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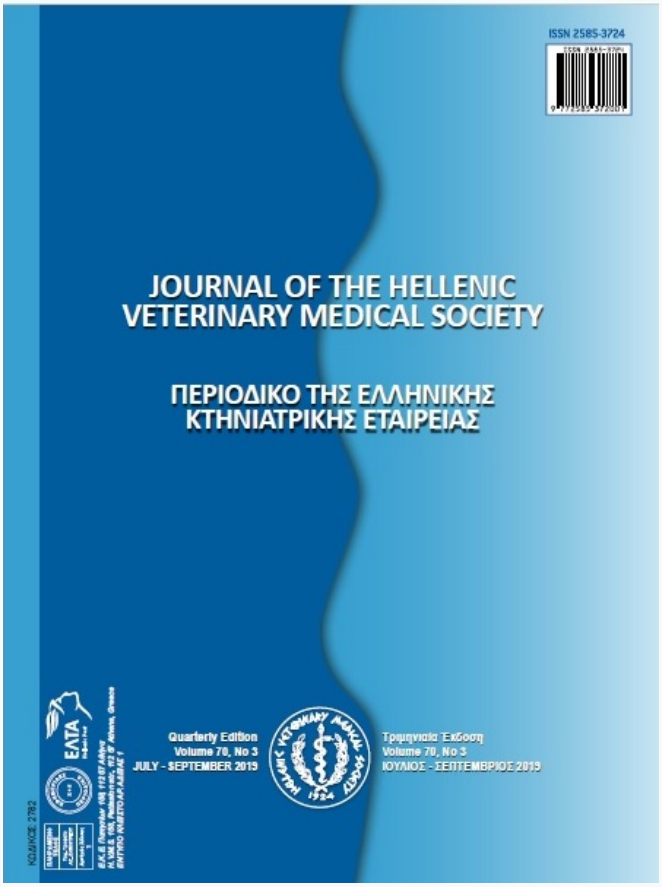

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R. SATO, E. KANAI, A. TSUKAMOTO

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Research article
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Comparison of Lidocaine-Xylazine and Procaine-Xylazine for Lumbar Epidural Anesthesia in Cattle

R. Sato[1], E. Kanai[2], A. Tsukamoto[3]

[1]*Laboratory of Farm Animal Internal Medicine, School of Veterinary Medicine, Azabu University, Japan*

[2]*Laboratory of Veterinary Radiology, School of Veterinary Medicine, Azabu University, Japan*

[3]*Laboratory of Laboratory Animal Science, School of Veterinary Medicine, Azabu University, Japan*

ABSTRACT. Lumbar epidural anesthesia is commonly utilized in veterinary medicine for diagnostic, obstetrical, and surgical intervention in the abdominal and perineal regions of large animals. The aim of this study was to directly compare the time to onset and duration of epidural anesthesia produced by lidocaine-xylazine and procaine-xylazine combinations to that produced by xylazine alone in cattle. A total of 24 healthy adult Holstein dairy cows were included in this study. The time to onset and duration of anesthesia were recorded. The heart rate, respiratory rate, and rectal temperature were recorded at 0 minute and at 10, 20, 30, 60, and 90 minutes after the epidural administration of each treatment. The time to onset of anesthesia did not significantly differ between the xylazine only group and the lidocaine-xylazine and procaine-xylazine combination groups. The duration of anesthesia in the xylazine only group was significantly shorter than that in the lidocaine-xylazine and procaine-xylazine combination groups ($p < 0.05$). Ataxia was not observed in any group. The heart rate, respiratory rate, and rectal temperature values in all the treatment groups throughout the study did not significantly differ from those at baseline.

We found that administration of procaine hydrochloride in combination with xylazine hydrochloride, an α2-adrenergic receptor agonist, offers the same time to onset and duration of anesthesia as does epidural anesthesia using a combination of lidocaine hydrochloride and xylazine hydrochloride. Furthermore, this combination of treatments did not cause adverse effects in the cardiovascular and respiratory systems. These findings indicate that combined administration of procaine and xylazine is an economic and useful approach for epidural anesthesia.

