Dokkyo Journal of Medical Sciences
35(1) : 1～6, 2008

Originals

Comparison of Sympathetic Block with 2.0 % Mepivacaine and Surgical Sympathectomy with Radiofrequency Thermocoagulation on Vasodilative Effect in Dogs

Mio Shinozaki, Shigeki Yamaguchi, Tadaomi Iwasaki, Yoshiyuki Takahashi, Daigo Fukagawa, Yoshiyuki Kimura and Shinsuke Hamaguchi

Department of Anesthesiology, Dokkyo Medical University,Mibu, Tochigi 321-0293, Japan

SUMMARY

The aim of this study is to compare sympathetic block using 2.0 % mepivacaine with surgical sympathectomy using radiofrequency thermocoagulation for the duration and magnitude of the vasodilative effect. Mean arterial pressure (MAP), heart rate (HR), and right and left brachial artery blood flow (BABF) were measured before and after left cervicothracic sympathetic block using 2.0 % mepivacaine or surgical sympathectomy in dogs. The experimental protocol was designed as follows : (1) left cervicothoracic sympathetic block using 1.0 ml of 2.0 % mepivacaine (n = 8), and surgical sympathectomy using radiofrequency thermocoagulation (n = 8). MAP and HR did not change significantly throughout the study in both groups. Left cervicothracic sympathetic block increased left BABF significantly from 5 min through 80 min after cervicothracic sympathetic block (baseline, 100 % ; peak at 10 min after the block, 186 ± 40 % ; $P < 0.01$). Left surgical sympathectomy increased left BABF significantly from 5 min through 120 min after the sympathectomy (baseline 100 % ; peak at 60 min after the sympathectomy, 265 ± 59 % ; $P < 0.01$). Left BABF in surgical sympathectomy was significantly higher than those in cervicothoracic sympathetic block throughout the study. The values of right BABF decreased significantly compared with the baseline value throughout the study in both groups. In conclusion left cervicothracic sympathetic block using 2.0 % mepivacaine induces less duration and magnitude of the vasodilative effect compared with surgical sympathectomy with radiofrequency thermocoagulation.

Key Words : Sympathetic block, Mepivacaine, Surgical sympathectomy, Radiofrequency thermocoagulation

INTRODUCTION

Three different concentrations of mepivacaine, 0.5, 1.0 % and 2.0 %, have been used in clinical practice. The concentration of local anesthetics is mainly determined by the type of nerve fibers to be blocked. The sympathetic nerve fibers are smaller and unmyelinated, and sensory and motor nerve fibers are larger and myelinated. A lower concentration of local anesthetics such as 0.5 % mepivacaine is used for sympathetic block, and a higher concentration of local anesthetics such as 1.0 % or 2.0 % mepivacaine is required for sensory or motor nerve block. Therefore, it is considered that 2.0 % mepivacaine induces the maximum inhibition of sympathetic nerve activity. However, no single study has examined if sympathetic block with 2.0 %

Received October 22, 2007 ; accepted November 16, 2007
Reprint requests to : Mio Shinozaki
Department of Anesthesiology, Dokkyo Medical University, Mibu, Tochigi 321-0293, Japan

mepivacaine completely inhibits nerve activity. In the present study, we examined the duration and magnitude of the increase in vasodilation induced by cervicothracic sympathetic block using 2.0 % mepivacaine, and compared these results with those of surgical sympathectomy in anesthetized dogs.

METHODS

This study was conducted according to the animal experimental guidelines of Dokkyo Medical University, which adhere to the National Institute of Health Animal Experimental Guidelines.

Sixteen adult mongrel dogs of either sex (10－15 kg) were anesthetized with an intravenous injection of sodium pentobarbital 25 mg/kg, and their tracheas were intubated. Mechanical ventilation was adjusted to provide $Paco_2$ between 35 and 40 mmHg by use of a respirator (Harvard Apparatus, Chicago, IL), and anesthesia was maintained by the intravenous administration of pentazocine 0.5 mg/kg, diazepam 0.05 mg/kg and vecuronium 0.1 mg/kg, supplemented as required. The left femoral artery was cannulated with a polyethylene catheter (outer diameter 2.75 mm) to measure mean arterial pressure (MAP), and to obtain blood samples for arterial blood gases. Electrocardiography was used throughout the experiment to monitor heart rate (HR). Bilateral brachial arteries in the forelegs were carefully dissected from the adjacent tissue, and a 2－mm ultrasonic flow probe (transonic system) was placed within each artery at the center of the proximal portion of the arteries. Right and left brachial artery blood flow (BABF) was measured by a Transonic T206 (Transonic System) as an ultrasonic timed flowmeter (ml/min). Physiological saline solution was continuously infused intravenously at a rate of 3 ml/kg/h via the left femoral vein during the study. The room temperature was kept constant at 25℃.

