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Analgesic Effects on the Oral Cavity by Electroacupuncture in Dogs

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Abstract : The purpose of this study is to evaluate the analgesic effects on the oral cavity in dogs which are treated with xylazine and electroacupuncture (EA). Furthermore, this study aims to find out its effects on glucose (GLU), serum alanine aminotransferase (ALT), and blood urea nitrogen (BUN) variation values, vital signs (rectal temperature, heart rate, respiratory rate) and pain responses to the noxious stimuli. Eight healthy dogs were randomly assigned to receive either xylazine or EA. Xylazine group dogs with weight of 3.6 ± 1.0 kg received 1.5 mg/kg of xylazine intramuscularly. EA group dogs with weight of 3.9 ± 1.0 kg received 1 volt (10-15 hz) for 5 minutes, and then 1-9 Volts (25-30 hz) for 60 minutes totally. The acupoints used were LI-3 (San Jian), LI-4 (He Gu) and ST-7 (Xia Guan). All dogs were examined before and 10, 25, 40, 55 and 120 minutes after administration of xylazine or EA. The mean rectal temperatures of the EA group were significantly higher than those of xylazine group after 25, 40 and 55 minutes ($p < 0.05$). The mean heart rates of the EA group were significantly higher than those of xylazine group after 10, 25, 40 and 55 minutes ($p < 0.05$). The mean respiratory rates of the EA group were significantly higher than those of xylazine group after 55 and 120 minutes ($p < 0.05$). The mean GLU concentration of the EA group were significantly lower than those of xylazine group after 55 and 120 minutes ($p < 0.05$). The sum of mean pain scores (SMPS) of the EA group were significantly higher than those of xylazine group after 10, 25 40 and 55 minutes ($p < 0.05$). In this study, the pain control of the EA group was shown to be better than that of the xylazine group. Also, there do not appear to be any negative physiologic effects associated with acupuncture-induced surgical analgesia. So, it was considered that these acupoints of EA analgesia might be useful for minor oral surgery in weak patients.

Key words **:** analgesia, electroacupuncture, dog, xylazine.

Introduction

Generally, anesthesia is a reversible process in which the conscious, sensual, motional and self-reflex functions are reduced, lost, or altered simultaneously. At the same time, the anesthetized patient neither perceives nor recalls the noxious or painful stimuli. However, various injectable or inhalant anesthetics have produced side effects such as respiratory depression, decreased blood pressure, and cardiac output. Therefore, inhalants or injectable anesthesia may be needed to use carefully on weakly and geriatric patients with heart, kidney, or liver failure. In response to this, acupuncture analgesia may become a substitute which is used in traditional veterinary medicine.

Acupuncture therapy has been used for thousands of years in various disorders (3). However, the use of acupuncture to induce anesthesia was developed in China in 1958 (4,17). Most researchers have performed studies on acupuncture mechanisms for a long time, and there were many suggested mechanisms for acupuncture analgesia which included the trigger point theory, the gate control theory, and the modulation of several neurotransmitters (4,9,16), as well as mechanisms of acupuncture anesthesia which divided the meridian theory of oriental medicine and the neuro-humoral theory of occidental medicine (17).

Electroacupuncture (EA) can be used to induce pain relief in clinical disorders and can also be utilized as a complementary method of pain control during surgical procedures for small animal patients in a well-restrained condition (16). EA has been used to induce surgical anesthesia as well as treat organic diseases. For instance, Kim *et al.* (6) and Jeong (4) reported on EA anesthesia in dogs (4,6), and Shin (21) also reported on EA analgesia in cats. The use of EA has also been reported in humans, experimental animals (13), horses, sheep, goats (14), cattle (18) and pigs (10). So far, there have been no negative physiological effects which appear to be associated with acupuncture-induced surgical analgesia. In fact, the major advantage of EA analgesia is good analgesia in high-risk patients without side effects (CNS and respiratory depression, bradycardia, hypotension) which are commonly observed after the use of sedatives, opioids, and general anesthetics (16), and which can reduce the dose of anesthetics (4).

