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Effects of intrathecal anesthesia with hyperbaric bupivacaine for hind limb orthopedic surgery in calves

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Summary

Anesthesia obtained by the injection of local anesthetic into the cerebrospinal fluid is defined as intrathecal or spinal anesthesia. This study aimed to compare intrathecal anesthesia with gas anesthesia in calves operated for hind limb fractures. Twelve calves with hind leg femur and tibia fractures were included in the study. Six of these calves were subjected to intrathecal anesthesia (IT) and the other 6 to gas anesthesia (GA). Sedation with xylazine was performed after general operative preparations. In the IT group, hyperbaric bupivacaine was injected lumbosacrally, while in the GA group, general anesthesia was achieved with isoflurane after mask induction. Anesthesia onset, operation and anesthesia durations, and intraoperative parameters were recorded. Systolic and diastolic blood pressure, pulse, respiratory rate, body temperature, and electrocardiography were monitored and recorded. In addition, postoperative pain was evaluated with the postoperative pain visual analog scale (VAS), simple descriptive pain scale (SDS), and bovine pain assessment scale (BPAS). Although there were statistical differences between the hemodynamic values measured in the study, they remained within reference ranges. In conclusion, it can be said that intrathecal anesthesia is practical for hind leg surgery in calves and has advantages, especially in terms of postoperative pain management.

Keywords: calves, hyperbaric bupivacaine, intrathecal anesthesia, postoperative pain

Spinal or intrathecal anesthesia is the blockade of the sympathetic, sensory and motoric nerves achieved by injecting a local anesthetic into the subarachnoid space. It is very easy to reach the dural space from the lumbosacral space in calves for injection. It has been reported that it ensures suitable surgical conditions especially for hind leg surgeries (1, 10, 11, 16, 17).

Bupivacaine is a local anesthetic widely used in intrathecal anesthesia (6, 10). It remains popular despite reports of its negative effects on the cardiovascular system, such as hypotension. A great advantage of a hyperbaric local anesthetic used for intrathecal anesthesia is its limited involvement and distribution at the injection site (7, 18, 19). The cranial distribution of the local anesthetic agent within the medullar canal is a vital risk in terms of blockade of the intercostal muscles and diaphragm (16).

This study aimed to comparatively investigate the effects of intrathecal anesthesia provided with hyperbaric bupivacaine and gas anesthesia on selected vital parameters and postoperative pain during orthopedic surgery of the hind limb in calves.

Material and methods

This study was conducted on 12 calves undergoing hind limb orthopedic surgery. The study protocol was approved by the Dicle University Health Sciences Application and Research Center Local Ethics Committee (E-35582840-020-500034). The calves were divided into two groups: an intrathecal anesthesia group (IT, n = 6) and a gas (inhalation) anesthesia group (GA, n = 6).

The calves sedated with Xylazine (2% Rompun®, Bayer, Türkiye, 0.2 mg/kg intramusculary) were laid on an operating table after routine preparations, such as shaving and disinfection for operation. In the IT group, the operating table was tilted at approximately 30 degrees, with the head and chest of the animal up. After being held in this position for 10 minutes, the calves were placed in a suitable position for surgery. Intrathecal injections were made through the lumbosacral (L6-S1) space with an 18 G spinal needle as previously reported by Yayla et al. (18). Subsequently, a slow injection of 15 mg/total (3 ml) hyperbaric bupivacaine (Marcaine® Spinal Heavy 0.5%, AstraZeneca, Türkiye, intrathecaly) was performed. All injections were performed by the same person (second author SY). In the GA group,

endotracheal intubation was performed after mask induction, followed by a mixture of 100% O_2 and volatile liquid anesthesia. Anesthesia was started at 3-5% concentration of isoflurane (Isoflurane® USP%100, Adeka, Türkiye). Animals were kept under anesthesia with spontaneous ventilation throughout the operation. In addition, electrolytes were administered intravenously (0.9 per cent to saline) at 10 ml/kg/hour through the jugular vein during the operation.

Each animal used in the study was monitored. Systolic (SBP), diastolic (DBP), and mean blood pressures (MBP), as well as heart rate (HR), respiratory rate (RR), and rectal temperature (RT) values were recorded at minutes 5, 15, 30, 60, 90, and 120 of anesthesia (IT or GA).

