

Infrared Thermographic Imaging in the Assessment of Successful Block on Lumbar Sympathetic Ganglion

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This study examined the net changes in temperature at various regions of the lower extremities in an attempt to identify the regions demonstrating the most significant temperature changes following a lumbar sympathetic ganglion block (LSGB).

Thermography was performed before and after the LSGB in 26 sympathetic nerve system disorder cases. The inspection points were the anterior and posterior surfaces of the thigh, the knee and leg, and the dorsal and plantar surfaces of the feet. The net increases in skin temperature following the LSGB (ΔT^{net}) at the plantar and dorsal surfaces of the feet, were $6.2 \pm 2.68^\circ\text{C}$ (mean \pm SD) and $3.9 \pm 1.89^\circ\text{C}$, respectively, which were higher than those observed in the other regions of the lower extremities ($p < 0.05$). The areas, in order of decreasing ΔT^{net} , are as follows: the plantar surface of the foot, the dorsal surface of the foot, the shin, the anterior surface of the knee, the calf, the posterior surface of the knee, the anterior surface of the thigh, and the posterior surface of the thigh. There was one case of orthostatic hypotension during the thermography procedure.

In conclusion, thermographic imaging is a useful method for demonstrating the success of a LSGB in various diseases. An evaluation of the ΔT^{net} on the plantar surface of the feet using thermographic imaging is the most effective, simple, and safe method for assessing a successful LSGB.

Key Words: Lumbar sympathetic ganglion block, thermography

INTRODUCTION

A great deal of experimental and clinical evi-

dence has indicated that a lumbar sympathetic ganglion block (LSGB), with the local anesthetics or neurolytic agents, is a useful diagnostic, prognostic or therapeutic procedure for various diseases, including complex regional pain syndrome (CRPS), hyperhidrosis and peripheral vascular diseases. When a neurolytic LSGB is being contemplated, a diagnostic or prognostic LSGB with local anesthetics is first recommended in order to predict the patient's response to the neurolytic block. The efficacy of the procedure and the minimization of side effects must be demonstrated before a neurolytic LSGB is performed.¹⁻³

Evaluating the effect of a LSGB, or its comprehensiveness, requires that specific tests of the sympathetic function be undertaken. The methods include skin conductance response, sweat tests, skin plethysmography and the ice response test.^{1,4} Measuring the changes in blood flow following a LSGB is also regarded as an effective method for determining the success of the block because a LSGB can change the blood flow by its direct vasodilatory effect on the blood vessels and indirectly by the breaking effect of the vicious cycle of sympathetically maintained pain. Blood flow in the skin can be measured by the changes in skin temperature, washout techniques, laser Doppler flowmetry, ulcer healing process, or the tissue PaO_2 .^{5,6}

The temperature at the extremities is largely dependent on blood flow. Therefore, its measurement by means of infrared thermographic imaging has been found to be useful.⁷ In addition, thermography has the advantages of being non-invasive, safe (without X-ray irradiation), simple, can be monitored remotely, and is capable of

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producing multiple recordings at short time intervals.⁴ In spite of such advantages, no data concerning a detailed methodology and the results of thermographic imaging following a LSGB has been published.

Therefore, the aim of this study was to determine the net changes in temperature at various regions of the lower extremities, and to identify the region demonstrating the most significant temperature changes following a LSGB.

MATERIALS AND METHODS

Informed consent for participation in this study was obtained from the patients prior to the block.

Twenty-six patients with various etiologies, 11 cases with complex regional pain syndrome (CRPS), 5 with failed back syndrome (FBS) and 10 suffering hyperhidrosis, were enrolled in this study. Patients were excluded if they had been taking any vasoactive drugs, had a known history of hypersensitivity to local anesthetics or contrast media, had vascular disease in the lower extremities, or had a significant illness within the preceding 2 weeks.

