pISSN 1598-298X
J Vet Clin 30(6) : 421-427 (2013)

Journal of Veterinary Clinics
www.ksvc.or.kr

Anesthetic and Cardiopulmonary Effects of Butorphanol-Tiletamine-Zolazepam-Medetomidine and Tramadol-Tiletamine-Zolazepam-Medetomidine in Dogs

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(Accepted: December 09, 2013)

Abstract : There are many intramuscularly injectable drugs commonly used for anesthesia in dogs and combination of drugs were used for decrease the side effects. The objective of this study was to evaluate the anesthetic and cardiopulmonary effects of butorphanol-tiletamine-zolazepam-medetomidine and tramadol-tiletamine-zolazepam-medetomidine in dogs. Ten healthy beagle dogs (intact male; mean body weight : 9.5 ± 1.60 kg) were used in the study. Experimental animals were divided into two groups (n = 5, each) and received 0.2 mg/kg of butorphanol (BZM) and 2 mg/kg of tramadol (TZM) according to the group after injection of Zoletil® (5 mg/kg) and medetomidine (10 ug/kg). All drugs were administered intramuscularly. Anesthesia and recovery, sedation and analgesia score, cardiovascular and respiratory parameters were measured. Induction and recovery time were not significantly different between the groups. Anesthesia time was 117.4 ± 25.64 minute and 81.2 ± 12.50 minute in BZM and TZM groups, respectively. Sedation and analgesia were satisfied in both groups. In both groups, common side effects related to the medetomidine, significant bradycardia and hypertension were not observed. There were no significant changes in respiratory data. In conclusion, tiletamine-zolazepam-medetomidine in combination with either butorphanol or tramadol can be suitable anesthetic protocol for minor procedures in dogs. They produced adequate anesthesia characterized by rapid induction, adequate analgesia and muscle relaxation without remarkable side effects.

Key words **:** Zoletil, medetomidine, butorphanol, tramadol, dog.

Introduction

Drug combination offers a wide margin of safety and several pharmacological advantage, such as induction time, duration of anesthesia, excellent muscle relaxation, cardiopulmonary effect and smooth recovery. There are many intramuscularly injectable drugs commonly used for anesthesia in dogs.

Tiletamine-zolazepam is a combination of equal parts of tiletamine HCl and zolazepam HCl that is popular to use of anesthesia of dogs. This combination is mainly used for pre-anesthetic medication, sedation and general anesthesia for diagnostic and minor surgical procedures. It provides smooth muscle relaxation and anticonvulsant activity (29). It results in a reliable and predictable immobilization, has a little physiological adverse effect and also is safe to handle. However, there are some disadvantages which includes that it has few antagonist, lengthy recovery time and minimal analgesic effect. Moreover, judging the depth of anesthesia is difficult because the corneal, pedal, and swallowing reflex remains. Because of these problems, tiletamine-zolazepam was combined with other sedatives and analgesics in previous studies (6,11,23).

Medetomidine is a potent and selective α_2-adrenoreceptor agonist, similar to xylazine, but is much more specific and has a lower incidence of side effects. It provides deep sedation and analgesia and can be rapidly and completely reversed by using the specific α_2-antagonist atipamezole (7). However, this agent also has some disadvantages. Its administration is followed by bradycardia, a severe decrease in cardiac output, and an increase in systemic vascular resistance (20). For this reason, lowering the dose of medetomidine is ideal for using. Decreasing the dose of medetomidine can be obtained in combination with analgesics (10).

Butorphanol and tramadol are commonly used analgesics for small animals. Butorphanol provides mild sedation, and limited, short duration of analgesia for less painful procedures. It is a synthetic compound with agonist-antagonist properties. Its analgesic effect comes from κ receptors and it has also shown to have affinity for μ receptors competitively where it acts as an antagonist (24,25). Butorphanol was used to combine with medetomidine frequently. This combination can reduce the dose of other drug required to induce anesthesia (5).

