Thermographic analysis and autonomic response in the hands of patients with leprosy*

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Abstract: Background: Low temperatures and slow blood flow may result from peripheral neuropathy caused by leprosy, and the simple detection of cold fingers could already be a preliminary classification for these patients. Objective: To investigate whether infrared thermography would be able to measure this change in temperature in the hands of people with leprosy.
Method: The study assessed 17 leprosy patients who were under treatment at the National Reference Center for Sanitary Dermatology and Leprosy, Uberlândia/MG, and 15 people without leprosy for the control group. The infrared camera FLIR A325 and Therma CAM Researcher Professional 2.9 software were used to measure the temperature. The room was air-conditioned, maintaining the temperature at 25°C; the distance between the camera and the limb was 70 cm. The vasomotor reflex of patients was tested by a cold stress on the palm.
Results: The study showed a significant interaction between the clinical form of leprosy and temperature, where the control group and the borderline-borderline form revealed a higher initial temperature, while borderline-lepromatous and lepromatous leprosy showed a lower temperature. Regarding vasomotor reflex, lepromatous leprosy patients were unable to recover the initial temperature after cold stress, while those with the borderline-tuberculoid form not only recovered but exceeded the initial temperature.
Conclusion: Thermography proved a potential tool to assist in the early detection of neuropathies, helping in the prevention of major nerve damage and the installation of deformities and disabilities that are characteristic of leprosy.
Keywords: Hand; Leprosy; Physical therapy modalities; Skin temperature; Thermography

INTRODUCTION

Leprosy in Brazil is still considered a public health problem. According to the World Health Organization, Brazil is the second country with the highest number of leprosy cases in the world.[1] And according to DataSUS data, in 2012, 33,741 new cases of leprosy were diagnosed in Brazil.[2] Of these, 1,486 were diagnosed in the state of Minas Gerais, being the majority male (886) and of multibacillary type (1,036).

According to the Ministry of Health, leprosy is an infectious-transmissible disease, with slow evolution, manifested by dermatological and neurological signs and symptoms.[3] It is caused by *Mycobacterium leprae*, which has skin and nerve cells affinity.

Clinical manifestation of leprosy depends on the individual's immune response to the bacillus. Thus, there is, on one hand, the tuberculoid pole, with high resistance to the bacillus and clinical manifestations related to exacerbation of the cellular immune response, as well as well-defined granuloma, bacilli destruction and skin lesions limitation. In this clinical form, the neural commitment is asymmetrical, unilateral and nerves are intensely thickened.[4-8]

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On the other hand, we have the lepromatous (Virchowian) pole, with low resistance to the bacillus, cellular immune response deficiency and humoral immune response activation, as well as multiple and diffuse skin lesions, rich in bacilli, and with strong power of spread of disease.[5,7,8] Lack of resistance allows the blood and lymphatic spread of bacilli, causing infiltrations in mucosa and viscera, and later, diffuse and asymmetrical neural impairment.[4]

Between these two poles there is the borderline forms (borderline tuberculoid - BT, borderline borderline – BB, and borderline lepromatous - BL), which have variable resistance to M. leprae, presenting characteristics of both poles.[5,7,8] It is an unstable form in which neural involvement is intense, early and multiple, and the reactions are more frequent, creating a high disabling potential.[4]

There is strong histopathologic and arteriography evidence that leprosy can cause changes in blood vessels of the limbs, and these changes can lead to deterioration of the vessels, such as narrowing, tortuosity and vascular thickening.[9-12]

These vascular abnormalities reduce the blood flow to the distal parts of the limbs, leading to ischemia and, together with the lymphocytic infiltration in the muscle, are the probable causes of deformities and ulcerations in leprosy.[10,11]

According to Wahi et al, these vascular changes are more severe in leprosy patients that present deformities observed in the fingers, but these vascular changes can also be detected in patients without clinical evidence of arterial disease or remarkable physical deformity.[12] Johnson et al also claim that these vascular changes precede the clinical manifestation, being important in the evaluation of disease progression and deformities prevention. [11]

Wilder-Smith, Wilder-Smith and Egger pointed out that subclinical dysfunction of autonomic nerves may be a manifestation of infection by M. leprae, and that, possibly, the measurement of these disorders would allow detection of leprosy before clinical disease progression.[13]

According to the study by Jiang et al, in many diseases there are blood flow changes, and this changes affect the temperature of the skin (skin would act as a blackbody that radiate and absorb infrared energy. This radiation is independent of color and gender).[14,15]

