

## Temperatures Along the Course of Certain Nerves Often Affected in Lepromatous Leprosy<sup>1, 2</sup>

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From antiquity, leprosy has been known to affect the skin, the superficial nerves, upper respiratory tract, anterior third of the eyes and testes. In 1959, Brand (1) observed the distribution of the most profoundly affected neural tissues and suggested that these structurally and functionally diverse tissues do have a common feature, i.e., all are several degrees below core body temperature. Certain studies since that time have added substance to this notion. Shepard (10) demonstrated that the growth rate of human leprosy bacilli within the mouse foot pad is highly temperature dependent. The best growth of bacilli was achieved by keeping the mice in air-conditioned rooms where their foot pad temperature would range between 27° C and 30° C. Hastings *et al* (7) correlated the number of bacilli in skin biopsies with the surface temperatures of the sites of biopsy. There was a definite link between decreased temperature and increased number of bacilli. These authors suggested that surface temperature would explain the distribution of certain areas consistently spared of obvious skin lesions in lepromatous leprosy. Sabin (9) has shown a correlation between detailed maps of sensory loss in leprosy and thermographic pictures of body surfaces of normal subjects. The cooler areas of the body show the earliest sensory loss. Only a small percentage of the sensory loss in leprosy is due to involvement of the mixed nerve trunks: the more extensive sensory loss results from direct destruction of intracutaneous nerve endings and networks. This body of evidence clearly implicates tis-

sue temperature as an explanation of the distribution of macroscopic lesions and neural deficits in lepromatous leprosy.

The role of tissue temperature in high resistance (tuberculoid) forms of leprosy is less clear. Lepromatous leprosy is likely to be the most perfect temperature-dependent system for two reasons. First, in high resistance forms of leprosy nerve deficits are already apt to exist by the time the patient is first seen by a physician and it is likely that nerve dysfunction is attendant to the vigorous tissue response to the presence of even very few bacilli. In lepromatous leprosy where the tissue response to the presence of bacilli is histologically much less intense and neural deficits come on later, the manifestations of the disease are more related to bacillary proliferation (excluding damage resulting from lepra reactions). This factor explains the observation that most of the atypical nerve deficits occur in cases with features of the high resistance types of leprosy (e.g., total facial nerve palsies, brachial plexus lesions and the triple paralysis of the arm where there is proximal ulnar, median and radial nerve palsies) since in high resistance cases fewer bacilli are capable of initiating neural dysfunction, whereas in uncomplicated lepromatous cases, nerve involvement is more stereotyped as to both the sites and temporal appearance of nerve trunk deficits. Second, low resistance forms of leprosy (lepromatous) are associated with a bacteremia in the untreated state (4). This results in distribution of the bacilli throughout body tissues. However, we feel that as one moves toward the tuberculoid side of the spectrum contiguous spread of bacilli within the tissues assumes increasing importance while bacteremia becomes less significant. This feature accounts for the relatively symmetrical, widespread involvement seen in lepromatous leprosy which contrasts with the asymmetrical, localized types of involvement seen in higher resistance cases.

In this study an attempt was made to see if the temperature of certain nerve beds correlated with the distribution of nerve en-

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largement and the sequence of appearance of nerve deficits in progressive lepromatous disease.

### MATERIALS AND METHODS

Microthermistors mounted in the tips of 1.5 inch #22 gauge hypodermic needles provided a direct readoff of temperature from the tip of the needles. These needles were inserted into normal volunteers at selected sites along the courses of the median, ulnar and peroneal nerves. When the subject experienced paresthesias clearly within the distribution of the nerve under study, the temperature reading was taken to be that of a nerve bed. Needle insertion depth was also measured. Points were selected and numbered as follows.

The peroneal nerve was studied at three points: 1) behind the head of the fibula, 2) one third of the distance between the head of the fibula and the lateral malleolus, and 3) at the intermalleolar line. The ulnar nerve was examined at four locations: 1) 10 cm proximal to the medial epicondyle of the humerus, 2) the proximal end of the cubital groove, 3) one third of the distance between the medial epicondyle and the pisiform bone, and 4) proximal to the wrist crease at the medial border of the flexor carpi ulnaris tendon. The median nerve was evaluated at two points: 1) 15 cm proximal to the flexor crease of the wrist, and 2) 3.5 cm proximal to the flexor crease. These sites were chosen because they included segments of each nerve which are consistently affected in lepromatous leprosy as well as loci which tend to be spared (?). The significance of temperature differences among the sites was determined by the one-tailed t-test. Studies were done in an air-conditioned room with temperatures ranging from 22-24° C.

