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Low reactive-level laser irradiation on the stellate ganglion in dogs

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Abstract: The aim of this study was to determine what effects low reactive-level laser irradiation (LLLI) of the stellate ganglion might have on the sympathetic fibers of the stellate ganglion in dogs. Following general anesthesia, the right stellate ganglion was exposed by thoracotomy. After stabilization, the following baseline measurements were taken: mean arterial pressure, heart rate, and blood flow of the common carotid artery. The stellate ganglion was directly irradiated for 10 min with a low-power laser. Measurements were taken for 60 min after LLLI. Immediately after the final measurement, stellate ganglion blockade was performed with 0.5% mepivacaine 1.5 ml. Measurements were taken again 15 min after stellate ganglion blockade with a local anesthetic. The changes in each variable were not statistically significant after LLLI. On the other hand, all variables changed significantly after the stellate ganglion blockade, including increased blood flow of the common carotid artery. In conclusion, this study demonstrated that LLLI to the stellate ganglion does not cause sympathetic blockade.

Key words: Low reactive-level laser irradiation, Stellate ganglion

Introduction

Low reactive-level laser irradiation (LLLI) has been reported to be effective in relieving various kinds of pain [1–6]. However, the mechanism of analgesia produced by LLLI is not yet clear. Since Sato et al. [7] reported that percutaneous LLLI around the stellate ganglion could act as a stellate ganglion blockade, one possibility may be blockade of the sympathetic nerve. To investigate whether or not LLLI around the stellate ganglion affects the sympathetic fibers of the stellate ganglion, the stellate ganglion of mongrel dogs was irradiated with a low-power laser.

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Materials and methods

On receiving approval by the appropriate institutional committee at Dokkyo University, six adult mongrel dogs weighing from 8 to 13 kg were anesthetized with sodium pentobarbital 25 $mg \cdot kg^{-1}$ i.v. and then intubated. Mechanical ventilation was adjusted so that the $Paco_2$ was between 35 and 40 mmHg, and anesthesia was maintained with intravenous administration of pentazocine (0.5 $mg \cdot kg^{-1}$), diazepam (0.05 $mg \cdot kg^{-1}$, and pancuronium (0.1 $mg \cdot kg^{-1}$). The left femoral artery and vein were cannulated with polyethylene catheters to obtain blood samples and to monitor pressure. Electrocardiographic monitoring of each dog was accomplished using electrodes attached to the forelegs.

The right common carotid artery in the neck was separated from the adjacent tissue, and the blood flow of the common carotid artery measured using a Transonic T201 (Advance, NY, USA) as an ultrasonic transit time flowmeter. The right stellate ganglion was then exposed by a right lateral thoracotomy at the second and third intercostal space. After stabilization, the following baseline measurements were taken: the mean arterial pressure, heart rate, and blood flow of the common carotid artery.

The stellate ganglion was directly irradiated with a low-power laser (60 mW, 830 nm) using a Luketron (Mochida, Tokyo, Japan) for 10 min, after which each parameter was measured at the following intervals: 10, 20, 30, 40, 50, and 60 min. Immediately after the final measurement, stellate ganglion blockade was performed using 0.5% mepivacaine 1.5 ml. The same parameters were measured 15 min after the stellate ganglion blockade. All values were described as the per-

centage change from the baseline value. Data are expressed as mean ± SD.

Analysis of variance (ANOVA) was used for statistical evaluation and Student's *t*-test was used to determine the statistical significance. The threshold for statistical significance was $P < 0.05$.

Results

As shown in Fig. 1, after direct LLLI to the stellate ganglion, the changes in mean arterial pressure, heart rate, and blood flow of the common carotid artery were not statistically significant. However, 15 min after the stellate ganglion blockade with the local anesthetic, all parameters changed significantly. Mean arterial pressure decreased significantly by 8.4%, heart rate decreased significantly by 17.1%, and the blood flow of the common carotid artery increased significantly by 65.1% after stellate ganglion blockade.

Discussion

Pain relief after percutaneous LLLI around the stellate ganglion is of decided interest, but its physiological mechanism remains unexplained. Sato et al. [7] reported that anhydrosis, Horner's syndrome, nasal stuffiness, and a slight rise in skin temperature were observed following percutaneous LLLI around the stellate ganglion. Based on these observations, it seems reasonable to assume that LLLI may effect sympathetic blockade.

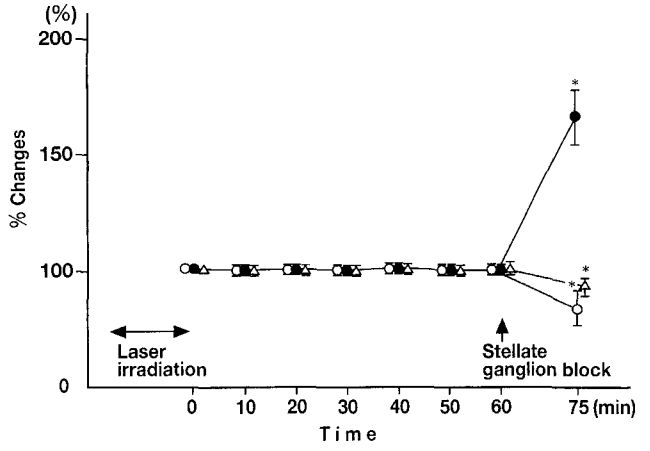

Fig. 1. The percent changes of mean arterial pressure, heart rate, and blood flow of the common carotid artery after low reactive-level laser irradiation and stellate ganglion blockade. *Vertical bars* represent mean and standard deviation of the mean (SD). *Open triangles*, mean arterial pressure; *Open circles*, heart rate; *closed circles*, blood flow of the common carotid artery. $P < 0.01$

Our previous study showed that blood flow of the common carotid artery increased significantly for the duration of local anesthetic after stellate ganglion blockade [8]. Therefore, increased blood flow of the common carotid artery was used as an index of blockade with LLLI. After direct LLLI to the stellate ganglion, there were no significant changes in blood flow of the common carotid artery. On the other hand, a statistically significant increase in blood flow of the common carotid artery occurred after stellate ganglion blockade with local anesthetic. The present study failed to show any effect of sympathetic blockade after the stellate ganglion was directly irradiated with a low-power laser.

We have performed stellate ganglion blockade with local anesthetic at the base of the transverse process of the 6th or the 7th cervical vertebra [9]. However, recent work [10] has cast doubt on this method by showing that a local anesthetic injected by these techniques probably fails to reach the ganglion, since it lies posteriorly in the chest on the head of the first rib. Therefore, we do not think that percutaneous LLLI at the base of the transverse process of the 7th cervical vertebra affects the stellate ganglion. In addition, the laser light is absorbed by fluid [11]. If percutaneous LLLI is performed at the base of the transverse process of the 7th cervical vertebra, the laser light is absorbed by the vertebral artery which lies just above the stellate ganglion. It was deduced from animal experiments and anatomical considerations that percutaneous LLLI does not cause sympathetic blockade in nerves with normal tone. However, it is possible that LLLI around the stellate ganglion is effective only for patients whose sympathetic nervous system is stimulated [12]. In conclusion, direct LLLI to the stellate ganglion has no effect on sympathetic blockade. However, final conclusions must await additional clinical data.

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