Anesthesia onset and anesthesia duration were determined by pin-prick test, as previously described by Derossi et al. (3) and Yayla et al. (18). In addition, postoperative pain was evaluated during the postoperative 24 hours with the postoperative pain visual analog scale (VAS, scored as 1-10), simple descriptive pain scale (SDS, scored as 1-10), and bovine pain assessment scale (BPAS, scored as 0-2), previously defined by Tan and Yayla (12). Postoperative pain was assessed at hours 1, 2, 4, 6, 8, 12, and 24. Ketoprofen (Ketobay®, Bayer, Türkiye, 3 mg/kg, subcutaneous) was used when the pain score was greater than 4.

Statistical analyzes of the data were performed using the Minitab-16 package program. Anderson-Darling test was used to determine the normality of data distribution, Kruskal-Wallis test for non-parametric data, and ANOVA (One-Way Analysis of Variance-Tukey pairwise comparisons) for parametric data. $P < 0.05$ was considered a statistically significant difference in comparisons. Also, the Mann-Whitney U test, which is a non-parametric test, was used to compare the two groups.

Results and discussion

All calves (n = 12) included in the study were of Simmental breed; 8 of them were males and the remaining 4 were females. The calves were 1 month old, and their average live weight was 45.20 ± 2.33 kg. There were 4 femur and 2 tibia fractures in the IT group, and 5 femur and 1 tibia fractures in the GA group. Open reduction was achieved in all calves, and osteosynthesis was performed. The mean operation time for these procedures was 35.40 ± 7.20 minutes.

The depth of anesthesia and muscle relaxation during the operation were sufficient for osteosynthesis and no additional anesthesia was required.

Tab. 1. Mean ± sd of hemodynamic values (HR, RR, SBP, MBP, DBP and RT)

Values		Time (min)							
		Initial	Sedation	IT or GA					
				5	15	30	60	90	120
HR	IT	101.83 ± 9.17^{a}	70.00 ± 33.00^{a}	66.80 ± 30.05^{ab}	84.17 ± 21.89^{b}	92.33 ± 15.58^{ab}	101.50 ± 12.26	98.17 ± 9.72^{a}	97.67 ± 8.87^{a}
	GA	94.33 ± 4.80^{a}	61.83 ± 15.47^{b}	60.83 ± 8.47^{b}	81.33 ± 8.91^{a}	89.00 ± 8.90^{a}	97.17 ± 2.48^{a}	100.67 ± 4.80^{a}	102.83 ± 7.19^{a}
SBP	IT	106.67 ± 9.37^{a}	75.83 ± 10.94^{b}	79.00 ± 9.51^{b}	89.00 ± 1.67^{ab}	85.50 ± 7.31^{ab}	89.00 ± 3.46^{ab}	89.50 ± 9.67^{ab}	103.17 ± 9.43^{a}
	GA	91.17 ± 10.78^{a}	61.66 ± 9.63^{b}	61.00 ± 11.03^{b}	71.17 ± 12.14^{bc}	77.00 ± 6.78^{ac}	81.33 ± 7.74^{ac}	83.50 ± 3.02^{ac}	93.83 ± 11.99^{a}
MBP	IT	97.83 ± 16.79^{a}	72.33 ± 15.08^{b}	77.17 ± 16.35^{b}	81.00 ± 10.33^{ab}	83.67 ± 4.97^{ab}	90.50 ± 9.91^{ab}	91.50 ± 10.60^{ab}	94.17 ± 6.55^{ab}
	GA	77.67 ± 11.89^{a}	62.67 ± 3.83^{ab}	61.17 ± 5.91^{b}	68.33 ± 9.31^{ab}	77.50 ± 10.37^{ab}	71.83 ± 12.11^{ab}	71.67 ± 10.60^{ab}	83.33 ± 11.62^{a}
DBP	IT	79.17 ± 6.43^{a}	58.17 ± 8.77^{b}	53.83 ± 2.04^{b}	62.00 ± 5.44^{b}	67.17 ± 7.81^{bc}	77.33 ± 5.92^{ac}	81.17 ± 8.40^{ac}	81.83 ± 7.22^{ac}
	GA	82.00 ± 7.92^{a}	54.17 ± 7.94^{b}	51.17 ± 3.43^{b}	55.50 ± 5.54^{b}	66.83 ± 6.91^{bc}	78.83 ± 8.40^{ac}	79.33 ± 7.79^{ac}	81.17 ± 8.01^{a}
RR	IT	15.16 ± 1.72^{a}	13.50 ± 2.59^{ab}	11.33 ± 0.81^{bc}	10.33 ± 1.50^{c}	12.50 ± 1.37^{bc}	13.33 ± 1.63^{ab}	14.00 ± 1.67^{a}	15.00 ± 0.63^{a}
	GA	15.50 ± 1.64^{a}	15.00 ± 1.09^{a}	11.83 ± 0.98^{b}	10.83 ± 1.60^{b}	12.50 ± 0.54^{bc}	14.16 ± 1.60^{ac}	15.16 ± 0.75^{a}	15.50 ± 0.54^{a}
RT	IT	38.01 ± 0.79^{a}	37.41 ± 0.04^{ab}	37.20 ± 0.33^{b}	37.31 ± 0.24^{b}	37.50 ± 0.31^{ab}	37.58 ± 0.29^{ab}	37.61 ± 0.18^{ab}	37.56 ± 0.32^{ab}
	GA	37.76 ± 0.10^{a}	37.40 ± 0.16^{a}	37.41 ± 0.29^{a}	37.43 ± 0.23^{a}	37.71 ± 0.11^{a}	37.61 ± 0.30^{a}	37.58 ± 0.33^{a}	37.78 ± 0.09^{a}

