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Effect of Electroacupuncture at SP-6 with Different Durations on Minimum Alveolar Concentration and the Cardiovascular System under Isoflurane Anesthesia in Dogs

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Abstract : The effects of electroacupuncture (EA) at SP-6 with different durations on the minimum alveolar concentration (MAC) and on the cardiovascular system were evaluated in dogs under isoflurane anesthesia. Eight healthy male beagles were randomly assigned to four study groups (n = 5/group) with washout period of 7 days for recovery and anesthetic withdrawal between experiments. Four study groups were control, nonacupoint electrical stimulation (NA), EA for 30 minutes (SP-6) and continuous EA for 70 or 90 minutes (SP-6C). For the nonacupoint electrical stimulation group, needles were inserted into the nonacupoint at the muscle bellies of left triceps brachii and right quadriceps femoris. MAC and cardiovascular parameters were determined after EA at SP-6 acupoint and at nonacupoint. Thirty minutes of EA and continuous EA until re-determination of MAC at SP-6 acupoint lowered the MAC of isoflurane by 21.3±8.0% and 16.1±4.6%, respectively ($p < 0.05$). The decrements in MAC values were not significantly different between two EA groups. However, electrical stimulation of nonacupoint did not induce a significant change in MAC. In SP-6 and SP-6C groups, significant changes in cardiovascular parameters were not observed. These results indicate that EA at SP-6 have an advantage in isoflurane anesthesia in terms of reducing the requirement for anesthetics and minimizing cardiovascular side effects. EA for 30 minutes at maximum might be the sufficient time to produce acupuncture analgesia.

Key words : dog, duration of electroacupuncture, isoflurane, MAC, SP-6

Introduction

Isoflurane was developed in 1965 and approved in the late 1970s in many countries. It has been widely used in veterinary and human practices because of its chemical stability and minimal side effects. However, isoflurane has the known dose-dependent cardiopulmonary side effects, which include dose dependent increase in heart rate, right atrial pressure, expired ventilation, and end-tidal CO_2 tension. On the other hand, isoflurane decreases blood pressure, cardiac output, stroke index, systemic vascular resistance, pH and arterial O_2 tension[14,17].

Reducing the amount of isoflurane required for general anesthesia would minimize its dose-dependent side effects. Quasha *et al.* reviewed the definition and determination of minimum alveolar concentration (MAC) and the factors affecting MAC[20]. MAC corresponds to the 50% effective dose or ED_{50}, required anesthetizing 50% of subjects. Therefore, the relative potency and the amount of inhalant anesthetic required can be expressed as MAC. Several physiological factors could affect the MAC. Lowering the MAC means reducing the dose of each inhalation anesthetics. Analgesics, such as morphine or fentanyl, reduce the MAC of inhalation anesthetics. However, though morphine reduces MAC, it also has cardiopulmonary side effects[16,24]. Doherty *et al* reported that 5-HT antagonist reduced the MAC of halothane in dogs[4], and Seitz *et al* reported that adenosine reduced the MAC of halothane in dogs, and reduced mean arterial pressure[22].

It was found that the MAC of halothane was reduced by electroacupuncture (EA) at the SP-6 acupoint in dogs[27]. Wright and McGrath suggested that additional acupuncture anesthesia could be beneficial for conventional surgical anesthesia, by reducing anesthetic requirements[30]. If the new MAC produced after EA treatment is less than the original MAC, then acupuncture would be implied to produce analgesia or anesthesia[9].

Over the past two decades, many studies upon acupuncture analgesia have been performed, and there have been many suggested mechanisms of acupuncture analgesia, which include trigger point theory, the gate control theory and the modulation of several neurotransmitters[7,15,25,28].

EA at ST-36 and GB-34 induced effective analgesia for an abdominal midline incision with a success rate of 89%[30], and Nam and Seo reported upon local and general anesthetic effects of EA at several acupoints located in the head, neck, trunk and extremities, and upon the combined use of EA and sedatives[18]. Kim *et al* reported that EA at SP-4, SP-6, TH-8 and *Quiang-feng* produced general anesthesia in dogs[8]. Transcutaneous electrical nerve stimulation (TENS) with dens-and-disperse mode of 2/100 Hz at ST-36 reduced opioid analgesic requirements in human patients[2]. In addition, in human patients, many surgical procedures have been performed under acupuncture anesthesia[3,10,29]. Most of EA protocols represents that duration of stimulation should last a mini-

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mum of 18 to 20 minutes[9].