Tramadol was introduced in 1977 in Germany. It has weak opioid properties, with low affinity to μ receptors (27). Analgesic mediates inhibition of the reuptake of norepinephrine

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and serotonin, achieving spinal cord modulation of pain and preventing impulses reaching brain (3,18,28).

It was hypothesized that the combination of tiletamine-zolazepam-medetomidine with butorphanol or tramadol would result in a suitable anesthetic protocol in dogs with lowering the dose requirements of each drug, thereby decreasing the side effects. The objective of this study was to evaluate the anesthetic and cardiopulmonary effects of butorphanol-tiletamine-zolazepam-medetomidine and tramadol-tiletamine-zolazepam-medetomidine in dogs.

Materials and Methods

Animals

Ten healthy beagle dogs (intact male; mean body weight: 9.5 ± 1.60 kg) were used in the study. Health status was assessed by means of physical examination, a complete blood count and serum biochemical analyses. All findings were within reference ranges. Food was given two times a day with free water supplies. The dogs were fasted for 6 hours before the experiment, and water was withheld for 2 hours before anesthesia in order to prevent any possible adverse effects, such as vomiting during anesthesia or recovery periods.

This study was conducted under the supervision of the Chungnam National University Animal Care and Use Committee (No. CNU-00054).

Instrumentation and drug administration

Anesthesia monitor (S-5 Anesthesia Monitor®, Datex-Ohmeda, Finland) was connected, followed by mask induction with isoflurane (Forane®, Choongwae Pharmaceutical Co, Korea) in oxygen. The dog was placed in right lateral recumbency. Anesthesia was maintained through a semi-closed circle system and 1.5MAC isoflurane under pure oxygen. A sterile 24-gauge arterial catheter (BD IV Catheter®, Becton Dickinson Korea Ltd, Korea) was inserted into the dorsal pedal artery of left hindlimb. The pressure transducer (TranStar® Single Monitoring Kit, MX9504, A Furon Company, Hilliard, USA) was connected to catheter and anesthesia monitor. After inserting the catheter, isoflurane supply was discontinued and pure oxygen was given, allowing recover from anesthesia. Baseline cardiopulmonary parameters were measured, and arterial blood sample was taken from the catheter. Since then drugs were administrated, and oxygen supply was kept on until the end of procedure.

Ten of experimental animals were randomly divided into two groups (n = 5, each). After baseline value recordings, each dog received four intramuscular drug combinations in randomized order. Two drugs, tiletamine-zolazepam (Zoletil 50®, Virbac Animal Health, France) and medetomidine (Domitor®, Orion Pharmaceutical Co, Finland) were mixed. Zoletil powder (tiletamine 125 mg and zolazepam 125 mg) was added with 4.5 ml of sterile solvent for rehydration of Zoletil and 0.5 ml of Domitor (1 mg/ml). This mixture contained 50 mg/ml of Zoletil and 100 μg/ml of medetomidine. Group BZM received 0.2 mg/kg of butorphanol (Butorphan®, Myoungmun Pharmaceutical Co, Korea) followed by 0.1 ml/kg of mixture drug by intramuscular injection. This 0.1 ml/kg of mixture drug contains 2.5 mg/kg of tiletamine, 2.5 mg/kg of zolazepam and 10 μg/ml of medetomidine. Group TZM received 2 mg/kg of tramadol (Tramadol HCl®, Huons, Korea) followed by 0.1 ml/kg of mixture drug by intramuscular injection.

Measurement of parameters

Anesthesia and recovery

Induction, anesthesia, sternal recumbency, standing, walking and recovery times were recorded for each dog.

Induction time was the time from BZM or TZM administration to complete immobilization. That was defined as the lack of response to handling. Anesthesia time was the time interval between complete immobilization and the first attempt made by the animal to lift its head. Sternal recumbency time was from the time BZM or TZM administration to the dog achieved sternal recumbency. Standing time was from the time BZM or TZM administration to the time when the dog stood up without assistance for longer than 10 seconds. Walking time was from the time BZM or TZM administration to when the animal was able to walk without knuckling. Recovery time was from the time first attempt head lift to when the dog was able to walk without knuckling.