The left cervicothoracic sympathetic ganglion was then exposed by a left lateral thoracotomy at the second and third intercostal space. In sympathetic block using 2.0 % mepivacaine, a 25－gauge winged needle was inserted under the fascia next to the ganglion and stabilized with a suture for performing cervicothoracic sympathetic block, and the chest was closed. To ascertain the spread of the local anesthetic, 1.0 ml of methylene blue was injected through the needle after each experiment.

In sympathectomy using radiofrequency thermocoagulation, a guiding needle (SMK, Radionics, USA) was inserted under the fascia, the radiofrequency electrode was inserted into the outer guiding needle, and the tip of the electrode was placed at the sympathetic trunk just beneath the cervicothoracic sympathetic ganglion. A radiofrequency generator (RFG－3C^{TM} Plus Generator, Radionics, USA) was used for thermocoagulation.

After stabilization of hemodynamic parameters for 20 min, the following baseline measurements were taken : MAP, HR, and left and right BABF. The dogs were then randomly divided into two groups : (1) left cervicothoracic sympathetic block using 1.0 ml of 2.0 % mepivacaine (n = 8), and (2) left surgical sympathectomy using radiofrequency thermocoagulation (90℃, 120 sec) (n = 8).

Hemodynamic parameters were measured 5 min after the block or surgical sympathectomy, and thereafter every 10 min for 120 min after the block or surgical sympathectomy. All values of BABF were described as percentages of change from the baseline value (100 %). Blood gas analysis was performed before cervicothoracic sympathetic block or surgical sympathectomy (baseline) and at the end of the experiment.

Data are presented as mean ± SD. Statistical analyses within a group were performed by repeated－measures analysis of variance with Bonferroni's correction as post hoc testing. Comparisons between groups were made by application of the Mann－Whitney U－test. The threshold for statistical significance was $P < 0.05$.

RESULTS

In cervicothoracic sympathetic block, the sufficient spread of methylene blue was ascertained in each experiment.

MAP and HR did not change significantly throughout the study in both groups (Fig. 1). Figure 2 compares changes on left BABF after cervicothoracic sympathetic block using 1.0 ml of 2.0 % mepivacaine with left surgical sympathectomy using radiofrequency thermocoagulation. In cervicothoracic sympathetic block, left BABF increased significantly by 86 % (baseline 100 % ; 10 min after the block) from 5 min through 80 min after the block. In surgical sympathectomy, left

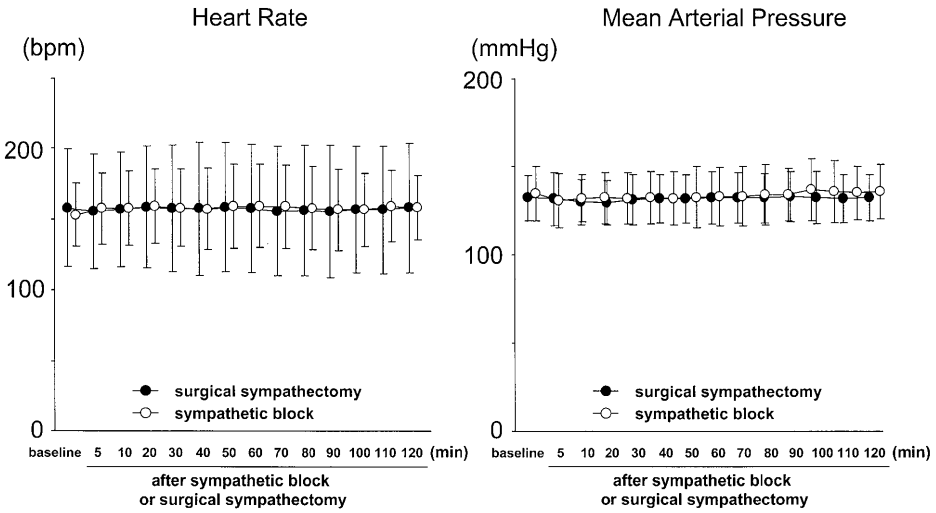

Fig 1. Changes in mean arterial pressure (MAP) and heart rate (HR) before and after cervicothoracic sympathetic block with 1.0 ml of 2.0 % mepivacaine or surgical sympathectomy with radiofrequency thermocoagulation. Values are shown as mean ± SD.