A study by Abbott et al demonstrated low temperatures on the fingers of patients with BL leprosy and slowing of blood flow in the fingers of BL and BT patients. This slowing was associated with vasomotor control changes and both changes can be consequences of peripheral neuropathy caused by leprosy. Thus, it was suggested that the simple detection of cold fingers in leprosy treatment clinics would be a preliminary classification of these patients.[9]

It is also important to highlight that the thermography assists in monitoring the distribution of temperature of human skin and measures small physiological changes caused by different pathological processes that arise with changes in heat and blood flow patterns of affected organs and tissues. Thus, the infrared image provides a useful non-invasive approach to the diagnosis of many circulatory, rheumatic, dermatological and orthopedic diseases.[14,15]

As thermography has been used as a diagnostic tool and has been showing excellent results in the evaluation of temperature in cancers or skin changes and in peripheral neuropathies, this study intended to investigate whether infrared thermography is able to measure this temperature changes in hands of patients with leprosy and also if there is a correlation among temperature, sensitivity and muscle strength.[16-20]

METHODS

We conducted an observational study, cross-sectional and controlled, to determine the temperature of the hands of people with leprosy. We used a non-probability sampling, or convenience sampling (because it is an exploratory study that aimed at identifying if the infrared thermography would be able to measure or not the temperature changes in the hands of people with leprosy).

From November 2012 to November 2013, patients who were undergoing treatment at the National Reference Center for Sanitary Dermatology and Leprosy (CREDESH) of Uberlândia/ MG were approached, as well as healthy people without leprosy, to be part of the control group.

Fifty individuals agreed to participate and signed the informed consent. Of these, 20 were in the control group and 30 in the group with leprosy.

Of the individuals who agreed to participate, 18 were excluded because they did not meet the eligibility criteria (adults of both genders, aged 20 to 70 years, healthy for the control group and with leprosy for the group with leprosy, who agreed to participate and signed the informed consent, who were non-smokers, did not drink alcohol and did not have associated diseases such as diabetes, hypertension, obstructive arterial disease, or neurological and musculoskeletal diseases).

Data on sensory and motor evaluation, palpation and degree of disability were collected from patient records, since these assessments are conducted periodically with all patients under treatment in CREDESH of Uberlândia/ MG, as recommended by the Ministry of Health.[21] For the control group, the sensitivity test was conducted with Semmes-Weinstein® monofilament esthesiometer and it was considered

that all had grade 5 muscle strength, since they were healthy and did not have any musculoskeletal or neurological disease.

For sensitivity analysis, the score was 0 to 5, according to the filament sensed at each point by the patient, where 5 corresponds to green filament (0,05 gr), 0 to red open filament (300 gr) and no response to black filament (Figure 1). Then a sum of this score was made to give the result of the sensitivity regarding the ulnar nerve of each limb (sum of the points of the 5th finger and hypothenar region) and median nerve (sum of the points of the 1st and 2nd fingers).[21]

For strength, the score was also 0 to 5, where 5 represents the completion of the full motion against gravity and with maximum resistance and 0 corresponds to the absence of motion. A sum was also included, grouping the muscles innervated by the ulnar nerve (1st dorsal interosseous muscle, 5th finger's abductor and the 4th and 5th fingers' lumbrical/ interosseous muscle; maximum of 15) and median nerve (2nd and 3rd fingers' lumbrical/ interosseous muscle and thumb's abductor; maximum of 10).[21]

For the measurement of temperature, we used the infrared camera FLIR® Systems A325, the ThermaCAM Researcher Professional 2.9 software, and the emissivity of the skin was considered of 0.98, according to the literature.[15,22] Before measuring, patients had to wait for 10 minutes, sitting at rest in the evaluation area so he/she could acclimatize to the room temperature and stabilize the cardiovascular system. The room was acclimatized with the aid of air-conditioned at 25° C. The distance between the camera and the assessed limb was 70 cm.

In the evaluation, the patient sat in front of the camera. In his/her lap, a cushion was placed so the patient could rest the arms and position the hands with the palm upward. In this position, we asked the patient to stay as still as possible so we could conduct the filming of hands with the infrared camera for 5 minutes.