The changes in skin temperature were measured at the lower extremities using thermographic imaging (IRIS-5000 Digital Infrared Imaging System, Medicores Co., Seoul, Korea), this being the widely accepted method.⁷ Briefly, the examinations were performed in a draft-free room with the temperature tightly controlled between 20°C and 23°C. Prior to the examination, each patient undressed and remained in the room for at least 20 min to adjust to the temperature range. Smoking or the ingestion of beverages containing caffeine was not permitted for 1 h prior to participating in this study. To provide a quantitative measure of thermographic imaging and to assist in the visual interpretation of the color images, each patient's lower extremities were divided into 8 regions and the temperature difference of each were calculated. The 8 regions are as followed: the anterior thigh (Region 1); the anterior knee (Region 2); the shin (Region 3); the foot dorsum (Region 4); the posterior thigh (Region 5); the posterior knee (Region 6); the calf (Region 7); and the plantar surface of the foot (Region 8) (Fig. 1).

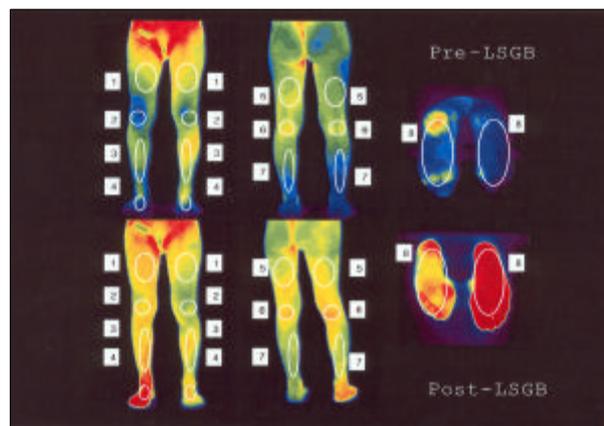


Fig. 1. Regions for evaluating the thermographic temperature difference between the right and left, and the thermographic image in a complex regional pain syndrome patient prior to the lumbar sympathetic ganglion block (pre-LSGB; top) or after the block (post-LSGB; bottom). Region 1; the anterior thigh, 2; the anterior knee, 3; the shin, 4; the foot dorsum, 5; the posterior thigh, 6; the posterior knee, 7; the calf, 8; the plantar surface of the foot.

Each of the 8 regions was checked by one of the authors without prior knowledge of the clinical diagnosis or of the temperature difference between the ipsilateral and contralateral sides before the LSGB (DT^{pre}) at the predetermined 8 regions. After a pre-block check of the thermographic image, the patients were transported to the operating room to undergo the LSGB.

The LSGB was performed following a widely used procedure at the L3 and L4 levels with a mixture of 1.5 ml of the contrast medium, Omnipaque (Nycomed Ireland Ltd., Cork, Ireland) and 1.5 ml of the 0.75% ropivacaine hydrochloride (Astra Pharmaceuticals Pty Ltd, NSW, Australia) at each level. At least 30 min after the LSGB, when the vital signs were stable, the post-block thermographic image was checked in order to calculate the temperature difference between the ipsilateral and contralateral lower extremities at the predetermined 8 regions (DT^{post}). The same preparations and procedures were performed as per the pre-block procedures.

The net change in skin temperature after the block (ΔT^{net}) was calculated to examine whether or not the LSGB leads to a change in skin temperature. The relevant equation used for the calculation is as follows: $\Delta T^{net} = DT^{post} - DT^{pre}$.

Statistical analysis

Statistical analysis was performed using Sigma Stat[®] software (Version 2.0, Jandel Co., Chicago, IL, USA). All results are represented as a mean \pm the standard deviation (SD).

All normality tests were done using the Kolmogorov-Smirnov test. In order to compare the ΔT^{net} in the 8 regions, statistical analysis was performed using either the Kruskal-Wallis one-way ANOVA on the ranks, with or without the Dunn's test, or an one-way ANOVA, with or without the Tukey test. For a comparison of the ΔT^{net} in the corresponding regions, either the t-test or the Mann-Whitney rank sum test was used. For Region 8, the comparison of the ΔT^{net} in the three disease entities included in this study was performed using a one-way ANOVA. A p value < 0.05 was considered statistically significant.

