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The perfusion index as a method of assessing epidural anaesthesia efficacy in healthy dogs

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Abstract

Introduction: Perfusion index (PI) is used as assessment of epidural anaesthesia efficacy in human medicine, but its usefulness in dogs is unknown. The aim of this study was to evaluate the usefulness of PI in determining epidural anaesthesia effectiveness. **Material and Methods:** This is prospective cross-over experimental study. Five healthy adult beagle dogs were anaesthetised and an epidural catheter was inserted in the lumbosacral area and adjusted so that the end of the catheter was placed at the fourth lumbar vertebra. Single-port catheters were used in the control group and multiple-port catheters were used in the treatment group. A PI probe was placed on a hind leg, and the catheter placement was confirmed *via* computed tomography. The treatment group received a bolus dose of lidocaine, and the control group received saline, *via* epidural catheter. The PI value was recorded every 5 min until 30 min after lidocaine injection. **Results:** The PIs of the hind limbs were not significantly different over time, nor were they between the control and lidocaine-injected groups at any point in time. **Conclusion:** The PI is not useful in determining the efficacy of epidural anaesthesia in dogs under general anaesthesia. In the future, finding a reliable method to evaluate the success of regional anaesthesia, even in patients under general anaesthesia, will be necessary.

Keywords: epidural catheter, lidocaine, perfusion index, single-port catheter, multiple-port catheter.

Introduction

Perioperative regional anaesthesia encompasses various methods that aim to suppress nerve stimulation at the surgical site by using local anaesthetic agents. Spinal anaesthesia is the administration of a local anaesthetic into the spinal subarachnoid space, and epidural anaesthesia is the administration of a local anaesthetic into the epidural space. Block anaesthesia is the administration of a local anaesthetic near a peripheral nerve, and infiltration anaesthesia is the administration of a local anaesthetic directly at the surgical site (10).

In human medicine, local anaesthesia is usually administered under awake conditions. Therefore, the effectiveness of local anaesthesia can be assessed using sensory and motor neuron tests such as the cold-sensation test and pinprick test (8, 13). However, in veterinary medicine, to evaluate local anaesthesia effectiveness before surgery is challenging because animals need to be immobilised *via* general anaesthesia before local anaesthesia administration. A veterinary anaesthesiologist often judges local anaesthesia effectiveness based on pain-related clinical signs during the course of surgery. Therefore, for minimising pain to the animal, clarifying whether local anaesthesia has been successful before surgery is necessary.

Nerve blocks using local anaesthetics result in peripheral vasodilation associated with sympathetic blockade (15). The perfusion index (PI) is used to measure peripheral perfusion non-invasively and continuously to quantify the ratio of pulsatile and static blood flow by using a pulse oximeter (5). In their human medicine study reporting a significant increase in the PI after epidural anaesthesia, Ginosar *et al.* (4) concluded that such an increase is a useful early indicator of local anaesthesia effectiveness. As a consequence, this effect

has been the target of recent attempts to establish the usefulness of PI measurements as an indicator of local anaesthesia efficacy.

In veterinary medicine, Gatson *et al.* (3) reported a significant increase in the PI in the hindlimb in which femoral and sciatic nerve blocks had been performed. However, another report (1) on groups of dogs that received morphine and a combination of morphine and lidocaine as epidural anaesthesia demonstrated no significant differences in the PI for each measurement time. Epidural anaesthesia, one of the most common techniques used in dogs, is ineffective in 6.8%–12% of cases, even when performed with proper techniques (6, 16). This insufficient effect may be because of the difficulty in locating the lumbosacral region and accurately administering local anaesthetics in the epidural space, especially in obese animals (7, 16). Furthermore, local anaesthetic dosages for epidural anaesthesia in dogs are often determined by consultation of tables for volume per kg body weight; however, dosage determination needs to account for variations in skeletal structure and body mass index between animals, which may have the effect of extending or constricting the blockage regions themselves. Therefore, the purpose of this study was to assess the usefulness of the PI in determining the efficacy of epidural anaesthesia in dogs before commencing surgery.

Material and Methods

Animals. The animal experiments were approved by the Institutional Animal Experiment Ethics Committee and were conducted in accordance with the institutional guidelines of Yamaguchi University (approval no. 454). This is prospective cross-over experimental study. Five clinically healthy beagles (one dog and four bitches), with a mean weight ± standard deviation of 11.63 ± 0.89 kg, were used for this study. The dogs were enrolled after an assessment of their health status by general physical examination, complete blood count, biochemical examinations, and chest and abdominal x-ray imaging. The subjects were kept in individual cages and maintained in an environment that allowed feeding once a day and constant water intake. They were fasted for 12 h, and drank no later than 1 h before general anaesthesia.

