Distribution of Contrast Medium Epidurally Injected at Thoracic and Lumbar Vertebral Segments

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ABSTRACT. The epidural distribution of iohexol (0.2 ml/kg) administered at thoracic vertebrae (Thoracic group) and lumbar vertebrae (Lumbar group) was compared by computed tomographic (CT) epidurography in dogs. The total spread of iohexol was similar between the 2 groups upon reaching a similar cranial level. The maximal CT values were higher at the C7/T1 and T4/T5 levels in Thoracic group, but they were higher at the T13/L1 and L4/L5 levels in Lumbar group (P<0.05). This result suggests that the distribution pattern of the drug administered epidurally at thoracic vertebrae and lumbar vertebrae is different in dogs.

KEY WORDS: canine, CT epidurography, lumbar segment, thoracic segment.


Epidural anesthesia and analgesia have been widely used in human medicine. Drugs can be delivered either directly through the epidural needle or through an indwelling catheter in the epidural space. Epidural catheterization provides the opportunity for repeated or constant delivery of anesthetics to the epidural space, allowing surgeons to tailor the anesthesia duration to the length of operation and maintain a route for analgesia during and after surgery. Thoracic epidural administration can provide optimal perioperative anesthesia and analgesia in cardiac, thoracic and upper abdominal surgery and decrease postoperative morbidity and mortality [2, 3, 8, 9].

At present, epidural anesthesia is usually limited to the caudal lumbar region due to anatomic and technical concerns, where it is performed for surgical procedures caudal to the umbilicus in dogs [1, 5, 11, 14]. Recently, we demonstrated that epidural catheterization was possible at the thoracic vertebral level at least in medium size dogs [16]. Although thoracic epidural anesthesia is supposedly effective for thoracic or upper abdominal surgery, in comparison with human medicine, little has been known about the difference in the distribution pattern of the drugs administered from the thoracic vertebral level and the caudal lumbar vertebral level in dogs.

Epidurography using a contrast medium has been used to conjugate the distribution of local anesthetic in the epidural space in humans [10, 13, 15]. It has been also used to observe the pattern of spread in animals [4, 6, 12]. Computed tomographic (CT) epidurography provides better insight into the morphology of the epidural space compared with radiography, and it allows for tomographic imaging of the spinal cord [4]. The detection of contrast medium with the use of CT epidurography is thought to be more accurate.

The purpose of this study was to compare, with the use of CT epidurography, the distribution of contrast medium injected through an epidural catheter placed at thoracic and lumbar vertebral levels.

This study was approved by the Animal Care Committee of the Graduate School of Agricultural and Life Sciences at the University of Tokyo. Six healthy female beagles with a mean age of 21.8 months (range, 17–42 months) and mean body weight of 12.0 kg (range, 10.9–14.0 kg) were used on two occasions with a minimum 3-day washout period in a random crossover design.

Dogs were housed in individual cages in which temperature and humidity were kept constant. Food was withheld for at least 12 hr before each experiment, and water was available ad libitum.

Dogs were not premedicated. General anesthesia was induced and maintained with isoflurane (Isoflur; Dainippon Pharmaceutical Co., Ltd., Osaka, Japan). After endotracheal intubation, the end-tidal concentration of isoflurane vaporized in pure oxygen was maintained at 1.8% (approximately equivalent to 1.4 MAC). The end-tidal concentration of CO2 was kept between 35 and 40 mm Hg by intermittent positive pressure ventilation (KV-1a; Kimura Medical Instrument Co., Ltd., Tokyo, Japan). The end-tidal concentration of isoflurane and CO2, arterial oxygen saturation, respiratory
ences were considered to be significant at \( P \leq 0.05 \).

Dogs were positioned in sternal recumbency with hind limbs pulled forward symmetrically. Hair was clipped, and the skin surface around the needle puncture site was sterilized according to a surgical preparation procedure. An epidural catheterization set (Hakko Co., Ltd., Nagano, Japan) was used. An 18G Tuohy needle supplied with the catheterization set was inserted through the intervertebral spaces at thoracolumbar (T11 to L1) or lumbosacral (L6 to S1) level in two groups, respectively. Correct needle placement within the epidural space was confirmed by the “loss of resistance” (LOR) technique with saline. If there was a positive LOR response, a 20G radiopaque flexible catheter supplied with the catheterization set was introduced through the needle and advanced 10 cm into the epidural space. After confirming the absence of blood and cerebrospinal fluid by aspiration with a syringe connected to the catheter, the remainder of the catheter was secured onto the skin. The dogs were turned to the supine position and prepared for CT scanning. During CT scanning, dogs in both groups were restrained in dorsal recumbency. The head and spinal canal were kept at the same level throughout observation period.