We considered that if EA produced analgesia, this should be reflected in a reduced dose of anesthetics. Moreover, lowering the anesthetic requirement would minimize dose-dependent side effects. The effect of EA on reducing the MAC of isoflurane in dogs has not been previously examined. This study was performed to compare the effects of EA with different durations at SP-6 on MAC and on the cardiovascular system under isoflurane anesthesia in dogs.

Materials and Methods

Experimental animals

Eight healthy male beagles (19 month-old, Jungang Lab Animal Co Seoul, Korea) were used for the study. Their mean body weight was 8.9 kg (7.6-10.5 kg). Dogs were assigned randomly to four study groups (n = 5/group) with 7 days of washout period at least for recovery with anesthetic withdrawal between experiments. Food was withheld for 12 hours before each experiment.

The experimental groups were the control, nonacupoint electrical stimulation (NA) and two EA groups at SP-6 acupoint with different duration of stimulation: for 30 minutes (SP-6), and continuous stimulation for 70 or 90 minutes until re-determination of MAC (SP-6C).

Isoflurane anesthesia

An open circle anesthetic system (Anesthesia Apparatus FO-20S, Acoma Medical Industry Co, Tokyo, Japan), with a Tec-type vaporizer for isoflurane (Acoma Vaporizer 1 MK-, Acoma Medical Industry Co), out of circle, was used for this study. Anesthesia was induced with 4% isoflurane (Isoflurane®, Rhodia, Bristol, UK) in oxygen, at a flow rate of 3 L/min via a facemask without any preanesthetics. After the induction of anesthesia, an endotracheal tube was inserted and the dog was placed in the right lateral recumbency. General anesthesia was maintained for one hour at least with 2% of isoflurane in oxygen at a flow rate of 100 ml/kg/min. Lactated Ringers solution was administered intravenously at a rate of 10 ml/kg/h. During the experiment the pulmonary arterial temperature was maintained at 38 ± 0.5°C using a circulating warm water pad and a water blanket.

Electrical stimulus

SP-6 acupoint is located on the medial aspect of the hindlimb, caudal to the tibial bone, three-sixteenth the distance from the medial malleolus of the tibia to the stifle joint. For the EA treatment, stainless steel needles (32 gauge, 30 mm long, Haeng Lim Seo Won, Seoul, Korea) were inserted at SP-6 acupoint bilaterally. An electrical stimulus was applied at 2-4 V and 20 Hz for 30 minutes (group SP-6) using an electrical stimulator (Pulse Stimulator AM 3000, Tokyo Electronic Co, Tokyo, Japan). In SP-6C group, electrical stimulus was applied continuously at the same condition until re-determination of MAC.

Minimum alveolar concentration (MAC)

The end-tidal concentration of isoflurane was measured by gas analysis and spirometry module (M-CaiOV, Datex-Ohmeda, Helsinki, Finland) of the anesthetic patient monitoring system (S-3, Datex-Ohmeda). MAC determinations were made according to the technique described by Eger *et al*[5]. The base of the dogs tail was shaved, and at least one hour after the induction of anesthesia for stabilization, catheterizations were performed into femoral artery and jugular vein. The end-tidal concentration of isoflurane was lowered to 1.5% after catheterization and this was maintained for 30 minutes at least. Noxious stimulation to determine MAC was performed using a tail-clamping technique with a hemostatic forceps. The tail was clamped with hemostatic forceps until the ratchet caught, and was then shaken continuously for one minute or until a purposeful movement was elicited from the dog. MAC was determined as the concentration midway between the end-tidal concentrations at which the animal would or would not respond to the noxious stimulus. MAC was determined to the closest 0.1% end-tidal isoflurane concentration, which was maintained for at least 15 minutes.

Baseline MAC was determined twice in each group and the mean value was taken. After EA for 30 minutes, MAC was re-determined. In SP-6C group, re-determination of MAC was initiated after 30 minutes of EA, but during the course of MAC determination, electrical stimulation was continued. For the NA group, needles were inserted into the nonacupoint at the muscle bellies of left triceps brachii and right quadriceps femoris. For the control group no treatment was applied for the 30-minute electrical stimulation period. The MAC value after EA treatment was compared to the mean baseline MAC value.