Study protocol. An intravenous 22-gauge catheter (Supercath Ztu-V 22 G; Medikit, Tokyo, Japan) was placed in the cephalic vein to induce general anaesthesia with propofol (up to a total of 7 mg/kg, until the required effect was observed; 20 mL of 1% propofol; Pfizer, Osaka, Japan), after which the dogs were orotracheally intubated. Anaesthesia was maintained with isoflurane in oxygen (isoflurane inhalation anaesthesia solution; Pfizer). End-tidal isoflurane was maintained between 1.6% and 2.3%.

After general anaesthesia induction, a mechanical ventilator maintained intermittent positive pressure (Fabius; Dräger Medical Japan, Tokyo, Japan). The end-tidal carbon dioxide was maintained at 30–40 mmHg. Intravenous fluids (Veen F (Ringer's solution with sodium acetate); Fuso Pharmaceutical Industries, Osaka, Japan) were administered at a rate of 3 mL/kg/h. A warm mat (Bair Hugger; 3M Company, Maplewood, MN, USA) was used to maintain the body temperature above 37.5°C throughout anaesthesia.

Heart rate was monitored *via* a lead II electrocardiogram. The end-tidal partial pressure of carbon dioxide and end-tidal isoflurane were monitored with side-stream sampling. The oxygen saturation was monitored with pulse oximetry and rectal temperature was monitored continuously. A 22-gauge catheter was placed in the medial caudal artery and connected to a pressure transducer (DTXPlus; Argon Medical Devices, Plano, TX, USA). In this way the mean arterial pressure, systolic arterial pressure and diastolic arterial pressure were monitored. All aforementioned vital signs were monitored using an anaesthesia monitor (Life Scope BSM-6501; Nihon Kohden, Tokyo, Japan).

The dogs were placed in the prone position and the lumbosacral region was sterilised. A Tuohy needle was inserted percutaneously under sterile conditions into the epidural space between the seventh lumbar vertebrae (L7) and the first sacral vertebrae (S1). The needle was confirmed to be in the epidural space by using the hanging drop technique or by detecting the loss of resistance. This procedure was followed by the insertion of an epidural catheter through the epidural needle. The catheter was then used to inject a contrast medium (Omnipaque 240; Dai-ichi Sankyo Pharmaceutical, Tokyo, Japan) into the epidural space that was diluted two-fold with saline at 1 mL/head. X-ray computed tomography (CT) imaging (Supria; Hitachi, Tokyo, Japan) was used to confirm catheter placement into the epidural space at the fourth lumbar vertebrae level. A 0.8-mm × 950-mm catheter (EF18HR-95 Epidural Anesthesia Set; Hakko, Nagano, Japan) was used as the single-port epidural catheter (for the control group and single-hole port group) and a 0.59-mm × 720-mm catheter (Perifix filter set 20 G; B. Braun Aesculap Japan, Tokyo, Japan) was used as the multiple-port epidural catheter (for the multiple-hole port group).

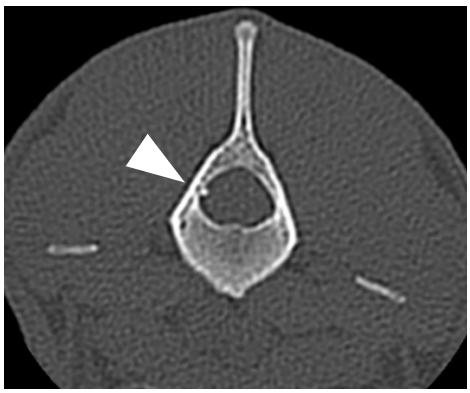

Fig. 1. Identification of the catheter position by computed tomography. Arrowhead – location of epidural catheter

Table 1. Mean ± the standard deviation of perfusion index in dogs administered saline (Control) or lidocaine *via* single-port or multiple-port epidural catheter

