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Unilateral Spinal Anaesthesia in Calves

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ABSTRACT: In this study, we aimed to evaluate the effects of unilateral anaesthesia by the administration of hyperbaric bupivacaine through the lumbosacral space into the subarachnoid space in calves. A total of 10 calves with unilateral femoral fractures were included in the study. After each calf was placed in a lateral position on the side intended for surgery, 15 mg of hyperbaric bupivacaine was slowly injected into the subarachnoid space. The onset, duration and depth of anaesthesia were determined by the pinprick test (scale 1–4). In addition, heart rate, diastolic arterial blood pressure, systolic arterial blood pressure, mean arterial blood pressure, respiratory rate and body temperature of the calves were monitored and recorded from the onset to 120 min after anaesthesia. The onset of unilateral spinal anaesthesia was within 20 s and the mean duration of anaesthesia was 155.40 min. Although there were statistical differences between hemodynamic values in the study, they were within the reference values. As a result, we believe that unilateral spinal anaesthesia in calves provides adequate anaesthesia for use in orthopaedic procedures; thus, it can be used in practice.

Keywords: Unilateral spinal anaesthesia, hyperbaric bupivacaine, calves

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INTRODUCTION

The blockage of sympathetic, sensory and motor nervous fibers rapidly occurs after administration of a local anaesthetic into the subarachnoid space and this procedure is referred to as subarachnoid, spinal or intrathecal anaesthesia (Derossi et al., 2007; Ozaydin and Kilic, 2003; Yayla and Kilic, 2010;Yayla et al., 2013). This technique can be performed in small ruminants and calves by injecting local anaesthetics into the subdural space through the lumbosacral junction (Derossi et al., 2007; Yayla et al., 2013). Spinal (intrathecal) anaesthesia provides appropriate surgical conditions for caesarean section, abdominal, pelvic or hind leg operations (Buttner et al., 2016; Malinovsky et al., 2000; Yayla et al., 2013).

Bupivacaine, commonly used in spinal anaesthesia, is an amide-type long-acting local anaesthetic. Although several side effects of bupivacaine such as ventricular arrhythmia and cardio toxicity have been reported in humans, it still remains popular (Liu and Lin, 2009; Malinovsky et al., 2000).

In spinal anaesthesia, factors such as dose of the local anaesthetic agent, injection site, additives in the anaesthetic drug, pH, baricity and temperature of the anaesthetic agents are influential on the local anaesthetic activity and its spread in the subarachnoid space (Yayla and Kilic, 2010;Yayla et al., 2013). Hypobaric solutions have specific gravity less than that of the cerebrospinal fluid (CSF), and can cranially migrate following injection and affect the diaphragm and intercostal muscles, which may cause death. In contrast, because hyperbaric solutions are heavier than CSF, they are locally retained or show limited spread in the injection site (Yayla and Kilic, 2010). Therefore, the use of hyperbaric local anaesthetic solutions may be an attractive option to avoid potential complications (Skarda and Tranquilli 2007; Yayla et al., 2013).

In humans, when a hyperbaric local anaesthetic is intrathecally administered, the anaesthetic result that is achieved by introducing the effect of the local anaesthetic on nerve roots in a certain area by limiting the distribution of the local anaesthetic with the effect of gravity and patient's position is defined as unilateral spinal anaesthesia (Kilavuz et al., 2015). However, this technique has not been used in the field of veterinary medicine. The hypothesis of this study is that hyperbaric local anaesthetic agent acts unilaterally on the spinal cord with the effect of gravity. In this study, we aimed to evaluate the effects of unilateral anaesthesia provided by the administration of hyperbaric bupivacaine solution through the lumbosacral space into the subarachnoid space in calves.

MATERIALS AND METHODS

The study was approved by the Kafkas University Animal Experiments Local Ethics Committee (KAU-HADYEK 2018/006). Ten calves with unilateral femoral fractures were included in the study. Unilateral femoral fracture was sufficient without any criteria for selection of these calves. Osteosynthesis with intramedullary nail was decided in all calves included in the study.