Keywords: Cow; epidural anesthesia; lidocaine; procaine; xylazine

Corresponding Author:
Reiichiro Sato, 1-17-71 Fuchinobe, Chuo-ku, Sagamihara, Kanagawa 252-5201, Japan
E-mail address: r-sato@azabu-u.ac.jp

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INTRODUCTION

Administration of general anesthesia to ruminants may involve aspiration due to regurgitation of the contents of the rumen and saliva (Trim, 1981; Hall et al., 2001), which creates a risk of bloating and muscle injury (Skarda and Tranquilli, 2007). In addition, the equipment used to deliver general anesthesia is expensive; it can be difficult to administer anesthesia to cattle in clinical fields, as it is necessary for another person to monitor the anesthesia during use. For this reason, local anesthesia is common when performing surgery or examination in ruminants with the animal in the standing position.

Local anesthesia procedures used in the ruminants include paravertebral nerve blocks, local administration, epidural anesthesia, and intravenous regional anesthesia of a distal limb (Skarda and Tranquilli, 2007). Among these approaches, the technique of epidural anesthesia includes the use of a dorsolumbar segment epidural block and a low-posterior or caudal epidural block. The former is commonly performed in conjunction with surgery of the gastrointestinal organs, such as abomasum reduction, rupture repair, intestinal surgery, and cesarean section with abdominal laparotomy assistance. The latter is widely used in conjunction with surgeries to repair anal and perineal cleft lacerations, or uterine or rectal prolapse, to alleviate difficulties occurring during delivery or ovum collection, and to restore control of urination and defecation (Elmore, 1980; Skarda, 1996). All the above-mentioned procedures can be performed with the animal maintaining the standing position.

Local anesthetics indiscriminately block motor, sensory, and sympathetic nerve fibers (Day and Skarda, 1991) that cause vasodilatation, which is attributed mainly to the inhibition of action potentials via sodium channel blocking in sympathetic nerves that cause vasoconstriction (Newton et al., 2007). They may also cause ataxia, hind limb weakness, and, occasionally, recumbency. Generally, lidocaine, mepivacaine, bupivacaine, and procaine are used for epidural anesthesia (Day and Skarda, 1991). However, these drugs are often administered in combination with α_2-adrenergic receptor agonists to extend the period of anesthesia (Grubb et al., 2002; McGrath and Richey, 2003) and minimize the risk of hind limb weakness and recumbency (Luttinger et al., 1985; Eisenach et al., 1996; Natalini and Robinson, 2000).

The purpose of this study was to compare anesthesia produced by lidocaine + xylazine, a combination of anesthetics commonly administered during epidural anesthesia of ruminants, and procaine hydrochloride + xylazine, a combination of ester-type local anesthetics, with respect to the time of onset and duration of anesthesia, heart rate (HR), respiratory rate (RR), and rectal temperature (RT).

MATERIALS AND METHODS

All animal experiments were performed in compliance with the Guide for the Animal Care and Use Committee at Azabu University, School of Veterinary Medicine (No. 160829-3).

The study included 24 healthy Holstein dairy cows (aged 28.2-98.9 months, weighing 406-698 kg, Body Condition Score 2.75-4.00) from a commercial dairy farm. These cows were randomized by age, body weight, and body condition score, and divided into five groups (Table 1).

Cows were restrained in stanchions. The epidural needle (16-gauge, 12 cm in length; Hakko Syoji., Tokyo, Japan) was inserted into the first to second lumbar (L1-L2) epidural space in standing cattle with the bevel pointed forward. Proper placement of the needle was determined by loss of resistance and by the hanging drop technique, which can be performed by placing a few drops of sterile water or lidocaine into the needle hub during insertion (Skarda and Tranquilli, 2007).

