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Circulation and sensation at the fingertips of claw hands

N. C. ABBOT*¶, J. SWANSON BECK*†,
B. BHASKAR RAO‡, F. FEVAL‡,
J. L. STANFORD§, F. WEISS‡, M. H. MOBAYEN‡
**Department of Pathology, University of Dundee, Dundee, Scotland DD1 9SY; †International Medical College, Kuala Lumpur, Malaysia; ‡Baba Baghi Leprosy Hospital, Tabriz, Iran; §University College London Medical School, London W1P 7LD*

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Summary Measurements of skin blood flow (by laser Doppler flowmetry) and temperature were made under environmental conditions promoting peripheral vasodilatation at the fingertips of a disfigured 'clawed' hand in 12 leprosy patients long-resident at Baba Baghi Leprosy Hospital, Tabriz, Iran. Sensory function was assessed by measuring the responses to light touch, pain and temperature of each finger, and peripheral autonomic function was gauged by estimating palmer sweating and by measuring skin vasomotor reflexes in response to inspiratory gasp.

In 2 patients all measured fingers had laser Dopper flux (LDFlux) values and skin temperatures lower than the 95% confidence limits for the mean of 20 healthy controls, i.e. were impaired; in 2 patients all fingers had normal values for LDFlux and temperature; and in 8 patients there was a combination of impairment with most fingers normal for these parameters but with the small finger most commonly impaired. There were 10 (67%) fingers with impaired LDFlux and temperature values who had significant sensory impairment, whereas only 5 (18%) of the fingers with normal LDFlux values and temperatures had a similar sensory deficit. Overall, the fingers with the most impaired sensation had significantly ($P < 0{\cdot}05$) lower LDFlux and temperature values than those with no sensory deficit. Microcirculatory impairment was not related to disordered skin vasometer reflexes or dysfunction of sweating.

We concluded that the relationship between motor (skeletal muscle) nerve paralysis and any subsequent sensory neuropathy and/or microcirculatory impairment is more complex than might be expected from previous understanding of the disease.

¶Correspondence: Institute of Physiology, The University, Glasgow G12 8QQ, Scotland, UK.

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Introduction

The effect of *Mycobacterium leprae* infection on blood flow to the extremities has not been intensively investigated up to now, although several studies employing radiological arteriographic techniques have reported impairment of flow in the terminal vascular loops of the fingers[1] or tapering and tortuosity of the digital arteries of the hands.[2,3]

Recently noninvasive estimates of blood perfusion through the fingertip skin have been obtained in Indian leprosy patients.[4] These studies showed that measurements of blood flow by laser Doppler flowmetry (LDFlux) were lower than those found in normal subjects. Further studies in Indian patients with a variety of orthopaedic complications of the lower limb resulting from long-standing leprosy, but with undisfigured hands, have shown that these patients' fingers were comparatively cold and had low blood flows despite conditions conducive to peripheral vasodilatation:[5,6] this abnormality was most prominent in the multibacillary patients but it was also found in some people with paucibacillary disease. Since severe hand deformity results from damage to the mixed sensory and motor peripheral nerve trunks, and becomes established permanently if prompt ameliorative physiotherapy is not provided, it was expected that LDFlux would be impaired at least to the same extent, and possibly to an even greater one, in long-term patients with claw hands, thus reflecting the dominant role of autonomic control over blood flow through the peripheral microcirculation.

This short report describes the measurement of fingertip blood flow, skin temperature and sensation in a small group of leprosy patients with characteristic claw hand. The findings show that the relationship between functional neuropathy and microcirculatory deficit is more complicated than was expected from previous understanding of the disease.