Following routine preparations such as clipping and disinfecting, the calves were sedated with xylazine (2% Rompun®, Bayer, Turkey, 0.2 mg/kg intramuscular) and placed on the operating table in a lateral position on the side intended for surgery. The operation table was tilted at approximately 30°, with the head and chest region of the animal facing upward. Under aseptic conditions, skin and subcutaneous tissues in the lumbosacral region were desensitized with 2 ml of the local anaesthetic (Adokaine®, Sanovel, Turkey) for subcutaneous tissue and ligamentum flavum. An 18 G spinal needle was used to enter the subarachnoid space through the lumbosacral junction (L6-S1) and the needle placement was confirmed by observing the flow of the CSF. Subsequently, the injection of Marcaine® Spinal Heavy 0.5% (Astra Zenaca) containing 15 mg/total (3 ml) of hyperbaric bupivacaine was slowly performed. All injections were performed by the same operator (first author, SY). After keeping the calves in this position for 15 min, they were again placed in a suitable position and osteosynthesis was performed. In addition, an electrolyte solution was intravenously administered in the jugular vein (0.9% saline) at the rate of 10 ml/kg/h throughout the operation.

Vital signs of each animal used in the study were monitored (Veterinary Monitor® MMED6000DP S6-V). Systolic blood pressure (SBP), diastolic blood pressure (DBP), mean blood pressure (MBP), heart rate (HR), respiratory rate (RR) and rectal temperature (RT) values were recorded at the onset, during sedation, and at 5, 15, 30, 60, 90 and 120 min after spinal anaesthesia. The onset and duration of anaesthesia were determined by the pinprick test. Pin-prick test was performed for 180 minutes from the beginning of anaesthesia. The pinprick test was evaluated on a scale of 1–4 as described by DeRossi et al. (2007) and Yayla et al. (2013) (1, no analgesia and reaction to stimulus; 2, mild analgesia and depressed reaction to stimulus; 3, moderate analgesia and no response to superficial needle-prick stimulation of the skin in response to stimulus and 4, complete analgesia and no response to insertion of the needle deep into the muscle layer). In addition, the anaesthetic effect was compared by performing this evaluation both on the leg intended for surgery and on the intact leg.

For postoperative pain, ketoprofen (Ketobay®, Bayer, Turkey, 3 mg/kg, subcutaneously) was administered for up to 3 days after surgery.

Statistical analysis of the data was performed using the Minitab-16 software package. The Anderson–Darling test was used to test the normality distribution of the data, a Kruskal–Wallis test was used for non-parametric data and one-way analysis of variance (ANOVA, Tukey's pairwise comparisons) with $p < 0.05$ was accepted as significant.

RESULTS

All the calves included in the study (n = 10) belonged to the Simmental breed, seven were male and the remaining three were female. The calves were 1-month old with unilateral femoral fractures and their mean live weight was 43.30 ± 4.88 kg. The mean operation time for osteosynthesis was 47.50 ± 8.90 min.

Subarachnoid injections through the lumbosacral region were easily performed, and after these injections, the onset of anaesthesia was within 20 s in all cases. A comparative evaluation of both hind legs using the pinprick test and analgesia scores is summarized in Figure 1. There was a statistically significant difference between the dependent leg and the contralateral leg from the 1st minute after the lumbosacral injection ($P < 0.05$, Kruskal–Wallis test). Unilateral spinal or intrathecal anaesthesia was performed in all calves and the mean duration of anaesthesia was calculated as 155.40 ± 27.71 min.

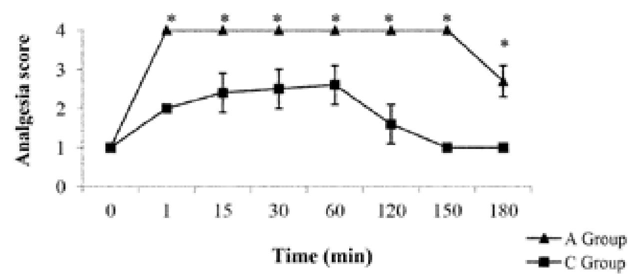

Figure 1. Analgesia scores in response to standard pinprick stimuli in calves that received unilateral spinal anaesthesia with hyperbaric bupivacaine. A group: hind leg affected by unilateral anaesthesia. C group: intact hind leg. (1, no analgesia; 2, mild analgesia; 3, moderate analgesia and 4, complete analgesia). *Statistically significant difference between the affected and unaffected legs ($P < 0.05$).

