The Journal of Veterinary Medical Science

FULL PAPER

Surgery

# Effects of a single-bolus bupivacaine injection into the coccygeal spinal canal of rabbits

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**ABSTRACT.** It has been reported that drugs intended for epidural administration through the lumbosacral junction are accidentally administered into the subarachnoid space frequently in rabbits. Therefore, we evaluated the epidural single-bolus injection technique for the administration of bupivacaine into the coccygeal spinal canal of rabbits. After epidural distribution was confirmed by the injection of iohexol into the coccygeal spinal canal, 0.3 ml/kg 0.5% bupivacaine or 0.3 ml/kg normal saline was injected via the same needle. After the first attempt of iohexol injection, although the contrast was found in the epidural space in all rabbits, the additional contrast was also found in blood vessel in 3 rabbits and in muscular layer in 1 rabbit. Subarachnoid distribution was not observed in any of the rabbits. The time taken to regain normal anal reflex, movement of the hind limbs during walking, conscious proprioception of the hind limbs, and pain sensation of the tail and left hind limb, following coccygeal spinal canal injection, were significantly longer in the bupivacaine group than in the normal saline group. These findings indicated that coccygeal epidural injection of bupivacaine in rabbits may provide anesthesia for the hind limbs, perineum, and tail, but inadvertent vascular entry of the epidural drug may occur.

**KEY WORDS:** analgesia, bupivacaine, epidural anesthesia, epidural single-bolus injection technique, rabbit

*J. Vet. Med. Sci.*
82(2): 197–203, 2020
doi: 10.1292/jvms.19-0555

Received: 9 October 2019
Accepted: 15 December 2019
Advanced Epub:
22 January 2020

Epidural anesthesia and analgesia are frequently administered by inserting a needle into the epidural space through the lumbosacral junction to deliver local anesthetics for procedures at the caudal part of the body, such as hind limbs [4, 16, 21]. This technique has also been used in rabbits [8, 12, 15]. In rabbits, however, it was reported that even if we intended to perform epidural administration, it frequently resulted in subarachnoid administration when the administration was done through the lumbosacral junction [22]. Subarachnoid administration of epidural dose may cause excessive cranial spread of the drug [21] and spinal cord puncture may cause spinal cord injury. On the contrary, drug injection into the sacrococcygeal epidural space has been performed in some animals especially cats [20, 23]. Because the spinal cord of rabbits ends at the sacral vertebrae [7], injection into the coccygeal spinal canal would not result in subarachnoid injection. In the present study, we aimed to evaluate the distribution of iohexol and the effects of bupivacaine after a single-bolus injection into the coccygeal spinal canal of rabbits.

## MATERIALS AND METHODS

The present study was approved by the Animal Experiment Committee of the University of Miyazaki. Rabbits were handled according to the Guidelines for the Institutional Care and Use of Laboratory Animals at the University of Miyazaki. In this study, six male Japanese White Rabbits, aged 6–33 months, weighing 3.6 ± 0.2 kg (mean ± SD), were used. All rabbits were considered to be healthy upon physical examination, neurological examination, and arterial blood gas analysis. Each rabbit underwent two experimental trials at 14-day intervals. Thereafter, either 0.3 ml/kg of 0.5% bupivacaine or 0.3 ml/kg of normal saline was randomly administered via epidural in separate trials. The epidural solution was prepared by one individual (HY) in a random manner. The individual (BO) who performed the coccygeal spinal canal injection and conducted the neurological examination was

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blinded to the treatment; bupivacaine or normal saline was injected into the coccygeal spinal canal.

The marginal auricular vein of rabbits was catheterized using a 22-gauge polyethylene catheter (Surflo; Terumo Corp., Tokyo, Japan) for propofol and intravenous fluid administration. The central auricular artery was also catheterized using the 22-gauge polyethylene catheter to collect arterial blood sample for blood gas analysis. Anesthesia was induced by intravenous administration of 10 mg/kg propofol (1% Propofol inj. 10 mg/m*l*; Maruishi Pharmaceutical Co., Ltd., Osaka, Japan) and maintained with isoflurane (Isoflurane Inhalation Solution; Pfizer Inc., Tokyo, Japan) in 100% oxygen (1 *l*/min) using a face mask attached to a circle breathing system [1, 10] with a pediatric breathing tube. The concentration of isoflurane (2.5–3.5% in vaporizer dial setting) was adjusted to maintain the mean arterial blood pressure more than 55 mmHg and to prevent spontaneous movement of the animals; the concentration was not changed from 15 min before the coccygeal spinal canal injection to 2 min after the coccygeal spinal canal injection. Rabbits were intravenously administered with normal saline (Otsuka Normal Saline; Otsuka Pharmaceutical Factory, Inc., Tokushima, Japan) at a rate of 10 m*l*/kg/hr throughout general anesthesia with a syringe pump (TOP-551V; TOP Corp., Tokyo, Japan).

