Volume 39, Number 4
Printed in the U.S.A.

The Relationship Between Surface Temperature and Dermal Invasion in Lepromatous Leprosy[1, 2]

Stephen A. Anish[3]

In the study of lepromatous leprosy one finds convincing evidence that a heavier dermal infiltrate occurs in cooler areas of the body than in regions closer to core body temperature (5, 4, 3, 1, 6, 8, 7, 2, 11). This factor has made the course of untreated disease easier to understand and to some extent, predictable. Hastings *et al* (9) reported that even regional temperature differences noted in the cooler lateral back versus the warmer midline influenced bacterial invasion. Warmer areas, such as the scalp, groin, and anus, have been labeled "immune" because they fail to demonstrate clinical involvement in the Negro, Caucasian and Spanish populations. The purpose of this study was to determine if such "immune" areas are indeed involved though perhaps to a lesser extent than cooler areas.

MATERIALS AND METHODS

Twelve patients with active lepromatous leprosy, diagnosed by clinical and histologic examination at the Carville U.S. Public Health Service Hospital, were selected. Each patient sat quietly in a room for 30 minutes at 20° C. Measurements of surface temperature were taken with a surface contact battery operated probe having a contact area of 0.5 sq. mm and read in degrees centigrade. Biopsies were obtained by using a 4 mm punch and operating it perpendicularly to the skin extending well into subcutaneous fat. Samples of either hairy scalp and mid-dorsal forearm, or axilla and forearm, were obtained from each patient. Each specimen was fixed in formalin and submitted to the same pathologist. They were read for (a) thickness in millimeters, (b) Morphological Index (MI) (13, 14), or the percentage of bacilli which stained uniformly on routine acid-fast staining, and (c) Bacterial Index (BI) in terms of the Ridley logarithmic scale (10). The percent dermis involved with lepromatous infiltrate represents the area of infiltrate over the entire cross-sectional area of one slide multiplied by one hundred. This was read by the author. From these data a biopsy index was calulated as a product of the percent dermis involved and the Bacterial Index. Results were analyzed for significance by means of the paired data t-test where

$$\text{t-test where } t = \frac{\bar{d}}{\frac{s}{d}}$$

Hypotheses were tested at the 5% level of confidence ($p = 0.05$).

DISCUSSION

The scalp and axilla were chosen because of their uniformly warmer temperature, freedom from traumatic injury, ease of accessibility and lack of clinical involvement. The forearm was selected in comparison because of the uniformly cooler temperature, freedom from traumatic injury, ease of accessibility and frequent clinical involvement.

Biopsies were taken from the same areas as those of temperature evaluation. Skin biopsies revealed similar thicknesses of dermis. Therefore, the biopsy index (10) is proportional to the actual number of *M. leprae* organisms present in each area.

The major differences occurred in temperature readings from the scalp (35.9°C) and axilla (35.5°C) as compared to the forearm (34.7°C). These differences were significant with a p value of 0.05. The biopsy index of hairy scalp was 0.17, and axilla was 0.09, both being significantly

1 Received for publication May 12, 1971.

2 Read before the U.S. Public Health Service Clinical Society-Commissioned Officers' Association Joint Meeting, April 5-8, 1971.

3 Stephen A. Anish, M.D., Surgeon USPHS, U.S. Public Health Service Hospital, Carville, Louisiana 70721.

TABLE 1. *Results of skin biopsy and skin temperature*

Pt. no.	Skin thickness	Skin temp.	M.I.	B.I.	% dermis involved	Biopsy Index (% x B.I.)
		Hairy scalp				
1	3.30 mm	35.6°C	0	2	5%	0.10
2	3.98	36.2	1	1	0	0.00
3	3.86	35.6	10	3	8	0.24
4	3.86	37.3	1	2	7	0.14
5	4.00	35.2	0	1	3	0.03
6	4.00	36.6	0	3	2	0.06
7	4.51	37.6	35	3	20	0.60
MEAN	3.93 mm	35.9°C	7.2	2.1	3.6%	0.17
		Axilla				
8	4.71 mm	37.0°C	0	0	3%	0.00
9	3.78	37.1	0	0	0	0.00
10	3.72	34.0	50	6	5	0.30
11	3.98	35.1	0	0	0	0.00
12	2.15	34.3	20	3	5	0.15
MEAN	3.6 mm	35.5°C	14	1.8	1.3%	0.09
		Forearm				
1	3.29 mm	34.1°C	0	1	15%	0.15
2	5.55	35.4	5	4	11	0.44
3	4.00	37.3	2	6	20	1.20
4	4.10	34.7	10	6	25	1.50
5	4.72	32.2	5	6	60	3.60
6	4.72	35.4	1	3	30	0.90
7	4.10	35.0	1	4	15	0.60
8	3.00	35.8	1	1	22	0.22
9	3.98	34.0	0	3	20	0.60
10	3.29	35.8	0	1	16	0.16
11	4.00	33.3	0	4	5	0.20
12	3.00	33.4	0	3	5	0.15
MEAN	3.98 mm	34.7%	2.3	3.5	20%	0.81

smaller than the forearm biopsy index of 0.81. Again the p value was 0.05. Thus these warmer areas had significantly fewer bacilli than the cooler forearm. These areas were, however, invaded by the organism, and the term "immune areas" is technically incorrect.