EA analgesia is achieved most effectively by electro-stim-

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ulation through acupuncture needles in acupoints (16). Many meridian points can be used to induce EA analgesia in animals (16,17). Nam and Seo (17) reported on the local and general anesthetic effects of EA at several acupoints located in the head (neck) of dogs, and upon the combined use of EA and sedatives. In addition, LI-3, LI-4 (large intestine meridian) (16), or ST-5, ST-6 and ST-7(stomach meridian) (20) which are coursed through the face have been used to induce face analgesia in humans (5). Therefore, LI-3, LI-4 and ST-7 were used in this study.

Xylazine was first synthesized in 1962 (2,11), and selective α_2-receptor agonist such as xylazine are commonly used as sedatives, pre-anesthetic agents and analgesia in veterinary medicine (1,2,8). The side effects of xylazine, cardiac depression, heart block, hypotension and emesis have been widely reported in dogs and other species (2,8). The effect of analgesia in a standard xylazine dosage is shorter than sedation, and the effect of analgesia in a horse limb can only be maintained for a short time (7-10 minutes) (11). Meanwhile, the effect of analgesia in dogs can be maintained from 20 minutes to 1 hour (16). Xylazine is commonly used in combination with ketamine for reduced muscle tonicity (8). If anesthesia induced by the drug has a shorter induction period and deeper maintenance than EA analgesia, it can be limited in the case of intensive care patients.

The purpose of this study is to determine the effect of EA analgesia in the oral cavity as an alternate for chemical anesthetic drugs in dogs. Thus, the changes of the pain value, vital signs (rectal temperature, heart rate, respiratory rate) and blood chemical values (glucose (GLU), alanine aminotransferase (ALT), and blood urea nitrogen (BUN)) by EA were examined with comparison by xylazine in the present study.

Materials and Methods

Experimental Design

The healthy mongrel dogs used in this study was 1-4 years old. These dogs were comprised of 5 females and 3 males. They were acclimated for 1 month before the experiment. They were fed with dry food (ANF®, ANF specialties, Inc., USA), but food and water were withheld for 12 hours prior to the experiments. These dogs were assigned randomly to the control group (xylazine; 4 dogs) and the treatment group (EA; 4 dogs). Treatment group dogs (EA group) with weight of 3.9 ± 1.0 kg (mean ± SD) and control group dogs (xylazine group) with weight of 3.6 ± 1.0 kg were used in the study. These experimental and housing protocols were approved by the CNU Animal Care and Use Committee.

Treatment Procedure

The analgesia of the treatment group was induced by EA with a current of 1 volt (10-15 hz) for 5 minutes, and then maintained with 1-9 volts (25-30 hz) until 60 minutes by bilateral loading (ST-7 (+), and transcurrency (-) of LI-4 and LI-3). Four needles were inserted at acupoints, and then connected to the electrodes. Each pair of electrodes was used on the same side of spinal cords. Meanwhile, the control group (xylazine, 1.5 mg/kg) was induced by intramuscular injection in the biceps femoris muscle.

All dogs were examined before and at 10, 25, 40, 55 and 120 minutes after xylazine injection or EA treatment. The LI-3 is approximately located in the head of the second metacarpal bone on the radial side, while LI-4 is located between the first and second metacarpal bones, approximately in the middle of the second metacarpal bone on the radial side. And, the ST-7 is located in a depression ventral to the zygomatic arch and rostral to the condyloid process of the mandible (7).

Acupuncture electrical stimulator (Pulse stimulator AM-3000, Tokyo Electrical Co., Japan), stain-less steel acupuncture needles (Haeng Lim Seo Weon Acu needle Co., Korea. with a diameter of 0.2 mm, length of 15 mm and 30 mm) and xylazine hydrochloride (Rompun®, Bayer Korea, Korea) were used.