Explanation: a-c – significantly different from baseline value in the same row ($p < 0.05$)

Tab. 2. Analgesic score comparisons of the groups

Analgesic scores		Postoperative time (hours)							
		0th	1st	2nd	4th	6th	8th	12th	24th
VAS	IT	1.00 ± 0.00	1.00 ± 0.00	1.00 ± 0.00	1.00 ± 0.00	1.16 ± 0.40	1.33 ± 0.50	1.33 ± 0.50	1.33 ± 0.50
	GA	1.00 ± 0.00	1.60 ± 0.50	3.60 ± 0.80*	5.00 ± 0.50*	2.40 ± 0.50*	2.06 ± 0.50*	1.33 ± 0.50	1.33 ± 0.50
SDS	IT	1.00 ± 0.00	1.00 ± 0.00	1.16 ± 0.40	1.16 ± 0.40	1.66 ± 0.51	1.66 ± 0.51	1.16 ± 0.40	1.00 ± 0.00
	GA	1.00 ± 0.00	1.50 ± 0.54	4.00 ± 1.09*	5.50 ± 0.83*	3.33 ± 1.03*	2.66 ± 0.81*	1.16 ± 0.40	1.00 ± 0.00
BPAS	IT	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.16 ± 0.40	0.16 ± 0.00
	GA	0.00 ± 0.00	0.50 ± 0.54	1.16 ± 0.98*	1.50 ± 0.83*	1.66 ± 0.51*	1.66 ± 0.51*	0.83 ± 0.40	0.16 ± 0.40

Explanation: * statistical difference between the two groups ($p < 0.05$)

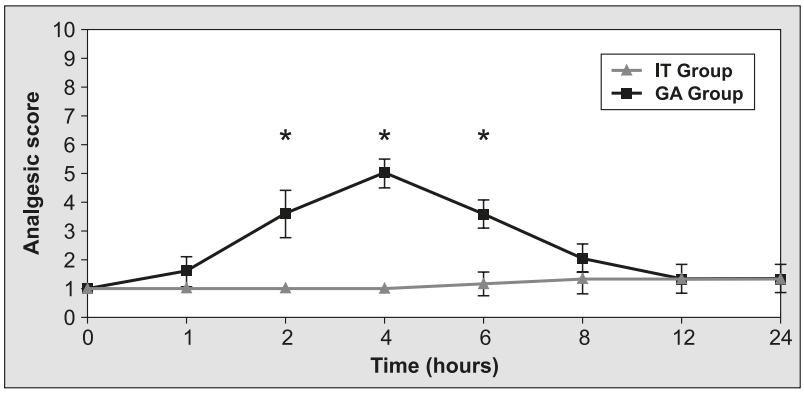

Fig. 1. VAS analgesic score of the groups: A statistically significant difference was found between the groups at postoperative hours 2, 4, and 6. Analgesic drug was administered at postoperative hour 4.

Subarachnoid injections from the lumbosacral region were performed easily, and the onset of anesthesia occurred in less than 20 seconds after these injections. The duration of anesthesia in the IT group was calculated as 135.20 ± 22.20 minutes.

The hemodynamic values (HR, RR, SBP, MBP, DBP, and RT) obtained from the study are summarized in Table 1. Postoperative analgesic scores are summarized in Table 2. A VAS comparison of the groups is shown in Figure 1.

