Effects of polarized infrared ray irradiation near the stellate ganglion on digital perspiration

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Abstract
Purpose: The mechanism of the effect of polarized infrared ray irradiation near the stellate ganglion (PIRISG) is unknown. The purpose of this study is to analyze peripheral sympathetic activity during PIRISG by quantitative measurement of perspiration and skin temperature.

Methods: Irradiation was performed near the stellate ganglion of ten healthy adults for 20 min using 80% maximum power output of 1,800 mW with cycles of 1 second on and 2 seconds off. The perspiration volume was measured for three minutes and was compared before irradiation, at 10 minutes, and at 20 minutes of irradiation. The skin temperature was recorded at one-minute intervals.

Results: The baseline volume of perspiration was 1.000±0.202 mg·3 min⁻¹, at 10 min of PIR irradiation was 0.931±0.238 mg·3 min⁻¹, and at 20 min of PIR irradiation was 0.953±0.289 mg·3 min⁻¹. There were no significant differences in perspiration volume among control, at 10 and 20 min of PIR irradiation. Skin temperature did not change during the study period.

Conclusion: PIRISG does not show any inhibitory activity on peripheral sympathetic nerve activity in healthy adults during irradiation.

Key words: Polarized infrared ray, Stellate ganglion, Perspiration

Introduction
Irradiation with low-level laser (LLL) or polarized infrared ray (PIR) is one of the less invasive and effective modalities for the treatment of patients with pain. The effectiveness of this modality was established for the control of musculoskeletal pain and chronic pain1). In addition, it has been reported that irradiation with LLL or PIR near the stellate ganglion showed almost the same clinical efficacy as did stellate ganglion block with local anesthetics2,5). These reports suggest that irradiation with LLL or PIR near the stellate ganglion exerts sympathetic inhibitory activity.

The authors investigated peripheral sympathetic activity during irradiation with PIR near the stellate ganglion by quantitative measurement of perspiration and skin temperature.

Materials and methods
The subjects of the study were healthy adult volunteers (five men and five women with a mean age of 30±3 years). They were placed on a supine position and provided with a probe of skin surface temperature thermometer (Coretemp, TERUMO, Tokyo, Japan) and a probe of sweat ratemeter for continuous recording of local perspiration volume (Kenz-perspiro OSS-100, Suzuken, Nagoya, Japan) in the bilateral first joint of the thumb, and put to complete bed rest for ten minutes.

The irradiation with PIR (Super Lizer HA-550,
Tokyo Iken, Tokyo, Japan) was performed near the stellate ganglion of left side for 20 minutes using 80% maximum power output of 1,800 mW with cycles of 1 second on and 2 seconds off.

The skin temperature and perspiration were measured on three occasions: 1) before PIR irradiation (controls); 2) at 10 minutes of irradiation; and 3) at 20 minutes of irradiation.

In order to measure perspiration, the subjects were allowed to maintain the supine position and bend and stretch both lower extremities four times at 30-seconds intervals to induce sweating. The perspiration volume was measured for three minutes from the onset of the first bend and stretch and was compared before irradiation, at 10 minutes, and at 20 minutes of irradiation. The skin temperature was recorded at one-minute intervals. The room temperature was maintained at 25±1°C.

Statistical analysis was performed using the Wilcoxon test, and all values are shown as means with standard deviations, a probability value of less than 0.05 was considered to be significant.

Results

The changes in digital perspiration are shown in Fig. 1. The baseline perspiration volume was 1.000±0.202 mg·3 min⁻¹ for the left thumb (irradiation side) and 0.815±0.268 mg·3 min⁻¹ for the right thumb (contralateral side). The perspiration volume at 10 min of PIR irradiation was 0.931±0.238 mg·3 min⁻¹ for the left thumb and 0.727±0.230 mg·3 min⁻¹ for the right thumb, and at 20 min of PIR irradiation was 0.953±0.289 mg·3 min⁻¹ for the left thumb and 0.803±0.208 mg·3 min⁻¹ for the right thumb. There were no significant differences between the groups. The baseline skin temperature was 35.6±0.6°C for the left thumb and 35.6±0.4°C for the right thumb. At 10 min of PIR irradiation was 35.3±0.9°C for the left and 35.1±0.7°C for the right, and at 20 min of PIR irradiation was 34.9±1.1 and 35.0±0.8°C. Skin temperature showed no significant differences (Fig. 2). In addition, no case of Horner’s syndrome was observed.

Discussion

Pain-relieving activity is obtained by directly irradiating LLL or PIR on the localized pain site in patients with myofacial pain and postherpetic pain. LLL’s inhibition of nociceptive signals in the peripheral sensory nerve by its depolarization block is thought to be one of the pain-relieving mechanisms. PIR, like LLL, increases local temperatures, it is reported that its augmentation of local blood circulation is involved in the alleviation of pain. On the other hand, it has also been documented that LLL or PIR irradiation near the stellate ganglion (LLLISG or PIRISG) shows the same effect as does stellate ganglion block (SGB) and that because of this, it is effective for the treatment of pain. These reports suggest a probability that LLLISG or PIRISG inhibits sympathetic actions. There are also studies of the effects of LLLISG or PIRISG on sympathetic nerve activity.

