Japanese Journal of Veterinary Research 67(1): 35–40, 2019

JJVR

REGULAR PAPER Experimental Research

Distance between the skin and the lumbosacral epidural space in dogs

Toshie Iseri[1], Ryohei Nishimura[2,*], Shotaro Nagahama[3], Takayuki Nakagawa[2], Yuka Fujimoto[4] and Nobuo Sasaki[2]

[1] Department of Clinical Veterinary Science, Joint Faculty of Veterinary Medicine, Yamaguchi University, 1677–1 Yoshida, Yamaguchi 753–8515, Japan

[2] Laboratory of Veterinary Surgery, Graduate School of Agricultural and Life Sciences, The University of Tokyo, 1–1–1 Yayoi, Bunkyo-ku, Tokyo 113–8657, Japan

[3] Japanese Association of Veterinary Anaesthesiologists, 1–15–1 Tamagawa, Setagaya-ku, Tokyo 158–0094, Japan

[4] Department of Advanced Clinical Medicine, Graduate School of Life and Environmental Sciences, Osaka Prefecture University, 1–58 Rinku-oraikita, Izumisano, Osaka 598–8531, Japan

Received for publication, July 19, 2017; accepted, June 29, 2018

Abstract

To measure the skin to lumbosacral epidural space distance (SED) and investigate its correlation with age, body weight (BW) and body condition score (BCS) in dogs. Client-owned dogs ($n = 123$) that received epidural anesthesia, SED was measured. Correlations were determined between SED and age, BW, and BCS. The mean age was 6.8 ± 4.5 years ($n = 118$), BW was 10.5 ± 8.3 kg and SED was 26.8 ± 8.1 mm. SED correlated with BW ($r = 0.78$, $P < 0.01$) and BCS ($r = 0.26$, $P = 0.004$). Dogs were classified into thin (BCS 1 and 2; $n = 13$), standard (BCS 3; $n = 76$), and obese (BCS 4 and 5; $n = 34$) groups, the mean SED in the thin, standard, and obese groups was 24.1 ± 7.5, 25.7 ± 7.8 and 30.2 ± 7.7 mm, respectively; there were significant correlations between SED and BW in each group. $SED = 0.54 \times BW + 17.2$ ($P < 0.05$, $r = 0.57$) in the thin group, $SED = 0.77 \times BW + 18.2$ ($P < 0.001$, $r = 0.82$) in the standard group and $SED = 0.81 \times BW + 21.3$ ($P < 0.001$, $r = 0.74$) in the obese group. This result provide useful information for safe lumbosacral epidural anesthesia in dogs.

Key Words: body mass index, body weight, distance, dogs, epidural anesthesia

Introduction

Epidural analgesia is a common and effective method for perioperative analgesia in dogs. The administration of drugs into the epidural space results in segmental blockade at the site of surgery. When the drug is injected into the epidural space, the tip of the needle must be located in the epidural space. And penetration of a needle to an appropriate depth is important because needle advancement to an increased depth may cause dural puncture result in the epidural hematoma and the cerebrospinal fluid outflow, or spinal nerve injury. Information about the skin to epidural distance (SED) is thus useful for adequate and safe needle puncture in clinical situations. Several human studies have focused on the correlation of SED with certain

*Corresponding author: Ryohei Nishimura, Laboratory of Veterinary Surgery, Graduate School of Agricultural and Life Sciences, The University of Tokyo, 1–1–1 Yayoi, Bunkyo-ku, Tokyo 113–8657, Japan
Fax: +81–3–5841–1132. E-mail: arn@mail.ecc.u-tokyo.ac.jp
doi: 10.14943/jjvr.67.1.35

anthropometric parameters, and statistically significant correlations have been observed between SED and body mass index (BMI)[12], body weight (BW)[1,9] and age[1]. We hypothesized that SED may be correlated with BW and the body condition score (BCS) in dogs. To the best of our knowledge, SED has been investigated in cattle[8]; however, there are no published studies in dogs. Therefore, we conducted this study to evaluate the SED in dogs and determine its correlation with age, BW, BCS and breed to gather useful information for administering effective epidural analgesia in these animals.