Vital Signs

Rectal temperature, heart rate, and respiratory rate were determined before and 10, 25, 40, 55, and 120 minutes after xylazine injection or EA treatment.

Blood Biochemistry

After each sample was coagulated, the serum was segregated using centrifugation with 650 *g* during 15 minutes. Serum sample data containing GLU, ALT, BUN were obtained using IDEXX Vetest 8008 Blood Chemistry Analyzer (USA). Blood chemistry was determined before and 10, 25, 40, 55 and 120 minutes after EA or xylazine administration, respectively.

Pain Scoring

Pain scoring criteria were used for their anesthetic effect on xylazine or EA. The analgesia scoring is shown in Table 1. Analgesic response was evaluated by mosquito forceps (3 inch), blade, and polyglycolic acid. Pain reaction was tested for three times between the canine and 4th premolar teeth of the upper lip and gingival area using mosquito forceps pinching. Tests of the incision and the suture were conducted three times in the pain reaction test region.

The assessment of scores was followed by Miyabe and Selmi (20) according to the criteria described in Table 1.

Table 1. Criteria of analgesic score

Score	Assessment	Observation
0	Normal response	Productive flight response Trying to bite
1	Mild	Activity movements of limbs and lips No bite
2	Moderate	Non-activity movement of limbs No bite and only lips movement
3	Profound	No productive flight response No movement

Statistical Analysis

All statistical calculations were performed using Microsoft Excel (Microsoft, USA) and SPSS 10.0 (SPSS Inc. USA). All data were expressed as mean ± SD.

Vital signs (rectal temperature, heart rate, and respiratory rate) and serum biochemistry (ALT, GLU and BUN) were analyzed by two-way ANOVA using repeated measures to compare the time-related variables of each anesthetic group.

Pain scores (lips, gingival stimuli, gingival incision, gingival suture, forepaw skin, and sum of mean pain scores (SMPS)) were compared using two-way ANOVA, while Chi square was used for the justification of pain scoring in the two-way ANOVA. All data were analyzed by student's *t*-test. The significance level of all tests was set at $P < 0.05$.

Results

Rectal Temperature

The mean rectal temperature of the EA group was highly increased as compared to that of the xylazine group. The mean rectal temperature of the EA group was gradually increased at 10 and 25 minutes (38.8 ± 0.3°C, 39.1 ± 0.7°C, respectively), and then returned to normal after EA removal (120 minutes : 38.3 ± 0.4°C). In the xylazine group, the decline of the mean rectal temperature was observed for 55 minutes after injection, and the temperature returned to normal after this time (Fig 1). Between the two groups, the mean rectal temperatures at 25, 40 and 55 minutes represent significant difference at the same time point ($p < 0.05$). In the xylazine group, the mean rectal temperature after 55 minutes showed a significant difference from baseline ($p < 0.05$).

Heart Rate

The mean heart rate of the EA group was highly increased as compared to that of the xylazine group (Fig 2). In the EA group, heart rate increased at 10, 25, 40 and 55 minutes (116.8 ± 5.4, 117.5 ± 13.3, 117.3 ± 9.0, 118.8 ± 14.5, respectively) from baseline (100.8 ± 12.8). In the xylazine group, heart rate was rapidly decreased until 10 minutes after xylazine administration, and then it gradually increased.

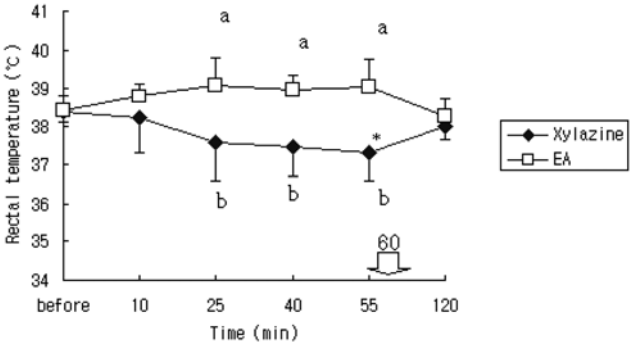

Fig 1. Rectal temperature in dogs treated with xylazine or EA.
EA: Electroacupuncture.
*Significantly difference from baseline ($p < 0.05$).
a,b: Values marked with different letters represent significant different means at same time point($p < 0.05$).
60: EA group dogs received EA from zero to 60 minutes (arrow).