Cardiovascular measurements

Cardiovascular parameters were measured before the 1st MAC was determined (B1.5), and after the determination of the 1st MAC (M1), and the 2nd MAC (M2), and after electro-acupuncture (A1.5) and after the determination of the post-EA MAC (AM).

Heart rate (HR) and electrocardiogram (ECG) recordings were taken using the anesthetic patient monitoring system. Systolic (SAP) and diastolic blood pressures (DAP) were measured at the femoral artery. Right atrial pressure (RAP) and pulmonary arterial pressure (PAP) were measured through a thermodilution catheter (Swan Ganz, 93-132-5F, Baxter Healthcare Co, Santa Ana, USA). Cardiac output (CO) was determined using the thermodilution technique with an injection of cold saline through the same catheter. Cardiac output was determined in triplicate at least and mean values were used as data. From the above data, the following cardiovascular variables were calculated: cardiac index (CI) = CO/body weight (ml/min/kg) and systemic vascular resistance (SVR) = (MAP RAP)/CO X 79.9 (dyness/cm^5).

To measure the cardiovascular parameters, instrumentation was positioned 60 minutes after the induction of anesthesia. A 20G, 4 cm over the needle catheter (D&B-Cath®, Sin Dong Bang Medical Co, Seoul, Korea) was inserted into the femoral artery and connected to a calibrated pressure transducer (TranStar® Single Monitoring Kit, MX9504, A Furon Company, Hilliard, USA). A 6-F, 10 cm introducer (Percutaneous Sheath Introducer Set, SI-09600, Arrow International Inc, Reading, USA) was placed by a percutaneous puncture into the left jugular vein, and a 5-F, 75 cm flow-directed thermodilution catheter (Swan Ganz, 93-132-5F) was then advanced through the introducer into the jugular vein. The distal end of the catheter was positioned in the pulmonary artery and at the proximal port in the right atrium. Correct catheter placement was verified by connecting the catheter to pressure transducers and observing the characteristic pressure waveforms on an anesthetic patient monitoring system (S-3, Datex-Ohmeda).

Statistical analysis

Statistical analyses of MAC and cardiopulmonary variables were performed using the SPSS 8.0 statistical analysis program.

To compare the baseline MAC and the post-EA MAC of each group, Wilcoxons signed rank test was used. For comparison of MAC decrements among groups the Kruskal-Wallis test was used. When a difference was found significant ($p < 0.05$) among groups, the Mann-Whitney U test, which is a nonparametric *t*-test for independent variables, was also performed (= 0.05).

Because of the non-Gaussian distribution of the cardiovascular variables, Friedmans test, which is a nonparametric ANOVA for repeated measures, was used to compare variables (B1.5, M1, M2, A1.5 and AM) within groups. When a difference was found to be significant between variables ($p < 0.05$), multiple comparisons were done using the Wilcoxons signed rank test. Differences in cardiovascular variables among groups were analyzed using the Kruskal-Wallis test, and when a difference was significant ($p < 0.05$) between groups, the Mann-Whitney U test was used for the multiple comparisons (= 0.05).

Results

Minimum alveolar concentration (MAC)

Thirty minute (group SP-6) and continuous (group SP-6C) EA at SP-6 acupoints significantly lowered the MACs of isoflurane ($p < 0.05$). However, the decrement of MAC between two EA groups was not significantly different. Decrements of MAC (%) in the EA groups were significantly different from those in controls or in the NA group (Table 1).

Cardiovascular system

No significant differences within or between groups were found in terms of heart rate (HR), systolic arterial pressure (SAP), diastolic arterial pressure (DAP), right atrial pressure (RAP), pulmonary arterial pressure (PAP), cardiac index (CI) and systemic vascular resistance (PVR) (Tables 2-8).