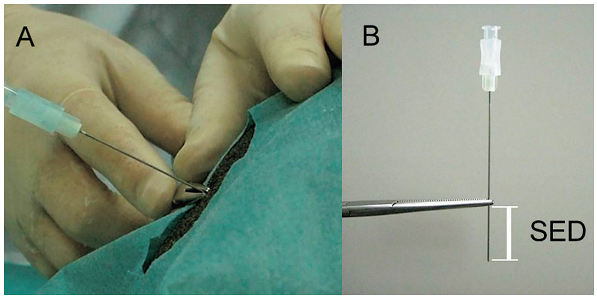

Fig. 1. Following insertion of the spinal needle tip into the epidural space and drug administration, the needle is clamped with forceps at the point of skin penetration (A) and the skin to epidural space distance (SED) is measured from the needle point to the forceps (B).

Materials and methods

Dogs scheduled for surgery under inhalation anesthesia with epidural analgesia at the Veterinary Medical Center, The University of Tokyo and the Veterinary Medical Center, Osaka Prefecture University were enrolled in this study. An informed consent was obtained from each owner. The age, BW, BCS and breed of the dogs were recorded before the induction of anesthesia. BCS was scored from 1 to 5, with 1 representing a very thin dog and 5 representing an obese dog[6].

Anesthesia was induced with propofol (prepared 6 mg/kg, gradual intravenous administration until intratracheal intubation could be achieved; Rapinovet®, Schering-Plough Co., Osaka, Japan) and maintained with isoflurane (Isoflu®, DS Pharma Animal Health Co., Ltd., Osaka, Japan) or sevoflurane (Sevofrane®, Maruishi Pharmaceutical Co. Ltd., Osaka, Japan). All dogs also received an epidural injection of bupivacaine (0.2 ml/kg, Marcain® Injection 0.5%, AstraZeneka K.K., Osaka, Japan) with/without morphine (0.1 mg/kg, morphine hydrochloride injection, Mitsubishi Tanabe Pharma Co., Osaka, Japan) through the lumbosacral space. Each animal was placed in the sternal position, and the lumbosacral area was clipped and aseptically prepared for needle puncture. A 22- or 23-gauge, 70-mm spinal needle (Terumo Co. Ltd., Tokyo, Japan) was then inserted through the lumbosacral space that located between the dorsal spinous processes of the 7th lumbar (L7) and the 1st sacral vertebra (S1). The needle was advanced through the skin and into the subcutaneous tissue, to confirm placement of the needle tip in the epidural space, the loss-of-resistance technique with saline or the hanging drop technique was used. The needle was inserted as perpendicular to the lumbosacral skin as possible. After drug administration, the point of needle penetration was clamped with forceps and SED was measured as the distance from the needlepoint to the forceps (Fig. 1). Epidural injection was performed by 33 veterinarians under instruction of authors.

The SED, age, BW and BCS data are expressed as means ± standard deviations (ranges). The correlation of SED with age, BW and BCS was analysed using Spearman's correlation coefficient. In addition, the dogs were classified into a thin group (BCS 1 and 2), a standard group (BCS 3) and an obese group (BCS 4 and 5), age, BW and SED within the three groups was analysed using single-factor ANOVA and Tukey-Kramer method after confirmed normality by Bartlett test, and the correlation between SED and age, BW and BCS was analysed for the each group using linear regression analysis and Spearman's correlation coefficient. All statistical analyses were performed using commercially available software (Statcel. Ver.3,