Table 1. Clinical details for the 12 leprosy patients, and the results of fingertip temperature, LDFlux and sweat function for the claw hand of each

Patient number	Hand: right (R) left (L)	Years at leprosy hospital	Age (years)	Type (multi/ paucibacillary)	Leprosy finger* impaired for temp (T) or flux (F) or both				Impairment of sweat (S) function
					index	middle	ring	small	
1	R	32	47	P	TF	TF	TF	TF	†
2	L	32	44	M	T	TF	TF	TF	S
3	R	32	51	M	TF	TF	†	TF	†
4	R	19	57	M			F	F	
5	R	17	25	P			TF	TF	
6	R	31	60	P				TF	S
7	L	21	31	M				TF	
8	L	35	65	P				F	S
9	L	35	52	M				TF	S
10	R	29	48	P				TF	S
11	L	26	43	M					†
12	R	28	47	P					S

* All fingers were tested: a blank space is left where no abnormality was found.
† Indicates that the investigated parameter could not be reliably obtained in this subject.

Methods

SUBJECTS

We selected 12 patient volunteers from the long-term residents of Baba Baghi Leprosy Hospital, Tabriz, Iran on the basis of severe disfigurement of at least 1 hand. Table 1 presents the age, length of residence and clinical classification of the disease (paucibacillary or multibacillary) in these patients. Disfigurement was defined as severe flexion of the fingers at both the distal and proximal interphalangeal joints. The ulnar nerves were involved most prominently in these patients but all exhibited median involvement to a greater or lesser extent. All 12 hands studied were functionally very disabled and none of the fingers had a normal range of movement. None of the hands were swollen or callused to visible inspection but thenar and hypothenar wasting was prominent in subjects 2 and 8.

We chose 20 people, mean age 31·5 (range 16–70) as controls: 10 were the offspring of treated leprosy patient who, as adults, continued to live and work within the large hospital compound; the other 10 were apparently healthy members of the hospital staff.

MEASUREMENT OF BLOOD FLOW AND VASOMOTOR REFLEXES

A laser Doppler flowmeter (model PF2, Perimed, Stockholm, Sweden) was used to measure the blood flow through the skin over the pulp of the distal phalanx in the manner and with settings described previously.[4,6] The laser Doppler flowmeter measures movement of erythrocytes in the most superficial 1 mm of skin from changes in the frequency of coherent light reflected out of the tissue and gives an integrated measurement of microvascular blood flow (LDFlux) expressed in Volts.[7]

This method also permits assessment of vasomotor reflex responses at the fingerpulp, determined from the fall in LDFlux signal following a physiological challenge such as a deep inspiratory gasp (IG).[4] Figure 1(a) shows the kind of trace obtained from a healthy subject: LDFlux is high and the IG response is large. Figure 1(b), from a leprosy patient, shows a reduced LDFlux signal and IG response. In this study a reflex response was attempted on each fingerpulp of the hand under investigation.

MEASUREMENT OF FINGERTIP SKIN TEMPERATURE

A platinum skin thermistor attached to an LCD output device was used to measure skin surface temperature in the manner described previously.[6] The probe (Model 4098, 9 mm diameter, Yellow Springs Instrument Co Inc, Yellow Springs, Ohio, USA) was held in close contact with the skin on the pulp of the distal phalanx close to the fingertip with a single strip of Millipore adhesive tape.

SENSORY TESTING

Sensation in the upper limb was examined for integrity of light-touch sensation with cottonwool, for sharp tough/pain by pin-prick and for temperature sensation using a