These data are supported by the work of Shepard ([12]), who correlated rapid bacterial growth with a foot pad temperature of 27-30°C. Slow multiplication occurred at 35° and 36° C.

The foregoing upholds the concept that environmental temperature has influence on the growth of *M. leprae*. This is certainly not the sole factor limiting growth, but in this disease it seems to be rather critical.

SUMMARY

Twelve patients with clinical and histological lepromatous leprosy were studied by evaluating skin biopsies and temperatures of the scalp, axilla, and dorsal forearm. The

TABLE 2. *Summary of t-test statistics for temperature and biopsy index.*

Area and Mean	VERSUS	Area and mean	t-Ratio	Significance of t-Ratio
Hairy scalp Temperature 35.9°C		Forearm Temperature 34.7°C	3.17	p = 0.05
Hairy scalp Biopsy Index 0.17		Forearm Biopsy Index 0.81	2.02	p = 0.05
Axilla Biopsy Index 0.09		Forearm Biopsy Index 0.81	2.07	p = 0.05

scalp and axilla were significantly warmer and had significantly less bacilli than the cooler forearm. The concept of "immune areas" is thus incorrect. These factors support the hypothesis that skin temperature differences contribute to the pattern of involvement in lepromatous leprosy.

RESUMEN

Se estudiaron doce pacientes con lepra lepromatosa clínica e histológica, por medio de la evaluación de biopsias de piel y la temperatura del cuero cabelludo, la axila y el dorso del antebrazo. El cuero cabelludo y la axila estaban significativamente más calientes y tenían significativamente menor cantidad de bacilos que el antebrazo, mfis frío. Por lo tanto, el conecpto de "áreas immunes" es incorrecto. Esots factores apoyan la hipótesis que las diferencias de temperatura de la piel contribuyen al patrón de compromiso en la lepra lepromatosa.

RÉSUMÉ

Chez 12 malades atteints de lèpre lépromateuse avec confirmation clinique et histologique on a procédé à une évaluation des biopsies cutanées et à des mesures de température au niveau du cuir chevelu, du creux axillaire et de la face dorsale de l'avant-bras. Le cuir chevelu et le creux axillaire présentaient des températures significativement plus élevées, et livraient significativement moins de bacilles que l'avant-bras, qui par ailleurs était moins chaud. Le concept de "Zones immunes" est dès lors incorrect. Ces observations sont en faveur de l'hypothèse qui veut que des différences dans la température cutanée contribuent à la distribution de l'atteinte lésionelle dans la lèpre lépromateuse.

Acknowledgements. The author is indebted to Mr. Fredric E. Stockwell, who performed the statistical analysis of the data.

REFERENCES

1. ANTIA, N. H., DIVEKAR, S. C. and DASTUR, D. K. The facial nerve in leprosy. I. Clinical and operative aspects. Internat. J. Leprosy **34** (1966) 103-117.
2. BAZETT, H. C. and MCGLONE, B. Temperature gradients in tissues in man. American J. Physiol. **82** (1927) 415.
3. BINFORD, C. H. Comprehensive program for inoculation of human leprosy into laboratory animals. Publ. Hlth. Rep. **71** (1956) 995-996.
4. BRAND, P. W. Temperature variation in leprosy deformity. Internat. J. Leprosy **27** (1959) 1-7.
5. BRAND, P. W. Deformity in leprosy: Orthopedic principles and practice methods of relief. *In:* Leprosy in Theory and Practice. R. G. Cochrane and T. F. Davey, Eds. Bristol, John Wright & Sons, Ltd.; Baltimore, Williams and Wilkins Co., 2nd ed. (1964) 451.
6. CHOYCE, D. P. The eyes in leprosy. *In:* Leprosy in Theory and Practice. R. G. Cochrane and T. FF. Davey, Eds. Bristol, John Wright & Sons, Ltd.; Baltimore, Williams and Wilkins Co., 2nd ed. (1964) 315.
7. DOULL, J. A. (Revised by Guinto, R. S. and Binford, C. H.) Leprosy. Veterans Administration Medical Bulletin MB-10, May 25, 1965, p. 14-15.
8. FRITSCHI, E. P. The pattern of sensory loss in leprosy and its significance in the pathogenesis of leprotic neuritis. Leprosy Rev. **27** (1958) 45-52.

9. HASTINGS, R. C., *et al* Bacterial density in the skin in lepromatous leprosy as related to temperature. Leprosy Rev. **39** (1968) 71-74.
10. RIDLEY, D. S. Therapeutic trials in leprosy using serial biopsies. Leprosy Rev. **29** (1958) 45-52.
11. SHEPARD, C. C. Stability of *M. leprae* and temperature optimum for growth. Internat. J. Leprosy **33** (3 Part III) (1965) 541-550.
12. SHEPARD, C. C. Temperature optimum of *M. leprae* in mice. J. Bacteriol. **90** (1965) 1271-1275.
13. WATERS, M. F. R. and REES, R. J. W. Changes in the morphology of *M. leprae* in patients under treatment. Internat. J. Leprosy **30** (1962) 266-277.
14. WATERS, M. F. R., REES, R. J. W. and SUTHERLAND, I. Chemotherapeutic trials in leprosy. V.A. study of methods used in clinical trials in lepromatous leprosy. Internat. J. Leprosy **35** (1967) 311-335.