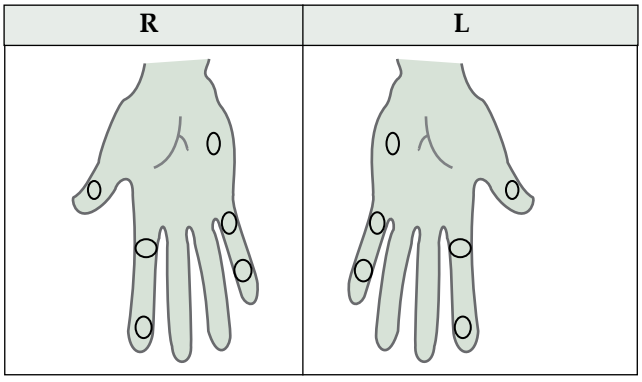

Figure 1: Sensory and temperature evaluation points (Brazil, 2010).

During filming, after initial 3 seconds, we performed the vasomotor reflex test (autonomic response of the vessel). The test is constituted of a cold stress on the palms. A cold jet, conducted with a spray for pulp vitality test (Endo-ice, of Maquira® brand), was splashed on the volunteer palm to observe how the autonomic response of the hand's vessel behaved to a cold stress.

The temperature was measured at 6 points (the same of the sensitivity, (Figure 1) on each hand at 0 (start), 2 minutes and 30 seconds (150 s) and 5 minutes (300 s). For analysis, a mean of the temperature was performed of the 3 points corresponding to the ulnar nerve (5th finger points and hypothenar region) and the other 3 corresponding to the median nerve (1st and 2nd fingers points).

Statistical analyzes were implemented in Freewares R software.[23] We used the methodology of generalized linear models in the variable response modeling because the assumptions of error were not met, and we also used the Wald test, with significance level of 5%.

Proposed by Nelder & Wedderburn, the generalized linear models are a new form of research and data modeling expressed discretely or continuously, becoming more flexible than linear models.[24] An important decision in the application of generalized linear models is the choice of the triad: the response variable, the distribution model matrix (design) and the link function.[25,26,27] Table 1 shows the description of the variable distribution, the model matrix and its respective link function.

The study was conducted in accordance with all ethical aspects, following the principles of the National Health Council Resolution 466/2012, and it was approved by the Ethics Committee on Human Research of the Federal University of Uberlândia (CEP/UFU) under the number 113.644.

RESULTS

This study evaluated 20 people in the control group – among these, 5 were excluded due to the eligibility criteria (hypertension and/or diabetes and smoking) – and 30 leprosy patients – of these, 13 were excluded due to the eligibility criteria (smoking and hypertension). Of the 17 patients remaining, 6 presented borderline tuberculoid (BT) form, 4 lepromatous (L) form, 4 borderline lepromatous (BL), 2 borderline borderline (BB) and 1 pure neural.

Of the 17 patients with leprosy who remained in the study, in 5 (29.4%) it was not possible to perform thermographic analysis due to the impossibility to evaluate all sensory and thermal points proposed because of the presence of characteristic deformities of the disease (claw and bone resorption). Of these 5, 2

presented BT clinical form, 1 presented L form, 1 BL and 1 presented neural form.

In palpation of the nerves, ulnar nerve presented thickened in all leprosy forms (87.5% in L form; 100% in BL; 75% in BB and BT) and median nerve was normal in the forms L (75%) and BL (75%), with shock sensation in the forms BB (75%) and BT (58,4%). According to these results, L, BL and BT clinical forms affect more the ulnar nerve, and BB form affects the ulnar and median nerves equally.

In table 2, Wald test results are presented for the study of the effects of the factors according to the completely randomized design (CRD) with 3 factors (clinical form of leprosy, nerve and time) in plot scheme sub-divided for the variable temperature.

The analysis shows a significant correlation between the clinical form of leprosy and nerve and between the clinical form of leprosy and time, indicating that the temperature presented a different behavior in relation to the clinical form of leprosy and the affected nerve, and between clinical form of leprosy and time. Therefore, we also analyzed the development of these significant correlations (clinical form and nerve; clinical form and time). The results of these interactions are shown in table 3.

Through the Wald test, at a significance level of 5%, the temperature of the hands of the control group and of the group with L clinical form of leprosy was higher in the hypothenar region and in the 5th finger (side innervated by the ulnar) compared with the side innervated by the median (1st and 2nd fingers region) and there was no difference between the limbs (right and left). For BL and BB clinical forms, there was a significant difference among the limbs; the BB form showed lower temperatures on the left side, in both the ulnar nerve as the median nerve, and BL form showed lower temperatures in the right side of the ulnar and median nerves. In BT clinical form, the mean temperature was the same for both nerve and limb.