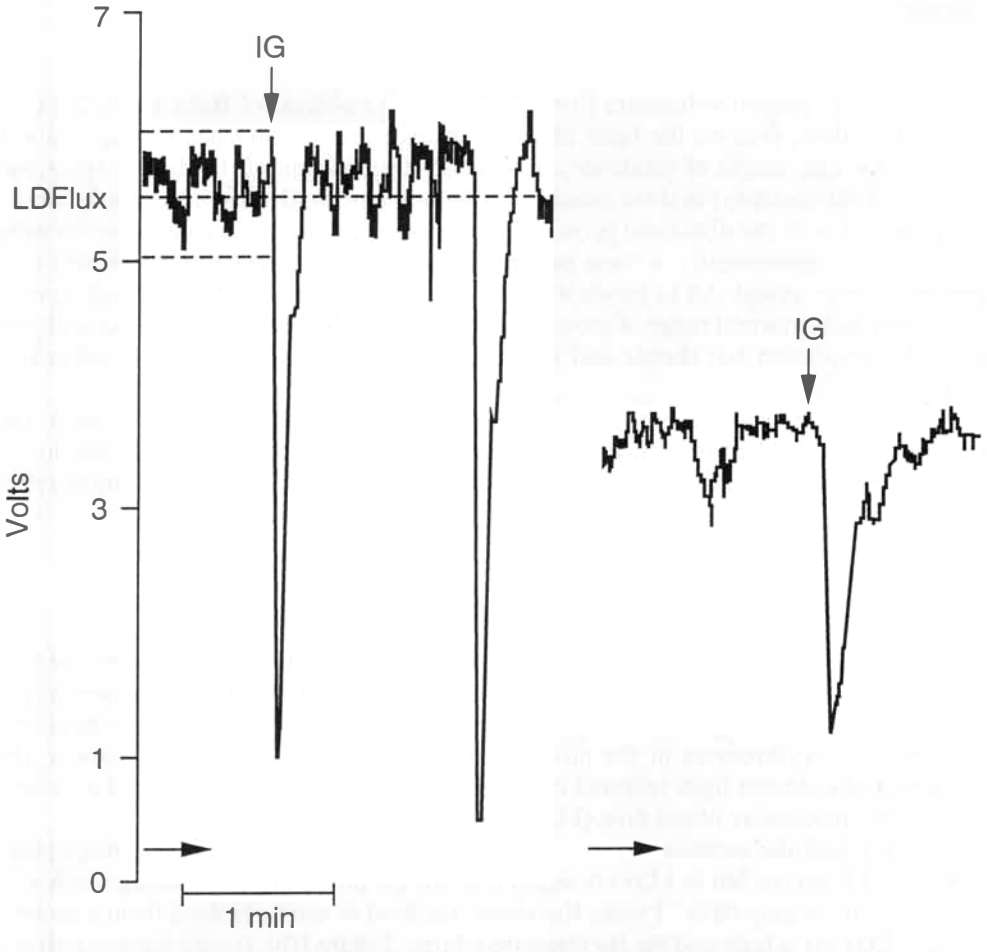

Figure 1. Typical LDFlux traces from (a) a healthy person, and (b) a leprosy patient. Under conditions of near-maximal vasodilatation the signal is pulsatile though stable around a mean value: this value is termed the LDFlux and can be recorded for analysis. Here, the leprosy patient has a reduced LDFlux and vasomotor reflex response to inspiratory gasp.

thermal sensibility tester.[8] We tested 3 sites on the palmer aspect of each finger, namely, at the fingerpulp and the middle and proximal phalanges. The results of all sensory tests on each finger were recorded on a 3-point scale: 1, absent or consistently mistaken; 2, partial sensation, i.e. variation from area to area on the volar aspect of the finger; and 3, unimpaired sensation (a positive result at all 3 sites on 1 finger). For convenience of analysis the final summary of results on each subject was the mean score (out of 3) combining the results for the 3 types of sensation tested.

In addition sweat function was crudely assessed from the subject's own report and was also confirmed by the experimenter from the appearance and texture of the skin of the relevant hand. Dry, hard and cracked hands reported by the subject as having swearing dysfunction were classed as impaired.

EXPERIMENTAL PROTOCOL

Each subject was seated comfortably with the forearm and hand resting on a table at heart level at an ambient temperature of 25–29°C, maintained by a large paraffin stove. These conditions would be expected to induce near maximal peripheral vasodilatation and a stable blood flow through the fingertips in healthy subjects.[9] Each subject was allowed to equilibrate under these conditions for at leas 20 min before measurements were started. All 4 fingers were studied on the hand under investigation. Skin temperature was recorded and then laser Doppler measurements of blood flow and vasomotor reflexes were made. At the end of the experiment, which lasted at least 1 h, the LDFlux measurements were repeated to check for any effects of warming over a longer period. On a separate occasion sensation was tested in the order of light touch, pin-prick, and finally, temperature discrimination.