The dosage of anesthetics in each group was determined by the method explained in a previous report (Ismail, 2016). The xylazine only group (XY) was administered 0.05 mg/kg b.w. of xylazine hydrochloride (Selactar 0.2%; Bayer, Ltd., Tokyo, Japan). The xylazine hydrochloride and lidocaine hydrochloride combination groups (XL-1 and XL-2) were administered a combination of xylazine hydrochloride (0.05 mg/kg b.w. for both groups) and 2% lidocaine hydrochloride (0.10 and 0.20 mg/kg b.w., respectively; LIDOCAINE Hydrochloride Injection 2 %; Pfizer Japan Inc., Tokyo, Japan). The xylazine hydrochloride and procaine hydrochloride combination groups (XP-1 and XP-2) were administered a combination of xylazine hydrochloride (0.05 mg/kg b.w. for both groups) and 2% procaine hydrochloride (0.10 and 0.20 mg/kg b.w., respectively; Procaine Hydrochloride Injection KS; Kyoritsu Seiyaku Inc., Tokyo, Japan). All the drugs were diluted with 0.9% saline to a final volume of 5 ml.

Table 1. Characteristics of the experimental cows

No.	Group	xylazine (mg/kg)	Local analgesic (mg/kg)		Body weight (kg)	BCS[a)]
			lidocaine	procaine		
1	XY	0.05	–	–	488.0	3.00
2					582.0	3.25
3					593.5	3.50
4					560.0	3.50
					555.9 ± 47.3	3.3±0.2
5	XL-1	0.05	0.1	–	575.0	3.25
6					478.0	2.75
7					588.5	3.50
8					555.0	3.25
9					587.0	3.50
					556.7 ± 46.0	3.3±0.3
10	XL-2	0.05	0.2	–	554.5	3.50
11					488.5	3.00
12					579.3	3.50
13					623.0	4.00
14					530.0	2.75
					555.1 ± 50.7	3.4±0.5
15	XP-1	0.05	–	0.1	578.5	3.00
16					481.0	2.75
17					526.5	3.00
18					545.0	3.50
19					651.5	4.00
					556.5 ± 63.7	3.3±0.5
20	XP-2	0.05	–	0.2	436.0	2.75
21					527.0	3.50
22					595.5	3.50
23					645.0	4.00
24					559.0	3.00
					552.5 ± 78.5	3.4±0.5

a) Body condition score.

The administered fluids were warmed to rectal temperature and injected gradually for over approximately 30 s to prevent collapse.

The analgesic effect was evaluated in terms of the presence or absence of a reaction at the left or right abdominal skin surface as a result of a pinprick test, and application of pinch pressure owing to the hemostatic force applied using forceps (when set to the first ratchet). After drug administration, the time to loss of sensation was considered the time to onset of anesthesia. The time from loss of sensation to restoration of sensation was considered as the duration of anesthesia. Determination of the time to onset of anesthesia was achieved via monitoring until loss of sensation was confirmed and at 10, 20, 30, 60, and 90 minutes afterward.

The HR, RR, and RT were similarly measured prior to drug administration (at 0, baseline value), and at 10, 20, 30, 60, and 90 minutes after administration. The HR was measured via an electrocardiogram (BIO-SCOPE, AM 130; Fukuda ME Kogyo, Tokyo, Japan). The RR was measured based on a 1-minute auscultation, and the RT was measured using an electronic thermometer (ThermoVision J, TV-714J; Astec, Ibaragi, Japan).

Continuous data were reported as the mean ± standard deviation, if the distribution was normal. A one-way analysis of variance (ANOVA) was performed to determine differences in "time to onset of anesthesia" and "duration of anesthesia." A two-way repeated-measures ANOVA (treatment as a between-subject factor and time as the repeated measures variable)

was performed to determine differences in the HR, RR, and RT. Between-group comparisons for continuous variables were conducted using an unpaired t-test. Within-group comparisons for continuous variables were conducted using a paired t-test. A P-value of < 0.05 was accepted as statistically significant. Statistical analyses were performed with SPSS version 22.0 for Windows (IBM Japan, Tokyo, Japan).

RESULTS

The epidural injection was easy to perform and well tolerated by all the experimental animals.