Each rabbit was positioned in sternal recumbency. A towel roll was then placed underneath the caudal abdomen to elevate the hip. At the dorsal surface of the tail base, a 70-mm-long 27-gauge spinal needle (TOP Spinal Needle; TOP Corp.) was inserted through the intercoccygeal site in the caudocranial direction at an angle of approximately 30° to the skin surface and sagittal to the spine axis. In the present study, determination of the intervertebral space by palpation was easier at the tail than at the sacrococcygeal area. The C-arm machine (OEC9900 Elite Standard-C 9" Basic Vascular Platform; GE Health Care, Tokyo, Japan) was then used to capture plain lateral and dorsoventral radiographs at the coccygeal vertebrae. Following the confirmation of the needle tip placement in the vertebral canal, 0.1 m*l*/kg iohexol (Iopaque 300; Konica Minolta, Tokyo, Japan) was administered. If the contrast was found only in the epidural space, which was determined by lateral (Fig. 1a) and dorsoventral radiographs, either 0.3 m*l*/kg bupivacaine 0.5% (Marcain® injection 0.5%; Aspen Pharma, Tokyo, Japan) (n=6) or 0.3 m*l*/kg normal saline (n=6) was randomly injected into the coccygeal spinal canal in a blinded manner. The needle was readjusted when the contrast was observed at sites besides the epidural space until identified in the epidural space only. Later, a coccygeal spinal canal injection of either bupivacaine or saline was performed as mentioned above, when the contrast was observed in the epidural space only. General anesthesia and oxygen supply were discontinued at 2 min after the coccygeal spinal canal injection.

At 1 min before and 1, 5, and 10 min after coccygeal spinal canal injection, pulse rate and non-invasive blood pressure of rabbits were measured using pulse oximeter and oscillometric device respectively, from a multi-parameter patient monitor (AT-208; Fukuda M-E Kogyo Co., Ltd., Tokyo, Japan). Neurological examination was performed before induction of general anesthesia and after the coccygeal spinal canal injection every 20 min until the findings were normal. Moreover, mentation, anal reflex, conscious proprioception of the forelimbs and hind limbs, and pain sensation of the forelimbs, hind limbs, and tail were evaluated and recorded in accordance with the method reported by Mancinelli E. [18]. The responses were recorded as normal (+2), weak (+1), and absent (0). Mentation was observed by allowing the rabbit to move freely around the room. Observation of the rabbit's responsiveness to the surrounding environment was carried out. In particular, normal mentation was defined by the rabbit's ability to be responsive to the surrounding environment. A cotton bud was used to gently stroke the anus to assess the contraction of the anal sphincter muscle. Contraction of the anal sphincter muscle was regarded as normal anal reflex responses.

Rabbit forelimb digits, hind limb digits, and tail base were squeezed with fingers to evoke a deep pain perception. Withdrawal of the limb and avoidance of the pain stimulus by walking away were perceived as normal pain sensation. Movement of limbs during walking was visually assessed using an assessment method by Malinovsky *et al.* [17] with modifications: +2 indicated that the rabbit had free limb movement without any limitation; +1 indicated limited or asymmetrical limb movements for spontaneous body support or walking, or the inability to achieve spontaneous body support or walking; and 0 indicated total limb paralysis. Conscious proprioception of forelimbs and hind limbs was assessed by holding the rabbit in the normal standing position and flexing each paw to make contact between its dorsal aspect and floor surface. Normal conscious proprioception was defined as the immediate return of the paw to a normal position. Neurological examination was carried out one week later.