STATISTICAL ANALYSIS

Differences between categories of patients were assessed using 2-way ANOVA taking intraindividual differences between fingers into account. The relationship between LDFlux and skin temperature was assessed by linear regression analysis.

Results

NORMAL SUBJECTS

Figure 2 illustrates the local fingertip skin temperature and corresponding LDFlux value for all 8 fingers (L2–L5, R2–R5) in the 20 normal subjects. The relationship between these 2 measurements was significant ($r = 0{\cdot}28$, $P < 0{\cdot}001$). The lower and upper 95% confidence limits[10] for the mean values of these subjects were 3·1–10·0 Volts, respectively, for LDFlux (mean 6·6), 31·0–35·0°, respectively, for skin temperature (mean 33·1)°C and 43–100%, respectively, for vasomotor gasp reflex (mean 77%). Figure 2 also shows that there were no significant differences in LDFlux and temperature between the index, middle, ring or little fingers in these healthy subjects. All had unimpaired sensory function and were without evidence of any disorder of palmar sweating function.

LEPROSY PATIENTS

Table 1 presents the distribution of impairment to fingertip temperature and LDFlux on the deformed (claw) hand of each of the 12 subjects. Impairment was defined as LDFlux, skin temperature and vasomotor reflex measurements of less than 3·1 Volts, 31·0°C and 43%, respectively (the lower limits for the 95% confidence limits for the healthy controls above). Patients Nos 11 and 12 had normal values, and Nos 1 and 3 had abnormal values for each parameter on all measured fingers. The remaining 8 patients had a combination of impaired and unimpaired fingers, the small finger being most commonly affected. On patient No. 3 the ring finger was clamped to the palm, so the volar aspect was inaccessible.

Abnormalities of sweating function were clearly visible in 6 of the patients; in 3 others