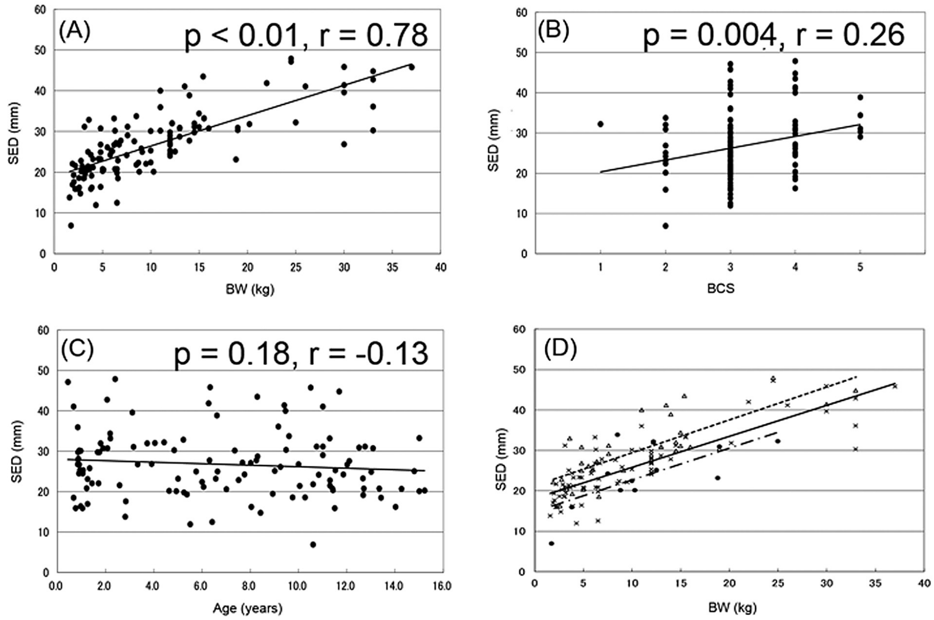

Fig. 2. Linear regression analyses to determine the correlation of the skin to epidural space distance (SED) with body weight (BW) (A), body condition score (BCS) (B) and age (C). Each circle represents values for a single dog and each line represents the linear regression equation. Linear regression analysis to determine the correlation between the skin to epidural space distance (SED) and body weight (BW) in the thin, standard and obese groups (D). Each mark represents values for a single dog, while the closed circles, cross marks, and open triangles represent the thin, standard, and obese groups, respectively. Each line represents the linear regression equation, and the dashed, solid, and chain lines represent the thin, standard,and obese groups, respectively. The association between BW and SED were as follows.
SED = 0.54 × BW + 17.2 ($P < 0.05$, r = 0.57) in the thin group (n = 13)
SED = 0.77 × BW + 18.2 ($P < 0.001$, r = 0.82) in the standard group (n = 76)
SED = 0.81 × BW + 21.3 ($P < 0.001$, r = 0.74) in the obese group (n = 34)

The Publisher OMS Ltd., Saitama, Tokyo). A P-value of <0.05 was considered statistically significant.

Results

A total of 123 client-owed dogs (46 male, nine castrated, 51 female and 17 spayed) were included in this study. Five dogs (three male and two female) of an unknown age were excluded from the age analysis. The mean age, BW and SED was 6.8 ± 4.5 (0.4–15.2) years (n = 118), 10.5 ± 8.3 (1.6–37.0) kg and 26.8 ± 8.1 (6.9–47.9) mm, respectively. The mean BW in the thin (n = 13; one dog with BCS 1 and 12 dogs with BCS 2), standard (n = 76; BCS 3), and obese groups (n = 34; 29 dogs with BCS 4 and five dogs with BCS 5) was 12.9 ± 7.8 (1.6–30.0), 9.9 ± 8.5 (1.6–37.0) and 11.0 ± 7.5 (1.9–33.0) kg, respectively, with no significant differences among the three groups. The mean age in the thin (n = 13), standard (n = 72), and obese groups (n = 33) was 7.6 ± 4.7 (1.0–15.0), 6.3 ± 4.5 (0.4–15.0) and 7.5 ± 4.3 (1.4–15.2) years old, respectively, with no significant differences among the three groups. And the mean SED in the thin, standard, and obese groups was 24.1 ± 7.5 (6.9–33.8), 25.7 ± 7.8 (11.9–47.2) and 30.2 ± 7.7 (16.2–47.9) mm, respectively. SED in the obese group was longer than in thin and standard group, significantly.