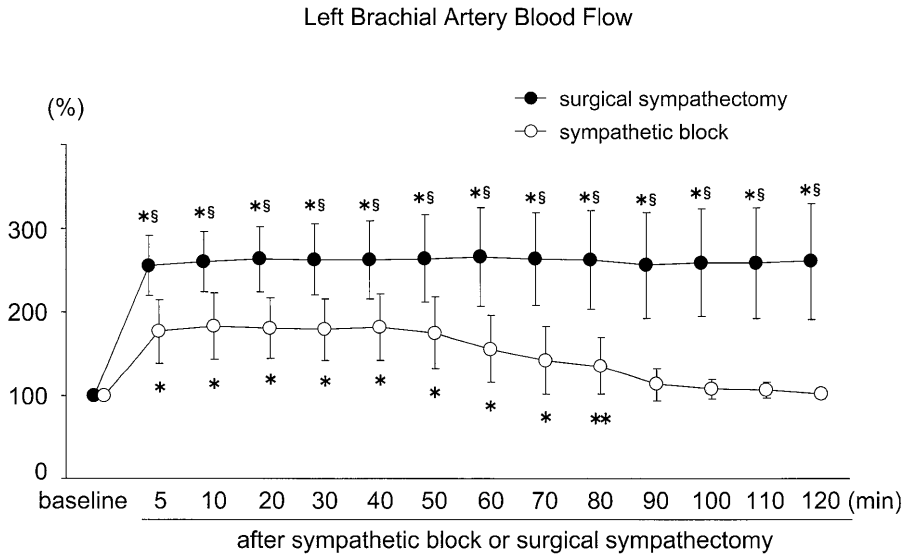

Fig 2. Changes in left brachial artery blood flow before and after cervicothoracic sympathetic block with 1.0 ml of 2.0 % mepivacaine or surgical sympathectomy with radiofrequency thermocoagulation. $^{*}p < 0.01$ vs baseline, $^{**}p < 0.05$ vs baseline. $^{\S}p < 0.01$ vs sympathetic block. Values are shown as mean ± SD.

BABF increased significantly by 165 % (baseline 100 % ; 60 min after the sympathectomy) from 5 min through 120 min after the sympathectomy compared with the baseline. Left BABF in surgical sympathectomy was significantly higher than that in cervicothoracic sympathetic block throughout the study. As shown in Fig. 3, right BABF in both groups decreased significantly after left cervicothoracic sympathetic block or surgical sympathectomy compared with the baseline value throughout the study. In surgical sympathectomy, right BABF decreased significantly from 100 min to 120 min compared with cervicothoracic sympathetic block using 2.0 % mepivacaine.

$Paco_2$ were maintained at 35 to 40 mmHg, and Pao_2 was maintained at 82 to 95 mmHg before the block or sympathectomy and at the end of experiment in both groups.

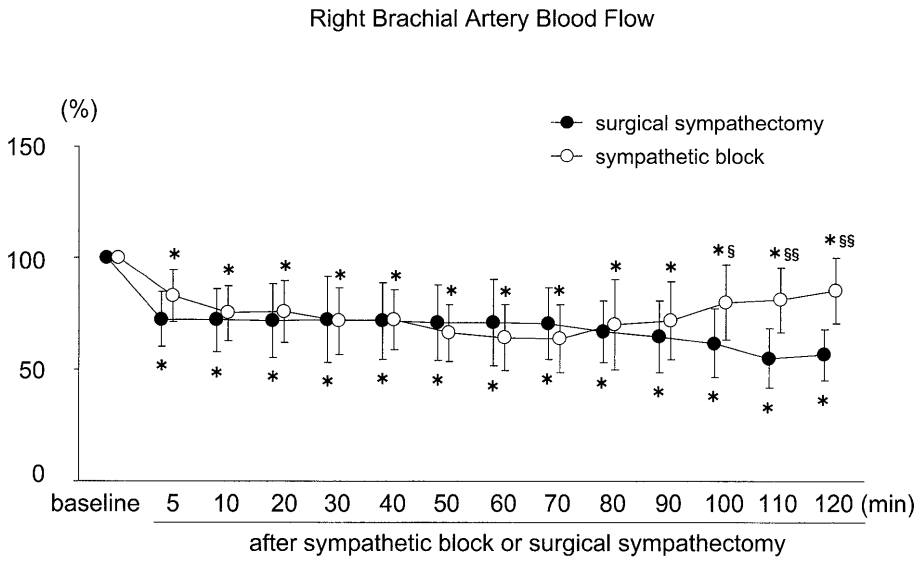

Fig 3. Changes in right brachial artery blood flow before and after cervicothoracic sympathetic block with 1.0 ml of 2.0 % mepivacaine or surgical sympathectomy with radiofrequency thermocoagulation. $^{*}p < 0.01$ vs baseline, $^{\S}p < 0.01$ vs sympathetic block, $^{\S\S}p < 0.05$ vs sympathetic block. Values are shown as mean ± SD.