### RESULTS

**Peroneal nerve.** Figure 1 shows the average temperatures in the various sites on the peroneal nerve. The average temperature at the head of the fibula was 33.8° C, with an average depth of 13 mm. In the anterior leg compartment the temperature was 36.0° C, with an average depth of 25 mm. At the ankle the temperature was 32.6° C, at a depth of 9 mm. The differences in temperature between these sites are statistically significant ( $P < .005$ ).

### Peroneal Nerve Temperatures

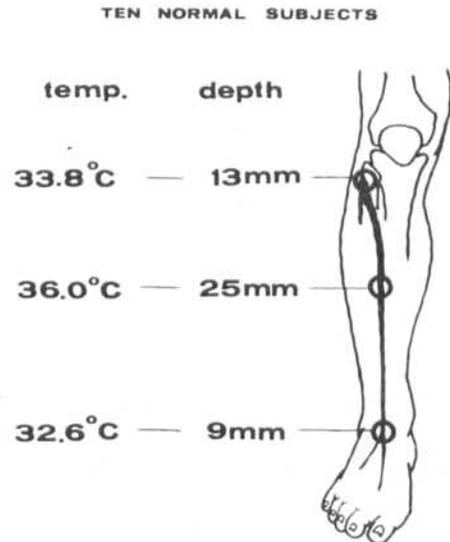


FIG. 1. Nerve bed temperatures of peroneal nerve with average depth of nerve at sites tested.

### Ulnar Nerve Temperature

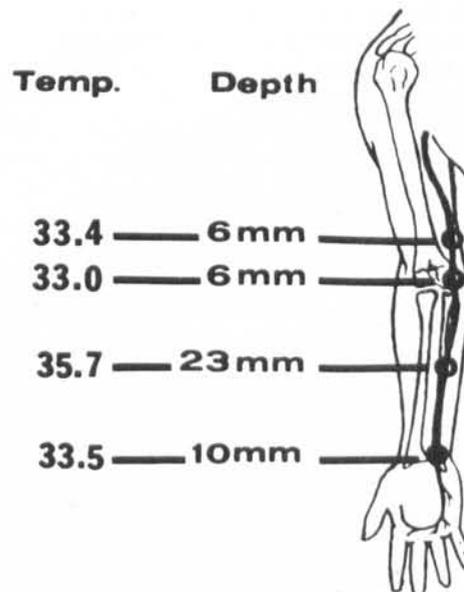


FIG. 2. Nerve bed temperatures of ulnar nerve with average depth of nerve at sites tested.

**Ulnar nerve.** The findings in the ulnar nerve are shown in Figure 2. The temperature at the upper arm site was 33.4° C, at an average depth of 6 mm. In the ulnar groove the figures were 33.0° C, and 6 mm respectively. In the forearm the temperature was 35.7° C, 23 mm under the skin. At the wrist readings of 33.5° C and 10 mm were obtained.

The forearm temperature is statistically significant from the other areas sampled ( $P < .05$ ). However, the remaining areas statistically do not separate from each other.

### Median Nerve Temperature

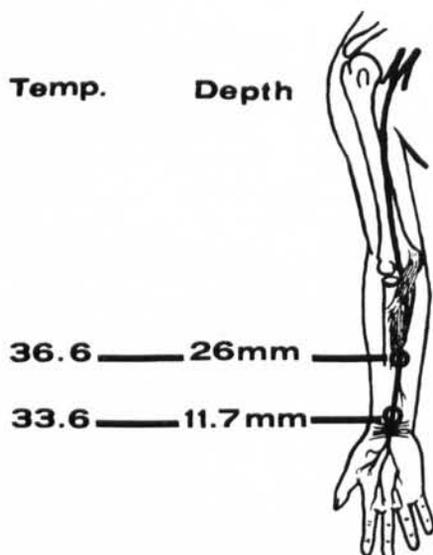


FIG. 3. Nerve bed temperatures of median nerve with average depth of nerve at sites tested.

**Median nerve.** There is a striking difference in the temperature of the forearm segment of the median nerve from the wrist segment as seen in Figure 3 ( $P < .005$ ). The temperature was 36.5° C and 33.5° C, respectively, with average depths of 20.4 mm and 9.4 mm.

### DISCUSSION

These findings are consistent with the idea that the pattern of peripheral nerve involvement of lepromatous leprosy is related to the optimal growth of the Hansen's bacillus occurring in tissues several degrees below core body temperature.