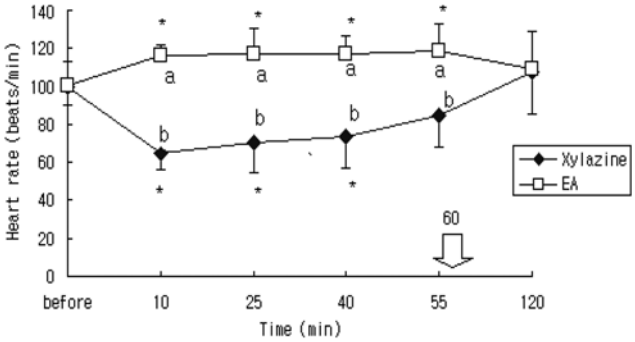

Fig 2. Heart rate in dogs treated with xylazine or EA.
EA: Electroacupuncture.
*Significantly difference from baseline ($p < 0.05$).
a,b: Values marked with different letters represent significant different means at same time point($p < 0.05$).
60: EA group dogs received EA from zero to 60 minutes (arrow).

The mean heart rate represent significant difference at 10, 25, 40 and 55 minutes between the two groups ($p < 0.05$). In the EA group, heart rate at 10, 25, 40 and 55 minutes showed a significant difference in comparison with that before the experiment, respectively ($p < 0.05$). In the xylazine group, heart rate at 10, 25 and 40 minutes showed a significant difference from baseline, respectively ($p < 0.05$).

Respiratory Rate

The mean respiratory rate of the xylazine group was gradually decreased until 40 minutes after injection, and then gradually increased.

In the EA group, respiratory rate was increased until 10 minutes after EA administration. Thereafter, the rectal temperature showed a slight change at 25 and 40 minutes, rapidly increased until 55 minutes, and then decreased after removal of EA (Fig 3).

The respiratory rate represent significant difference at 55 and 120 minutes between the two groups ($p < 0.05$). In the xylazine group, respiratory rate at 10, 25, 40 and 55 minutes, showed a significant difference from baseline, respectively ($p < 0.05$).

Serum Chemical Profiles (GLU /ALT/BUN)

The serum GLU concentration of the EA group gradually increased until 10 minutes, and then it decreased until the end of the experiment. However, the serum GLU concentration of the xylazine group increased at 40 to 55 minutes (Fig 4). Between the two groups, the serum GLU concentration at 55 and 120 minutes represent significant difference at the same time point ($p < 0.05$).

The serum ALT concentration of the EA group was slightly increased until 40 min, and then it was highly increased at 40 to 55 minutes after EA administration. The serum ALT concentration of the xylazine group was increased at 40 minutes,

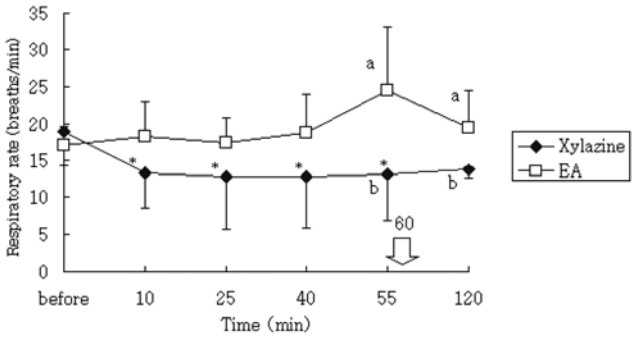

Fig 3. Respiratory rate in dogs treated with xylazine or EA.
EA: Electroacupuncture.
*Significantly difference from baseline ($p < 0.05$).
a,b: Values marked with different letters represent significant different means at same time point($p < 0.05$).
60: EA group dogs received EA from zero to 60 minutes (arrow).