Table 1. Effect of electroacupuncture on minimum alveolar concentration (MAC) of isoflurane in dogs (n = 5/group)

Group		MAC		
		Baseline	Post treatment	Decrement (%)
Control		1.31 ± 0.06	1.27 ± 0.08	3.1 ± 4.2
NA[1]		1.21 ± 0.11	1.14 ± 0.16	5.9 ± 3.9
EA	SP-6[2]	1.28 ± 0.13	1.01 ± 0.19*	21.3 ± 8.0[a,b]
	SP-6C[3]	1.25 ± 0.05	1.05 ± 0.10*	16.1 ± 4.6[ab]

Data are expressed as mean ± SD (n = 5). *significantly different from baseline MAC; Wilcoxon's signed rank test ($p < 0.05$), [a]significantly different from control group, [b]significantly different from nonacupoint electrical stimulation group; Mann-Whitney U test ($p < 0.05$), [1]nonacupoint electrical stimulation group, [2]electroacupuncture with 2-4 V and 20 Hz for 30 minutes, [3]continuous electroacupuncture with 2-4 V and 20 Hz until re-determination of MAC, it took for 70-90 minutes.

Table 2. Effect of electroacupuncture on heart rate (HR) under isoflurane anesthesia in dogs

Group		HR (bpm)				
		B1.5[a]	M1[b]	M2[c]	A1.5[d]	AM[e]
Control		170 ± 22	170 ± 26	157 ± 21	158 ± 24	156 ± 20
NA		160 ± 15	153 ± 18	148 ± 24	155 ± 26	147 ± 17
EA	SP-6	148 ± 32	151 ± 22	158 ± 22	150 ± 25	160 ± 20
	SP-6C	149 ± 7	147 ± 32	154 ± 7	155 ± 15	148 ± 9

Data are expressed as mean SD (n = 5). [a]before determination of 1st MAC, [b]after determination of 1st MAC, [c]after determination of 2nd MAC, [d]after electroacupuncture, [e]after determination of post-EA MAC.

Table 3. Effect of electroacupuncture on systolic arterial pressure (SAP) under isoflurane anesthesia in dogs

Group		SAP (mmHg)				
		B1.5	M1	M2	A1.5	AM
Control		152±16	150±19	146±23	143±23	152±22
NA		136±15	137±14	150±15	141±6	148±17
EA	SP-6	161±22	155±18	167±17	146±14	160±20
	SP-6C	143±9	143±1	144±1	139±7	155±8

Data are expressed as mean± SD.

Table 4. Effect of electroacupuncture on diastolic arterial pressure (DAP) under isoflurane anesthesia in dogs

Group		DAP (mmHg)				
		B1.5	M1	M2	A1.5	AM
Control		79±13	83±23	89±27	87±24	83±13
NA		73±15	75±13	81±13	80±19	81±13
EA	SP-6	86±9	80±6	84±9	80±11	83±15
	SP-6C	80±12	76±7	79±11	86±12	79±19

Data are expressed as mean± SD (n = 5).

Table 5. Effect of electroacupuncture on right atrial pressure (RAP) under isoflurane anesthesia in dogs

Group		RAP (mmHg)				
		B1.5	M1	M2	A1.5	AM
Control		0.2±1.1	0±0.7	0.2±0.8	0±1.0	0±1.0
NA		0.6±0.5	-0.2±1.8	1.4±0.9	0.4±2.3	0.8±1.6
EA	SP-6	1.2±1.3	1.4±1.3	0.8±1.1	0.4±1.3	1.2±1.3
	SP-6C	2.0±1.0	0.7±0.6	2.0±1.0	1.7±1.5	1.0±1.7

Data are expressed as mean± SD.

Table 6. Effect of electroacupuncture on pulmonary arterial pressure (PAP) under isoflurane anesthesia in dogs

Group		PAP (mmHg)				
		B1.5	M1	M2	A1.5	AM
Control		16.8±5.3	16.8±3.8	15.8±3.0	15.0±3.4	15.4±3.5
NA		15.2±1.5	14.2±1.6	15.0±0	13.8±0.8	15.2±1.1
EA	SP-6	18.4±4.0	18.4±3.8	17.4±3.5	16.8±2.6	16.8±3.6
	SP-6C	16.3±0.6	15.7±1.5	16.0±1.7	15.3±0.6	14.7±0.6

Data are expressed as mean± SD.

Table 7. Effect of electroacupuncture on cardiac index (CI) under isoflurane anesthesia in dogs

Group		CI (ml/kg/min)				
		B1.5	M1	M2	A1.5	AM
Control		395±136	421±135	376±110	360±108	376±87
NA		371±75	362±57	363±46	361±58	360±36
EA	SP-6	322±56	313±36	353±105	339±87	276±45
	SP-6C	327±25	391±43	399±48	386±58	378±45

Data are expressed as mean± SD (n = 5).