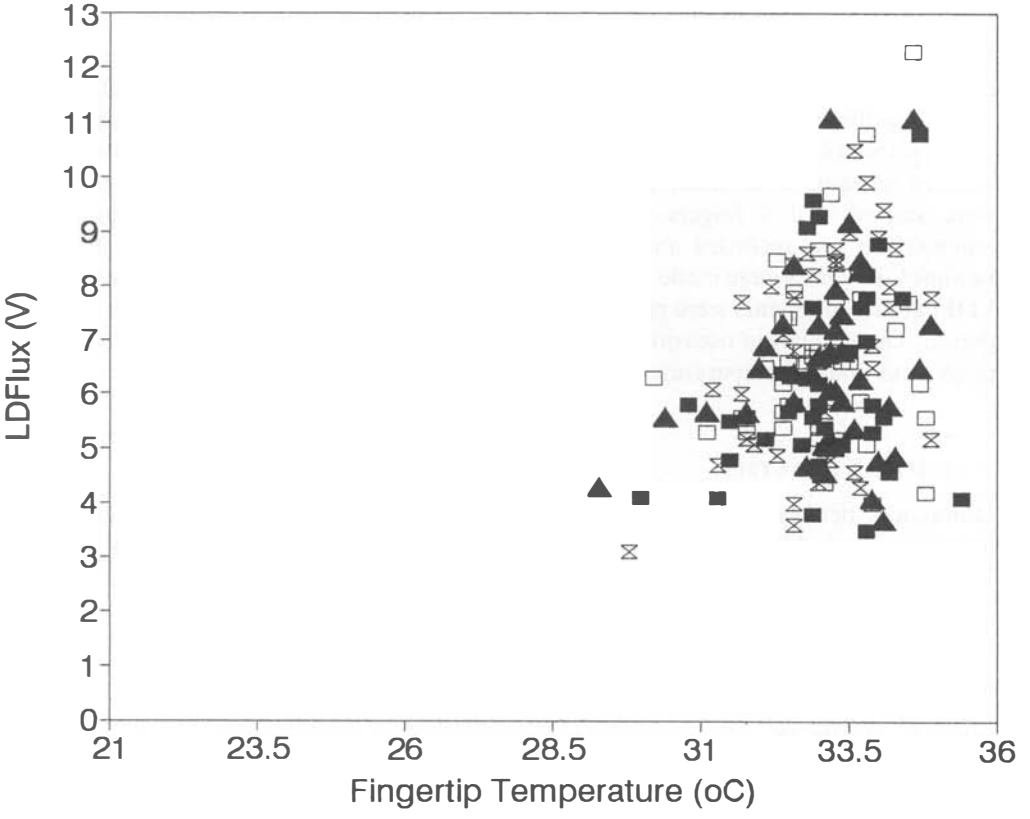

Figure 2. The temperature and LDFlux measured on 8 fingertip of 20 healthy subjects. There were no significant differences in the measured values between the index (■), middle (□), ring (▲) or small (⧖) fingers in this control group.

(Nos 1, 3 and 11) disorder of sweating could not be confidently confirmed by visual and tactile inspection.

Vasomotor reflexes were impaired or absent in all fingers studied in 7 patients; 2 patients (Nos 8 and 12) had normal grasp reflex responses in only 1 finger; and only patient No. 11 had a normal grasp response on 3 fingers. In patients Nos 1 and 3 the LDFlux measurements at the fingers were too low for assessment of vasomotor grasp reflex responses.[4]

There was no significant difference in temperature, LDFlux or sensation between the fingers of patients with multibacillary or paucibacillary types of lepsory. Figure 3 shows the significant relationship ($r = 0{\cdot}81$, $P < 0{\cdot}00001$) between temperature and corresponding LDFlux in the patient group. Of the 47 fingers studied 27 had both temperature and LDFlux values within the normal range and 15 fingers were impaired for both parameters. In addition it can be seen from this scattergram that those fingers with a low mean score for sensation (0–1·5) tend towards low LDFlux and low temperatures. Low sensory scores were seen in 10/15 (67%) fingers with impaired LDFlux and temperature but in only 5/28 (18%) fingers which had normal LDFlux and temperature. Overall, there was a significant difference ($P < 0{\cdot}05$) between those fingers