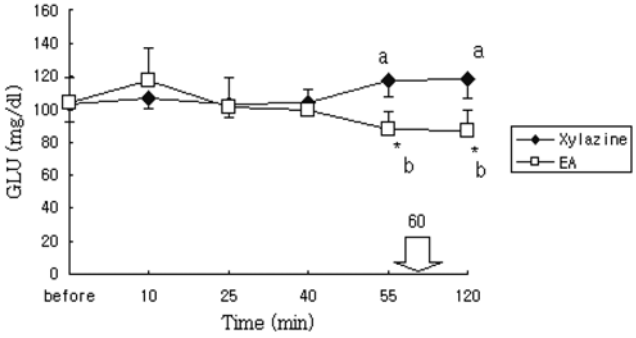

Fig 4. GLU in dogs treated with xylazine or EA.
EA: Electroacupuncture.
*Significantly difference from baseline ($p < 0.05$).
a,b: Values marked with different letters represent significant different means at same time point ($p < 0.05$).
60: EA group dogs received EA from zero to 60 minutes (arrow).

and then gradually decreased (Fig 5). In the EA group, the serum ALT concentration at 55 minutes, showed a significant difference from baseline ($p < 0.05$).

The concentration of serum BUN in the EA group was higher than in the xylazine group throughout the period of analgesia (Fig 6).

Pain Scoring

All values of pain scoring (lips, gingival stimuli, gingival incision, gingival suture, forepaw skin, and SMPS) showed similar shapes (Table 2). All values of pain scoring gradually increased until 25 minutes, and then gradually decreased toward the end of the experiment. In the pain scoring data, the xylazine group was definitely lower than the EA group after 10 minutes.

Table 2 represents the changes in pain scores (lips, gingival stimuli, gingival incision, gingival suture, forepaw skin, and SMPS) in the xylazine and EA groups.

All the dogs in the EA group showed normal reflex after

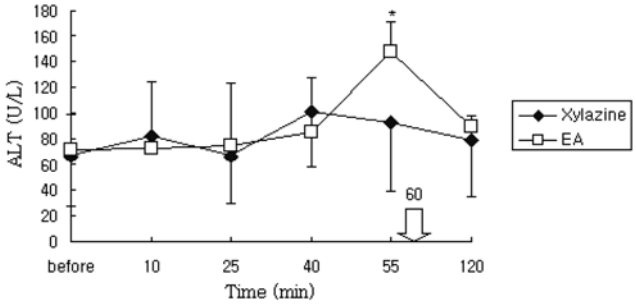

Fig 5. ALT in dogs treated with xylazine or EA.
EA: Electroacupuncture.
*Significantly difference from baseline ($p < 0.05$).
60: EA group dogs received EA from zero to 60 minutes (arrow).

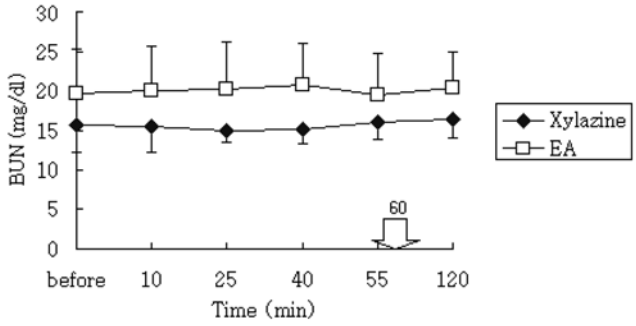

Fig 6. BUN in dogs treated with xylazine or EA.
EA: Electroacupuncture.
60: EA group dogs received EA from zero to 60 minutes (arrow).

elimination of EA.

Discussion

Acupuncture has been used to induce surgical analgesia in dogs (6), cats (21), humans (9), experimental animals (13), horses (16), goats (14), cattle (18), sheep (16), and pigs (10).