During the operation, both the depth of anaesthesia and muscle relaxation was deemed adequate for osteosynthesis and no further interventions were required.

Hemodynamic values obtained from the study (HR, RR, SBP, MBP, DBP and RT values) are summarized in Table 1. Although there was a statistically significant (ANOVA, One Way test) decrease from baseline in SBP value following the administration of xylazine, SBP increased as from the 30th to the 60th minute of anaesthesia. There was a statistically significant difference in the diastolic value from baseline, but improved after 60 min. In terms of MBP and HR values, there was a statistically significant between the initial and the 5th minute of spinal anaesthesia.

Table 1. Mean ± sd of heart rate (HR), systolic blood pressure (SBP), diastolic blood pressure (DBP), mean blood pressure (MBP), respiratory rate (RR) and rectal temperature (RT) in calves that received unilateral spinal anaesthesia with hyperbaric bupivacaine.

Values	Time (min)								P
	Initial	Sedation	Spinal anaesthesia						
			5	15	30	60	90	120	
SBP	100.20±13.46^{a}	68.50±13.04^{b}	69.80±14.09^{b}	81.20±11.86^{b}	81.30±7.83^{b}	85.20±6.44^{ab}	87.30±7.96^{ab}	99.10±12.49^{a}	0.000
DBP	80.80 ±7.47^{a}	55.70 ±7.56^{b}	52.20 ±3.22^{b}	58.40±6.33^{bc}	66.60±6.96^{c}	78.80±7.02^{a}	81.30±7.47^{a}	82.40±7.34^{a}	0.000
MBP	90.10 ±18.27^{a}	69.20±12.10^{b}	70.60±15.48^{b}	75.60±12.64^{ab}	81.70±8.82^{ab}	82.40±15.56^{ab}	83.10±15.51^{ab}	88.50±11.73^{a}	0.008
HR	98.90 ±8.39^{a}	67.90±26.28^{b}	65.10±23.33^{b}	83.50±17.07^{ab}	91.80±12.77^{a}	99.70±9.53^{a}	99.60±8.17^{a}	100.60±8.95^{a}	0.000
RR	15.30 ±1.33^{a}	14.20 ±2.15^{a}	11.60 ±0.96^{b}	10.90±1.44^{ab}	12.50±1.08^{a}	13.90±1.44^{a}	14.40±1.43^{a}	15.20±0.63^{a}	0.000
RT	37.90 ±0.61^{a}	37.41±0.12^{ab}	37.29 ±0.29^{b}	37.40±0.22^{b}	37.57±0.25^{ab}	37.57±0.30^{ab}	37.60±0.26^{ab}	37.64±0.26^{ab}	0.004

a–c: Significantly different from baseline values on the same line ($p < 0.05$)

DISCUSSION

Spinal or intrathecal anaesthesia is used in the fields of both human and veterinary medicine because of the several benefits it offers (Kilavuz et al., 2015; Ozaydin and Kilic, 2003; Singh et al., 2014; Yayla et al., 2013; Yayla et al., 2017). While unilateral spinal anaesthesia is widely used in human medicine (Esmaoglu et al., 1998; Kilavuz et al., 2015), its use has not been described in veterinary medicine or is not sufficiently known. Therefore, in this study, we aimed to evaluate the effects of unilateral anaesthesia provided by the administration of hyperbaric bupivacaine through the lumbosacral space to the subarachnoid space in calves. The data obtained from this study showed that unilateral spinal anaesthesia in calves provides adequate anaesthesia for use in orthopaedic procedures and can be used in practice.

There is a controversy over some side effects of spinal anaesthesia, particularly cardio respiratory effects (e.g. hypotension) of the local anaesthetics used in spinal anaesthesia, which is known to be a good alternative to general anaesthesia (Ozaydin and Kilic, 2003; Yayla and Kilic, 2010; Yayla et al., 2013). Utilization of unilateral spinal anaesthesia technique may have several advantages in orthopaedic procedures of the hind leg without these side effects (Buttner et al., 2016; Esmaoglu et al., 1998; Kilavuz et al., 2015; Singh et al., 2014). In unilateral spinal anaesthesia, use of low-dose local anaesthetics, slow injection, proper positioning of the patient, attention to baricity of the local anaesthetic used and maintenance of the appropriate position of the patient during injection are recommended for unilateral spread of the local anaesthetic drug (Kilavuz et al., 2015). The most important advantage of unilateral spinal anaesthesia compared with bilateral spinal anaesthesia is fewer and less severe cardiovascular side effects and a better nerve block on the side to be operated despite using a low dose. The maintenance of the position of the patient is a challenge (Esmaoglu et al., 1998; Kilavuz et al., 2015).