Discussion

Minimum alveolar concentration (MAC) has units of percentage per atmosphere, and therefore, is an alveolar anesthetic partial pressure. MAC should represent the anesthetic partial pressure at the brain, the site of action. An end-tidal

Table 8. Effect of electroacupuncture on systemic vascular resistance (SVR) under isoflurane anesthesia in dogs

Group		SVR (dyness/cm^5)				
		B1.5	M1	M2	A1.5	AM
Control		2622±714	2455±570	2729±316	2799±332	2677±325
NA		2284±373	2427±540	2562±494	2505±421	2543±230
EA	SP-6	3021±618	2888±383	2706±725	2696±596	3338±681
	SP-6C	2556±233	2124±107	2119±413	2244±260	2338±436

Data are expressed as mean± SD.

anesthetic concentration is held at a constant level for at least 15 minutes in an attempt to reach equilibrium between the alveolar gas (end-tidal), the arterial blood and brain. The determination of MAC has three basic components: the applied noxious stimulus, a defined response and the measurement of end-tidal anesthetic concentration[20].

A number of studies have been performed to determine whether the MAC may be affected by certain conditions, such as the duration of anesthesia, sex, age, $PaCO_2$, PaO_2, pH, blood pressure, body temperature, sedatives, or neurotransmitters[5,20]. In the present study, most of the conditions that might affect the MAC were controlled.

In the present study, EA at SP-6 lowered the MAC of isoflurane by about 20% in dogs. This result was similar to that of a report, which described the effect of EA at SP-6 during halothane anesthesia in dogs[27].

EA reduced the MAC of halothane in dogs[27]. Tay *et al* investigated the mechanism of EA in terms of reducing the MAC of halothane[26], and found that a MAC decreased by high frequency (200 Hz) EA was not reversed by naloxone, an endorphin antagonist. However, the analgesic effect of high frequency EA was partially blocked by serotonin synthesis inhibitor[1].

In the present study, EA was performed at intermediate frequency (20 Hz), and was found to lower the MAC of isoflurane in dogs. Fei *et al* reported differences in the production of endorphins following EA at different frequencies[6]. Methionine enkephalin concentrations increased after EA at low (2 Hz) and intermediate (15 Hz) frequencies. After EA at high frequency dynorphin levels increased but enkephalin levels were unaltered. Enkephalin is released from periaqueductal gray (PAG) and activates the raphe descending inhibitory system, which blocks pain transmission of spinal cord by releasing monoamines, such as 5-HT and norepinephrine (NE), thereby causes analgesia[9].

There are several reports dealing with the role of stimulation period and acupuncture analgesia. In the rat, about 10 minutes of EA stimulation raised cerebral endorphins significantly, and this elevation outlasted the stimulation by 20 minutes[12]. Continuous EA at ST-36 and SP-6 acupoints revealed a gradual fading of a analgesic response during 6 hours in rats. This might be caused by the development of tolerance to acupuncture analgesia[21]. Ulett *et al* reported that the peak pain threshold was achieved at 20-40 minutes of EA stimulation during the 50 minutes of EA at LI-4 in man, then decreased gradually and returned to preacupuncture level 45 minutes after removal of needles[28]. In the present study, the decrement of MAC was not significantly different between two EA groups with different stimulation period. However, the decrement of MAC in SP-6C group (continuous EA until re-determination of MAC) was slightly lower than that in SP-6 group (30 minutes of EA) and this might be caused by the early stage of tolerance to acupuncture analgesia.

Philbin and Lowenstein reported that the cardiovascular changes observed after isoflurane anesthesia were caused by the beta-adrenergic stimulation[19].

In the present study, EA at SP-6 did not produce significant changes in the cardiovascular system. Tseng *et al* reported similar results that EA at SP-6 did not alter heart rate and blood pressure under halothane anesthesia in dogs[27].