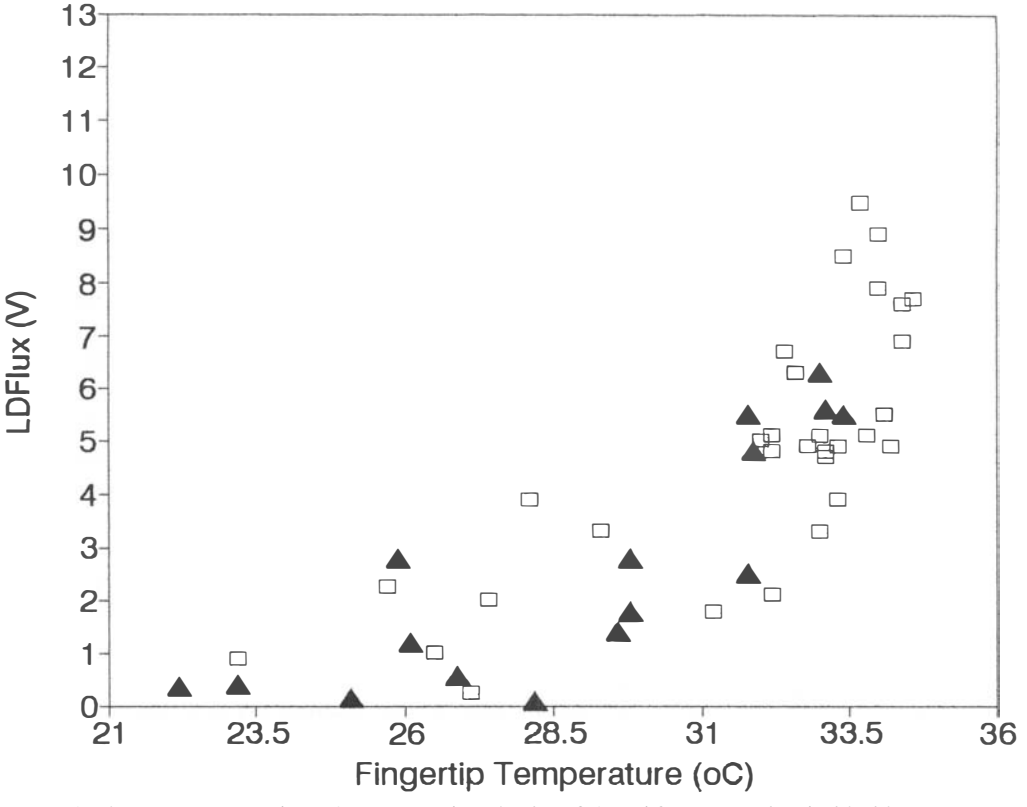

Figure 3. The temperature and LDFlux measured on the tips of clawed fingers associated with either poor (▲) or good (□) sensory function in 12 leprosy patients.

with a low mean score for sensation (0–1·5) and those with a high mean score (1·6–3) as regards fingertip temperature (28·9 *vs* 31·8°C, respectively) and LDFlux (2·61 *vs* 4·82 V).

Discussion

The typical claw hand deformity of leprosy results from peripheral neuropathy producing paralysis of the intrinsic muscles of the hand. In paucibacillary patients the most likely immediate cause is the inflammatory process within the nerve trunks during a reversal reaction but slower paralysis may result from the gradual development of intraneural granulomata causing pressure and ischaemia within the perineurium.[11] Similar deformity in multibacillary patients results from damage to nerve trunks by bacillary multiplication within them, sometimes complicated by erythema nodosum leprosum. The distribution of the paralysis in these patients indicates that damage has occurred at both the median and ulnar mixed nerve trunks where it is possible that the smaller sensory fibres and the nonmyelinated autonomic fibres are also affected. The recent evidence that the combination of orthopaedic complication and sensory deficit can be associated with impaired digital circulation in some long-term patients with both

multibacillary and paucibacillary disease[6] makes it feasible that patients with claw hands could also have a disorder of fingertip microcirculatory control.

The hands of the present 12 subjects have had ulnar and medial nerve paresis of long standing, but most have retained both the capacity for relatively normal blood flow in most fingers under warm environmental conditions and a relatively unimpaired digital sensation. While some autonomic deficit in the form of vasomotor reflex impairment or crude estimate of sweating dysfunction was seen in all patients, low flows/low temperatures tended to occur in fingers exhibiting paresis in association with sensory deficit, confirming previous studies.[6]

The pathogenesis of these mixed nerve lesions is not clear. The subjects we have studied have all been treated with full courses of multidrug therapy and it is possible that, following initial damage to all fibre types, selective regeneration of the small sensory fibres could have occurred. This would have restored sensory and/or autonomic function without restoration of motor functions which are dependent on intact larger fibres. The duration of the motor denervation was probably prolonged in these patients. Absence of innervation for more than 3 years leads to irreversible changes in contractile tissue with no possible return of functional activity even when nerve fibres have returned to the grossly atrophic and fibrotic muscle.[12]

Wide-ranging and patchy nerve lesions can be produced by focal leprosy granulomata or bacillary infiltration due to the complicated pattern of intraneural fascicle branching[13] or by the spread of existing lesions in the manner postulated in the Dehio concept[11] with migration of organisms from a skin patch to the nerve branches coursing beneath the patch.[14] An alternative explanation for our findings is that large myelinated fibres are more susceptible than the smaller fibres to damage at the site of such lesions. There is good evidence that motor fibres are less resistent to the effects of compression than sensory fibres:[15] an example is the 'Saturday-night' paralysis in which muscle function is lost while sensation is spared or only transiently affected.[16] In the leprosy patient without the benefits of prompt ameliorative physiotherapy muscle paralysis could become established without impairment of sensory or sympathetic function.

Whatever the explanation, the cases reported in this short report provide evidence that a claw hand, though cosmetically ugly and functionally very inadequate, may be spared the gross microcirculatory and sensory impairment found in some undisfigured hands.

Acknowledgments

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