THE PATTERN OF SENSORY LOSS IN LEPROSY AND ITS SIGNIFICANCE IN THE PATHOGENESIS OF LEPROTIC NEURITIS

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The pathogenesis of the neuritis of leprosy occupied the attention of workers at the turn of the century and has recently again come into the foreground as a result of the work of Khanolkar in the early changes in the nerve terminals resulting from the leprosy bacilli.[9] Although in general it may be said that the theory of Gerlach and Dehio[4] has found the most wide acceptance of all the theories, there yet remains some doubt in the minds of observers that it is not the whole picture.

The possibility of the lesion being in the spinal cord as suggested by Danielssen and others, has been denied by Woit.[11] The degenerative changes in the cord being regarded as secondary by Woit and subsequent workers. The discovery of bacilli in lesions which were previously considered negative (by standard methods of investigation) brought discredit to the theory that the neuritis of leprosy was centrifugal, or that the patch in leprosy was the remote effect of a proximal nerve lesion at the " site of predilection " as occurs in herpes (Virchow and others quoted by Dharmendra).[5]

In brief the theory of Dehio and Gerlach states that the primary involvement of the nerve fibre occurs at the periphery in the skin patch. The sensory nerves which supply this patch become invaded by bacilli and are surrounded and subsequently destroyed by the cellular infiltration which is the host's response to the presence of the bacilli. This inflammatory reaction ascends up the nerve fibres involving in its course a greater and greater number of nerve fibres until finally, when the sensory nerve joins the motor nerve, there is destruction of the whole mixed nerve trunk, resulting in the paralyses which are commonly seen.

In the material available to us in the orthopaedic unit we have attempted to study the absolute pattern of sensory involvement and also to correlate this with the pattern of motor paralysis.

Material

A total of 186 charts of patients who had attended the orthopaedic research department were examined. This covered a period of five years, from 1951 to 1955. The pattern of sensory loss had been a routine investigation for the upper extremity in each case. This pattern was drawn into a printed outline of the hand and forearm. Two modalities were noted: pain, as tested for by a pin or a bit of wire; and light touch, as tested for by a feather or a nylon thread. The sensory tests had been done by two observers, and the method was feather and pin in the earlier cases and nylon thread and wire (blunt pin) in the later cases.

In order to determine the error to these methods two observers assessed the same case using the two different methods for the touch and pain tests. The diagram Fig. 1 represents the result of this test. It will be seen that the pattern is the same but the measurements are different. This indicates that there is quite a margin of error but that the general pattern is comparable.

