the sweat-gland (figs. 4, 5). A further modification of the plaque was the acellular, stopper-shaped bit of keratin inserted into the mouth of the duct (fig. 4).

As an almost invariable concomitant of the plugged, distended ducts was a cellular inflammatory response in the cutis. The cells of the exudate were almost exclusively of the lymphocytic variety, but an occasional neutrophilic leucocyte and large monocyte were also present. The amount of exudation varied appreciably (figs. 4, 5, 6), but its location was always paraductal. The

Fig. 4. "Epithelial Pearl" in Orifice of Sweat-Gland Duct
Note inflammatory cells surrounding tubules and the edema of rete malpighi. The tubules on the left are dilated as a result of the obstruction.

Fig. 5. Same as in Fig. 2, About 40 Micra Removed

Fig. 6. Keratin Plug in Orifice of Sweat-Gland Tubule

Fig. 7. Extension of Paraductal Inflammation into Epidermis; Note Intercellular Edema

Fig. 8. Vesicle at Orifice of Sweat-Gland Duct
The lower part of the tubule is dilated as the result of blockage by inflammation in upper portion of corium and in epidermis; note distended tissue spaces and lymphatics.

Fig. 9. Duct is Intact Although Dilated
The periductal tissue spaces are distended.

Fig. 10. Cellular Exudation Is Limited to Region of Upper Half of Duct
inflammatory cells followed the course of the ducts through the epidermis, occupying intercellular positions in the epithelium (fig. 7).

The role of edema in the inflammatory process was not unimportant, for it was conspicuous not only in the tissue spaces of the corium but also in the intercellular spaces of the epithelium (fig. 8). In the former location, among the connective tissue fibers, it created wide channels which were distinguishable from dilated lymphatics. In the epidermis, the intercellular edema led to microscopic vesiculation. Careful scrutiny of the sweat-glands and their ducts in serial microscopic preparations failed to disclose any direct anatomic connections between the occluded ducts and the dilated tissue spaces and lymphatics (figs. 8, 9). The walls of the ducts were invariably intact even when adjacent lymphatic vessels were distended, thereby suggesting absorption of sweat from ducts into the lymphatics.

The condition of the tubular sweat-glands themselves elicited interest, but they were entirely unchanged in microscopic appearance. The collars of cellular exudate around the ducts ended in the upper parts of the corium, so that the lower ends of the tubes traversed the deeper portions of corium unencumbered by exudate (fig. 10). Thus, there were no inflammatory changes in and around the acini of the sweat-glands. Nor were there any secondary atrophic effects to be noted in the glandular epithelium. Other accessory structures of the skin, such as hair follicles, sebaceous glands and blood vessels were unaltered by the changes due to prickly heat.

**DISCUSSION**

The results of our clinical observations, of the iodine-starch tests and of our histologic examinations all indicate that manifest sweating is inhibited or absent in areas of skin occupied by the lesions of prickly heat. The inhibition of sweating is presumably not due to impairment or failure in the secretion of sweat, but to failure in the delivery of sweat to the skin's surface. This failure of delivery of sweat to the surface is apparently caused by the horny plugs in the sweat-gland orifices and/or by inflammatory reaction and edema constricting the terminal part of the ducts.

The inhibition or absence of sweating can persist for many weeks after the inflammatory phase and the subjective complaints of prickly heat have passed. And in some cases the zone of inhibited sweating continues to enlarge and extend well beyond the sites formerly occupied by grossly visible lesions.

The possible importance of these findings in relation to the pathogenesis of tropical anidrotic asthenia is obvious. Should a sufficient number of available sweat-pores become occluded as the result of extensive eruptions of prickly heat, this would, in our opinion, suffice to produce the manifestations of the syndrome known as tropical anidrotic asthenia (2, 3, 4). In other words, now that relatively persistent absence or reduction of sweating has been shown to occur regularly in areas occupied by ordinary prickly heat, it seems reasonable to hold the idea that tropical anidrotic asthenia is simply an end stage of the process which causes severe, extensive or generalized eruptions of prickly heat.
This opinion is supported by the fact that in our patients with ordinary prickly heat and without systemic signs of anidrotic asthenia, the histologic changes were fundamentally the same as those described in tropical anidrosis by previous authors (2, 3, 4).