DISCUSSION

The concentration of local anesthetics affects the duration and intensity of nerve blocks[1]. The anesthetic effect due to a different concentration of local anesthetics has been reported in clinical practice[2~5]. A higher concentration of local anesthetics induces a faster onset and longer duration of action. The concentration of local anesthetics in clinical practice is also determined by the type of nerve fibers to be blocked. A lower concentration of local anesthetics is clinically used for sympathetic block because the postganglionic nerve fibers of the sympathetic nervous system are smaller and unmyelinated. Sensory or motor nerve block requires a higher concentration of local anesthetics because these nerve fibers are larger and myelinated. Moreover, the higher concentration of local anesthetics may induce greater inhibition of sympathetic nerve activity in a concentration-dependent manner[6]. We consider that 2.0 % mepivacaine, which is the highest concentration of mepivacaine in clinical practice, may induce the complete inhibition of sympathetic nerve activity. Therefore, we examined the duration and magnitude of the increase in vasodilation induced by cervicothoracic sympathetic block using 1.0 ml of 2.0 % mepivacaine, and compared these results with those of the complete inhibition of sympathetic nerve activity induced by surgical sympathectomy. In the present study, cervicothoracic sympathetic block using 1.0 ml of 2.0 % mepivacaine induced a significant increase in the blocked side of BABF for 80 min and less duration and magnitude of vasodilative effect compared with surgical sympathectomy in dogs. These results suggest that 2.0 % mepivacaine does not induce the complete inhibition of sympathetic nerve activity.

The dose of local anesthetics also exerts an influence on the duration and intensity of nerve blocks. A larger volume of local anesthetics may increase the duration of action and intensity induced by sympathetic block. We have previously demonstrated that 1.0 ml of local anesthetics inhibited sympathetic nerve activity when applied directly to the ganglion in dog[7~10]. However, 1.0 ml of mepivacaine might be insufficient for the canine cervicothoracic sympathetic block. In this study, a 25-gauge needle was inserted under the thin fascia next to the cervicothoracic sympathetic ganglion. If more than 1.0 ml of mepivacaine was injected through the needle, the local anesthetic often leaked out and the fascia was torn. Therefore, the volume of local anesthetics for canine cervicothoracic sympathetic block was limited to 1.0 ml when used in this experimental model.

Malmqvist et al.[11] suggested that sympathetic block was complete when skin blood flow reached 50 % or more of the baseline value 30 min after the block. In the present study, cervicothoracic sympathetic block with 1.0 ml of 2.0 % mepivacaine induced 80 % of increase of BABF 30 min after the block, and surgical sympathectomy using radiofrequency thermocoagulation increased by approximately 165 % from 30 min after the sympathectomy to the end of the study. We believe that peripheral arterial blood flow may increase approximately 2.5-fold magnitude of the baseline value when sympathetic block is performed almost completely.

Cervicothoracic sympathetic block with a local anesthetic is used to treat and diagnose pain syndromes and peripheral vascular diseases. Surgical cervicothoracic sympathectomy is used for the treatment of these diseases[12], and the most common indication is palmar hyperhidrosis[13,14]. Gofeld and Faclier[12] reported that the radiofrequency electrode must be located as close to the sympathetic ganglion as possible in order to maximize the probability of success. In this study, the tip of the electrode was placed adjacent to the cervicothoracic sympathetic ganglion. The ganglion and sympathetic trunk were then thermocoagulated at 90℃ for 120 sec. In clinical practice radiofrequency thermocoagulation is performed with 90℃ for 120 sec. We used same temperature and duration in this study. The thermocoagulation procedure was considered successful because the blocked side of BABF increased significantly compared with the baseline value during the study in all dogs.

