NOTE *Surgery*

Effect of Electroacupuncture on Minimum Alveolar Concentration of Isoflurane in Dogs

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ABSTRACT. The effect of electroacupuncture (EA) on minimum alveolar concentration (MAC) of isoflurane was evaluated in dogs. After determination of baseline MAC, EA was applied at each acupoints (LI-4, SP-6, ST-36 and TH-8) and nonacupoint for 30 min. MAC was determined again. EA at acupoints significantly lowered the MAC of isoflurane in dogs (17.5 ± 3.1%, 21.3 ± 8.0%, 21.2 ± 7.5% and 15.4 ± 3.1%, respectively). In control group and nonacupoint electrical stimulation group MAC were not decreased significantly. From these results, electroacupuncture at each acupoints used in the present study would have an advantage in isoflurane anesthe sia with reducing its requirement.

KEY WORDS: canine, electroacupuncture, minimum alveolar concentration.

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Acupuncture has been used for thousands of years for practice and analgesia. Kim *et al.* reported that electroacupuncture (EA) produced general anesthesia in dogs [5]. Nam and Seo reported upon local and general anesthetic effect of EA and upon the combined use of EA and sedatives [9]. Wright and McGrath suggested that additional acupuncture anesthesia could be beneficial for conventional surgical anesthesia with reducing anesthetic requirements [17]. Minimum alveolar concentration (MAC) of halothane was reduced with EA at SP-6 acupoint in dogs [13]. In human patients, many surgical procedures were performed under acupuncture anesthesia [2, 15, 16].

This study was performed to investigate the effects of electroacupuncture at several acupoints on MAC of isoflurane anesthesia in dogs.

Nineteen-month old eight healthy male beagles (Jungang Lab Animal Co., Seoul, Korea) were used. Their mean body weight was 8.9 kg (7.6–10.5 kg). This study was conducted under the guidelines of the College of Veterinary Medicine, Seoul National University.

Dogs were assigned randomly to six study groups (n=5). Six groups were control, nonacupoint electrical stimulation and four electroacupuncture groups at each acupoint (LI-4, SP-6, ST-36 and TH-8).

Food was withheld for 12 hr before each experiment. 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-III, Acoma Medical Industry Co.), out of circle, was used for this study. Anesthesia was induced with 4% isoflurane (Isoflurane®, Rhodia, Bristol, UK) in oxygen *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. Lactated Ringer's solution was administered intravenously at a rate of 10 m*l*/kg/hr. Body temperature was maintained 38 ± 0.5°C using a circulating warm water pad and a water blanket during each study. Two per cent of isoflurane in oxygen was delivered *via* the endotracheal tube at least 60 min. Following this stabilization period, end-tidal concentration of isoflurane was maintained at 1.5% for 20 min at least.

Determination of baseline MAC was initiated at 1.5% isoflurane and was duplicated following the method of Eger *et al.* [4]. 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 min. End-tidal concentration of isoflurane was monitored continuously using the gas analysis module (M-CaiOV, Datex-Ohmeda, Helsinki, Finland) connected to the anesthetic patient monitoring system (S-3, Datex-Ohmeda). For EA treatment group, stainless steel needles (32 gauge, 30 mm long, Haeng Lim Seo Won, Seoul, Korea) were inserted at each acupoint bilaterally. Electrical stimulus was applied at 2 to 4 volts and 20 Hz for 30 min using electrical stimulator (Pulse Stimulator AM 3000, Tokyo Electrical Co., Tokyo, Japan). After electroacupuncture, MAC was redetermined. For nonacupoint electrical stimulation group, needles were inserted into the nonacupoint at the muscle bellies of left triceps brachii and right quadriceps femoris muscles. For control group, no treatment was applied for 30 min of electrical stimulation period. The MAC value after