Evaluation of sedation and analgesia

The level of sedation (spontaneous posture) and analgesia (pedal withdrawal) were assessed each designated times during anesthesia according to the criteria of Table 1. Spontaneous posture and pedal withdrawal response to pinching of a digit or interdigital web were scored by the same investigator who was unaware of which drug was administered.

Heart rate, blood pressure and rectal temperature

Cardiovascular parameters were measured and recorded at 0 (before injection of the drugs) and at 5, 10, 20, 30, 40, 50 and 60 minutes after drug administration.

The heart rate (HR), blood pressure (BP)[systolic arterial pressure (SAP), mean arterial pressure (MAP), diastolic arterial pressure (DAP)] and rectal temperature (RT) were measured by using anesthesia monitor and additional heating was not applied afterward.

Respiratory rate and blood gases

Respiratory parameters were also measured and recorded at 0 (before injection of the drugs) and at 5, 10, 20, 30, 40, 50 and 60 minutes after drug administration. The respiratory rate (RR) was measured on the basis of the thoracic movements of the animal. Arterial blood gas analysis was performed by portable arterial blood gas analyzer (i-STAT®, HESKA Co., USA). The analyzer calculated arterial oxygen partial pressure (PaO_2), carbon dioxide partial pressure ($PaCO_2$), arterial oxygen saturation (SaO_2) and arterial pH (pH).

Table 1. Subjective criteria used to score levels of sedation and analgesia in dogs treated with BZM or TZM

Sedative score		
Spontaneous posture (0-5)		
	0	Normal
	1	Being able to stand or sit on their hind legs
	2	Keeping the position of ventral recumbency
	3	Lateral recumbency with apparent spontaneous movement (head lifting or struggling)
	4	Lateral recumbency with subtle spontaneous movement (ear and nose twitching or blink)
	5	Lateral recumbency without spontaneous movement
Score of response to noxious stimulus Pedal withdrawal response to pinching of a digit or interdigital web (0-3)		
	0	Hypersensitive or normal
	1	Slightly impaired
	2	Clearly weak
	3	Absent

Statistical analysis

Values were expressed as means and standard deviation. Kruskal-Wallis analysis of variance and Mann-Whitney *U*-test were used for group comparison. Differences in physiological parameters within group were tested with one-way analysis of variance (ANOVA) and Duncan's post hoc tests. Differences in score levels of sedation and analgesia were compared by using Wilcoxon signed rank's test within group. $P < 0.05$ was considered statistically significant. All statistics were performed using a computer statistical package (Statistics Package for the Social Sciences, version 18.0; SPSS Inc, IL, USA).

Results

Anesthesia and recovery

Duration of induction, anesthesia, sternal recumbency, standing, walking and recovery were shown in Table 2.

Induction time was not significantly different between two groups. Anesthesia time was significantly different between BZM group (117.4 ± 25.64 minutes) and TZM group (81.2 ± 12.50 minutes) ($p < 0.05$). Sternal recumbency, standing and walking times in BZM group were significantly longer than those of TZM group ($p < 0.05$). However, the recovery time was not significantly different between two groups.

Evaluation of sedation and analgesia

Sedation and analgesia were satisfied in both groups until 60 minutes. There were significantly different changes in the scores related to sedation and analgesia immediately after administration of drugs in both groups ($p < 0.05$). There was no statistically significant difference in the both scores between BZM and TZM groups (Table 3).

Heart rate, blood pressure and rectal temperature

Data related to heart rate, systolic arterial pressure, mean arterial pressure, diastolic arterial pressure and rectal temperature are summarized in Table 4.

In both groups, the heart rate decreased significantly within 20 minutes ($p < 0.05$), and remained consistently below baseline for 60 minutes. However, there were no significant differences between two groups. In the TZM group, the DAP was significantly higher than BZM group at 10 minutes after administration ($p < 0.05$).