RESULTS

The patients' characteristics are listed in Table 1.

Table 1. Patient Characteristics

Variable	Data
Age (yr)	49.5 \pm 19.7
Sex (Male/Female)	12 / 14
Disease	
CRPS	11
FBS	5
Hyperhidrosis	10
Side of blockade (Right/Left)	15/11

Data are mean \pm SD and number of patients. CRPS, complex regional pain syndrome; FBS, failed back syndrome.

There was one case of orthostatic hypotension during the post-block thermography.

The ΔT^{net} on Region 8 and 4 were 6.216 ± 2.67 $^{\circ}\text{C}$ (mean \pm SD) and 3.873 ± 1.888 $^{\circ}\text{C}$, respectively. The ΔT^{net} on both regions were significantly higher than those of the other regions ($p < 0.05$), but there was no significant difference between

the ΔT^{net} on Region 8 and 4. The areas examined, in order of decreasing ΔT^{net} , are as follows: Region 8, Region 4, Region 3, Region 2, Region 7, Region 6, Region 1, and Region 5 (Fig. 2).

When the patients were classified into two categories, those having either hyperhidrosis or painful disease, the ΔT^{net} values of both groups showed a similar pattern to that shown in Fig. 2; the ΔT^{net} values on both Region 8 and 4 were significantly higher than those of the other regions in each group and the ΔT^{net} on Region 8 was the highest value regardless of the disease type. The hyperhidrosis group showed relatively higher ΔT^{net} values than the painful disease group, particularly on Region 6 and 7, whereas no difference on Region 8 was observed (Fig. 3).

When the patients were again classified into two groups, those with a DT^{pre} value either below 0.6 or above 0.6, the ΔT^{net} values on both Region 8 and 4 were significantly higher than those of the other regions. The ΔT^{net} on Region 8 was the highest and was also more specific than that on Region 4 regardless of the DT^{pre} value (Fig. 4).

At Region 8 (the plantar surface of the foot), a comparison between all disease entities included in this study did not reveal any statistical differences (Fig. 5).

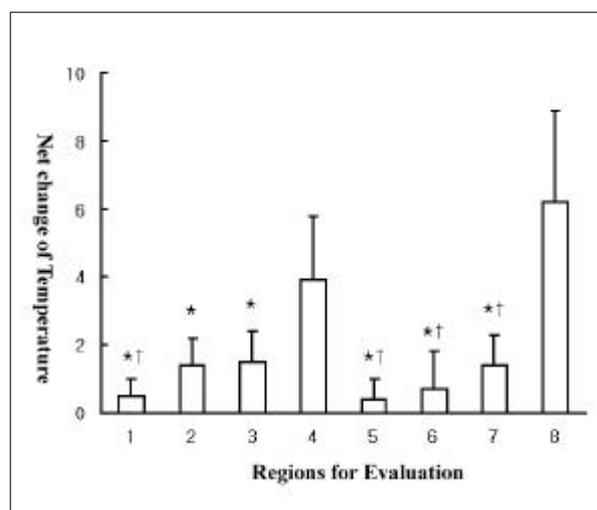


Fig. 2. Net increase in the thermographic temperature ($^{\circ}\text{C}$) after the lumbar sympathetic block at each region. Region 1; the anterior thigh, 2; the anterior knee, 3; the shin, 4; the foot dorsum, 5; the posterior thigh, 6; the posterior knee, 7; the calf, 8; the plantar surface of the foot. * $p < 0.05$ vs Region 8. † $p < 0.05$ vs Region 4.