The time to onset of anesthesia and duration of anesthesia are presented in Table 2. The time to onset of anesthesia did not significantly differ among the XY (14.5 ± 1.8 min), XL-1 (11.1 ± 3.3 min), XL-2 (12.3 ± 3.4 min), XP-1 (11.5 ± 3.5 min), and XP-2 (11.8 ± 3.2 min) groups.

The duration of anesthesia was significantly shorter in the XY group (68 ± 26.0 min) than in the XL-1 (215 ± 56.0 min), XL-2 (220 ± 55.1 min), XP-1 (205 ± 47.1 min), and XP-2 (214 ± 20.1 min) groups ($P < 0.05$ for all). Ataxia was not observed in any of the studies cows. The HR, RR, and RT are presented in Table 3. The values of these measures did not significantly differ from the baseline values throughout the study in any treatment group (Table 3).

Table 2. Anesthetic indices of epidural administration of xylazine (XY), xylazine-lidocaine (XL-1, XL-2), and xylazine-procaine (XP-1, XP-2) in cows (mean ± SD)

Indices	XY	XL-1	XL-2	XP-1	XP-2
Onset of analgesia (min)	14.5 ± 1.8	11.1 ± 3.3	12.3 ± 3.4	11.5 ± 3.5	11.8 ± 3.2
Duration of analgesia (min)	68 ± 26.0†	215 ± 56.0	220 ± 55.1	205 ± 47.1	214 ± 20.1

† Significant differences between the duration of XY with XL-1 and XL-2, XP-1, XP-2.

Table 3. Heart rate (HR), respiratory rate (RR), and rectal temperature (RT) in cows treated with epidural administration of xylazine (XY), xylazine-lidocaine (XL-1, XL-2), and xylazine-procaine (XP-1, XP-2) combination (mean ± SD)

Treatment	Time (min)					
	0	10	20	30	60	90
HR (beat/min)						
XY	68.3 ± 9.8	54.8 ± 4.3	57.2 ± 4.1	67.5 ±1.0	68.5 ± 3.4	66.5 ± 3.0
XL-1	68.8 ± 6.7	68.4 ± 1.7	70.6 ± 3.0	67.2 ± 2.3	70.4 ± 5.0	66.0 ± 2.8
XL-2	67.2 ± 9.8	69.2 ± 7.0	65.2 ± 4.4	66.4 ± 3.6	66.4 ± 4.8	67.2 ± 5.9
XP-1	69.6 ± 7.4	69.2 ± 5.2	66.4 ± 3.3	68.8 ± 2.3	69.6 ± 2.6	68.4 ± 2.2
XP-2	68.0 ± 5.3	68.4 ± 3.8	67.6 ± 5.4	67.6 ± 3.6	68.4 ± 1.7	68.0 ± 1.4
RR (breath/min)						
XY	23.5 ± 3.4	21.6 ± 2.5	24.4 ± 4.4	25.6 ± 1.9	30.8 ± 1.0	37.2 ± 1.6
XL-1	23.2 ± 2.3	23.2 ± 1.1	23.2 ± 1.1	21.6 ± 1.7	24.0 ± 2.0	23.6 ± 1.7
XL-2	23.6 ± 2.6	24.4 ± 5.0	24.4 ± 3.3	24.0 ± 1.4	25.6 ± 3.0	24.8 ± 3.0
XP-1	25.6 ± 3.3	24.4 ± 1.7	24.0 ± 2.0	25.6 ± 1.7	27.2 ± 1.8	25.6 ± 1.7
XP-2	24.4 ± 3.0	26.4 ± 2.6	26.4 ± 1.7	24.8 ± 3.3	25.6 ± 2.6	25.2 ± 1.1
RT (°C)						
XY	38.3 ± 0.1	38.4 ± 0.1	38.5 ± 0.1	38.5 ± 0.1	38.5 ± 0.2	38.5 ± 0.1
XL-1	38.3 ± 0.2	38.3 ± 0.2	38.4 ± 0.2	38.3 ± 0.2	38.4 ± 0.2	38.4 ± 0.2
XL-2	38.3 ± 0.1	38.3 ± 0.1	38.4 ± 0.3	38.4 ± 0.3	38.4 ± 0.3	38.4 ± 0.3
XP-1	38.2 ± 0.3	38.3 ± 0.2	38.4 ± 0.3	38.4 ± 0.3	38.4 ± 0.2	38.4 ± 0.3
XP-2	38.3 ± 0.2	38.3 ± 0.2	38.5 ± 0.1	38.4 ± 0.1	38.5 ± 0.1	38.3 ± 0.2