Group	Time points								P-value (within group)
	T_0	T_1	T_2	T_3	T_4	T_5	T_6	T_7	
Control	1.60 ± 0.55	2.24 ± 1.01	2.30 ± 0.99	2.28 ± 0.97	2.28 ± 0.92	2.26 ± 0.81	2.26 ± 0.94	2.02 ± 0.62	0.94
Single-hole port	2.08 ± 1.01	1.94 ± 1.24	1.92 ± 1.36	1.94 ± 1.21	1.96 ± 1.24	2.00 ± 1.22	2.02 ± 1.17	2.10 ± 1.17	>0.9999
P-value (*vs* control)	0.44	0.72	0.67	0.67	0.69	0.73	0.76	0.91	
Multiple-hole port	2.64 ± 1.56	3.02 ± 1.50	2.98 ± 1.62	2.78 ± 1.54	2.74 ± 1.57	2.73 ± 1.62	2.73 ± 1.61	2.73 ± 1.60	>0.9999
P-value (*vs* control)	0.27	0.42	0.50	0.60	0.63	0.62	0.63	0.44	

T0 – baseline (prior to catheter placement; T1 – immediately after catheter placement; T2–T7 – successive 5-min intervals after lidocaine or saline injection up to 30 min; P-values < 0.05 were considered significant

After anaesthesia induction and arterial and epidural catheter placement, the dogs were maintained under anaesthesia for 30 min to wean them from the effects of propofol and to stabilise their haemodynamics. The CT identification of the catheter position was used to determine in which hindlimb to place the pulse oximeter (Rad-87; Masimo, Tokyo, Japan) – hereafter referred to as the observation limb (Fig. 1). The PI prior to catheter placement (as the baseline – T_0) was measured in both hindlimbs, and then measured in the observation limb in isolation. After these parameters were measured post epidural catheter placement (T_1), 2% lidocaine hydrochloride (100 mL of 2% Xylocaine injection solution; Aspen Japan, Tokyo, Japan) – hereafter referred to as lidocaine – was injected into the epidural space *via* the epidural catheter over 30 s in the experimental beagles, and a saline solution was injected into the epidural space over 30 s in the control dogs. The PI was recorded every 5 min for 30 min (T_2–T_7).

Statistical analysis. The means ± the standard deviation were calculated from all measurements in each experiment. Comparisons of each measure over time were tested for equal variances by using Bartlett's test. Measurements with equal variances were subjected to the one-way analysis of variance test. If significant differences were found, a post-hoc Dunnett's multiple comparison te was performed. Unequal variances were subjected to the Kruskal–Wallis test. If a significant difference was found, a post-hoc Dunn's multiple comparisons test was conducted. The PI obtained in each study was compared between groups. For between-group comparisons, the F-test was used to test for equal variances. No-correspondence *t*-tests were used for treatment groups exhibiting equal variances, whereas Welch's *t*-test was used for treatment groups exhibiting unjustified variances. For all tests, a P-value of 0.05 or less was considered a significant difference. All statistical analyses were performed using GraphPad Prism 7 (GraphPad Software, La Jolla, CA, USA).

Results

No significant differences in the rate of PI change were observed between single- and multiple-port groups. Neither did they exist between the control and single-hole port groups or between the control and multiple-hole port groups at baseline (T_0). This situation persisted immediately after catheter placement (*i.e.* T_1), as well as at all time intervals after lidocaine administration (*i.e.* T_2–T_7). Significant variations were also not observed in each measurement over time (Table 1).

Discussion

The aim of this study was to evaluate the usefulness of the PI in determining epidural anaesthesia effectiveness. We found no significant differences when lidocaine was administered into the epidural space using a single-port catheter to when it was administered using a multiple-port catheter. In human medicine, the PI has been studied as a non-invasive indicator of regional anaesthesia success. However, its usefulness in veterinary medicine remains unclear. In this study, we tested single- and multiple-port epidural catheter treatments to administer a 0.2 mL/kg bolus dose of lidocaine as described by Jones (7). Based on previous reports, this agent has been widely used for experimental epidural anaesthesia and subsequent observation of PI variations in dogs. One such report examined a local anaesthetic's area of effect when administered into the epidural space of the lumbosacral region in dogs and suggested that a dose of 0.2 mL/kg produced cutaneous sensory zone relief up to the first lumbar region (2). However, in the present study, no variation or significant difference in PI was observed when the injectant was lidocaine instead of saline.