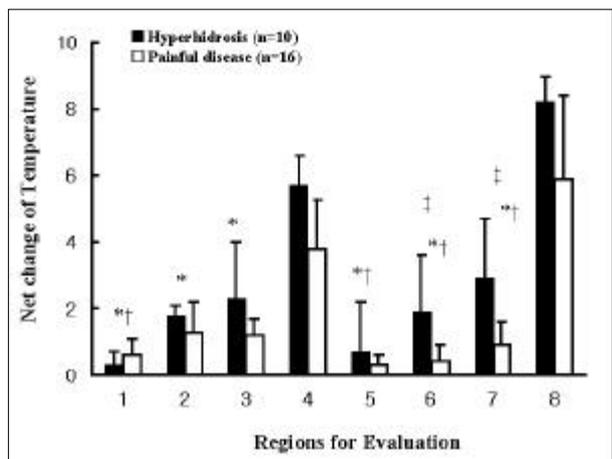


Fig. 3. Net increase in the thermographic temperature ($^{\circ}\text{C}$) after the lumbar sympathetic block in the hyperhidrosis and painful disease group. Region 1; the anterior thigh, 2; the anterior knee, 3; the shin, 4; the foot dorsum, 5; the posterior thigh, 6; the posterior knee, 7; the calf, 8; the plantar surface of the foot. * $p < 0.05$ vs Region 8 in each group. † $p < 0.05$ vs Region 4 in each group. ‡ $p < 0.05$ vs painful disease group.

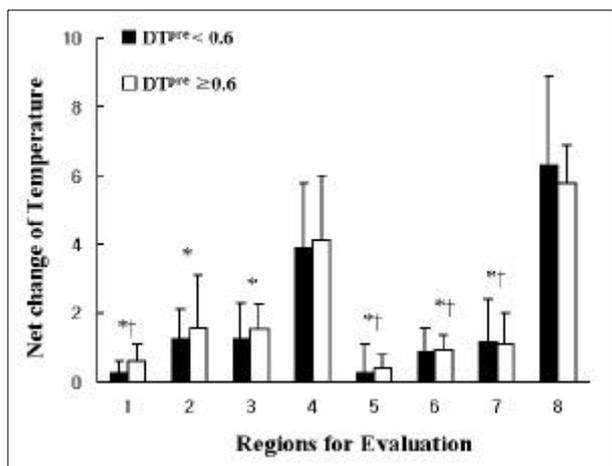


Fig. 4. Comparison of the net increases in the thermographic temperature ($^{\circ}\text{C}$) after the lumbar sympathetic block when the patients were classified into two groups; the pre-block temperature difference (DT^{pre}) $< 0.6^{\circ}\text{C}$ and the $DT^{pre} \geq 0.6^{\circ}\text{C}$. Region 1; the anterior thigh, 2; the anterior knee, 3; the shin, 4; the foot dorsum, 5; the posterior thigh, 6; the posterior knee, 7; the calf, 8; the plantar surface of the foot. * $p < 0.05$ vs Region 8 in each group. † $p < 0.05$ vs Region 4 in each group.

DISCUSSION

The duration, as well as the qualitative and

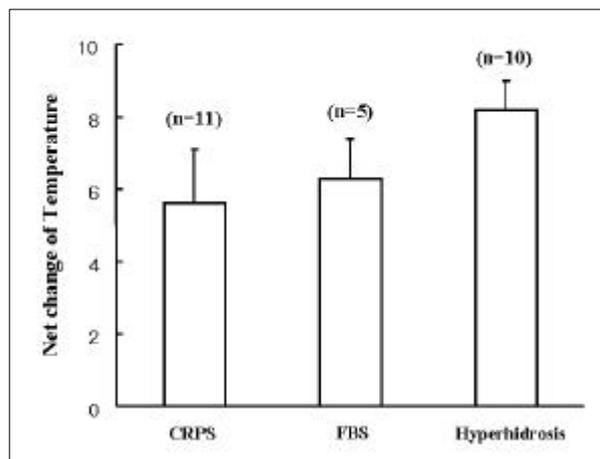


Fig. 5. Net increase in the thermographic temperature ($^{\circ}\text{C}$) on the plantar surface of the foot in each disease group after the lumbar sympathetic block. CRPS; complex regional pain syndrome, FBS; failed back syndrome. There were no significant differences between the groups.