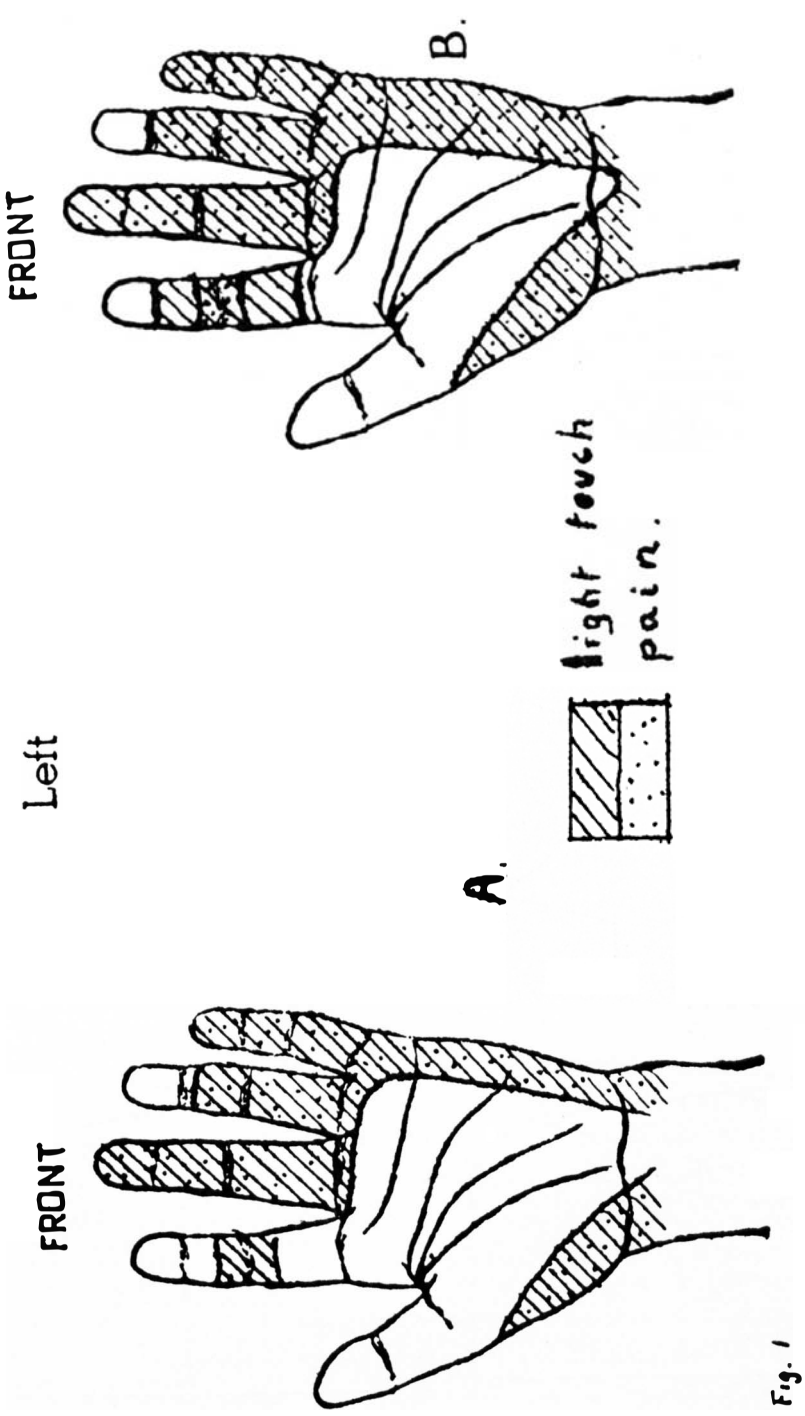
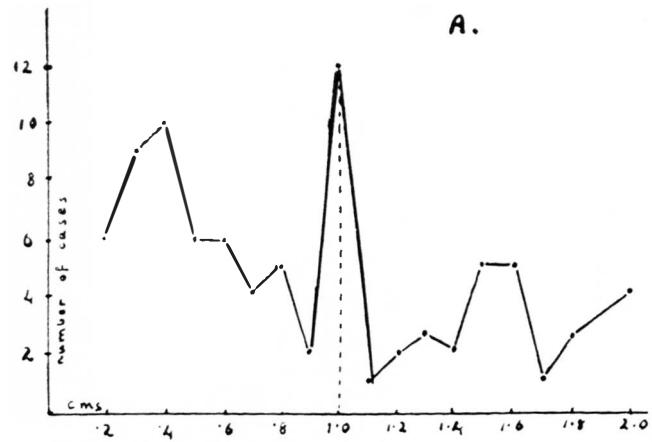