General anesthesia is not always advisable in cattle, and local anesthesia techniques are often limited in interventions such as orthopedic surgery. However, it has been reported that intrathecal anesthesia offers important advantages, especially for the hind extremities (10, 14, 16, 18, 20). Despite the advantages of intrathecal anesthesia over other anesthesia techniques, some cardiorespiratory side effects of local anesthetics used in spinal anesthesia, such as bupivacaine, are also known (19). Local anesthetic in a hyperbaric concentration is preferred in orthopedic surgery of the hind limb, both to reduce the dose of local anesthetic and to avoid these side effects (20). Therefore, this study aimed to compare gas anesthesia (GA) with intrathecal (IT) anesthesia obtained by administering hyperbaric bupivacaine from the lumbosacral space to the subarachnoid space for orthopedic surgery of a hind limb in calves.

The intrathecal anesthesia technique is based on the development of spinal block by injecting local anesthetic directly into the cerebrospinal fluid surrounding the spinal cord in the medullary canal (10, 17). Therefore, in intrathecal anesthesia, it is important to limit the spread of the local anesthetic in the cerebrospinal fluid to a specific area, and thus prevent the progression of the local anesthetic towards the cranial region. The spread of the anesthetic depends on several variables, such as injection speed, local anesthetic baricity, and the patient's position and anatomy. Rapid injection is not recommended to avoid possible complications in intrathecal anesthesia. In addition, since local anesthetics with hyperbaric properties are heavier than the cerebrospinal fluid, they concentrate in the lower part of cerebrospinal fluid because of gravity and exert their effect on the underlying nerve roots of the spinal cord (18, 20). In our study, hyperbaric bupivacaine was used as a local anesthetic. It can be said that hyperbaric bupivacaine is a special form for intrathecal anesthesia.

In our study, the other group was GA rather than a control group. In terms of the onset, duration, and depth of anesthesia, both groups were very similar to those in previous studies (15, 20). In addition, both groups achieved sufficient muscle relaxation for the operation.

According to reports, intrathecal anesthesia may be associated with bradycardia or cardiovascular depression, which has been attributed by some authors to the slowing down of peripheral venous circulation, and by others to the local anesthetic used. It is worth pointing out that precautions should be taken against temporary hypotension that occurs during anesthesia (16, 18-20). In our study, there was a significant decrease in post-sedation SBP, DBP, MBP, HR, and RR values compared to baseline values in both the IT group and the GA group. Although these values continued to decrease throughout anesthesia, they later returned to their baseline levels. Even though there were statistical differences in the vital parameters summarized in Table 1, they remained within reference ranges.

Pain scales for cats and dogs are widely used for the assessment of pain (4, 12). However, the use of a specific scale for the determination of acute pain in cattle is not common. In cattle, it is interpreted based on the animal's behavior towards the environment, and the need for analgesia is determined on the basis of changes in head, eye, ear, and facial muscles rather than physiological or vital changes (12). Determining the reactions to pain in cattle is more difficult than it is in other animal species, and in these animals it should be based on their appetite, body position, head and facial expressions, holding the ears, and interest in other animals or the environment. Postoperative pain studies have been performed in newborn calves, usually after surgical procedures, such as castration or dehorning. Molony et al. (8) studied a scale about restlessness, standing, kicking, responses to impact, head movements, tail movements, holding the body tense and posture, and reported the results they obtained. On the other hand, Ting et al. (13) compared the efficacy of various analgesics in epidural use and postoperative pain after castration in calves and used a scale based on the animal's condition, such as the general condition of the animal during standing and lying down, restlessness, head and tail movements, as well as inflammation mediators. Similarly, Currah et al. (2) used a scale based on post-operative behavioral changes in animals, while De Oliveira et al. (9) focused on postoperative pain directly using the VAS and SDS

scales. Unlike these studies, Gleerup et al. (5) reported BPAS, including the condition or movements of the ears, the condition of the eyes, the position of the head, in addition to the animal's posture and behavior, as in the VAS and SDS. In our study, these three pain scales were used together and their results confirmed each other.

In conclusion, the depth of spinal anesthesia and muscle flexibility obtained by the intrathecal injection of hyperbaric bupivacaine from the lumbosacral region is sufficient for hind limb orthopedic surgery of calves. A great advantage of intrathecal anesthesia, compared with gas anesthesia, is that it contributes to postoperative analgesia.

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