Table 2: Wald test results for the study of the effects of the factors for CRD with three factors (leprosy form, nerve and time) in split plot scheme regarding the variable temperature, Uberlândia, Minas Gerais, November 2012 to November 2013

Fontes de Variação	LF	Wald	p-value
Leprosy form	4	8018.338	< 0.000
Error1	22	--	--
Plot	26	--	--
Nerve	3	196,562	< 0.000
Form * Nerve	12	267,707	< 0,000
Error2	66	--	--
Split plot	107	--	--
Time	2	212,150	< 0.000
Form * Time	8	109,785	< 0.000
Nerve * Time	6	4,554	0.602
Form * Nerve * Time	24	15,668	0.900
Error3	176	--	--
Split Split plot	323	--	--

* Wald test, at 5% significance level.
LF: Level of freedom; Error: random

Table 1: : Information on the trinomial adopted for the variables analyzed in the methodology of generalized linear models, Uberlândia, Minas Gerais, November 2012 to November 2013

Variable	Distribution	Design	Link function
Temperature	gamma	(1) CRD with 3 factors (type of leprosy, nerve and time) in sub-split plot design	logarithmic
Strength	gamma	CRD with 2 factors (type of leprosy and ulnar nerve) in factorial structure	logarithmic
Strength	gamma	CRD with 2 factors (type of leprosy and median nerve) in factorial structure	logarithmic
Sensitivity	Normal	CRD with 2 factors (type of leprosy and nerve) in factorial structure	Reciprocal
Initial temperature	gamma	CRD with 2 factors (type of leprosy and nerve) in factorial structure	logarithmic
Initial temperature	gamma	CRD with 2 factors (type of leprosy and degree of disability) in factorial structure	logarithmic
Temperature difference	Normal	CRD with 2 factors (type of leprosy and nerve) in factorial structure	Reciprocal

(1)CRD: completely randomized design.

In the vasomotor reflex test, the control group, at the end of five minutes (300 s), recovered 98.2% (32.587/33.177) of its initial temperature; BB clinical form recovered 97.3%; BT recovered 103.4% (that is, it exceeded the initial temperature); and BL recovered 99.7%; there was no significant difference between the initial and final temperatures; and L clinical form only recovered 95% of the initial temperature, and this difference was statistically significant.

Through the Wald test, at a significance level of 5%, during the 5 minutes, the temperature of the clinical forms of leprosy and control group differed. The control group showed the highest temperature and L clinical form, the lowest temperature (Figure 2). At 2 minutes and 30 seconds (150 s), the control group and the clinical forms BT and BL recovered 96-97% of the initial temperature. BB clinical form recovered 95.5%, while L form recovered 93.7% of the initial temperature.

As the correlation between strength, initial temperature, difference between the initial and final temperatures, and sensitivity were not significant, we evaluated then the effect of the factors in isolation. It is noteworthy that the factor "nerve" was analyzed/divided into 2 groups (ulnar and median) because of the difference in the sum of muscle strength. The results on the effects of factors "form of the disease" and "nerve" for the variables strength, sensitivity, initial temperature and temperature difference are presented in table 4.