Following the withdrawal and discarding of more than 0.5 m*l* of blood, 0.2 m*l* of arterial blood was withdrawn anaerobically, using a heparinized syringe, through the catheter placed in the central auricular artery for immediate blood gas analysis, using a blood gas analyzer (i-STAT 300F; Fuso Pharmaceutical Industries, Ltd., Osaka, Japan). Blood gas analysis was performed before general anesthesia and at 30, 60, and 120 min following epidural injection in conscious rabbits with spontaneous breathing under room air.

### *Statistical analyses*

Data for pulse rate, arterial blood pressure, partial pressure of oxygen ($PaO_2$) and carbon dioxide ($PaCO_2$), pH, base excess (BE), and bicarbonate ($HCO_3^-$) in the arterial blood are presented as mean ± SD. The duration of general anesthesia and the time between the end of epidural injection and the recovery of normal neurological function are presented as median (minimum values–maximum values). The baseline values of pulse rate, arterial blood pressure, $PaO_2$, $PaCO_2$, pH, BE, and $HCO_3^-$ in the arterial blood were compared between treatments using the paired *t*-test. The difference in duration of general anesthesia between treatments and the time to regain normal neurological responses between treatments were analyzed using the Wilcoxon signed-rank test. The pairwise Wilcoxon rank-sum test was used to analyze the changes in pulse rate, blood pressure, $PaO_2$, $PaCO_2$, pH, BE, and $HCO_3^-$ in the arterial blood before and after treatment in the normal saline and bupivacaine groups, respectively. $P$ values <0.05 were considered statistical significant. All analyses were carried out using the computer programing language R (version 1.1.463; R development core team, Vienna, Austria).