Involvement of the distal motor portion of the peroneal nerve has not been commonly described because the resulting disability is so minor. Wasting of the extensor digitorum brevis is noted in patients with lepromatous disease who have either no paralysis or only early weakness in the distribution of the ulnar nerve. It is often impossible to detect activity of the extensor digitorum brevis when peroneal nerve conduction velocities are attempted (6). Early involvement of the distal branch to the extensor digitorum brevis would explain both of these observations and is consistent with the finding of relatively low temperatures in this area.

Clinically and pathologically the most prominent involvement of the ulnar nerve is the segment of 10 to 12 cm above the ulnar groove (8). The temperatures in Figure 2 are quite consistent with the temporal evolution of nerve involvement that is observed clinically. Analysis of segmental conduction velocities in leprosy patients also coincides with this data (5).



FIG. 4. Median nerve of patient with leprosy exposed at surgery. Arrow points to line of demarcation between swollen, inflamed nerve and normal nerve. The overlying muscle protects the normal nerve from inflammation due to the higher temperature.

Figure 4 shows a median nerve exposed at surgery with a clear line of demarcation between the relatively normal appearing nerve and grossly diseased nerve. The swollen, inflamed median nerve submerges beneath the "warm" overlying muscle bellies and assumes a normal appearance. A striking difference in temperature between the proximal and distal sites is evident (Fig. 3) at midarm and at the wrist.

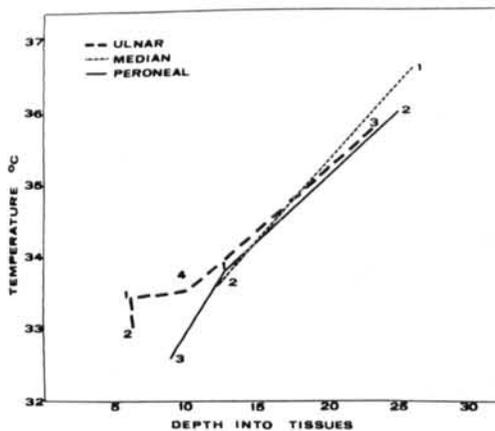


FIG. 5. Graph comparing nerve bed temperatures of all three nerves with the depth in the tissues. Site 2 on the ulnar line and site 3 on the peroneal are the coolest sites and become clinically involved in lepromatous leprosy earlier than any other sites.

The plotting of the temperatures of these nerves fits rather well with clinical observations of the progression of the nerve involvement in lepromatous leprosy. Thus, an ulnar nerve deficit above the cubital groove would be the earliest defect (point 2, Fig. 5); at the same time one might see involvement of the branch of the peroneal to extensor digitorum brevis (point 3, Fig. 5). One would then expect to see either a low median nerve deficit (point 2, Fig. 5), a high peroneal nerve deficit (point 1, Fig. 5), or an ulnar lesion at the wrist (point 4, Fig. 5). We have not seen a case of pure lepromatous leprosy at Carville where a median nerve deficit was present without having an already well-established ulnar nerve deficit.

There is a well-established relationship between temperature and nerve conduction velocity. A  $2 \pm .2$  meter per second decrease in nerve conduction velocity occurs with each

decrease of one degree centigrade of the nerve (3). A difference in conduction velocity of eight meters per second along the course of nerves could be explained by variations in temperature alone when segmental nerve conduction velocities are undertaken. The studies of Hackett *et al* (5) show this variation in normal control subjects.

The possible influence of fat distribution (which may vary with sex), race and climatic temperatures on the occurrence of paralysis in lepromatous leprosy has not yet been studied.

### SUMMARY

Temperatures along the course of the peroneal, ulnar and median nerves were obtained by placing micro-thermistors in the nerve beds of normal subjects. Significantly lowered temperatures were found in certain locations along the nerve which correlate with the loci and sequence of nerve involvement in lepromatous leprosy.

### RESUMEN

Se obtuvieron las temperaturas a lo largo del trayecto de los nervios peroneal, cubital y mediano, colocando microtermistores en los lechos nerviosos de sujetos normales. En ciertas localizaciones a lo largo del nervio se encontraron temperaturas significativamente disminuidas, que se correlacionan con las zonas y secuencia de compromiso nervioso en la lepra lepromatosa.

### RÉSUMÉ

Au moyen de micro-thermistors placés dans les fibres nerveuses de sujets normaux, on a relevé les températures le long des nerfs péroniers, cubital et médians. En certains sites le long de ces nerfs, on a observé des températures significativement plus basses, qui étaient associées à la localisation et à l'évolution de l'atteinte nerveuse dans la lèpre lepromateuse.

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