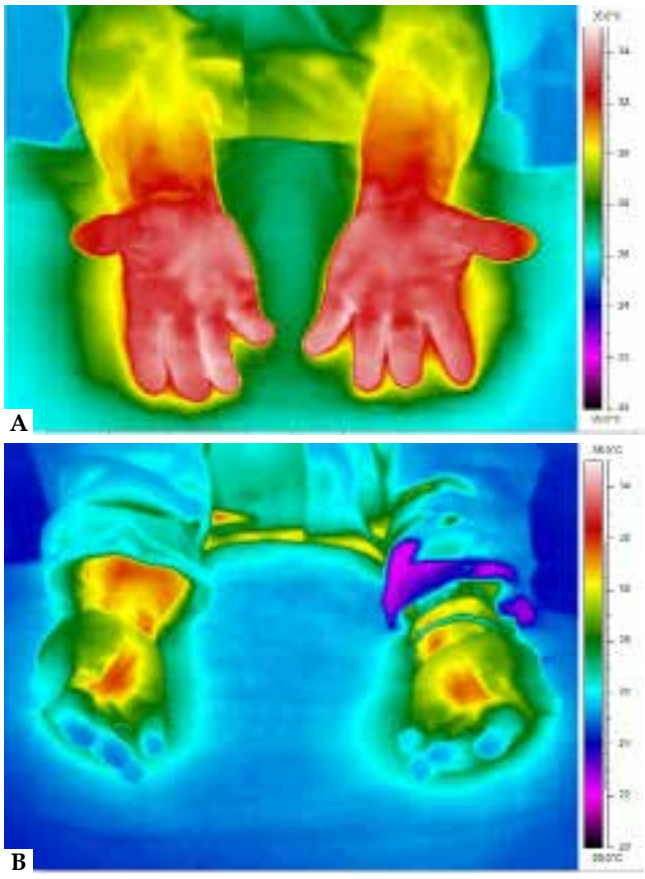

Figure 2: Thermographic image of initial temperature, Uberlândia, Minas Gerais, November 2012 to November 2013. **(A)** Initial temperature of a subject in control group; **(B)** Initial temperature of a subject wit leprosy, lepromatous form

Table 3: Results of the display of the correlation form of leprosy, nerve and time for variable temperature, Uberlândia, Minas Gerais, November 2012 to November 2013

Leprosy form	Nerve			
	Right ulnar	Left ulnar	Right median	Left median
Control	32.741aA(*)	32.808aA	32.341bA	32.480bA
BB	33.159aA	31.632bB	31.816bB	29.720cC
BT	31.601aB	31.213aC	31.397aB	31.328aB
BL	28.597bC	30.802aC	27.907cC	28.224bcD
L	25.574aD	25.538aD	24.397bD	24.490bE
Leprosy form	**Time**			
	0''	150''	300''	
Control	33.177aA	32.022cA	32.587bA	
BB	32.334aB	30.879cBC	31.477bB	
BT	31.338bC	30.436cC	32.411aA	
BL	29.216aD	28.258bD	29.119aC	
L	25.973aE	24.350cE	24.687bD	

* Means with distinct lowercase letters in line differ by Wald test, and median with distinct capital letters in the column differ by Wald test, at 5% significance level

According to the results, at the significance level of 5% by the Wald test, the L form and the control group showed greater strength, both in the muscles innervated by the ulnar as by the median. The smaller strength of the ulnar nerve was found in the BB and BT forms, and of the median nerve, in the BL form. Thus, the finding indicates that the motor part of the nerve is preserved in the group with L form of leprosy; that the motor part of the ulnar nerve is most affected in the BB and BT clinical forms; and that the median nerve is more affected in BL form of leprosy.

No difference was obtained, at a significance level of 5% by the Wald test, in the initial temperature between nerves and between the degrees of disability. However, the initial temperature changed according to the clinical form of leprosy presented: the control group and BB clinical form showed higher initial temperature (33.17 ° C and 32.33 ° C, respectively), and BL and L clinical forms showed lower temperature (29.21ºC and 25.97ºC, respectively)

The temperature difference (final temperature minus initial temperature) was also significant regarding the clinical form of leprosy. The BT group showed higher positive difference, which means that this group could return to and overcome the initial temperature after the cold stress, while the L group had greater negative difference, indicating that this group could not return to the initial temperature after cold stress. This difference in temperature was higher than in other clinical forms (Figures 3 and 4).

Regarding sensitivity, there was no significant difference between the nerves, but between control and leprosy groups. Control group differed from leprosy group, but there was no difference between the clinical forms of the disease.

Therefore, it can be observed, based on these results, that there was a change in the temperature of the hands of patients with leprosy, even those who did not present observable deformities, and that this change was significant when compared to the control group.

Regarding nerve impairment, it varied according to the clinical form of leprosy. The L form showed greater autonomic impairment (lower temperature) with preservation of the motor part of the

Table 4: Results of the effects of the factors "form of leprosy" and "nerve" to the variable strength, initial temperature, sensitivity and temperature difference, Uberlândia, Minas Gerais, November 2012 to November 2013