Statistically significant correlations were observed between SED and BW (r = 0.78, $P <$ 0.01) (Fig. 2(A)) and BCS (r = 0.26, $P = 0.004$) (Fig. 2(B)), whereas no correlation was observed between SED and age (Fig. 2(C)). The associations between BW and SED in each group were as

Table 1. Breed and number of included dogs and their mean body weight (BW) and skin to epidural space distance (SED)

Breed	Number of dogs	BW (kg)	SED (mm)
Beagle	24	12.2 ± 1.7	28.5 ± 3.9
Shih-tzu	13	5.9 ± 1.2	22.6 ± 4.5
Miniature dachshund	12	5.5 ± 1.3	24.6 ± 5.3
Mix	10	13.2 ± 5.2	29.7 ± 6.3
Maltese	7	3.0 ± 0.7	20.8 ± 6.5
Yorkshire terrier	7	2.9 ± 1.1	20.0 ± 3.5
Labrador retriever	6	26.6 ± 6.3	36.9 ± 8.7
Golden retriever	5	31.6 ± 4.4	38.9 ± 7.2
Papillon	5	3.6 ± 1.8	18.2 ± 7.5
Shetland sheepdog	4	12.5 ± 4.6	26.8 ± 5.2
Toy poodle	4	3.8 ± 0.7	18.1 ± 2.5
Chihuahua	3	2.9 ± 0.4	19.7 ± 1.0
Pomeranian	3	2.3 ± 0.7	19.1 ± 2.0
American cocker spaniel	2	13.0, 9.1	28.7, 25.0
Bernese mountain dog	2	24.5, 30.0	47.2, 45.9
Cavalier king charles spaniel	2	6.5, 14.0	19.8, 38.9
French bulldog	2	10.3, 11.0	20.1, 36.0
Miniature pinscher	2	15.9, 21.5	15.9, 33.2
Pug	2	3.1, 8.3	31.2, 27.6
Welsh corgi	2	12.0, 15.4	27.1, 43.5
English setter	1	15.5	33.2
German shepherd dog	1	30.0	26.9
Miniature schnauzer	1	13.5	41.1
Shiba	1	12.2	32.1
Pekinese	1	5.9	25.3
Pyrenean mountain dog	1	26.0	41.1
26 breeds	123 dogs	10.5 ± 8.3 kg	26.8 ± 8.1 mm

With regard to the breed, the CD breeds (n = 72) included 12 breeds (American cocker spaniel, Beagle, Cavalier king charles spaniel, Miniature dachshund, Miniature schnauzer, Pekinese, Pug, Shih-tzu, Toy poodle, Welsh corgi and Yorkshire terrier)[3,4,13], and the NCD breeds (Bernese mountain dog, Chihuahua, English setter, German shepherd dog, Golden retriever, Labrador retriever, Maltese, Miniature pinscher, Papillon, Pomeranian, Pyrenean mountain dog, Shetland sheepdog and Shiba) (n = 41), with the exception of 10 dogs that were of a mixed breed, included 13 breeds. Data are expressed as mean ± standard deviation (if the number of dogs is ≤ 2, an actual value is shown).

follows (Fig. 2(D)):

$SED = 0.54 \times BW + 17.2$ ($P < 0.05$, $r = 0.57$) in the thin group ($n = 13$)

$SED = 0.77 \times BW + 18.2$ ($P < 0.001$, $r = 0.82$) in the standard group ($n = 76$)