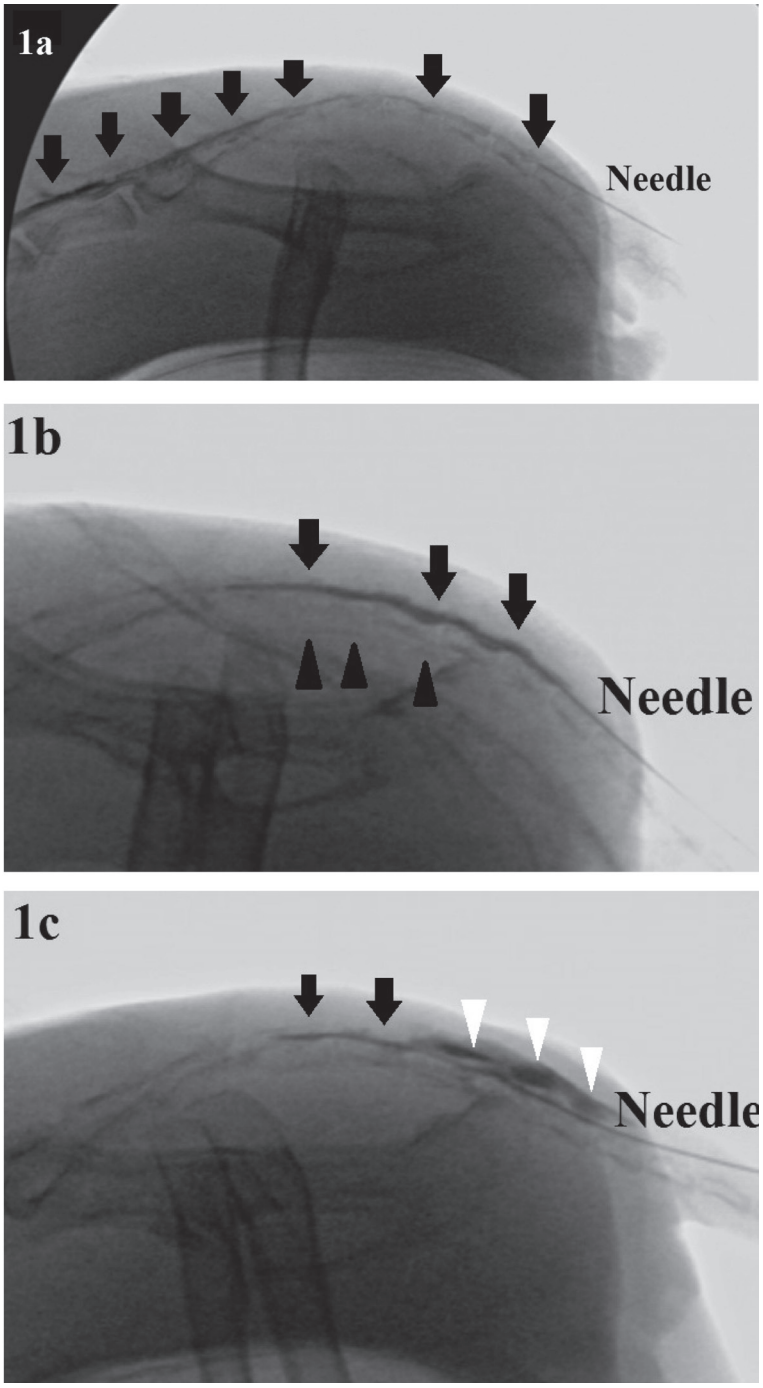


**Fig. 1.** Lateral radiograph obtained after coccygeal spinal canal injection of 0.1 m*l*/kg of iohexol in a rabbit. The contrast agent is present in the (a) lumbosacral epidural space (arrows), (b) epidural space (arrows) and the linear structure ventral to the vertebrae (black arrowheads), and (c) epidural space (arrows) and muscle (white arrowheads).

## RESULTS

When a needle was inserted into the coccygeal spinal canal, no active flow of cerebrospinal fluid or blood from the needle hub was observed. On the first attempt of iohexol injection, the contrast was found in the epidural space in all 12 rabbits. However, in 3 of the 12 rabbits, an additional contrast line, possibly a blood vessel (Fig. 1b, discussed below), was also found ventral to the vertebrae. In 1 of the 12 rabbits, additional contrast was found in the muscular layer (Fig. 1c). On the second attempt of iohexol injection in these 4 rabbits, the contrast was found in the epidural space only in 2 rabbits, in both the epidural space and possibly a blood vessel in 1 rabbit, and in both the epidural space and the muscular layer in 1 rabbit. On the third attempt of iohexol injection in the remaining 2 rabbits, the contrast was found in the epidural space only in 2 rabbits.

**Table 1.** Median (minimum values–maximum values) values for the times (min) to regain normal neurological response after a coccygeal spinal canal injection with bupivacaine (n=6) or normal saline (n=6)

| | Bupivacaine | Saline | *P*-value |
|---|---|---|---|
| Mentation | 30 (20–40) | 20 (20–20) | 0.149 |
| Anal reflex | 90 (40–180) | 20 (20–20) | 0.031 |
| Limb movement during walking | | | |
| Left hind limb | 60 (40–160) | 20 (20–20) | 0.034 |
| Right hind limb | 80 (40–160) | 20 (20–20) | 0.035 |
| Left forelimb | 20 (20–20) | 20 (20–20) | - |
| Right forelimb | 20 (20–20) | 20 (20–20) | - |
| Pain sensation | | | |
| Left hind limb | 90 (40–220) | 20 (20–20) | 0.036 |
| Right hind limb | 90 (20–220) | 20 (20–20) | 0.059 |
| Left forelimb | 20 (20–20) | 20 (20–20) | - |
| Right forelimb | 20 (20–20) | 20 (20–20) | - |
| Tail | 110 (100–200) | 20 (20–20) | 0.034 |
| Conscious proprioception | | | |
| Left hind limb | 70 (40–180) | 20 (20–20) | 0.036 |
| Right hind limb | 80 (40–180) | 20 (20–20) | 0.036 |
| Left forelimb | 20 (20–20) | 20 (20–20) | - |
| Right forelimb | 20 (20–20) | 20 (20–20) | - |

Differences between the bupivacaine and normal saline groups with *P*-values <0.05 were considered to be significant.

Table 1 shows the time to regain normal neurological responses. Before anesthesia, all neurological examinations displayed normal results for all rabbits. In addition, the time taken to regain normal anal reflex, conscious proprioception and movement of left and right hind limbs during walking and pain sensation of the tail and left hind limb were significantly longer in the bupivacaine group than those of the normal saline group. The time taken to regain normal response for the other neurological examination had no significant differences between the bupivacaine and normal saline groups. Although there were no statistically significant differences in the time to regain normal pain sensation between left and right hind limbs in the bupivacaine group, some rabbits had a seemingly large difference between the left and right hind limbs. The time taken to regain normal pain sensation for each of the 6 rabbits' left and right hind limbs were 40 and 120 min, 160 and 100 min, 220 and 220 min, 40 and 40 min, 80 and 80 min, and 100 and 20 min, respectively. At one week after the experiment, neurological examination revealed no neurological abnormality in all rabbits.