Fig. 1

Fig. 2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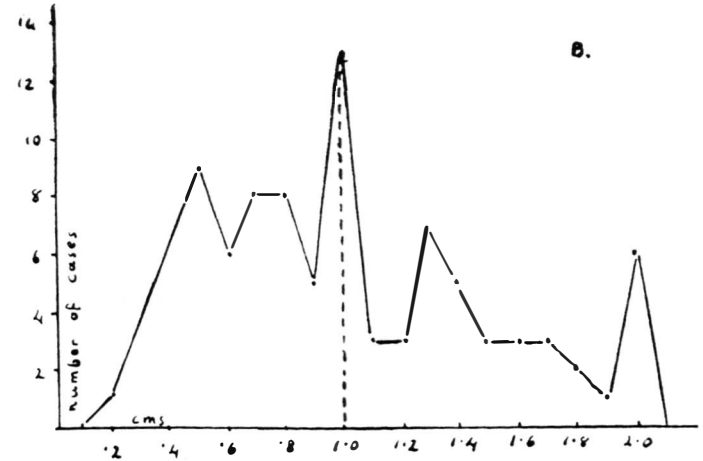
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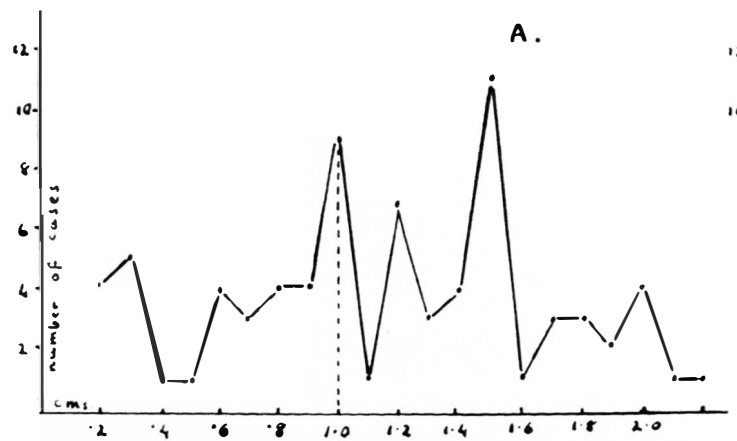
Fig. 3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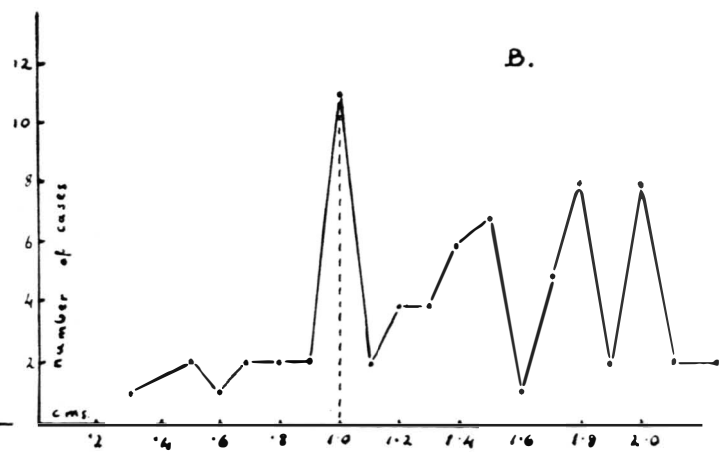
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FIG. 1. *Two sensory assessments of the same hand, done by different methods and two different assessors.*
(a) Assessment by M.A.F. using a feather and a sharp pin.
(b) Assessment by E.P.F. using a nylon thread and bent pin.

A total number of 304 hand charts were examined with a view to determining the percentage of incomplete sensory involvement (Table I). All the hands examined did not necessarily have a motor lesion, since in some cases only one hand had a motor lesion and both hands had a sensory deficit. In these cases the unparalysed hand was also included in these figures.

TABLE I

	Total	Complete Anaesthesia	Incomplete Anaesthesia	
Palmar aspect ...	304	181	123	(59.5%)
Dorsal aspect ...	304	191	113	(63.1%)

The percentage of incompletely anaesthetic hands (light touch).

The extent of involvement in the incompletely anaesthetic cases was now examined. The distance of the edge of the anaesthetic area from the ulnar border was measured on the diagram, this measurement was noted, and the results plotted as a graph with the distance across the palm plotted against the the number of cases. The results for the two modalities of light touch and pain (pin prick) are given in Fig. 2. It will be seen from the figures that in the majority of the incomplete cases the anaesthetic margin fell within the 1 cm. category (Table II) and that there was a marked peak at the 1 cm. distance. This distance on the diagram represents roughly the anatomical edge of the ulnar supplied skin area. None of the cases showed anaesthesia involving only the radial border of the hand, and in a few cases (due to the presence of a tuberculoid lesion on the hand) the anaesthesia was irregular and corresponded only to the area covered by the lesion.

On the dorsal surface the picture is less significant and no such clear cut peak could be demonstrated (Fig. 3). The number of cases falling within the ulnar border was considerably less than the number of cases beyond this (Table II).

FIG. 2. (*a*) *Pain* (*pin prick*); (*b*) *light touch.*
Graph showing the extent of the anaesthesia across the palmar surface of the hand from the ulnar border.

FIG. 3. (*a*) *Pain* (*pin prick*); (*b*) *light touch.*
Graph showing the extent of the anaesthesia across the dorsal surface of the hand from the ulnar border.

TABLE II

	Modality	Incomplete Anaesthesia	Within 1 cm.	Beyond 1 cm.
Palm ...	Touch	86	50	36
	Pain	85	60	25
Dorsum ...	Touch	71	21	50
	Pain	73	35	38

Table showing the number of cases in which the anaesthesia was limited to the ulnar area as compared with the number where it extended beyond.