In human medicine, individual differences in agent infiltration after epidural anaesthesia have been reported. Yokoyama *et al*. (18) reported that when a contrast agent was administered into the epidural space, the local anaesthetic did not infiltrate evenly and tended to spread in the vertical, horizontal and circumferential directions. However, predicting the spread of the contrast agent is difficult. In humans, unilateral nerve block is more likely to occur with a single-port catheter than with a multiple-port catheter, such a block having been reported in 78% and 22% of applications of these catheters, respectively (11). Considering the possibility that a more uniform distribution occurs near the catheter tip, we examined PI variation with multiple-port epidural catheters. However, no

significant differences in PI were observed. Variations in the PI during regional anaesthesia with multiple-port epidural catheters have been reported in humans, with the PI increasing within 10 min after local anaesthetic administration and continuing to increase for at least 20 min (4). In addition, a previous report (14) compared between single- and multiple-port catheters how complications of epidural anaesthesia influenced the analgesic effect and demonstrated no significant differences between the two catheter types. However, some reports (9) suggest that single-port epidural catheters are superior for local infiltration of drug solutions. In veterinary medicine, we found no reports comparing single- with multiple-port epidural catheters in dogs. The current study found no significant difference in the evaluation of epidural anaesthesia effectiveness related to catheter type by using the PI, and this finding suggests that other evaluation methods should be used to investigate the differences in the shape of the tip of the epidural catheter.

In adult humans, regional anaesthesia is often performed in the awake state. Therefore, most reports describing the relationship between the PI and regional anaesthesia cannot be extrapolated to explain PI variation in dogs that are under general anaesthesia. Unfortunately few reports have examined the correlation between regional anaesthesia under general anaesthesia and the PI. A previous study reported an increase in the PI on administration of a caudal block under general anaesthesia in paediatric patients (17). This finding suggested that using the PI as a proxy for regional anaesthetic success could be of great utility under general anaesthetic conditions. Another report comparing the PI before and after interscalene brachial plexus block performed under awake conditions revealed a significant PI increase after regional anaesthesia (12). The same report detailed that, when general anaesthesia was subsequently switched to regional anaesthesia, the PI increased on the contralateral side instead of on the local blockade side, which indicated no significant difference in the PI between the blocked and opposite limbs (12). These findings suggested that general anaesthesia may have affected the PI. In our study, an inhalation anaesthetic was also used, which indicates that peripheral vasodilation caused by such agents may affect the PI.

In veterinary medicine, one study (3) under general anaesthesia conditions reported a significant increase in the PI on the limb that received femoral and sciatic nerve blocks using bupivacaine (*i.e.* a local anaesthetic agent) compared with the control limb. By contrast, another study (1) examining changes in the PI due to epidural anaesthesia (using morphine or a mixture of morphine and lidocaine) in dogs under general anaesthesia preceding knee surgery demonstrated no significant differences in the PI, either within or between treatment groups at any of the measurement times; in addition, no significant differences existed in the PI before or after skin incision or osteotomy.

The lumbosacral plexus is a possible site for epidural anaesthesia, and a wide range of blocks can be performed there, including blocks of the femoral and sciatic nerves. However, these blocks can also be performed locally and need not be through the lumbosacral plexus. Therefore, the findings of these studies suggest that the usefulness of the PI for assessing local anaesthesia success may depend on the site of local anaesthetic administration and regional anaesthesia technique. Future studies are needed to compare the usefulness of the PI using the same amount of local anaesthetic but using multiple techniques of its administration.

This study used experimental animals selected for similarity across key aspects. As such, variations in body mass, fat composition and physique were relatively minimised. Inevitably patients varying in body fat composition, weight and physique were encountered by Doyle *et al.* (1), there possibly being among them cases of unsuccessful epidural anaesthesia because it was administered to such physically heterogenous dogs in those clinical cases. The epidural catheter placement and epidural anaesthesia were dependable in this study, whereas anaesthesia, at least, was not in the investigation by Doyle *et al*. (1). A further difference between the present study and the cited one is Doyle *et al.* (1) having used a single puncture in their anaesthetic technique. Nonetheless, similarly to this and previous reports, we did not find significant variations in the PI under the experimental conditions.

Conclusion

Owing to the nature of veterinary patients, a successful assessment of regional anaesthesia must be achieved indirectly through physiological parameters, rather than *via* tests that require awake conditions as in human medicine. Our results suggested that using PI measurements as a method of determining the effectiveness of epidural anaesthesia using lidocaine is challenging and requires further exploration. Furthermore, other methods for local anaesthesia success assessment are necessary and further studies are needed on the effect of dosage and administration rates on regional anaesthesia.

Conflict of Interests Statement: The authors declare that there is no conflict of interests regarding the publication of this article.

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Animal Rights Statement: This study using dogs kept by the Department of Small Animal Clinical Science was approved by the Ethics Review Board of the Joint Faculty of Veterinary Medicine of Yamaguchi University (approval no. 454).

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