There was no significant difference in the duration of general anesthesia between the bupivacaine group (62 min [range: 47–143 min]) and the normal saline group (62 min [range: 49–104 min]). The blood gas data and cardiovascular data are shown in Tables 2 and 3, respectively. Due to dislodgement or occlusion of an arterial catheter, or movement of rabbits after discontinuation of isoflurane, some data of blood gas analysis and cardiovascular measurements could not be obtained. The numbers of data obtained are shown in Tables 2 and 3. In both groups, the changes in blood gas data were not significant after treatment. Pulse rate and blood pressure could not be measured after 10 min following the coccygeal spinal canal injection in some rabbits, because the rabbits moved. There were no significant changes in the pulse rate and blood pressure within each group, although the baseline value of systolic arterial blood pressure in the bupivacaine group was slightly higher than the baseline value of the normal saline group.

## DISCUSSION

In the present study, a coccygeal epidural injection of 0.3 m*l*/kg of 0.5% bupivacaine resulted in longer time taken to regain normal neurological responses at the hind limbs, tail, and perineal region. Following the administration of iohexol at the coccygeal site in the present study, the contrast was observed in the epidural space but not in the subarachnoid space in all rabbits. The end of the rabbit's spinal cord at the sacral site has been presented anatomically by Greenaway *et al.* [7]. Thus, we considered that drugs injected into the coccygeal spinal canal could be distributed to the epidural space. Our result was opposite to a previous study where injecting the contrast agent via epidural through the lumbosacral junction resulted in its entry into the subarachnoid space of all 7 rabbits [22].

Neurological examination was performed after isoflurane discontinuation. The incomplete recovery from general anesthesia may have affected the results of neurological examination even after isoflurane discontinuation. Thus, we compared the results of neurological examination between the bupivacaine and normal saline groups under the same condition. The time taken to regain normal anal reflex, conscious proprioception, movement of the left and right hind limbs during walking, and pain sensation of the left hind limb and tail were significantly longer in the bupivacaine group than in the normal saline group. Although there was no significant difference in the time to regain normal pain sensation in the right hind limb between the bupivacaine and normal saline group, median time to regain normal pain sensation tended to be longer in the bupivacaine group (median: 90 min, range: 20–220 min) than in the normal saline group (median: 20 min, range: 20–20 min, *P*=0.059). In contrast, the time to regain normal

**Table 2.** Arterial blood gas analysis data before (baseline) and at 30, 60, and 120 min after coccygeal spinal canal injection of 0.5% bupivacaine (0.3 m*l*/kg) or normal saline (0.3 m*l*/kg)

| | Group | Baseline | Time (min) after epidural injection | | |
|---|---|---|---|---|---|
| | | | 30 | 60 | 120 |
| $PaO_2$ (mmHg) | Bupivacaine | 83.8 ± 3.3 (5) | 88.5 ± 4.4 (4) | 84.0 ± 5.4 (5) | 84.8 ± 4.6 (5) |
| | Normal saline | 81.2 ± 10.9 (5) | 88.6 ± 6.1 (5) | 84.4 ± 6.4 (5) | 85.2 ± 3.4 (5) |
| pH | Bupivacaine | 7.502 ± 0.04 (5) | 7.472 ± 0.05 (4) | 7.430 ± 0.04 (5) | 7.501 ± 0.04 (5) |
| | Normal saline | 7.493 ± 0.03 (5) | 7.467 ± 0.03 (5) | 7.472 ± 0.03 (5) | 7.460 ± 0.03 (5) |
| $PaCO_2$ (mmHg) | Bupivacaine | 28.7 ± 2.1 (5) | 33.3 ± 3.2 (4) | 30.6 ± 2.1 (5) | 26.3 ± 2.4 (5) |
| | Normal saline | 27.9 ± 3.8 (5) | 30.2 ± 2.9 (5) | 28.8 ± 2.9 (5) | 26.9 ± 4.4 (5) |
| BE (mmol/*l*) | Bupivacaine | −0.8 ± 3.3 (5) | 1.5 ± 5.8 (4) | −4.0 ± 2.9 (5) | −2.4 ± 2.7 (5) |
| | Normal saline | −1.8 ± 2.7 (5) | −1.8 ± 2.8 (5) | −2.6 ± 3.6 (5) | −4.8 ± 2.9 (5) |
| $HCO_3^-$ (mmol/*l*) | Bupivacaine | 22.6 ± 2.7 (5) | 25.1 ± 5.1 (4) | 20.3 ± 2.5 (5) | 20.6 ± 2.3 (5) |
| | Normal saline | 21.4 ± 2.5 (5) | 21.8 ± 2.3 (5) | 21.2 ± 3.1 (5) | 19.2 ± 3.0 (5) |