Variable	Factor	Factor levels				
Strength	Ulnar nerve (n.s.)	Right	Left			
		12.48	10.93			
	Leprosy form	Control	BB	BT	BL	L
		15.0a	10.0c	9.33c	10.83bc	14.33ab
	Median nerve(n.s.)	Right	Left			
		8.99	8.56			
	Leprosy form	Control	BB	DT	BL	L
		10.00a	8.22bc	8.25bc	7.67c	10.00ab
Sensitivity	Nerve (n.s.)	Right				
Ulnar	Left					
ulnar	Right					
median	Left					
median						
		9.85	7.82	10.71	7.71	
	Leprosy form	Control	BB	BT	BL	L
		13.92[a]	6.12b	9.98b	7.68b	10.00b
Initial temperature	Degree of disability(n.s.)	Zero	One	Two		
		30.24	29.45	30.22		
	Leprosy form	Control	BB	BT	BL	L
		33.17[a]	32.33ab	31.33ab	29.21b	25.97c
Temperature difference	Nerve (n.s.)	Right	Left	Right	Left	
		Ulnar	ulnar	median	median	
		-1.068	-6.974	-0.359	0.408	
	Leprosy form	Control	BB	BT	BL	L
		-0.514ab	-0.389abc	1.052a	0.385abc	-1.249c

* Means with distinct lowercase letters in line differ by Wald test, at 5% significance level. (n.s.): not significant.

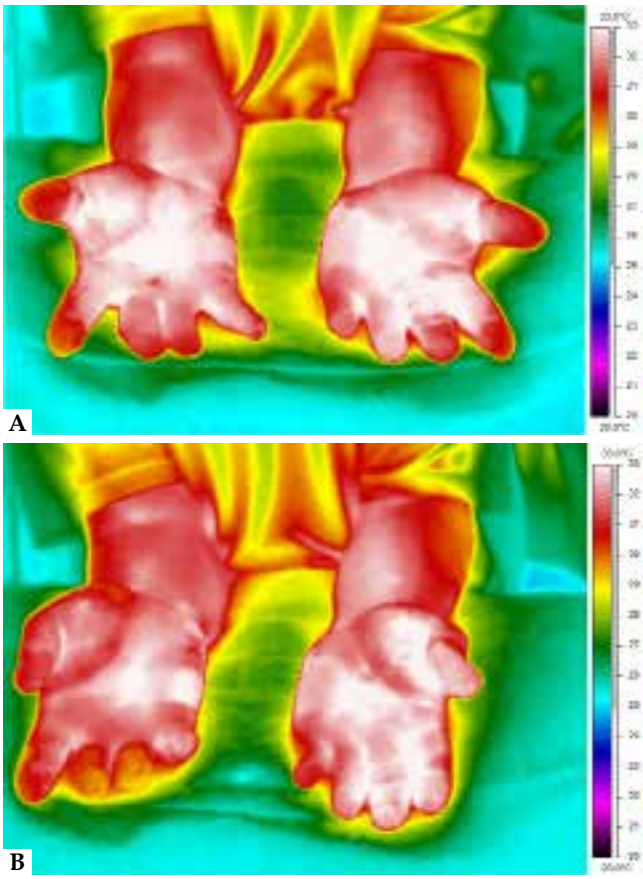

Figure 3: Thermographic imaging of patient with lepromatous tuberculoid leprosy, Uberlândia, Minas Gerais, November 2012 to November 2013. **(A)** Initial temperature; **(B)** Final temperature