Rectal temperature decreased relatively to baseline after administration and did not change significantly at all times points in both groups.

Respiratory rate and blood gases analysis

Data of respiratory rate and blood gases are shown in Table 5. Respiratory rate was significantly different between

Table 2. Duration of induction, anesthesia, sternal recumbency, standing, walking and recovery following administration of BZM or TZM in dogs (minute)

Group	Induction time	Anesthesia time	Sternal recumbency time	Standing time	Walking time	Recovery time
BZM	1.2 ± 0.45	117.4 ± 25.64	125.0 ± 22.76	134.2 ± 21.48	142.6 ± 23.35	25.2 ± 11.08
TZM	1.4 ± 0.55	81.2 ± 12.50*	90.6 ± 15.58*	101.0 ± 18.26*	109 ± 20.95*	28.4 ± 11.17

Data are expressed as mean ± SD (n = 5)
*Significantly different between groups ($p < 0.05$)
BZM: butorphanol-tiletamine-zolazepam-medetomidine combination
TZM: tramadol-tiletamine-zolazepam-medetomidine combination

Table 3. Scores of sedation and analgesia following administration of BZM or TZM in dogs

	Group	0 min	5 min	10 min	20 min	30 min	40 min	50 min	60 min
Sedation	BZM	0.0 ± 0.0	5.0 ± 0.0*	5.0 ± 0.0*	5.0 ± 0.0*	5.0 ± 0.0*	5.0 ± 0.0*	5.0 ± 0.0*	5.0 ± 0.0*
	TZM	0.0 ± 0.0	5.0 ± 0.0*	5.0 ± 0.0*	5.0 ± 0.0*	5.0 ± 0.0*	5.0 ± 0.0*	5.0 ± 0.0*	5.0 ± 0.0*
Analgesia	BZM	0.0 ± 0.0	3.0 ± 0.0*	3.0 ± 0.0*	3.0 ± 0.0*	3.0 ± 0.0*	3.0 ± 0.0*	3.0 ± 0.0*	3.0 ± 0.0*
	TZM	0.0 ± 0.0	3.0 ± 0.0*	3.0 ± 0.0*	3.0 ± 0.0*	3.0 ± 0.0*	3.0 ± 0.0*	3.0 ± 0.0*	3.0 ± 0.0*

Data are expressed as mean ± SD (n = 5)
*Significantly different from the base line ($p < 0.05$)
BZM: butorphanol-tiletamine-zolazepam-medetomidine combination;
TZM: tramadol-tiletamine-zolazepam-medetomidine combination

Table 4. Heart rate, blood pressure and rectal temperature following administration of BZM or TZM in dogs

	Group	0 min	5 min	10 min	20 min	30 min	40 min	50 min	60 min
HR (beats/min)	BZM	112.6 ± 16.18	97.8 ± 16.48	94.6 ± 14.76	81.4 ± 15.49*	73.8 ± 11.30*	65.6 ± 8.71*	62.0 ± 6.16*	57.6 ± 9.13*
	TZM	114.6 ± 22.83	108.6 ± 22.14	105.6 ± 13.58	85.2 ± 10.57*	74.6 ± 7.30*	68.6 ± 9.63*	65.0 ± 9.43*	64.6 ± 7.70*
SAP (mmHg)	BZM	120.4 ± 12.03	121.2 ± 13.26	120.8 ± 16.16	117.8 ± 20.47	123.8 ± 7.01	124.8 ± 9.23	127.4 ± 17.64	125.2 ±2 0.09
	TZM	118.4 ± 12.42	121.4 ± 11.19	137.8 ± 13.74	132.8 ± 8.76	139.0 ± 15.84	136.8 ± 14.50	132.6 ± 9.69	130.4 ± 8.08
MAP (mmHg)	BZM	81.6 ± 7.67	82.4 ± 13.72	79.2 ± 13.18	87.0 ± 20.72	89.4 ± 13.30	90.2 ± 11.03	94.2 ± 13.46	88.2 ± 11.37
	TZM	88.8 ± 7.66	90.2 ± 9.52	99.4 ± 9.07	93.4 ± 8.88	103.6 ± 8.50	100.6 ± 11.67	96.8 ± 8.58	94.0 ± 7.31
DAP (mmHg)	BZM	64.2 ± 3.70	66.6 ± 16.15	62.2 ± 13.05	73.4 ± 22.41	74.8 ± 16.60	75.2 ± 16.81	77.0 ± 10.86	74.0 ± 12.14
	TZM	69.8 ± 8.61	69.8 ± 10.23	83.2 ± 9.52[a]	77.2 ± 10.59	87.0 ± 7.07	80.2 ± 6.69	79.0 ± 7.75	76.2 ± 7.95
RT (°C)	BZM	37.5 ± 0.46	37.4 ± 0.51	37.3 ± 0.50	37.1 ± 0.54	37.1 ± 0.59	37.0 ± 0.59	36.9 ± 0.59	36.8 ± 0.62
	TZM	37.5 ± 0.65	37.4 ± 0.75	37.3 ± 0.59	37.2 ± 0.63	37.0 ± 0.57	36.8 ± 0.63	36.7 ± 0.62	36.7 ± 0.58