$SED = 0.81 \times BW + 21.3$ ($P < 0.001$, $r = 0.74$) in the obese group ($n = 34$)

The Table 1 shows the 26 breeds and the mean BW and SED for each breed included in this study. With regard to the breed, the CD breeds (n = 72) and the NCD breeds (n = 41), with the exception of 10 dogs that were of a mixed breed, included 13 breeds. There were no significant differences in BCS (CD: 3.3 ± 0.65, NCD: 3.1 ± 0.65, $P = 0.09$), age (CD: 6.4 ± 4.6 years, NCD: 6.4 ± 4.1 years, $P = 0.98$), and SED (CD: 25.7 ± 6.2 mm, NCD: 28.0 ± 10.8 mm, $P = 0.22$) between the two groups, but BW showed a significant difference (CD: 8.2 ± 3.9 kg, NCD: 13.6 ± 12.3 kg, $P = 0.01$).

Discussion

This is the first report about the canine SED. This study showed that SED was 26.8 ± 8.1 mm of the dog mean BW was 10.5 ± 8.3 kg. SED was significantly correlated with BW and BCS, with a particularly strong correlation between SED and BW.

Knowledge of SED in dogs would be useful for administering safe and effective epidural analgesia. The success of epidural analgesia primarily depends on correct identification of the epidural space and accurate placement of the needle tip. In addition, penetration of the spinal needle to an appropriate depth is important because needle advancement to an increased depth may cause dural puncture result in the epidural hematoma and the cerebrospinal fluid outflow, or spinal nerve injury. Although the recent advanced technology such as electrical nerve stimulation[10], ultrasonography [14], measurement of pressure change[2] or running-drip method[7] have been reported in dog for identifying the epidural space more accurately, those methods are technically difficult and require specific equipment; SED data may be also useful for confirming the epidural needle position in dogs by using simultaneously with these techniques.

In humans, several studies have reported that BW[1,9] and BMI[9,12] were significantly and positively correlated with SED. These studies indicated that the presence of subcutaneous fat tissue in obese patients increased the distance from the skin to the vertebral ligament, consistent with the finding of our study. Another study in humans reported that age was positively correlated with SED[1]. Elderly patients often exhibit vertebral kyphosis, and this anatomical change may increase SED, particularly in the thoracic region. In contrast, the present study showed that age was not significantly correlated with SED in the lumbosacral region.

Ethnicity, in addition to BMI, influences SED in humans[5,12]. SED in Asian parturients was found to be lesser than that in Caucasian parturients, and this was probably because Asians have smaller spinous and transverse processes and larger vertebral bodies compared with Caucasians[12]. Dogs also exhibit anatomical variations among breeds, SED was suspected to be influenced by breed, although the sample size for each breed was inadequate for statistical analysis in this study. Therefore, the dogs were divided into CD and NCD breeds and evaluated. There were no significant differences in BCS and age between the two groups, whereas SED was similar in the NCD and CD groups despite BW being lesser in the CD group significantly. These findings indicate that SED is greater for CD breeds than for NCD breeds of the same BW. Thus, when epidural analgesia is administered to CD dogs, the depth of needle penetration should be greater than that for NCD dogs of the same BW. However, to provide general information and techniques to practitioners, it is recommended to gather more SED data of each breed.

The limitation of this study was the influence of the needle insertion angle, even though the needle was inserted as perpendicular to the lumbosacral skin as possible. Previous studies reported that the angle of needle insertion influenced SED in humans[9], while another study reported that adjustment of the insertion angle did not improve the accuracy of SED prediction though the angle of insertion of the epidural needle was measured[5,11]. However, further studies on the influence of the needle insertion angle in dogs are required.

