Effects of lumbar acupuncture stimulation on blood flow to the sciatic nerve trunk – an exploratory study

Motohiro Inoue, Tatsuya Hojo, Tadashi Yano, Yasukazu Katsumi

Abstract
Introduction Acupuncture may have a role in the treatment of intermittent claudication of the cauda equina due to lumbar spinal canal stenosis. The aim of this study was to explore the possible physiological mechanisms.

Methods In a laboratory experiment, manual acupuncture was performed at a point adjacent to the sixth lumbar vertebra of 13 animals and its effect on sciatic nerve blood flow was measured using a laser Doppler flowmetry. Simultaneously, changes in blood pressure and cardiac rate were observed. Each animal was stimulated four to eight times, making a total of 58 experiments.

Results Acupuncture stimulation did not produce consistent changes in sciatic nerve blood flow, with increased and decreased blood flow as well as no change in blood flow observed. Among the 58 individual experiments, sciatic nerve blood flow was increased in 33, reduced in 12, and unchanged in 13. Approximately half of the stimulations showed a correlation between blood flow and blood pressure change.

Conclusion Our results indicate that lumbar acupuncture stimulation can have an influence on sciatic nerve blood flow. The effect is dependent not only on blood pressure but also other factors, for example vasodilator and vasoconstrictor nerve activity. This mechanism may contribute to a clinical effect on intermittent claudication of the cauda equina.

Keywords
Nerve blood flow, acupuncture stimulation, laser Doppler flowmetry.

Introduction
Clinical experience has suggested that acupuncture treatment to the lumbar region can be an effective therapy for the treatment of conditions that are associated with lumbar spinal canal stenosis, such as intermittent claudication of the cauda equina and reduced sciatic nerve blood flow. Previous reports of the effect of physical stimulation on sciatic nerve blood flow have shown that electrical stimulation of the lumbar sympathetic trunk and lumbosacral nerve roots, particularly the electrical stimulation of the ventral and dorsal roots of the L6 spinal nerve, leads to increased sciatic nerve blood flow, without any increase in blood pressure.1,2 These investigations were carried out using laser Doppler flowmetry, and although this method only provides relative changes in the blood flow and not absolute flow volume, it has the advantage of real-time, continuous, and non-invasive measurement of the blood flow.1,2 There are several reports concerning the effect of acupuncture or electroacupuncture on blood flow.3,4 However, the effects of acupuncture stimulation of lumbar muscle on sciatic nerve blood flow have not yet been reported. We thought that if electrical stimulation of the L6 spinal nerve caused increased sciatic nerve blood flow, it was possible that manual acupuncture stimulation of the muscles innervated by the posterior ramus of the spinal nerve at that level might also produce changes in sciatic nerve blood flow. In this study, therefore, our objective was to observe the changes in sciatic nerve blood flow during acupuncture stimulation to the muscle close to the L6 vertebra. We therefore conducted a laboratory experiment in which the effects of lumbar acupuncture stimulation on sciatic nerve blood flow were measured with laser Doppler flowmetry.
**Method**

**Experimental animals**

Thirteen Wistar rats (male, 260–350g) were administered intraperitoneal doses of urethane (1.2g/kg). Following induction of anaesthesia, rectal temperature was monitored and a body temperature of 37.5±0.3ºC maintained with a body temperature control device (MK-900, Muromachi Co Ltd, Tokyo, Japan). Heart rate was monitored with an electrocardiogram and recorded with a pen recorder (RTA-1100, Nihon Kohden Co Ltd, Tokyo, Japan). An incision was made in the necks of the rats, a tracheal cannula inserted, and a respirator (SN-4807, Sinano Co Ltd, Tokyo, Japan) connected. A cannula was inserted in the jugular vein for drug administration. A continuous infusion of muscle relaxant pancuronium bromide (2mg/h) was administered with a syringe pump (SCT-525, Terumo Co Ltd, Tokyo, Japan) to immobilise the animals. To measure blood pressure, a cannula containing a solution of heparin and physiological saline was inserted in the common carotid artery, and blood pressure and heart rate were measured continuously with a transducer (P23XL, Sanei Co Ltd, Tokyo, Japan), and recorded with a pen recorder. After this, unilateral exposure of the sciatic nerve was performed, and the probe (Type N, Advance Co Ltd, Tokyo, Japan) of the laser Doppler flowmeter (ALF2100, Advance Co Ltd, Tokyo, Japan) was placed in contact with the exposed nerve. A fixed contact pressure was maintained with a pressure control device (ALF-B, Advance Co Ltd, Tokyo, Japan). Blood flow measured with a time constant of three seconds was recorded with a pen recorder. Measurements were conducted in a paraffin oil pool to prevent drying of the sciatic nerve and surrounding tissue.

**Acupuncture stimulation**

Manual stimulation was performed with acupuncture needles (diameter: 0.18mm, length: 40mm, Seirin, Japan) inserted perpendicularly to the depth of 10mm into the paraspinal muscle at lumbar vertebra L6, 10mm lateral to the L6 vertebra spinous process on the same side that blood flow measurements were conducted. The rats were kept in a resting condition for at least 10 minutes before acupuncture stimulation, after nerve blood flow, blood pressure and heart rate had become adequately stabilised. Rotatory stimulation was conducted in one direction, and the needle was left in place for three minutes before being removed. Each rat received stimulation four to eight times for a total of 58 stimulations.

**Statistical analysis**

For nerve blood flow changes on acupuncture stimulation, values measured every 30 seconds before and during stimulation were used. The standard deviation (SD) of the value measured before stimulation was calculated for each experiment, and changes during stimulation of double that value (2SD) were taken as indicating an increase or decrease, while values less than 2SD were taken as indicating no change. The same method was used to define increased, decreased or no change in blood pressure and heart rate.