The usual acupoints tended to be chosen for anesthesia are LI-4, LI-11, PC-6, TH-5, ST-36, SP-6, GV-5, GV-20, and so on (4,9,16). Acupuncture-induced analgesia is adequately used for laparotomy and enterotomy in dogs (6), and is used for the resection of mixed tumor of the soft palate and the repair of buccolabial defect in humans (5). Meanwhile, the control of dental pain could use the LI-4, LU-7, ST-6, ST-5, and SI-18 acupoints (19). In the present study, pain control was revealed by EA using LI-3, LI-4 and ST-7 acupoint.

In the present study, we examined the control group with the use of xylazine, and the treatment group with the use of EA analgesia. The study's results were in accordance with the report that EA analgesia does not need more time than general anesthesia in terms of recovery (12,21).

According to the experiment, the temperature of the patient anesthetized with EA revealed a slight increase, while that of the patient anesthetized with xylazine decreased. This result was in accordance with the report that EA analgesia increases

Table 2. Mean of pain scoring (lip, gingival stimuli, gingival incision, gingival suture, forepaw skin, sum of mean pain score) for analgesia of the four dogs treated with xylazine or EA

	Group	Before	10min	25min	40min	55min	120min
Lip	Xylazine	0	0.8 ± 0.5	0.8 ± 1.0	0.5 ± 0.6	0	0
	EA	0	2.5 ± 0.6	3.0	2.8 ± 0.5	2.8 ± 0.5	0
Gingival stimuli	Xylazine	0	0.8 ± 1.0	0.8 ± 1.0	0.8 ± 0.5	0.3 ± 0.5	0
	EA	0	2.5 ± 0.6	2.5 ± 0.6	2.5 ± 0.6	2.3 ± 1.0	0
Gingival incision	Xylazine	0	1.5 ± 0.6	1.8 ± 0.5	0.8 ± 0.5	0.3 ± 0.5	0
	EA	0	2.8 ± 0.5	3.0	2.8 ± 0.5	2.5 ± 0.6	0
Forepaw skin	Xylazine	0	0.3 ± 0.5	0.3 ± 0.5	0	0	0
	EA	0	0.8 ± 0.5	0.8 ± 0.5	0.3	0	0
Gingival suture	Xylazine	0	1.5 ± 0.6	1.8 ± 0.5	0.8 ± 0.5	0.3 ± 0.5	0
	EA	0	2.8 ± 0.5	2.5 ± 0.6	2.5 ± 0.6	2.5 ± 0.6	0
Sum of mean pain score	Xylazine	0	4.8	5.3	2.8	0.8	0
	EA	0	11.3	11.8	10.8	10.0	0

EA: Electroacupuncture

body temperature contrary to that of ketamine anesthesia (15). Therefore, electroacupuncture analgesia is safer than xylazine anesthesia for patients whose temperature is low under narcosis.

Xylazine has a profound effect on the cardiovascular system. It causes bradycardia, decreased cardiac output, and increased central venous pressure (22). In this study, the heart rate was higher in the EA group than in the xylazine group at 10 to 55 minutes ($p < 0.05$). This result is probably due to the bradycardia by xylazine.

In clinically useful doses, xylazine does not cause great changes in respiratory parameters. Respiratory rate and PaO_2 are decreased and $PaCO_2$ is increased, but the changes are usually small (22). In this study, respiratory rate in the EA group was higher than in xylazine group at 55 to 120 minutes ($p < 0.05$). It was considered that the result was probably due to the respiratory effect of xylazine.

Xylazine causes hypoinsulinemia with subsequent hyperglycemia (22). Meanwhile, the EA at limb acupoints of the lower limbs induces a decrease in glucose (23). In this study, GLU was lower in the EA group than in the xylazine group at 55 to 120 minutes ($p < 0.05$). It was considered that the result is probably due to the hyperglycemia by xylazine and also probably due to the hypoglycemic effect by EA.