Data are expressed as mean ± SD (n = 5)
*Significantly different from the base line ($p < 0.05$); [a]Significantly different between groups ($p < 0.05$)
BZM: butorphanol-tiletamine-zolazepam-medetomidine combination;
TZM: tramadol-tiletamine-zolazepam-medetomidine combination

Table 5. Respiratory rate and blood gas analysis following administration of BZM or TZM in dogs

	Group	0 min	5 min	10 min	20 min	30 min	40 min	50 min	60 min
RR (beats/min)	BZM	16.0 ± 6.32	10.3 ± 4.19	9.8 ± 4.35	9.3 ± 2.75	11.8 ± 2.63[a]	14.0 ± 4.90	16.7 ± 4.16	15.3 ± 3.06
	TZM	16.6 ± 2.97	15.4 ± 4.98	14.2 ± 2.49	14.8 ± 3.90	21.4 ± 4.22[a]	21.4 ± 4.10	18.8 ± 3.03	23.8 ± 9.91
pH	BZM	7.31 ± 0.05	N.E	7.23 ± 0.06*	7.22 ± 0.04*	N.E	7.26 ± 0.03	N.E	7.28 ± 0.04
	TZM	7.27 ± 0.04	N.E	7.23 ± 0.04	7.22 ± 0.03	N.E	7.27 ± 0.04	N.E	7.32 ± 0.03
$PaCO_2$ (mmHg)	BZM	49.8 ± 9.52	N.E	58.2 ± 6.00	58.4 ± 3.23*	N.E	57.6 ± 3.10[a]	N.E	55.6 ± 4.27[a]
	TZM	51.8 ± 4.49	N.E	54.8 ± 7.02	54.4 ± 6.94	N.E	49.1 ± 5.85[a]	N.E	48.3 ± 4.88[a]
PaO_2 (mmHg)	BZM	560.2 ± 40.95	N.E	523.4 ± 32.50	558.4 ± 55.88	N.E	561.8 ± 73.56	N.E	588.2 ± 20.91
	TZM	550.2 ± 21.95	N.E	542.8 ± 84.06	585.4 ± 66.10	N.E	595.6 ± 33.72	N.E	607.2 ± 49.64
SaO_2 (%)	BZM	100.0 ± 0.00	N.E	100.0 ± 0.00	100.0 ± 0.00	N.E	100.0 ± 0.00	N.E	100.0 ± 0.00
	TZM	100.0 ± 0.00	N.E	100.0 ± 0.00	100.0 ± 0.00	N.E	100.0 ± 0.00	N.E	100.0 ± 0.00

Data are expressed as mean ± SD (n = 5)
*Significantly different from the base line ($p < 0.05$); [a]Signidicantly different between groups ($p < 0.05$); N.E : Not examined
BZM: butorphanol-tiletamine-zolazepam-medetomidine combination;
TZM: tramadol-tiletamine-zolazepam-medetomidine combination

two groups at 30 minutes ($p < 0.05$).