HR, Heart rate; RR, Respiratory rate; RT, Rectal temperature

DISCUSSION

Epidural anesthesia is a useful technique in ruminant animals, that is widely used in conjunction with not only abdominal surgeries, but also in perineal surgeries and procedures to implant fertilized eggs (Elmore, 1980; Skarda, 1996). In cattle and small ruminants, 2% lidocaine is used for epidural anesthesia (Mama, 2013). In addition, by administering an α_2-adrenergic receptor agonist in combination with lidocaine, the dosage of local anesthetic can be reduced while also extending the duration of the analgesic effect (Hall, 2000; Skarda, 1996; Grubb, 2002). Epidural xylazine also results in mild to moderate sedation and mild ataxia (Saifzadeh et al., 2007; Shekidef and Saleh, 2011).

Procaine was the first artificially-synthesized ester-type local anesthetic, with a mechanism characterized by prevention of neurotransmission via blockage of Na channels, which is similar to that of other local anesthetics. Procaine has a high ionization constant (pKa) at 8.9 and low lipid solubility at 0.6. Although procaine offers immediate anesthesia onset, it is classified as a short-acting local anesthetic, and has been used less frequently for non-invasive anesthesia in recent years. Thus, there have been few comparisons of procaine administration to lidocaine and bupivacaine administration as an epidural anesthetic.

Moreover, lidocaine hydrochloride offers stronger topical and visceral anesthetic effects for a longer duration, than does procaine. However, when converting the degree of neuropathic toxicity from the clinically applicable concentration, lidocaine hydrochloride has relatively greater toxicity. As per the reports, it is 2.5-fold more toxic than procaine hydrochloride and 13.2-fold more toxic than mepivacaine hydrochloride (Kasaba et al., 2003). Administration of lidocaine hydrochloride in high doses also increases the risk of ataxia and recumbency due to motor paralysis of the hind limbs (Ismail, 2016).

However, in this study, no subject developed ataxia following administration of either lidocaine or procaine. In addition, by administering procaine hydrochloride, a short-acting anesthetic that is rarely used for epidural anesthesia, in combination with xylazine hydrochloride, an α_2-adrenergic receptor agonist, it is possible to obtain the same duration of epidural anesthesia as that produced by lidocaine combined with xylazine, without the risk of adverse cardiovascular or respiratory effects. These results indicate that procaine+ xylazine is a useful combination of anesthetics for providing simple epidural anesthesia.

CONCLUSION

Lumbar epidural anesthesia is commonly used in veterinary medicine for diagnostic, obstetrical, and surgical interventions in the abdominal and perineal regions of large animals. This study was performed to directly compare the time to onset and duration of epidural anesthesia produced by lidocaine-xylazine and procaine-xylazine combinations with that produced by xylazine alone in cattle. The time to onset of anesthesia did not differ significantly among the groups, but the duration of anesthesia in the xylazine-only group was significantly shorter than that in the other groups.

We found that administration of procaine hydrochloride in combination with xylazine hydrochloride, an α2- adrenergic receptor agonist, offers the same time to onset and duration of anesthesia as does epidural anesthesia using a combination of lidocaine hydrochloride and xylazine hydrochloride. Furthermore, this combination of treatments did not cause adverse effects in the cardiovascular and respiratory systems. These findings indicate that combined administration of procaine and xylazine is an economic and useful approach for epidural anesthesia.

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CONFLICTS OF INTEREST STATEMENT

The authors declare no conflict of interest.

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