Data are presented as mean ± SD. Numbers of data in parentheses.

**Table 3.** Effect of coccygeal spinal canal injection of 0.5% bupivacaine (0.3 m*l*/kg) or normal saline (0.3 m*l*/kg) on pulse rate (PR), systolic (SAP), mean (MAP), and diastolic (DAP) arterial blood pressure

| | Group | Baseline | Time (min) after epidural injection | | |
|---|---|---|---|---|---|
| | | | 1 | 5 | 10 |
| PR (beats/min) | Bupivacaine | 271 ± 24 (6) | 257 ± 27 (6) | 252 ± 23 (5) | 254 ± 28 (4) |
| | Normal saline | 278 ± 27 (6) | 282 ± 21 (6) | 286 ± 12 (5) | 270 ± 9 (4) |
| SAP (mmHg) | Bupivacaine | 128 ± 10[a)] (6) | 122 ± 24 (6) | 121 ± 27 (6) | 109 ± 18 (6) |
| | Normal saline | 107 ± 10 (6) | 115 ± 13 (6) | 128 ± 24 (5) | 108 ± 14 (5) |
| MAP (mmHg) | Bupivacaine | 75 ± 9 (6) | 69 ± 13 (6) | 70 ± 16 (6) | 63 ± 9 (6) |
| | Normal saline | 70 ± 5 (6) | 72 ± 6 (6) | 78 ± 11 (5) | 73 ± 11 (5) |
| DAP (mmHg) | Bupivacaine | 53 ± 9 (6) | 50 ± 11 (6) | 47 ± 9 (6) | 45 ± 6 (6) |
| | Normal saline | 53 ± 4 (6) | 53 ± 4 (6) | 56 ± 6 (5) | 56 ± 12 (5) |

Data are presented as mean ± SD. Numbers of data in parentheses. a) Significantly different from the baseline value of normal saline ($P<0.05$).

mentation, movement during walking, conscious proprioception, and pain sensation in both forelimbs were not affected by the bupivacaine injection. At 20 min after epidural injection, all rabbits' forelimbs were able to move and sense pain in the bupivacaine group, but only the anal reflex, movement of the left and right hind limbs, and pain sensation of the left hind limb did not return to normal. Thus, we considered that prolongation of the recovery time for movement and sensation of hind limbs and anal reflex in the bupivacaine group may not be related to the mentation status. Walking disturbances after epidural anesthesia is considered to be attributed to motor block in rabbits [17]. Thus, in the present study, we considered that bupivacaine injected into the epidural space could block some of the motor and sensory nerves that innervate the hind limbs, tail, and perineal region.

In 3 rabbits of the bupivacaine group, the difference in the recovery time of normal pain sensation of the right and left hind limbs was between 60 and 80 min, but the remaining 3 rabbits showed no difference in the recovery time of normal pain sensation

between the right and left hind limbs. This may have been attributed to differences in the effect of epidural bupivacaine injected through the intercoccygeal site on the right and left sides of the body in some rabbits. For humans, unilateral sensory block could occur after epidural anesthesia [3]. Thus, the unilateral block-like phenomenon may occur after coccygeal epidural anesthesia in some rabbits placed in the sternal recumbency.