The arterial pH decreased during the first 20 minutes and then gradually increased in both groups. In the BZM group, pH was significantly lower than base line at 10 and 20 minutes ($p < 0.05$). The $PaCO_2$ in the BZM group was significantly higher than baseline at 20 minutes ($p < 0.05$). There

were significant differences in $PaCO_2$ between two groups at 40 and 60 minutes ($p < 0.05$).

Discussion

This study reported that intramuscular injection of either BZM or TZM showed rapid induction and no response to noxious stimuli for more than 60 minutes. Both combinations provide an adequate anesthesia time for carrying out minor procedures. In the BZM group (117.4 ± 25.64 minutes), anesthesia time was significantly longer than TZM group (81.2 ± 12.50 minutes) ($p < 0.05$). Sternal recumbency, standing and walking times were significantly different, this was caused by longer anesthetic time of BZM group. The recovery time was not significantly different between two groups.

Combining of anesthetic drugs to provide hypnosis, analgesia and muscle relaxation is referred to as balanced anesthesia. Balanced anesthesia may act in an additive or synergistic manner which can minimize the adverse effects of individual drugs and lead to correct anesthesia (9,16,21).

Triple mixed solution, tiletamine-zolazepam and medetomidine, were employed in the present study. Because the dose of medetomidine (10 μg/kg) was too little to inject accurately, medetomidine was mixed with tiletamine-zolazepam and sterile solvent of package supply. The mixture of drug could also reduce a total injection volume and minimize a volume of medetomidine loss.

Tiletamine-zolazepam have narrow margins of safety and have resulted in unacceptable mortality rates when used alone. In order to minimize this problem, use of α_2-adrenoreceptor agonist medetomidine may increase the sedative and analgesic effects and provide safer anesthesia (13). Medetomidine produce sedative analgesia by stimulating receptors at various sites in the pain pathway at the spinal and supraspinal level but precautions are required when using it in dogs. Medetomidine stimulates receptors centrally and peripherally to cause marked bradycardia and decrease the cardiac output (4,8).

In this study, heart rate was decreased in all of the dogs during period of anesthesia. A significant decrease in heart rate was seen 20 minutes of administration of both groups, but there was no significant difference in heart rate between two groups. A significant decrease in heart rate is considered to be the typical response after administration of a medetomidine in animals (22). The decrease in heart rate found in this study was not considered to be clinically significant, and treatment was not deemed necessary.

The blood pressures in both groups were not significantly different compare to base line value within time. The diastolic arterial pressure was only significant difference between two groups at 10 minutes ($p < 0.05$). Vasoconstriction effect of medetomidine's via α_2-adrenoreceptor activity has been well documented in the previous study (14). However, it is notable that there was not a significant difference observed in the present study. This might be caused by reduced dose of medetomidine (10 μg/ml). Moreover, blood pressure did not increased markedly in the BZM group because butorphanol can cause a decrease in heart rate secondary to increased parasympathetic tone and mild decreases in arterial blood pressures (1).

While inducing anesthesia in dogs, either hypothermia or hyperthermia can occur regardless of heart rate (2). The rectal temperatures in both groups gradually decreased after anesthesia. In both groups, hypothermia might be caused by the laboratory air temperature and vasoconstrictive effects of the drugs.

Analgesic plays an important role in anesthesia. Postoperative pain is common experience after surgery, and lead to anorexia, exacerbated protein catabolism, respiratory depression, arrhythmia, central hypersensitivity to noxious stimuli and chronic pain. For these reasons, analgesics are used in veterinary medicine (17).