As the inhibition of sweating, the plugging of the pores and the inflammation around the terminal ducts were present in all cases examined, we are inclined to regard such changes as an integral part of the disease process. However, our studies to date do not permit a decision as to how critical and fundamental a role these changes may play in the chain of causation. It is conceivable that profuse and continued sweating followed by maceration, swelling of the horny layer (see also Pollitzer (1)) and/or irritation of the pores and ducts by substances derived from sweat may lead to the horny occlusions and periductal inflammation and thus initiate the entire disease process. Should this be the case, prickly heat could be regarded in a certain sense as analogous to ordinary acne, the former taking place in the sudoriferous apparatus and the latter in the sebaceous structures. For it is now generally accepted that in acne the horny plugs in the openings of follicles, plus stasis of sebum and irritation of the sebaceous ducts, are the fundamentals of the pathologic process. In this connection, it may be noteworthy that in many persons severe eruptions of acne are brought on or aggravated by precisely the same environmental factors which bring on and aggravate eruptions of prickly heat (5).

Our findings do not help explain the great variations in individual and local susceptibility to prickly heat, the erratic course and the apparently spontaneous onsets, remissions and healings. However, if our hypothesis is correct, the factors predisposing to prickly heat should be sought among the conditions which are known to affect the formation and swelling of the horny substance of the skin, as well as among those which tend to make sweat become concentrated and irritating. The logical general approaches to prevention and treatment of prickly heat would then include systemic and local measures designed to:

1. Inhibit excessive sweating
2. Promote evaporation and drying
3. Prevent and counteract maceration
4. Diminish swelling of keratin
5. Obviate faulty keratinization
6. Prevent formation of horny plugs
7. Remove horny plugs once formed
8. Reduce the concentration of irritating agents in the sweat
9. Allay the periductal inflammation

SUMMARY AND CONCLUSIONS

1. Clinical observations and starch-iodine sweat tests were made on a series of subjects presenting well defined patches of typical prickly heat.

2. The results showed that, instead of sweating more than do normal areas of skin, the patches of prickly heat regularly exhibited a marked reduction or absence of sweating.
3. Histologic examinations of affected areas revealed horny plugs in the ori-
fices of sweat-ducts, edema around the ducts in the epidermis and upper cutis, 
and periductal cellular infiltration. The acini of sweat-glands were morphologi-
cally unaltered.

4. Reduction or absence of sweating in areas of skin occupied by prickly heat 
was shown to be capable of persisting for at least several weeks after clinical 
evidences of inflammation and subjective symptoms had subsided; and in some 
instances the areas of skin involved became larger during this time.

5. The hypothesis is advanced that continuous profuse sweating leads to 
maceration of the skin’s surface, faulty keratinization, occlusion of the sweat-
pores by horny plugs, and irritation of the tissues by substances derived from 
concentrated or retained sweat in the orifices and superficial ducts, the causal 
chain of events in prickly heat.

6. Attention is called to the similarities between this process in the sudorif-
erous apparatus and that process in the sebaceous structures which is today 
recognized as causing acne.

7. As our cases of typical patchy prickly heat were regularly associated with 
persistent and often enlarging areas of diminished or absent sweating, it appears 
possible that the syndrome described as tropical anidrotic asthenia may be an 
ultimate stage in widespread or generalized eruptions of ordinary prickly heat. 
The similarity between the histologic picture seen in our cases of ordinary 
prickly heat and that described in cases of tropical anidrotic asthenia support 
this concept.

8. General suggestions for prophylactic and therapeutic approaches to prickly 
heat, which are in accord with our hypothesis of the causation of the disease, 
are given.

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