**Results**

During acupuncture stimulation to the muscle immediately lateral to the L6 vertebra, the responses observed included increased blood flow, decreased blood flow and unchanged blood flow. The results indicated that of the 58 stimulations, sciatic nerve blood flow increased with 33, decreased with 12, and was unchanged with 13 (Figure 1). The curves for typical examples of increased and decreased cases are indicated in Figures 2 and 3.

Among the 33 stimulations in which nerve blood flow increased, heart rate increased in eight cases (24.2%), decreased in three cases (9.1%), and did not change in 22 cases (66.7%). Also among the 33
Figure 2. Sciatic nerve blood flow (NBF), heart rate (HR), and blood pressure (BP) changes in a typical case of increased sciatic blood flow.

Figure 3. Sciatic nerve blood flow (NBF), heart rate (HR), and blood pressure (BP) changes in a typical case of decreased sciatic blood flow.

Figure 4. In the 33 cases in which sciatic nerve blood flow increased with acupuncture, this figure shows the proportion of increase, decrease and no change in blood pressure and heart rate.
stimulations, blood pressure increased in 15 cases (45.5%), decreased in two cases (6.1%), and did not change in 16 cases (48.5%) (Figure 4). For the stimulations that increased nerve blood, nerve blood flow returned to the value directly before stimulation 9.7±4.7 minutes after the discontinuation of stimulation, while heart rate and blood pressure returned to the pre-stimulus values 7.2±6.1 and 6.8±3.9 minutes after discontinuation of stimulation respectively.

Among the 12 stimulations in which nerve blood flow decreased, heart rate decreased in three cases (25%), increased in two cases (16.7%), and did not change in seven cases (58.3%). Also among the 12 stimulations, blood pressure decreased in six cases (50.0%), increased in two cases (16.7%), and did not change in four cases (33.3%) (Figure 5). For the stimulations that decreased nerve blood, nerve blood flow returned to the value directly before stimulation 7.1±4.8 minutes after the discontinuation of stimulation, while heart rate and blood pressure returned to the pre-stimulus values 6.5±2.5 and 6.1±5.4 minutes after discontinuation of stimulation respectively.

**Discussion**

In acupuncture treatment for lumbar spinal canal stenosis, a therapeutic effect is obtained by inserting acupuncture needles in lumbar muscle rather than inserting them as far as the nerve root itself. Therefore it appears that the peripheral nerve does not necessarily need to be directly stimulated for effective treatment of the reduced cauda equina and sciatic nerve blood flow that are caused by spinal canal stenosis. This suggests that even without inserting an acupuncture needle as far as the nerve root, acupuncture stimulation of lumbar muscle has, in some way, an effect on sciatic nerve blood flow.

Sato et al reported that direct electrical stimulation of the L6 spinal nerve in the rat caused a temporary increase in sciatic nerve blood flow, but there have been no reports of experiments indicating that lumbar acupuncture stimulation influences sciatic nerve blood flow. We performed acupuncture stimulation to the muscle 10mm lateral to the L6 vertebra spinous process in rats and used the laser Doppler method to observe changes in sciatic nerve blood flow. Although the method has the limitation that it only provides relative changes in the blood flow and not absolute values, we utilised the method here because the purpose of our study was to investigate the changes in the sciatic nerve blood flow during acupuncture stimulation at the lumbar area.

After passing through the surface of the epineurium and entering the nerve trunk, peripheral nerve nutrient arteries form netlike anastomoses while encircling the perineurium and finally forming a capillary network within the endoneurium. Since the laser Doppler flowmeter employed in this study
measured the blood flow at a depth of approximately 1mm from the probe, it was not possible to differentiate between intra- and extra-fascicular blood flow. Consequently, in this study the sciatic nerve blood flow measured is the sum total of the intra- and extra-fascicular blood flow.

Results of the present study indicate that although the increase and decrease in the blood pressure tend to influence the changes in sciatic nerve blood flow in response to lumbar acupuncture stimulation, no uniform pattern was observed.

It has been reported that vasodilator and vasoconstrictor nerves participate in sciatic nerve blood flow control in the rat. Among the reports, two theories have been put forward, one proposing that muscarinic cholinergic receptors play a role in mediating control of the vasodilatory response, and the other proposing that the axon reflex induced by afferent fibre retrograde excitation plays a role. It has also been reported that nerve nutrition blood vessels are controlled by a large number of neurotransmitters. It is thought that vasodilator and vasoconstrictor nerve fibres mediated by these neurotransmitters participate in the changes in nerve blood flow caused by lumbar acupuncture stimulation, and in addition to blood pressure changes, the degree of acupuncture stimulation and other factors modify nerve blood flow to cause a range of other changes.

This study supports the hypothesis that, even without electrical stimulation of the nerve root, acupuncture stimulation of lumbar muscle can cause large, temporary changes in sciatic nerve blood flow. It also suggests that, although nerve blood flow tended to be influenced by changes in blood pressure, it is also modified by the participation of vasodilator and vasoconstrictor nerves. This study examined only normal nerves and nerve blood flow. It is important that future studies use animal models of spinal canal stenosis to observe the effects of acupuncture stimulation on changes in nerve blood flow, in order to explore the mechanism of its effectiveness for treating cauda equina intermittent claudication. Studies such as those using autonomic blocking agents should also be conducted to evaluate the participation of vasodilator and vasoconstrictor nerves.

Lumbar acupuncture stimulation may have an indirect effect on sciatic nerve blood flow, and it is suggested that further studies of its application as a basis for the effective treatment of lumbar spinal disorders are important.

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