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Heat Loss Response Induced by Local Heating of Spinal Cord with Argon Laser*

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Abstract: The parts of spinal cord were locally heated with an argon laser in order to induce the heat loss responses in rabbits. And the spinal cord touched with a guide tube for a glass fiber (0.4 mm in diameter) was heated by the argon laser irradiation inside the guide tube. This local heating method is possible selectively to heat a part of spinal cord within length of implanted guide tube. The guide tube was implanted into the peridural space from lumbar vertebrae (L4/L5) to thoracic vertebra (Th7) of the rabbit in anesthesia. Two days after implantation of the guide tube, the lateral portion of spinal cord was locally heated in 10 mm sections. Then the heat loss responses such as increases in an ear skin temperature and a respiratory rate were induced by local heating of only 10 mm length in lumbar spinal cord. However, every 10 mm sections of spinal cord could not induce the marked heat loss responses when the spinal cord was locally heated in 10 mm sections.

Key words: Heat loss response, Spinal cord, Local heating, Argon laser, Rabbit

An argon laser (GLG−3202, NEC) irradiation through a glass fiber (0.4 mm in diameter) heats only a small area surrounding the tip of the glass fiber. This local heating method with argon laser is available for selective heating of a part of the spinal cord by the means of irradiation inside a guide tube for the glass fiber. The guide tube (0.8 mm in diameter) of which the tip was closed, was implanted into the peridural space through an opening from between L4 and L5 to Th7 of a rabbit in anesthesia. The irradiation of argon laser increased the temperature of the part of guide tube near by the tip of glass fiber, which caused thermal stimulation of the part of spinal cord. As compared with U-shaped thermode of polyethylene tubing which the thermal stimulation occurs along the entire length of the implanted thermode tubes, the argon laser irradiation is possible to heat a small part of spinal cord and easily to select a level of spinal heating only by shifting the glass fiber. In this study, the spinal cord was locally heated in 10 mm sections by the

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shifting the glass fiber, because the 10 mm length of spinal cord was locally heated more than 1 ℃ temperature increase by the irradiation at 80 mW laser power.

Two days after implantation of the guide tube, experiments were carried out in an environmental controlled chamber at 26 ℃ and 60% relative humidity. The glass fiber was inserted into the implanted guide tube in the peridural space of the rabbit in anesthesia with Urethane (0.7 g/kg i. p.). Spinal cord was locally heated in 10 mm sections by shifting the glass fiber. Temperatures of rectum (Tre), ear skin (TeaR', TeaL' and TeaR) and ambient (Ta) were measured every minute by using a thermistor-thermometer (K−270, TAKARA K. K.). TeaR' and TeaL' were measured at the middle branch of retroauricular artery of right ear and that of left ear, respectively. Data were stored on a computer (PC-9801, NEC). Respiratory rate (RR) were recorded by another computer (ATAC-450, NIHON KOHDEN).

Fig. 1 shows that heat loss responses induced by local heating of the spinal cord in a rabbit with argon laser irradiation. As shown at the bottom of this figure, squares and