Relationship between motor and sensory paralysis

A study of the pattern of sensory loss as compared with the pattern of motor loss was made (Tables III and IV). It is seen that in the majority of cases the anaesthesia corresponds to the motor loss but this is not uniformly the case. Thus, 10 cases out of 96 cases of ulnar motor paralysis still had some areas of sensation in the ulnar supplied area. And in 121 cases of ulnar and median paralysis there were 6 who had sensation in the ulnar area and 19 in the median area. This would seem to indicate that it is not necessary for the sensory component of the nerve to be completely destroyed before the motor component is affected.

TABLE III

Motor Lesion	No.	Complete hand anaesthesia	Incomplete anaesthesia
No motor lesion ...	25	0 (0%)	25
Ulnar	96	40 (42%)	56
Ulnar Median ...	121	97 (80%)	24
Ulnar Median Radial	2	2 (100%)	0

Table showing the percentage of cases in the different categories of motor involvement who show complete anaesthesia.

TABLE IV

Motor Lesion	No.	Sensation still present in part or whole of Ulnar area	Median area	Radial area
Ulnar	96	10	58	44
Ulnar Median ...	121	6	19	12
Ulnar Median Radial	2	0	0	0

Table showing the areas which are incompletely anaesthetic in the three motor nerve lesions.

The difference in the behaviour of the nerves in the two main sub-divisions of leprosy led to a study of the paralysis in these two sub-divisions. Table V gives the classifications of the 186 cases composing the series.

TABLE V

Leproma	57
Indeterminate	64
Tuberculoid	19
Dimorphous	15
Maculoanaesthestic	7
Unclassified	24
	186

Classification of the cases composing the series. The relatively large number of cases unclassified is due to the rapid turnover in the orthopaedic wards. Some of the patients were discharged before the chief leprologist had seen them.

Dividing these cases into the two categories Leproma and Non-Leproma, the charts were again examined and the result noted in Table VI.

TABLE VI

Class	No. of Hands	Complete Anaesthesia	Incomplete Anaesthesia	Areas showing incomplete involvement Ulnar	Median	Radial
Lepromas	99	67 (67%)	32 (32%)	11	33	23
Non ,,	145	72 (50%)	73 (50%)	5	44	33

Among lepromas there is seen to be a slightly greater tendency for the anaesthesia to involve the whole hand. In the non-lepromatous cases the proportion is almost exactly equal.

Discussion

In Figures 2 and 3 and Table II we see that in cases which show incomplete sensory involvement of the hand the largest number show a sensory deficit corresponding to the ulnar sensory area. This area is always involved at least in part, and, except in the case of a tuberculoid lesion which involves the hand, there were no cases seen where the anaesthesia involved areas of the hand other than the ulnar and left this latter area with sensation. This finding in itself indicates that the ulnar nerve is for some reason peculiarly susceptible to paralysis. In its motor component, too, this nerve is with very rare exceptions the first to be involved. This susceptibility of the ulnar nerve is familiar to everybody. Its site of predilection is, as was pointed out by the very earliest workers, just above the medial epicondyle of the humerus. The next most susceptible nerve appears to be the sensory terminals of the radial, although this is not often completely involved. In its motor component, however, the radial is the least commonly involved. The median nerve stands next to the ulnar in frequency of motor involvement, and is very often the last to be completely destroyed in its sensory component.

Thus, in the ulnar nerve the motor and sensory components are equally liable to damage. In the median nerve the motor component is more susceptible, and in the radial nerve the sensory elements are by far the most susceptible. There is, however, no provision in the hypothesis of Gerlach and Dehio to account for these irregularities. Why should the bacilli preferentially select for their entry into the nerve terminals, those of the ulnar nerve? Why is it that a lesion of the median nerve without involvement of the ulnar nerve is such a rarity? Why is a motor lesion of the radial nerve without involvement of the ulnar and median nerves never seen? Even in the cases of a single nerve trunk, the infiltration is not continuous but intermittent, leaving untouched the more deeply situated parts of the nerve. The sensory terminals may be the first affected, but the involvement of the motor branches is not in the ascending order of their joining the main trunk of the nerve but occurs as a whole, and very often is accompanied by obvious clinical signs at the site of predilection.