However, there are some reports that EA at ST-36 lowers blood pressure in dogs with different mechanisms[11,13]. Li *et al* reported that inhibiting the sympathetic vascular tone by EA at ST-36 lowered blood pressure without changing the heart rate[13], whereas Lee *et al* reported that decreased cardiac output was the major role of decreasing the blood pressure, and it was caused by decreased stroke volume mediated by increased parasympathetic input[11].

EA at SP-6 offer an advantage in isoflurane anesthesia by reducing isoflurane requirements without associated cardiopulmonary side effects. Moreover, EA for 30 minutes at maximum might be sufficient to produce acupuncture analgesia.

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References

1. Cheng RSS, Pomeranz B. Electroacupuncture analgesia could be mediated by at least two pain-relieving mechanisms: Endorphin and non-endorphin system. Life Sci 1979; 25: 1957-1962.
2. Chen L, Tang J, White PF, Sloninsky A, Wender RH, Naruse R, Kariger R. The effect of location of transcutaneous electrical nerve stimulation on postoperative opioid

analgesic requirement: Acupoint versus nonacupoint stimulation. Anesth Analg 1998; 87: 1129-1134.
3. Chen P, Chen Y. Clinical approaches to improvement of appendectomy effects under acupuncture anesthesia. Zhen Ci Yan Jiu 1990; 15: 167-169.
4. Doherty TJ, McDonell WN, Dyson DH, Black WD, Valliant AE. The effect of a 5-hydroxytryptamine antagonist (R51703) on halothane MAC in the dog. J Vet Pharmacol Therap 1995; 18: 153-155.
5. Eger EI II, Saidman LJ, Brandstater B. Minmum alveolar anesthetic concentration: A standard of anesthetic potency. Anesthesiology 1965; 26: 756-763.
6. Fei H, Xie GX, Han JS. Differential release of met-enkephalin and dynorphin in spinal cord by electroacupuncture of differential frequencies. Kexue Tongbo 1986; 31: 1512-1515.
7. Han JH, Terenius L. Neurochemical basis of acupuncture analgesia. Ann Rev Pharmacol Toxicol 1982; 22: 193-220.
8. Kim DH, Jo HY, Shen HQ, Cho SW, Lee SH, Lee SO, Kim IB, Kwon GO, Nam TC. Studies on canine electro-acupuncture anesthesia 1. Investigation on the effect of acupoints of the limbs. Kor J Vet Clin Med 1998; 15: 404-409.
9. Klide AM, Gaynor JS. Acupuncture for surgical analgesia and postoperative analgesia. In: Veterinary acupuncture: Ancient art to modern medicine, 2nd ed. Philadelphia: Mosby. 2001: 295-302.
10. Kuang X, Su Y, Guo H. Study on combined acupunctural and general anesthesia in pneumonectomy. Zhongguo Zhong Xi Yi Jie He Za Zhi 1996; 16: 84-86.
11. Lee DC, Lee MO, Clifford DH, Morris LE. The autonomic effects of acupuncture and analgesic drugs on the cardio-vascular system. Am J Acupunct 1982; 10: 5-30.
12. Liang XN, Zhang WQ, Tang J, Han JS. Individual variation of acupuncture analgesia in rats in relation to 5-HT and endogenous opiate-like substances in the brain. Nat Med J China 1981; 61: 345-349.
13. Li P, Sun FY, Zhang AZ. The effect of acupuncture on blood pressure: the interrelation of sympathetic activity and endogenous opioid peptides. Acupunct Electrother Res 1983; 8: 45-56.
14. McMurphy RM, Hodgson DS, Bruyette DS, Fingland, RB. Cardiovascular effects of 1.0, 1,5, and 2.0 minimum alveolar concentrations of isoflurane in experimentally induced hypothyroidism in dogs. Vet Surg 1996; 25: 171-178.
15. Melzack R, Wall PD. Pain mechanisms: a new theory. Science 1965; 150: 971.
16. Murphy MR, Hug CC Jr. The anesthetic potency of fentanyl in terms of its reduction of enflurane MAC. Anesthesiology 1982; 57: 485-488.
17. Mutoh T, Nishimura R, Kim HY, Matsunaga S, Sasaki N. Cardiopulmonary effects of sevoflurane, compared with halothane, enflurane, and isoflurane, in dogs. Am J Vet Res 1997; 58: 885-890.
18. Nam TC, Seo KM. Induction of local and general analgesia by electroacupuncture in dogs. Kor J Vet Clin Med 1997; 14: 244-253.
19. Philbin DM, Lowenstein E. Hemodynamic consequences of the combination of isoflurane anesthesia (1 MAC) and beta-adrenergic blockade in the dog. Anesthesiology 1975; 42: 567-573.
20. Quasha AL, Eger EI II, Tinker JH. Determination and applications of MAC. Anesthesiology 1980; 53: 315-334.
21. Ren MF, Han JS. Rat tail flick acupuncture analgesia model. Chin Med J 1979; 92: 576-582.
22. Seitz PA, Riet M, Rush W, Merrell J. Adenosine decreases the minimum alveolar concentration of halothane in dogs. Anesthesiology 1990; 73: 990-994.
23. Steffey EP. Inhalation anesthetics. In: Lumb and Jones Veterinary Anesthesia, 3rd ed. Baltimore: Williams & Wilkins. 1996: 297-329.
24. Steffey EP, Baggot JD, Eisele JH, Willits N, Woliner MJ, Jarvis KA, Elliott AR, Tagawa M. Morphine-isoflurane interaction in dogs, swine and Rhesus monkeys. J Vet Pharmacol Therap 1994; 17: 202-210.
25. Steiss JE. The neurophysiologic basis of acupuncture. In: Veterinary acupuncture: Ancient art to modern medicine, 2nd ed. Philadelphia: Mosby. 2001: 27-46.
26. Tay AL, Tseng C, Pace NL, Wong KC, Hong-Goka BC. Failure of narcotic antagonist to alter electroacupuncture modification of halothane anesthesia in the dog. Can Anaesth Soc J 1982; 29: 231-235.
27. Tseng CK, Tay AL, Pace NL, Westenskow DR, Wong KC. Electro-acupuncture modification of halothane anesthesia in the dog. Canad Anaesth Soc J 1981; 28: 125-128.
28. Ulett GA, Han S, Han JS. Electroacupuncture: Mechanisms and clinical application. Biol Psychiatry 1998; 44: 129-138.
29. Wang K, Wang S, Li Z. A Clinical observation for the posterior atlanto-axial arthrodesis under acupuncture anesthesia. Zhen Ci Yan Jiu 1996; 21: 8-10.
30. Wright M, McGrath CJ. Physiologic and analgesic effects of acupuncture in the dog. J Am Vet Med Assoc 1981; 178: 502-507.