Okuda et al. investigated the effects of LLLISG on the autonomic nerve in the cardiovascular system and reported that LLLISG does not affect sympathetic nerve activity in dogs. Noro et al. described that PIRISG inhibits relative sympathetic nerve activity in healthy adult volunteers by activating parasympathetic nerve activity. The following report indicating
the effects of PIRISG on the peripheral sympathetic nerve is in agreement with our findings. Hirano et al. investigated the effects of PIRISG on volunteers by measurement of blood flow, skin temperature and sympathetic skin response (SSR) and indicated, as we did, that PIRISG does not inhibit peripheral sympathetic activity. However, there is a difference in changes in skin temperature between the present study and their study. They reported that PIRISG increases skin temperature. The reason for this difference may be attributable to the following: First, there were differences in the irradiation time of PIRISG. Specifically, we irradiated for a time frame of 20 minutes, whereas they did only for five minutes. Second, our technique for measuring skin temperature measured the local skin temperature of the first joint of the thumb at one-minute intervals over a period of 20 minutes, whereas they employed thermography to measure the skin temperature of the back of the hand 30 minutes after the end of irradiation. These two facts suggest that despite the length of irradiation, PIRISG is likely to increase skin temperature due to some unknown mechanism after the end of irradiation without affecting skin temperature during irradiation. At the same time, it is also probable that the two different skin temperature measuring devices resulted in temperature differences. A previous study reported that thermographic temperature measurement, even by SGB using local anesthetics, produced three different temperature areas. Therefore, we used the present thermometer to measure only local temperature, the same site of perspiration measurement.

Nonetheless, it is the reliability of skin temperature as an index of sympathetic nerve activity that requires careful reconsideration. The skin temperature secondarily reflects the tonus of the smooth muscle of peripheral blood vessels through adrenergic sympathetic nerve activity, that is, blood flow changes. Blood flow, however, is affected not only by sympathetic nerve activity but also by some blood vessel dilating factors. This is described in a report that indicated that LLLISG increases the serum levels of calcitonin gene-related peptide (CGRP), a blood vessel dilating factor. In contrast, the sweat glands are directly governed by the cholinergic sympathetic nerve and it is reported that quantitative measurement of perspiration or SSR is effective for the determination of SGB effectiveness. In particular, the authors have previously reported that using the method described by the present study, the perspiration volume is significantly decreased 10 min after SGB with 6 ml of 1% mepivacaine in ten patients (from 1.49 ± 0.46 to 0.73 ± 0.33 mg·3 min⁻¹).

From the findings described above, we believe that
PIRISG does not show an inhibitory effect on the activity of the postsynaptic fibers of sympathetic nerve, at least in healthy volunteers. Nevertheless, some cases showed marked blood flow augmentation in patients with the neuropathic pain. Further study is necessary to examine the effectiveness of PIRISG involving the blood vessel dilating factors.

In conclusion, perspiration and skin temperature of the thumb showed no changes by PIRISG during irradiation. We consider that PIRISG does not show any inhibitory activity on peripheral sympathetic nerve activity in healthy adults during irradiation. In addition, the quantitative measurement of perspiration is more usefulness than the skin temperature as an index of the sympathetic nerve activity. The authors still believe that further studies are required for blood flow augmentation effects without involving the sympathetic nerve system.

References

直線偏光赤外線の星状神経節近傍照射が手指発汗に及ぼす影響

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直線偏光赤外線の星状神経節近傍照射（PIRISG）による手指の発汗量の変化を定量的に計測することにより，PIRISGの未梢交感神経活動に及ぼす影響を検討した。

健康成人10名を対象とし，左側 PIRISG（東京医研社製スーパーライザー HA-550）を20分間施行した，照射前を対照とし，照射10分，20分の時点で同側拇指の発汗量，および皮膚温を比較した。その結果，発汗量，皮膚温ともに対照と比較し有意な変化を認めなかった。また，照射側，非照射側間にも有意な差を認めなかった。

PIRISGによって，その照射後に照射側の皮膚温が上昇するなど PIRISG の交感神経抑制作用を示唆する報告がある。しかし，皮膚温は交感神経のみならず内因性血管拡張因子によっても変化する。一方，汗腺はコリン作動性交感神経に直接支配されるため，交感神経活動をより観察上とらえられると考えられる。今回の結果は，PIRISGは健康成人において少なくともその照射中には末梢交感神経活動に影響を及ぼさないことを示唆すると同時に，PIRISGの内因性血管拡張因子などに対する影響を検討する必要性を示すものである。

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