There were no significant differences in MAP and HR after cervicothoracic sympathetic block or surgical sympathectomy. Because left cervicothoracic sympathetic block exerts less influence on hemodynamics compared with the right side of block[15~18], left cervicothoracic sympathetic block or sympathectomy was performed in this study. In the present study, contralateral BABF decreased after cervicothoracic sympathetic block or surgical sympathectomy, probably because of compensatory vasoconstriction.

In conclusion, sympathetic block with 2.0 % mepivacaine induces less increase in both duration and magnitude of peripheral arterial blood flow compared with surgical sympathectomy with radiofrequency thermocoagulation in dogs.

REFERENCES

1) Strichartz GR, Berde CB. : Local anesthetics. in "Miller's Anesthesia. ed by Miller RD. Elsevier Churchill Livingstone, Philadelphia, pp584-585, 2005.
2) Camorcia M, Capogna G, Lyons G, et al. : The relative motor blocking potencies of intrathecal ropivacaine : effects of concentration. Anesth Analg, **98** : 1779-1782, 2004.
3) Ivani G, De Negri P, Lonnqvist PA, et al. : A comparison of three different concentrations of levobupivacaine for caudal block in children. Anesth Analg, **97** : 368-371, 2003.
4) Umbrain VJ, van Gorp VL, Schmedding E, et al. : Ropivacaine 3.75 mg/mL, 5 mg/mL, or 7.5 mg/mL for cervical plexus block during carotid endarterectomy. Reg Anesth Pain Med, **29** : 312-316, 2004.
5) Sakura S, Sumi M, Kushizaki H, et al. : Concentration of lidocaine affects intensity of sensory block during lumbar epidural anesthesia. Anesth Analg, **88** : 123-127, 1999.
6) Morita M, Tezuka M, Kimura Y, et al. : Optimal effective concentration of lidocaine for stellate ganglion block in pigs. The Pain Clinic, **18** : 207-216, 2006.
7) Iwasaki T, Takahashi Y, Kimura Y, et al. : Comparison of 0.25 % levobupivacaine, 0.25 % bupivacaine, and 0.125 % bupivacaine for duration and magnitude of action in peripheral arterial blood flow induced by sympathetic block in dogs. Reg Anesth Pain Med, **32** : 97-101, 2007.
8) Takahashi T, Yamaguchi S, Tezuka M, et al. : Comparison of 0.2 % ropivacaine, 0.125 % bupivacaine, and 0.25 % bupivacaine for duration and magnitude of action in peripheral arterial blood flow induced by sympathetic block in dogs. Reg Anesth Pain Med, **29** : 441-445, 2004.
9) Kimura Y, Hamaguchi S, Okuda Y, et al. : Addition of clonidine increases duration and magnitude of vasodilative effect induced by sympathetic block with mepivacaine in dogs. Reg Anesth Pain Med, **26** : 323-329, 2001.
10) Kitajima T, Okuda Y, Mishio M, et al. : Acute cigarette smoking reduces vasodilative effect induced by sympathetic block in dogs. Reg Anesth Pain Med, **26** : 41-45, 2001.

11) Malmoqvist EL-A, Bengtsson M, Sorensen J. : Efficacy of stellate ganglion block : a clinical study with bupivacaine. Reg Anesth, **17** : 340-347, 1992.
12) Gofeld M, Faclier G. : Bilateral pain relief after unilateral thoracic percutaneous sympathectomy. Can J Anesth, **53** : 258-262, 2006.
13) Wilkinson HA. : Percutaneous radiofrequency upper thoracic sympathectomy. Neurosurgery, **38** : 715-725, 1996.
14) Chuang KS, Liu JC. : Long-term assessment of percutaneous stereotactic thermocoagulation of upper thoracic ganglionectomy and sympathectomy for palmar and craniofacial hyperhidrosis in 1742 cases. Neurosurgery, **51** : 963-969, 2002.
15) Fujiki A, Masuda A, Inoue H. : Effects of unilateral stellate ganglion block on the spectral characteristics of heart rate variability. Jpn Circ J, **63** : 854-858, 1999.
16) Cinca J, Evangelista A, Montoyo J, et al. : Electrophysiologic effects of unilateral right and left stellate ganglion block on the human heart. Am Heart J, **109** : 46-54, 1895.
17) Schlack W, Schäfer S, Thämer V. : Left stellate ganglion block impairs left ventricular function. Anesth Analg, **79** : 1082-1088, 1994.
18) Kashima T, Tanaka H, Minagoe S, et al. : Electrocardiographic changes induced by the stellate ganglion block in normal subjects. J Electrocardio, **14** : 169-174, 1981.