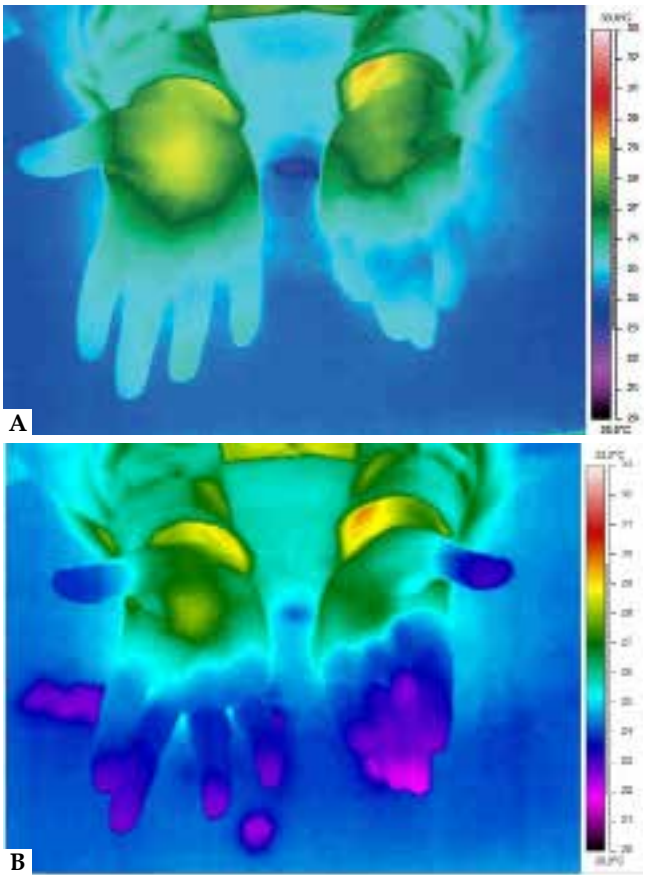

Figure 4: Figure 4: Thermographic image of a patient with leprosy, lepromatous form, Uberlândia, Minas Gerais, November 2012 to November 2013. **(A)** Initial temperature; **(B)** Final temperature

nerve (greater strength), while the lepromatous clinical forms showed greater motor impairment than the autonomic. In all clinical forms, there was a change of sensitivity.

DISCUSSION

Neural impairment

According to Chaurasia et al (2011), the form of neural commitment is different for the different clinical forms of leprosy, which could explain the correlations found in the study on the clinical form of leprosy presented.[28]

Therefore, involvement of the peripheral nerves occurs through inflammatory processes caused by the presence of bacillus or by immune reactions of the organism to the bacillus.[5]

The nerve damage mechanism is still much discussed in the literature, presenting, in general, 3 mechanisms of injury: 1) direct effect of M. leprae infection, causing damage to the Schwann cells and axons, and subsequent demyelination; 2) secondary damage to the inflammatory process, cytotoxic cells, antibody binding to the nerve, deleterious cytokines leading to cell death; 3) damage resulting from edema and mechanical factors, neural and vessels compression, causing ischemia and additional damage.[4,29]

Temperature

One possible explanation for the low temperatures found in the hands of patients with L and BL forms of leprosy in this study was that involvement of the sympathetic autonomic system, which controls subcutaneous blood flow and volume, will cause a decrease of blood flow with a consequent reduction of infrared radiation and appearance of hypothermic images.[30]

This hypothesis is supported by the study of Abbott et al, [9] which reports that some patients with leprosy, especially in BL clinical form, have colder hands and slower blood flow in the fingertips.

Thus, the abnormal vasomotor response of the L clinical form, according to Andrade Filho and Nunes,

would be explained as a sympathetic hyperactivity caused by the presence of chronic inflammation.[30] The lack of resistance of this clinical form allows blood and lymphatic spread of bacilli. Perhaps because of this hematogenous dissemination that this clinical form showed higher autonomic impairment when compared with other forms.[4]

In the BT clinical form, which not only recovered but increased the temperature, or the autonomic system was not affected or a total failure of this system occurred, causing loss of vasomotor reflex and faster temperature recovery, since there was no decline in the vascular caliber.[30]

Sensitivity

Based on the results found in this study, the sensitivity was altered regardless of its clinical form. In the study by Kar et al, sensory changes were also the most frequent and more severe in relation to motor impairment.[31] According to these authors, first there is a sensory loss of temperature discrimination, followed by tactile loss and subsequently pain.

This first involvement of nerve sensory fibers can be explained by their anatomical location. According to Machado, the sensory fibers have a more superficial path, being easily attacked, while the motor fibers have a deeper path.[32] According to this author, the cutaneous nerves are not purely sensitive, presenting autonomic fibers, responsible for the innervation of sweat glands, hair erector muscles and superficial vessels, which exemplify the manifestations observed in leprosy (anhidrosis and temperature change).

Strength

The preservation of strength found in L clinical form by this study corroborates the findings by Scollard that, in his review, concluded that the L clinical form keeps nerve basic integrity for much longer, and patients who have this clinical form are able to keep surprising levels of function, even when heavily infected.[33] According to this author, a possible explanation for this force maintenance is related to the degree of immune resistance of the person to M. Leprae.