In their original papers Dehio and Gerlach point out that the parts of the ulnar nerve which lie deep in the forearm and hand are not infiltrated, whereas those parts which lie superficially above

the elbow and on the dorsum of the hand are heavily infiltrated. They fail to point out, however, that the anaesthesia is not due to the perineural infiltration of the terminal fibres, but to the proximal involvement of the nerve trunk at the site of predilection. Our anaylsis has demonstrated a regularity of pattern of anaesthesia and a conformity to nerve trunk distribution in most cases that could not be due to terminal infiltration. Moreover, it is well known that all affected skin shows the typical perineural accumulation of round cells, even where there is no clinically demonstrable sensory deficit in the area from which the biopsy has been taken.

Why, then, should certain portions of the nerve be relatively immune to involvement? In the case of the median nerve the site of predilection is the part of the nerve just proximal to the flexor retinaculum. Where the nerve lies under cover of the retinaculum it again assumes a relatively normal appearance, only to become involved again in its terminal cutaneous and muscular branches. Why does the radial nerve enjoy a relative immunity to affection —except in its terminal cutaneous branches, where it curves around the radius? Examining these commonly affected sites and the relatively immune sites we see that the nerves in these areas have some factors in common, viz:—

(a) They are superficially situated and not covered by layers of muscle. At operation it is so often seen that the nerve begins to assume a normal size and appearance at the point where it becomes covered by a layer of muscle fibres.

(b) They are in relation to bone or fascia: the ulnar nerve just proximal to the ulnar groove under the medial epicondyle of the humerus; the median nerve proximal to the anterior surface of the carpals; the radial nerve (terminal sensory elements) just as it winds around the lower end of the radius. And when this nerve is affected totally the lesion is in the part of the nerve which is in relation to the lateral intermuscular septum in the upper arm. (In this position the nerve is more deeply situated than the corresponding sites of predilection of the ulnar and median nerves. Does this factor account for the infrequency of its involvement?)

Regarding factor (a) Brand[1] has pointed out that the more superficial tissues of the body are at a lower temperature; the nerves

lying in the subcutaneous fat are at a lower temperature than nerves lying under a layer of muscle; the nerves of the extremities are at a lower temperature than the ones in the trunk; and the nerve terminals in the skin will have the lowest temperature of them all. It is an established fact that certain varieties of mycobacterium require a lower temperature for optimum growth. Thus *M. ulcerans* isolated from an indolent ulcer on human skin will not grow at 37° C. but when first isolated only grows at 33° C.[7] Even though, in modern times, leprosy is commoner in the tropics, the clinical manifestations of the disease are usually more severe in the colder climates.[3]

Regarding factor (b) the proximity to bone and fascia, especially when these lie near the surface, obviously renders the nerve more liable to minor trauma. Moreover, these structures are also relatively avascular and therefore likely to be at a lower temperature than highly vascular structures such as muscle. It is to be noted that Cochrane[3a] states that in the Mongolian or European, alopecia following leprotic infitration of the scalp affects the entire scalp with the exception of the areas in immediate relation to the superficial temporal artery or the occipital artery. Is the factor in this case also the temperature, which will, of course, be higher in the immediate vicinity of the artery?

It must be accepted that the bacilli probably find their way into the system via the peripheral nerve terminals,[9] that there the damage they do is great, that the bacilli then " migrate " either up the axon filaments,[9, 8] or along the lymphatics accompanying the nerve or along the vasa nerorum.[6] These bacilli can, however, only do damage in those parts of the nerve where conditions are favourable.

Summary

1. A study of 304 hand charts was made and the pattern of sensory loss examined in each case.
2. Of the incomplete cases the commonest pattern was ulnar loss. And the area which retained sensation most commonly was the middle of the median area. This suggests that the anaesthesia is not due to peripheral nerve fibre destruction but to the proximal nerve trunk lesion at the site of predilection.

3. These findings were related to the motor paralysis of the same hand. Thus, in the ulnar nerve motor and sensory involvement is commonest; in the median nerve motor involvement is slightly more common than sensory involvement; in the radial nerve motor involvement is rare, sensory involvement is common.

4. The possibility of the temperature of the nerve fibre being a factor in determining the site of predilection of the nerve is discussed.

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