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

Group		MAC		
		Baseline	Post treatment	Decrement (%)
Control		1.28 ± 0.07	1.25 ± 0.07	2.2 ± 5.3
	LI-4[b)]	1.32 ± 0.12	1.09 ± 0.11[a)]	17.5 ± 3.1
	SP-6[c)]	1.28 ± 0.13	1.01 ± 0.19[a)]	21.3 ± 8.0
EA	ST-36[d)]	1.31 ± 0.09	1.04 ± 0.16[a)]	21.2 ± 7.5
	TH-8[e)]	1.31 ± 0.07	1.11 ± 0.09[a)]	15.4 ± 3.1
Nonacupoint		1.21 ± 0.11	1.14 ± 0.16	5.9 ± 3.9

a) Significantly different from baseline MAC; $p<0.05$ (two tail paired t-test), b) Between the first and second metacarpal bones, at the level of the head of the first metacarpus, c) 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, d) Three-sixteenth the distance from the depression on the ventral margin of the patella to cranial tarsus, about one digit breadth lateral to the tibial crest, in the lateral portion of the cranial tibial muscle, e) Interosseous space between ulnar and radius, at the level of one-third the distance from styloid process to olecranon of the ulnar, between the common digital extensor muscle and the origin of abductor pollicis longus muscle.

treatment was compared to the baseline MAC value.

Changes in MAC in each group were evaluated by paired *t* test.

Electroacupuncture at LI-4, SP-6, ST-36 and TH-8 acupoints significantly lowered the MAC of isoflurane ($p<0.0005$, $p<0.002$, $p<0.003$ and $p<0.0003$, respectively). In control group and nonacupoint electrical stimulation group, MACs were not decreased significantly.

Electroacupuncture at each acupoint lowered MAC of isoflurane approximately 20% in dogs and among EA groups the decrement in MAC value was not significantly different. EA induced decrease in MAC of isoflurane in this study is similar to that of previous report, which describes the effect of EA at SP-6 during halothane anesthesia [13]. But there is no report on the acupoint that decreases or increases the MAC of isoflurane. Anesthetic effects of several acupoints were investigated. These acupoints were GV-5, GV-20, GB-34, SP-4, SP-6, ST-36, TH-8, TH-13 and others [1, 5, 9, 13]. Chen *et al*. compared the analgesic effect of transcutaneous electrical nerve stimulation (TENS) at acupoint and nonacupoint. More postoperative opioid analgesic was required after TENS at nonacupoint than that at acupoint [1]. This was the similar result to that of present study. Ulett *et al*. reported that during the course of 50 min of manual acupuncture in man, the peak pain threshold was occurred 20–40 min after needle insertion and the threshold returned preacupuncture level 45 min after the needles were removed. This result confirmed the analgesic effect of acupuncture [14]. In the present study, 30 min after EA treatment re-determination of MAC was initiated and it took for 40–60 min usually.

Eger *et al*. examined the differences in MAC using several kinds of noxious stimulation. The variations in MAC decreased as the intensity of stimulation increased. The tail clamping or electrical stimulation with 50 V was reasonable, whereas paw clamping, skin incision, or low volts electrical stimulations were not preferable [4]. In the present study, noxious stimuli were applied at the tail base using hemostatic forceps. Moreover, the acupoints used in the present study were LI-4, SP-6, ST-36 and TH-8, and medial branch of radial nerve, saphenus nerve, peroneal nerve and radial nerve were innervated around these acupoints, respectively [10]. During the course of EA, there was no evidence of peripheral nerve paralysis around acupoint.

Isoflurane was produced in 1965 and approved in late 1970's in many countries. It has been widely used in veterinary and human practice ever since because of its chemical stability and minimal side effects [3, 12]. MAC of isoflurane in the dog is 1.3%. At 1 MAC surgical anesthesia cannot be obtained. For the surgical plane of anesthesia, 1.5 MAC is required [12]. Mutoh *et al*. reported that at 1.5 MAC of isoflurane, mean arterial pressure, systemic vascular resistance, arterial blood oxygen partial pressure (PaO_2) and pH were decreased, but heart rate, respiratory rate and arterial blood carbon dioxide partial pressure ($PaCO_2$) were increased [8]. Decreased anesthetic requirements would reduce the dose dependent side effects on cardiopulmonary system. However, acupuncture has been used also for the treatment of several cardiovascular disorders [11]. Lee *et al*. and Li *et al*. reported that EA at ST-36 reduced the blood pressure in dogs [6, 7]. Additional experiment should be performed about the effect of EA on MAC and cardiovascular system under isoflurane anesthesia in dogs.

In the present study, lowering the MAC of isoflurane was observed after 30 min of EA treatment at each acupoint. However, many investigators have used two or more acupoints simultaneously for acupuncture anesthesia. Further studies should be undertaken upon the effects of EA at two or more acupoints simultaneously on the MAC of isoflurane.

From the result of the present study, electroacupuncture

offer an advantage in isoflurane anesthesia by reducing isoflurane requirements.

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