Before epidural injection of contrast medium, control images were obtained using a 4-slice helical CT unit with a slice thickness of 8 mm and a pitch of 0.875 at 120 kV and 150 mA (Asteion S4; Toshiba Medical Systems Corporation, Tochigi, Japan). A dose of 0.2 ml/kg of iohexol (140 mgI/ml; Omnipaque; Daiichi Sankyo Co., Ltd., Tokyo, Japan) was injected epidurally through the catheter attached to a syringe pump (TOP syringe pump TOP-5500; TOP Corporation, Tokyo, Japan) at a rate of 0.01 ml/sec [4]. The volume of iohexol (0.2 ml/kg) was chosen, because this volume of local anesthetic is commonly used for abdominal and orthopedic surgeries caudal to the diaphragm [11]. CT epidurographic images were obtained at 5, 10, 15, 20 and 30 min after injection under the same CT conditions. The longitudinal distribution of contrast medium was evaluated and expressed as the total number of vertebral segments reached by the contrast medium cranial to the lumbosacral space. The spread from the intervertebral level to the midline of the next vertebral body was counted as 0.5 vertebral body units (VBU), and spread from 1 intervertebral level to the next was counted as 1 VBU [7]. Moreover, the maximal CT value of the epidural space at the C7/T1, T4/T5, T13/L1 and L4/L5 vertebral levels was measured in each dog.

The number of vertebral segments reached by the contrast medium was expressed as the median (minimum-maximum). The maximal CT value of the selected vertebral region was expressed as mean ± SD. Wilcoxon’s rank-sum test was used to analyze the number of segments with vertebral spreading. For comparing the maximal CT values, time-related changes were evaluated by repeated measures ANOVA, followed by Dunnett’s test, and differences between two groups at the same time were analyzed by paired Student’s t test. Differences were considered to be significant at \( P \leq 0.05 \).

The epidural catheter was successfully inserted into the epidural space in all dogs. The median location of the tip was at the T8 (T7 to T10) level in Thoracic group and at the L3 (L2 to L4) level in Lumbar group. No adverse events related to needle puncture, epidural catheterization or contrast medium injection were observed in either group.

Contrast medium was found within the epidural space by CT after injection in all dogs. The median number of vertebral segments contacted by the contrast medium was 17.0, 18.0, 18.75, 20.0 and 20.25 in Thoracic group and 18.5, 19.75, 20.0, 20.5 and 21.5 in Lumbar group at 5, 10, 15, 20 and 30 min after epidural injection, respectively (Fig. 1). A time-related increasing trend in the number of spreading segments was found after contrast medium injection in both groups. Although the contrast medium spread more cranially in Lumbar group, while more caudally in Thoracic group (at 20 and 30 min) (Fig. 2), no difference in the total spread of contrast medium was found between the two groups (Fig. 1).

With the exception of C7/T1, at which level the maximal CT value initially increased or remained unchanged, there was a time-related decreasing trend in the maximal CT value at the other selected vertebral levels in both groups. The maximal CT values were significantly higher at the C7/T1 and T4/T5 levels in Thoracic group, whereas they were significantly higher at the T13/L1 and L4/L5 levels in Lumbar group (Fig. 3).

In the present study, the total number of spreading segments was comparable between two groups, and the contrast medium reached to a similar vertebral level cranially in both groups. In contrast, the maximal CT values were significantly different between the groups. In Thoracic group, the maximal CT values were higher at the C7/T1 and T4/T5 levels, whereas in Lumbar group, they were higher at the T13/L1 and L4/L5 levels. High CT values indicated that a greater amount of contrast medium was distributed in the thoracic vertebral region when it was epidurally injected.

![Fig. 1. Contrast medium distribution over time, reported as the total number of vertebral segments. There were no differences in spreading segments after epidural injection between two groups. A time-related extent of contrast medium was found in both groups. † Significant difference compared with 5 min; ‡ Significant difference compared with 10 min; ‡‡ Significant difference compared with 15 min (\( P \leq 0.05 \)).](image-url)
from the thoracic level; meanwhile, more contrast medium was distributed in the lumbar region when it was injected from the lumbar level. Although the relationship between the spread of contrast medium and the extent of neural blockade is controversial [10, 15], Yokoyama et al. reported the clear correlation between contrast medium distribution and blockade extent in humans. In addition, epidurography has been used to evaluate the distribution of the drugs administered epidurally in animals [4, 6, 12]. Therefore, the results obtained in the present study suggest that the distribution of the drug administered epidurally from the thoracic vertebral level and the lumbar vertebral level is different, and additionally support the possible use of thoracic epidural anesthesia in thoracic and cranial abdominal surgeries in dogs. Further investigation is necessary to confirm the analgesic effects of thoracic epidural anesthesia in dogs.

REFERENCES


Fig. 2. The median epidurographic distribution after injection of 0.2 ml/kg iohexol, 140 mgI/ml in two groups. From the tip of the catheter, contrast medium distributed equally in both cranial and caudal direction in Thoracic group, but it spread more cranially than caudally in Lumbar group. C= cervical segment; T= thoracic segment; L= lumbar segment; S= sacral segment. * Significant difference in cranial extent between groups; ** Significant difference in caudal extent between groups; # Significant difference between cranial and caudal extent within group (P<0.05).

Fig. 3. Maximal CT values at 4 selected vertebral levels over measurement time points between Thoracic and Lumbar group. ¶ Significant difference between two groups at the same observation time (P<0.05).