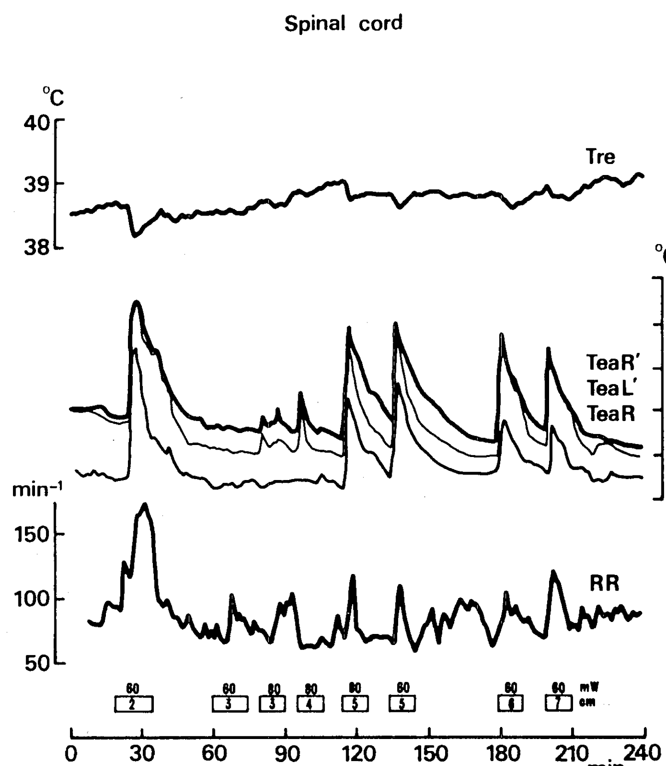

Fig. 1. Heat loss responses induced by local heating of lumbar spinal cord in 10 mm sections with argon laser in a rabbit. Squares, number above and in squares indicate irradiation time, irradiation power and distance from between L4 and L5 to the tip of glass fiber during spinal heating.

The: Rectal temperature; TeaR',TeaL', TeaR: Ear skin temperature (TeaR', TeaL': at the middle branch of retroauricular artery of right and left); RR: Respiratory rate numbers above and in the squares indicate irradiation time, irradiation power (IP) and distance from between L4 and L5 to the tip of glass fiber (DI: distance of insertion) on each spinal heating, respectively. The irradiation time of argon laser was for 10 or 15 minutes. The first spinal heating (IP: 60 mW, DI: 2 cm, for 15 min) caused marked increases in TeaR', TeaL', TeaR and RR which induced a decrease in Tre with no more than 10 mm length heated over 1 ℃ temperature increase. However, the parts of spinal cord at 3 and 4 cm of DI were also heated by 60 and/or 80 mw of IP, but the heat loss responses were almost never induced. Furthermore, increases in RR induced by the spinal heating at 5, 6 and 7 cm of DI were lower than that at 2 cm of DI.

TeaR' and TeaL' increased simultaneously due to the vasodilatation in ears for the heat dissipation and only a little difference between TeaR' and TeaL'. The rise of ear skin temperature at the middle branch of retroauricular artery served particularly as an indicator of the vasodilatation. Because TeaR' increased even if TeaR hardly changed during spinal heating.

It is well known that skin blood flow is appropriately influenced by thermal stimulation of the spinal cord; namely, spinal cooling reduces skin blood flow, while spinal warming causes cutaneous vasodilatation. The Vasodilatation in ears of a rabbit and increases in RR induced by spinal heating was the same result in already reported studies (Jessen *et al.*, 1967; Kosaka *et al.*, 1969).

Brück and Wünnenberg (1966) found spinal heat sensitivity in guinea pigs to be concentrated in the lower cervical and upper thoracic segments of the spinal canal. In the pig the cervical part of the spinal canal was also found to be more sensitive to spinal thermal stimulation than the lumbar and sacral sections (Carlisle and Ingram, 1973). However, the heat loss responses was also induced by the heating of lumbar spinal cord in the present study. The present results supported that the spinal thermosensitivity was more or less equally distributed over the whole length of the spinal canal (Simon, 1974), because that effects of spinal cooling and heating increased with the length of the thermodes in dogs (Simon *et al.*, 1964) and pigeons (Rautenberg, 1969).

The thermally sensitive structures might be localized within the spinal cord itself was supported by investigations that selective cooling of the deafferentiated section of the spinal cord was still effective in evoking cold tremor in dogs with chronical bilateral transection of the dorsal roots of lumbosacral spinal cord (Meurer *et al.*, 1967). The thermal distribution in spinal canal during argon laser irradiation suggested that the heat loss responses might be induced by activation of thermosensitivity in the heated part of spinal cord. Furthermore, no more than 10 mm length in spinal heating evoked enough the heat loss responses.

Every 10 mm sections of spinal cord could not induce the marked heat loss responses when the spinal cord was locally heated in 10 mm sections. Thus the location of spinal thermosensitive structure must be detected experimentally in consideration of a shifting length of the glass fiber or a segmental length of the spinal cord.

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