In conclusion, SED was found to correlate significantly with BW and BCS in dogs, and the mean SED in the thin, standard, and obese groups was 24.1 ± 7.5, 25.7 ± 7.8 and 30.2 ± 7.7 mm, respectively. $\mathrm{SED} = 0.54 \times \mathrm{BW} + 17.2$ ($P < 0.05$, $r = 0.57$) in the thin group, $\mathrm{SED} = 0.77 \times \mathrm{BW} + 18.2$ ($P < 0.001$, $r = 0.82$) in the standard group and $\mathrm{SED} = 0.81 \times \mathrm{BW} + 21.3$ ($P < 0.001$, r = 0.74) in the obese group. These findings would facilitate safer and more effective lumbosacral epidural analgesia in dogs.

References

1) Adachi YU, Sanjo Y Sato S. The epidural space is deeper in elderly and obese patients in the Japanese population. Acta Anaesthesiol Scand 51, 731–735, 2007
2) Adami C, Bergadano A Spadavecchia C. Limitations of the use of pressure waves to verify correct epidural needle position in dogs. Vet Med Int 2013: 159489, 2013
3) Bergknut N, Auriemma E, Wijsman S, Voorhout G, Hagman R, Lagerstedt AS, Hazewinkel HA Meij BP. Evaluation of intervertebral disk degeneration in chondrodystrophic and nonchondrodystrophic dogs by use of Pfirrmann grading of images obtained with low-field magnetic resonance imaging. Am J Vet Res 72, 893–898, 2011
4) Blaser A, Lang J, Henke D, Doherr MG, Adami C Forterre F. Influence of durotomy on laser-Doppler measurement of spinal cord blood flow in chondrodystrophic dogs with thoracolumbar disk extrusion. Vet Surg 41, 221–227, 2012
5) D'Alonzo RC, White WD, Schultz JR, Jaklitsch PM and Habib AS. Ethnicity and the distance to the epidural space in parturients. Reg Anesth Pain Med 33, 24–29, 2008
6) Hand M, Thatcher D, Remillard R Roudebush P. Small Animal Clinical Nutrition: An Interactive Process. In: Small Animal Clinical Nutrition, 4th ed. Hand M, Thatcher D, Remillard R Roudebush P. eds. Mark Morris Institute, Topeka pp. 1–19, 2000.
7) Martinez-Taboada F Redondo JI. Comparison of the hanging-drop technique and running-drip method for identifying the epidural space in dogs. Vet Anaesth Analg 44, 329–336, 2017
8) Lee I, Yamagishi N, Oboshi K Yamada H. Eliminating the effect of epidural fat during dorsolumbar epidural analgesia in cattle. Vet Anaesth Analg 31, 86–89, 2004
9) Okutomi T, Saito M Hoka S. The distance from skin to the lumbar epidural space or epidural space to dura mater in Japanese parturients in the sitting position. The Journal of Japan Society for Clinical Anesthesia 26, 260–265, 2006
10) Otero PE, Verdier N, Ceballos MR, Tarragona L, Flores M Portela DA. The use of electrical stimulation to guide epidural and intrathecal needle advancement at the L5 -L6 intervertebral space in dogs. Vet Anaesth Analg 41, 543–547, 2014
11) Segal S, Beach M Eappen S. A multivariate model to predict the distance from the skin to the epidural space in an obstetric population. Reg Anesth 21, 451–455, 1996
12) Sharma V, Swinson AK, Hughes C, Mokashi S Russell R. Effect of ethnicity and body mass index on the distance from skin to lumbar epidural space in parturients. Anaesthesia 66, 907–912, 2011
13) Smolders LA, Bergknut N, Grinwis GC, Hagman R, Lagerstedt AS, Hazewinkel HA, Tryfonidou MA Meij BP. Intervertebral disc degeneration in the dog. Part 2: chondrodystrophic and non-chondrodystrophic breeds. Vet J 195, 292–299, 2013
14) Viscasillas J, Sanchis S Sneddon C. Ultrasound guided epidural catheter placement in a dog. Vet Anaesth Analg 41, 330–331, 2014