In previous studies [5, 17], 1.1–3.0 mg/kg (0.3–0.8 m*l*/kg) of bupivacaine was used for epidural anesthesia in rabbits. The dose (1.5 mg/kg) and volume (0.3 m*l*/kg) of bupivacaine used in the present study were set to be within the doses used in these studies. Dollo *et al.* [5] showed that when 3 mg of 0.3% bupivacaine (1.1–1.2 mg/kg) was injected into the epidural space by an epidural catheter with the tip of the catheter at the L6 level, no rabbit displayed complete sensory block and 6 out of 7 rabbits experienced motor block for 79 ± 23 min (mean ± SD). However, in the present study, following injection of 0.3 m*l*/kg 0.5% bupivacaine (1.5 mg/kg) at the coccygeal site, median time to regain normal pain sensation was 90 min (range: 40–220 min) for the left hind limb and 90 min (range: 20–220 min) for the right hind limb, whereas duration of the motor block was 60 min (40–160 min) for the left hind limb and 80 min (40–160 min) for the right hind limb. Duration of the sensory block might have been longer in our study compared to that of Dollo *et al.* [5]. Thus, the difference in the injection site, the dosage, or concentration of bupivacaine might have resulted in the difference between the results of our study and those of Dollo *et al.* [5].

There was a variation in time to regain normal pain sensation among rabbits in the bupivacaine group. In humans, epidural fat volume or epidural blood flow might affect the duration of epidural anesthesia [11, 19]. However, the reason for the variation in the present study is unknown. As we carried out an examination on several neurological reflexes, evaluation was time consuming. We evaluated the neurological reflex parameters every 20 min, and found significant differences between the bupivacaine group and the saline group. However, the duration of bupivacaine effect could have been evaluated more accurately using a shorter time interval between each neurological examination.

When bupivacaine reaches the sympathetic nerves and intercostal nerves during epidural anesthesia, a decrease in blood pressure or pulse rate and respiratory depression may occur [25]. Eatwell *et al.* [6] reported that in healthy awake rabbits, pH, $PaCO_2$, $PaO_2$, bicarbonate, and BE in arterial blood were 7.35–7.54, 25.29–40.37 mmHg, 50.3–98.2 mmHg, 17.96–29.41 mmol/*l*, and −6.7–6.5 mmol/*l*, respectively. Thus, we considered that baseline blood gas data in the present study were acceptable. The blood gas data did not significantly change after the coccygeal epidural injection of bupivacaine, indicating that coccygeal epidural injection of bupivacaine has minimal effect on respiratory function. We focused on the effects of coccygeal epidural injection of bupivacaine on sensory and motor function. Thus, to minimize the residual effect of isoflurane, we intended to discontinue isoflurane as early as possible after coccygeal epidural injection of bupivacaine. Discontinuing isoflurane could affect blood pressure. In addition, epidural bupivacaine may have a hypotensive effect as mentioned above. In the present study, there was no significant change in blood pressure within the bupivacaine group. Thus, the immediate cardiovascular effects of bupivacaine appeared to be negligible. The values determined by the oscillometric device may not be consistent with those determined by invasive blood pressure measurement. However, an oscillometric device has been used in rabbits experimentally [13, 14] and it can be used to evaluate the trend in blood pressure change. As bupivacaine has slow onset of action and long duration of action, further studies are required to evaluate its cardiovascular effects, preferably by invasive blood pressure measurement.

For 4 of the 18 attempts, the contrasted linear line (Fig. 1b) was found to be ventral to the coccygeal and sacral vertebrae. In humans, a similar contrasted linear line was observed after epidural administration of contrast agent and was considered to be a blood vessel [24]. Inadvertent intravascular injection is a complication that can be associated with epidural anesthesia [2]. In addition, an epidural drug may enter into the vessels via torn vessels without direct intravascular injection [9]. Thus, in the present study, the contrasted linear line ventral to the sacral and coccygeal vertebrae may be attributed to the entering of contrast agent into blood vessel. Aspiration before injection of contrast agent, which we did not perform, may help avoid inadvertent intravascular injection.

In conclusion, administration of 0.3 m*l*/kg 0.5% bupivacaine into the coccygeal spinal canal could provide sensory and motor block to the hind limbs, tail, and perineal region in rabbits. However, incorrect needle placement, inadvertent vascular entry of the epidural drug, and unilateral block-like phenomenon were noted in some rabbits. Further studies are required to improve this technique and to determine the optimal dosage or volume of bupivacaine.

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