In addition, the patients in the treatment group showed a smaller change in ALT and BUN within the limit of safety than those in the control group using xylazine until 40 minutes. Hence, it may be safe to apply EA analgesia for patients who have weakly or toxic syndrome.

During the pain score test, patients anesthetized with EA started to feel no pain after EAA. However, patients anesthetized with xylazine felt pain almost immediately after injection.

In the xylazine group, the SMPS before and 10, 25, 40, 55 and 120 minutes, was 0, 4.8, 5.3, 2.8, 0.8 and 0, respectively. In the EA group, the SMPS before and 10, 25, 40, 55 and 120 minutes was 0, 11.3, 11.8, 10.8, 10.0 and 0, respectively. Therefore, the effect of pain control is good as reflected by the high scores in this study.

Consequently, the pain control of the EA group was found to be better than that of the xylazine group. All in all, though, the two groups did not show impairment of liver and kidney functions. The heart and respiratory rates were in normal range.

It is suggested that these acupoints may be useful for oral minor surgery in weakly and geriatric dogs which are exposed to drug danger by organ dysfunction. Also, the results presented in this study may be used as references for the application of acupuncture analgesia for the oral cavity in veterinary clinics.

Acknowledgements

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개에서 전침에 의한 구강 수술 시 진통효과

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요 약 : 개에서 구강 수술 시에 있어서, xylazine 또는 전침 진통을 적용시의 진통효과를 측정하기 위하여 본 연구를 실시하였다. Glucose (GLU), serum alanine aminotransferase (ALT), 및 blood urea nitrogen (BUN) 혈액화학치의 변화와 Vital signs (호흡수, 맥박수, 심박수) 그리고 통증 반응에 대한 영향을 알아보았다. 8마리의 건강한 2년령의 잡종개를 사용하였으며, 각 4마리씩 무작위로 선별하여 xylazine 또는 전침 군에 배정하였다. Xylazine 군의 개는 체중이 3.6 ± 1.0 kg 이었으며, xylazine 1.5 mg/kg을 근육주사 하였으며, 전침 군의 개는 체중이 3.9 ± 1.0 kg 이었으며, 최초 5 분 동안은 1 volt (10-15 hz)를 적용하였고, 그 이후에는 1-9 Volts (25-30 hz)를 유지시켜서 총 60 분의 전침을 적용하였으며, 사용된 경혈은 삼간 (LI-3), 합곡 (LI-4) 및 하관(ST-7) 이었다. 모든 개들은 약물 처치 또는 전침 실행에 있어서, 투여 전 및 투여 후10, 25, 40, 55 및 120분에 검사하였다. 전침 군의 평균 직장체온은, 투여 후 25, 40 및 55 분에 있어서 xylazine 군에 비하여 유의성 있게 높은 결과를 나타내었다 ($p < 0.05$). 전침 군의 평균 심박수는, 투여 후 10, 25, 40 및 55분에 있어서 xylazine 군에 비하여 유의성 있게 높은 결과를 나타내었다 ($p < 0.05$). 전침 군의 평균 호흡수는, 투여 후 55 및 120분에 있어서 xylazine 군에 비하여 유의성 있게 높은 결과를 나타내었다 ($p < 0.05$). 전침 군의 평균 GLU는, 투여 후 55 및 120분에 있어서 xylazine 군에 비하여 유의성 있게 낮은 결과를 나타내었다 ($p < 0.05$). 전침 군의 평균 통증지수 총계는, 투여 후 10, 25, 40 및 55분에 있어서 xylazine 군에 비하여 유의성 있게 높은 결과를 나타내었다 ($p < 0.05$). 전침 군의 진통이 xylazine 군에 비하여 더욱 양호 하였다. 침술 유도된 외과적 진통과 관련된 어떠한 부정적인 생리학적 영향도 나타나지 않았다. 따라서, 허약한 환자에서 구강의 소 수술에 있어서, 이들 경혈을 사용한 전침 진통은 유용할 것으로 생각된다.

주요어 : 진통, 전침, 개, xylazine.