So in the lepromatous polo the segmental demyelination (neuropraxia) would occur, in which an isolated internode, or multiple internodes of the myelin sheath, would be destroyed, lentifying impulse conduction, but preserving the axon, which would explain the preservation of strength in this form.[33] Histological evidence shows unorganized cutaneous infiltrates and highly active tuberculosis.[31]

The electrophysiological results of the nerves of patient with leprosy at the beginning of the disease reveal demyelinating features, such as slowing of the conduction velocity and prolongation of latency. However, with the progression of the disease, secondary axonal damage occurs.[28,34]

In the tuberculoid pole, Wallerian degeneration occurs, destroying the entire distal part of the affected axon.[33] Histological evidence shows a granulomatous inflammation in T clinical form, which would justify the nerve damage and loss of function found in this clinical form.[31]

Affected nerve

Our results indicate a greater involvement of the ulnar nerve in the clinical forms L, BL and BT, corroborating the findings of Van Brakel et al, which affirms that the ulnar nerve is the most affected nerve and the one that manifests greater weakness when compared to the median and peroneal nerve. [29] Kar et al also state that the ulnar nerve is not only the most affected, but also the most precociously impacted in leprosy, both unilaterally as bilaterally [31]

A possible explanation for the greater involvement of the ulnar nerve would be its more superficial anatomical location, being more easily traumatized, and the presence of a restrictive anatomical structure to the nerve (the epitrocleo-olecranon fossa).[3]

Thermography and early diagnosis

Based on the results of this study, it was possible to observe changes in the temperature of the hands of patients with leprosy, even in those who had no observable deformities. Thermography was able to detect these temperature changes, highlighting the potential of this technique as a non-invasive tool for early diagnosis of neuropathies caused by leprosy.

Illarramendi et al [35] indicate that household contacts of leprosy patients are at an increased risk of peripheral autonomic neuropathy when compared with the general population. But the importance of this is still poorly elucidated.

Cabalar et al, in their study, found neurophysiological abnormalities in 40% of leprosy patients without evident nerve involvement.[34] In the literature, there are studies indicating a high prevalence of defects in vasomotor responses of both leprosy patients as their household contacts.[13,36]

Lockwood and Saunderson study shows a high nerve damage in leprosy: 60% of patients with multibacillary leprosy present clinically observable nerve damage at diagnosis, 30% may develop damage during treatment and 10% after treatment, showing the importance of early diagnosis of the nerve damage and its correct treatment, since the antibiotics used in the treatment of M. leprae infection have little effect on nerve injury. [37]

According to Chacha et al, the destruction of at least 30% of nerve fibers is necessary to begin the

clinical manifestation of leprosy. Thus, cases of late diagnosis may develop with serious motor and sensory impairment.[38,39]

The results found in this study, with 29.4% of the sample with deformity or injury, highlights the disabling potential that leprosy still has and the consequences of late diagnosis, reinforcing stigma and discrimination caused by this disease, which is still present nowadays.

Currently, the focus of professionals are visible deformities, however it is known that attention should also be focused on the prevention of new deformities, especially when they may already be predicted by reliable tests. [40]

Mainenti [41] states that any organizational measure that can prevent cases with grade 2 disabilities (trophic and/or traumatic lesions, claws, resorption, wrost drop) in discharge due to cure will reduce costs in the post-discharge care. Thus, we see the importance of monitoring, early diagnosis and intervention to preserve the structure and function of peripheral nerve to prevent disability. [21]

CONCLUSION

Infrared thermography was able to detect temperature changes in the hands of leprosy patients. The temperature presented different behavior in relation to the clinical form of leprosy and the affected nerve. BB clinical form showed higher initial temperature and BL and L forms, lower temperature. The side of the hand innervated by the ulnar nerve showed a higher temperature when compared with the side innervated by median nerve, and the involvement of the ulnar nerve was higher than that of the median nerve.

Regardless of the form, the primary neural involvement is predominantly sensory. In lepromatous clinical form, autonomic impairment is evident, preserving the motor part; in other clinical forms, the impairment is mixed: sensory, motor and autonomic. It is believed that this difference in neural involvement is related to the degree of immunological resistance to M. leprae of each individual.

There was, in this study, significant correlation between temperature, sensitivity and muscle strength. Thermography showed to be a potential tool for early detection of autonomic dysfunction in neuropathy caused by leprosy, assisting in the prevention of major neural damage and installation of deformities and disabilities features of leprosy. However, more studies are needed to better understand these disorders.

Study limitations

It is known that the sample was small, but because it is a pilot study to determine whether thermography would be able to measure this change in temperature, this study met its objective. Studies evaluating the temperature of the hands of people with leprosy are still scarce, which hampers the discussion. We suggest, therefore, further studies with larger sample sizes to better understand these temperature changes in leprosy.

It is also known that muscle strength test is subjective and poorly reproducible, but, being the most used and being inserted in the assessment of patients with leprosy, we decided to use it.❑

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