Spinal anaesthesia technique is based on the induction of spinal block by directly injecting the local anaesthetic into the cerebrospinal fluid (CSF), which surrounds the spinal cord, and nourishes and protects it in the medullar canal (Yayla and Kilic, 2010; Yayla et al., 2013). The local anaesthetic drug, which starts to spread over the spinal cord in the CSF, has an effect on the nerve roots exiting the spinal cord and dorsal root ganglia. In spinal anaesthesia, however, it is desirable to limit the spread of local anaesthesia in the CSF and to prevent local anaesthesia from spreading excessively cranially (Ozaydin and Kilic 2010; Yayla et al., 2013; Yayla et al., 2013). Several factors such as the injection rate, positioning of the patient, local anaesthetic baricity and patient's anatomy may affect the spread of the drug. In both bilateral and unilateral spinal anaesthesia, rapid injection is not recommended to avoid possible complications. In addition, because hyperbaric local anaesthetics are heavier than the CSF, they precipitate with the effect of gravity on the dependent part of the spinal cord and show their effect on the dependent nerves and nerve roots. Positioning the patient laterally is required. In addition, keeping the local anaesthetic dose low compared with that used in bilateral spinal anaesthesia contributes to the decrease in the volume of medication injected into the CSF and to a more limited spread (Casati et al., 1998; Fanelli et al., 2000; Kilavuz et al., 2015; Kuusniemi et al., 2000; Malinovsky et al., 2000; Yayla et al., 2013; Yayla et al., 2017). To the authors' knowledge, this is the first study on calves that examined hyperbaric bupivacaine as a local anaesthetic to provide unilateral spinal anaesthesia. Lumbosacral injection was performed in all animals by the same operator and at a very slow pace. The dose in calves was designed as 15 mg and 3 ml of anaesthetic drug was injected (Yayla et al., 2013). In addition, because the duration needed for the spread of the local anaesthetic in the CSF after injection or removal of the effect of the gravity has been reported to be 15 min (Yayla and Kilic, 2010; Kilavuz et al., 2015), calves were kept in a lateral position with the side intended for surgery dependent for at least 15 min following injection and were then positioned for surgery. In all the calves in this study, unilateral spinal anaesthesia was obtained within 20 s after injection and lasted for 155 min on average. Complete spinal block was not observed in the contralateral extremity (Figure 1).

Because of the slowing down of peripheral venous circulation in spinal anaesthesia, bradycardia or cardiovascular depression is an expected side effect. Studies have reported that despite being widely used in spinal anaesthesia, bupivacaine may trigger cardiopulmonary side effects (Casati et al., 1998; Fanelli et al., 2000; Kilavuz et al., 2015; Kuusniemi et al., 2000; Yayla et al., 2013). In our study, there was a significant decrease from baseline in SBP, DBP, MBP, HR and RR values after sedation. We attribute these changes to the effect of xylazine (Kamiloglu et al., 2005). In addition, during spinal anaesthesia and especially after 15 min, xylazine was well tolerated in terms of values of hemodynamic parameters which returned to baseline and remained within the reference range. The depressive effect on hemodynamic parameters is closely related to the dose of the local anaesthetic used (Malinovsky et al., 2000). In this regard, it is important to use a low dose of a local anaesthetic in unilateral spinal anaesthesia. In fact, the most important advantage of unilateral spinal anaesthesia compared with bilateral spinal anaesthesia is the lower incidence of cardio respiratory side effects.

CONCLUSION

In conclusion, unilateral spinal anaesthesia provided by the administration of intrathecal hyperbaric bupivacaine through the lumbosacral space with appropriate positioning in calves with unilateral femoral fractures provides adequate anaesthesia and of adequate duration to allow its use in orthopaedic procedures. We believe that unilateral spinal anaesthesia can be used in orthopaedic interventions for the hind leg in daily practice.

CONFLICT OF INTEREST STATEMENT

The authors declare that they have no conflicts of interest.

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