개에서 Isoflurane 마취시 SP-6 혈위의 전침자극시간이 최소폐포농도 및 심맥관계에 미치는 영향

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초 록 : 본 연구에서는 개에서 전침술이 isoflurane 마취시의 MAC 및 심맥관계에 미치는 영향 및 전침처치시간에 따른 차이에 대하여 조사하였다. 임상적으로 건강한 19개월령, 수컷 비글견 8두를 사용하였다. 대조군, 비혈위 전기자극군, 30분간 전침군(SP-6) 및 연속 전침군(SP-6C)으로 나누어 군 당 5두씩 무작위로 최소 7일간의 휴약기를 두며 실험에 사용하였다. 전침처치는 SP-6 혈위에 2-4 V, 20 Hz로 30분간(SP-6) 또는 MAC의 측정이 끝날 때 까지 연속적으로(SP-6C) 실시하였다. SP-6C군에서의 전침자극시간은 70-90분이었다. Isoflurane으로 마취를 유도한 후 전침을 실시하고 MAC와 cardiovascular parameters를 측정 하였다. 전침 후 MAC는 SP-6 및 SP-6C 군에서 각각 21.3±8.0% 및 16.1±4.6% 씩 유의적으로 저하되었으나($p<0.05$) 전침시간에 따른 유의성은 없었다. 그러나 대조군과 비혈위 전기자극군에 비해서는 유의적으로 저하되었다($p<0.05$). 전침처치 후 심맥관계에는 유의성 있는 변화가 인정되지 않았다. 이상의 결과로 보아, SP-6혈위에 대한 전침은 개에서 심맥관계의 부작용을 최소화하면서isoflurane의 MAC을 유의성 있게 감소시켰으며, 이러한 효과는 30분간의 전침자극으로 충분하다고 사료된다.

주요어 : 개, 전침자극시간, 아이소플루란, 최소폐포농도, 삼음교