quantitative extent of the effective increase in peripheral vascular perfusion, following a LSGB, can provide clinicians with important information for validating the success of the procedure. Of equal concern to the physician is an understanding of the most effective, simple, and safe means, by which the success of the block can be assessed. This study shows that thermography of the feet can be used effectively to assess the success of a LSGB. An abundant blood supply to the plantar surface and dorsum of the feet may give rise to a marked increase in skin temperature following a LSGB.⁸

Therefore following a LSGB, it may be advantageous to perform thermography on the plantar surface rather than on the dorsum of the foot. Firstly, as shown in Fig. 2, the ΔT^{net} value of the foot dorsum was less than two thirds that of the plantar surface. Moreover, the ΔT^{net} value on the plantar surface was similar in each disease entity included in this study. Secondly, a LSGB sometimes causes significant orthostatic hypotension, particularly when it is performed as a simultaneous bilateral procedure.⁹ In this study, one case who underwent unilateral LSGB, complained of dizziness during thermography procedure caused by hypotension in the standing position. Thermography at the plantar surface can be done safely in the supine position, without having to be

concerned about orthostatic hypotension, even when performed immediately after the LSGB. However, performing the thermography at the foot dorsum is difficult in the supine position.

One limitation of this study was the absence of a volunteer control group. For ethical reasons, we did not attempt to submit a volunteer control group to a LSGB, because it is one of the most invasive blocks. In this study, we classified the sympathetic dysfunction patients into several groups; 1) not painful disease (hyperhidrosis) vs sympathetically maintained pain (CRPS, FBS), 2) patients with a DT^{pre} below 0.6 vs a DT^{pre} above 0.6, and 3) three disease etiologies.

The hyperhidrosis patients generally showed no significant DT^{pre} , and had no specific systemic or peripheral cardiovascular diseases that might have affected the thermogram. Between the 10 hyperhidrosis patients and the 16 patients with painful diseases, a comparison of the ΔT^{net} at each region demonstrated that the hyperhidrosis patients showed a greater response pattern. Therefore, it was concluded that the limitation of this study as a result of the absence of normal volunteers was not a significant factor, and did not jeopardize the overall results. This also suggests that the thermogram could be used effectively to estimate the temperature changes, without having to be concerned with the type of disease involved.

Bruehl et al.¹⁰ reported that the difference in temperature between the lesion site and corresponding contralateral site, in painful conditions such as CRPS, was $\geq 0.6^\circ\text{C}$. Therefore, this study arbitrarily dichotomized the DT^{pre} at the 0.6°C level, at each region, in the evaluation of the effects of the DT^{pre} . A comparison of the ΔT^{net} at each region, between the data for which the $DT^{pre} \geq 0.6^\circ\text{C}$ and that for which $DT^{pre} < 0.6^\circ\text{C}$, did not show any statistical differences. However, this might be due to the relatively low proportion of areas where the $DT^{pre} \geq 0.6^\circ\text{C}$ within each predetermined region. Further study will be required in order to ascertain the exact ΔT^{net} values in the focal areas where the $DT^{pre} \geq 0.6^\circ\text{C}$. Overall, this study suggests that thermography can be used effectively to evaluate the success of a LSGB, although the exact ΔT^{net} of a volunteer control study could not be verified.

It was assumed that the ΔT^{net} of the peripheral vascular obstructive disease patients might be relatively low. This was based on the fact that the vasodilatory effect was very limited because of the vascular obstruction and that it is very difficult to estimate the ΔT^{net} in these patients. In addition, the degree and extent of the vascular obstruction differs from patient to patient. Therefore, we are currently collecting data for vascular disease patients. Preliminary results for these patients show that the ΔT^{net} does not differ in the eight predetermined regions, and that the values obtained are somewhat lower than those of this study, at the corresponding regions. Therefore, our evaluation of the peripheral vascular obstructive disease patients in terms of this study was discontinued and they were consequently excluded from this study.

In conclusion, a thermogram can be used effectively to confirm the success of a LSGB, regardless of the disease involved with the exception of peripheral vascular disease cases. The evaluation of the temperature changes following a LSGB, at the feet particularly at the plantar surface, using thermographic imaging represents an effective, simple, and safe method for determining the success of a LSGB.

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