Butorphanol causes less respiratory depression, less nausea and vomiting. And tramadol reduces brainstem's sensitivity to carbon dioxide, but does not depress the hypoxic ventilator response and it is not believed to cause significant respiratory depression at recommended dosage (12,26). Tramadol also was given in general anesthesia, and no changes in arterial blood pressure, pulse and respiratory rates (19). In the present study, respiratory rate did not changed for 40 minutes significantly in both groups. However, there were significant differences in respiratory rate only 30 minutes between groups.

In the blood gas analysis, a significant increase in $PaCO_2$ was seen at 20 minutes of administration in the BZM group, and there was significant difference in $PaCO_2$ at 40 minutes and 60 minutes between two groups. There were no significant differences observed in PaO_2 and SaO_2. It might be due to oxygen supplement until the end of procedure. In a previous study, medetomidine-sedated dogs were provided 100% oxygen via endotracheal intubation, which increased oxygen content and tissue oxygenation in treated dogs versus breathing room air (15). Based on this information, it is advised that 100% oxygen via endotracheal intubation might be available when using BZM or TZM groups.

In conclusion, tiletamine-zolazepam-medetomidine in combination with either butorphanol or tramadol can be suitable anesthetic protocol for minor procedures in dogs. They produced adequate anesthesia characterized by rapid induction, adequate analgesia and muscle relaxation without remarkable side effects.

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개에서 Butorphanol-Tiletamine-Zolazepam-Medetomidine과 Tramadol-Tiletamine-Zolazepam-Medetomidine 합제의 마취효과 및 심폐에 미치는 영향

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요 약 : 개의 마취를 위해 많은 주사용 마취제를 사용하고 있으며, 그 부작용을 줄이기 위하여 다양한 약물을 병용하여 사용한다. 본 실험은 개에서 tiletamine-zolazepam-medetomidine과 함께 butorphanol 또는 tramadol을 병용투여 하여 마취효과 및 심폐기능에 미치는 효과를 비교하였다. 임상적으로 건강한 중성화 하지 않은 10 마리의 수컷 비글견 (체중: 평균 9.5 ± 1.60 kg)을 사용하였다. 실험군은 BZM군과 TZM군으로 나누었으며, BZM군은 0.2 mg/kg의 butorphanol과 tiletamine (2.5 mg/kg)-zolazepam (2.5 mg/kg)-medetomidine (10 μg/kg)의 혼합용액을 0.1 ml/kg의 용량으로 투여하였다. TZM군에서는 2 mg/kg의 tramadol과 동량의 혼합용액을 투여하였다. 모든 주사는 근육 내로 투여하였다. 마취유도 및 회복시간, 진정 및 진통점수, 심박수, 혈압, 직장온도 및 호흡수를 측정하였으며 동맥혈액가스분석을 실시하였다. 마취유도시간과 회복시간에는 BZM과 TZM군간 유의성은 없었으며, 두 군간 마취시간은 BZM군 (117.4 ± 25.64 minutes)이 TZM군 (81.2 ± 12.50 minutes)보다 유의성 있게 길었다. 진정 및 진통은 BZM군과 TZM군 두 군 모두에서 만족스러운 결과를 얻었다. 심박수는 투여 후 20분부터 두 군 모두에서 유의성 있게 감소하였으며 군간 유의적인 차이는 없었다. 두 군에서 혈압과 직장온도는 유의적인 차이를 보이지 않았다. 호흡수는 TZM 군에서 투여 후 30분에 BZM군보다 유의적인 증가를 나타내었다. 동맥산소분압(PaO_2) 및 동맥산소포화도(SaO_2)는 군 간 유의적인 차이를 보이지 않았다. 본 실험 결과를 바탕으로 개에서 butorphanol-tiletamine-zolazepam-medetomidine 및 tramadol-tiletamine-zolazepam-medetomidine 병용마취는 만족할만한 마취효과를 얻을 수 있었으며 심폐기능에 큰 영향을 미치지 않았으므로, 단 시간의 마취가 필요한 진단 또는 가벼운 수술에 효과적으로 적용될 수 있을 것으로 생각한다.

주요어 : Zoletil, medetomidine, butorphanol, tramadol, 개.