Evaluation of epiduroscopy for detection of vertebral canal and spinal cord lesions in dogs

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OBJECTIVE
To evaluate the potential usefulness of epiduroscopy for clinical diagnosis and treatment of vertebral canal and spinal cord lesions in dogs.

SAMPLE
Cadavers of 6 mixed-breed dogs.

PROCEDURES
Dogs were positioned in sternal recumbency, and an endoscope was introduced into the lumbosacral epidural space. A fiberscope (diameter, 0.9 mm; length, 30 cm) was used for 3 dogs, and a videoscope (diameter, 2.8 mm; length, 70 cm) was used for the other 3 dogs. Visibility and identities of anatomic structures were recorded, and maneuverability of the endoscopes was assessed. Extent of macroscopic tissue damage was evaluated by manual dissection of the vertebral canal at the end of the procedure.

RESULTS
Intermittent saline (0.9% NaCl) solution infusion, CO_2 insufflation, and endoscope navigation improved visualization by separating the epidural fat from the anatomic structures of interest. Images obtained with the fiberscope were small and of poor quality, making identification of specific structures difficult. Maneuverability of the fiberscope was difficult, and target structures could not be reliably reached or identified. Maneuverability and image quality of the videoscope were superior, and spinal nerve roots, spinal dura mater, epidural fat, and blood vessels could be identified. Subsequent manual dissection of the vertebral canal revealed no gross damage in the spinal cord, nerve roots, or blood vessels.

CONCLUSIONS AND CLINICAL RELEVANCE
A 2.8-mm videoscope was successfully used to perform epiduroscopy through the lumbosacral space in canine cadavers. Additional refinement and evaluation of the technique in live dogs is necessary before its use can be recommended for clinical situations. (*Am J Vet Res* 2016;77:766–770)

Epiduroscopy represents a successful treatment alternative for humans with chronic back pain who are refractory to conventional treatment following unsuccessful decompressive surgery.[1–3] The technique can be used to remove adhesions, flush away inflammatory mediators, and inject corticosteroid drugs and local anesthetic within the target area. Epiduroscopy is also useful for identifying the inciting cause of chronic back pain in patients for which standard imaging modalities fail to provide this information. Epiduroscopy is even superior to advanced imaging techniques, including MRI, for identification of the lesions responsible for producing pain in patients for whom MRI fails to reveal any abnormalities.[4] Furthermore, information obtained through epiduroscopy can be used to predict outcomes for humans with chronic low back pain after treatment.[5,6]

In horses, cervical epiduroscopy and myeloscopy are reportedly feasible diagnostic tools.[7–9] In 1 study,[10] locations of spinal cord compression were incorrectly identified by use of myelography, compared with results of vertebral canal endoscopy.[10] Lesion location in that study was confirmed by subsequent histologic evaluation of spinal cord specimens.

Epiduroscopy can also be used as a treatment tool. In humans, epiduroscopic treatments include adhesiolysis, targeted administration of epidural medication, laser ablation, and saline (0.9% NaCl) solution flushing.[3,10–13] In dogs, an injection site commonly used for provision of neuroaxial regional anesthesia is the lumbosacral space.[14,15] This intervertebral space is considered a safe entry point because the spinal cord ends cranial to L7 in dogs.[16] Epiduroscopy would be a less invasive procedure than conventional surgery to provide spinal decompression in dogs with IVDH and could be used as a diagnostic tool for various diseases affecting the epidural space, such as IVDH, spinal neoplasia, nerve root entrapment, foraminal stenosis, tethered spinal cord syndrome, and other compressive diseases of the spinal cord. Additionally, these interventions would cost much less than the surgical approach to IVDH, particularly when postoperative care is con-

ABBREVIATIONS

IVDH	Intervertebral disk herniation

sidered. Therefore, potential uses of epiduroscopy in veterinary medicine should be further investigated.

The purpose of the study reported here was to evaluate the feasibility of lumbosacral epiduroscopy for safe visualization of the spinal cord (covered by the dura mater), nerve roots, and dorsal and ventral vertebral canals in dogs. We hypothesized that epiduroscopy would allow visualization and examination of the neural structures in the epidural space and that use of a videoscope would provide results superior to those obtained with a fiberscope. We also preliminarily evaluated whether measurements made with the videoscope would agree with those made via manual dissection of the spinal cord.

Materials and Methods

Dogs

Cadavers of 6 mixed-breed dogs (4 males and 2 females, all sexually intact) of unknown age that had been euthanized for reasons other than the present study were used. Mean ± SD body weight was 25.5 ± 10.8 kg (range, 4.5 to 35 kg). No neurologic diseases had been reported prior to euthanasia. The study was approved by the Institutional Animal Care and Use Committee of the University of Florida (protocol No. 201307786).

Procedures

Each dog was positioned in sternal recumbency, with pelvic limbs extended cranially. The lumbosacral area was clipped of hair and cleaned. The lumbosacral interarcuate space was identified, and an 18-gauge, 8.75-mm Tuohy needle[a] was introduced into the epidural space. Needle placement in the epidural space was confirmed by means of the hanging drop technique and by loss of resistance to injection. The guidewire of an introducer was then advanced into the needle until 10 cm of its length had been introduced into in the epidural space.

A No. 11 scalpel blade was used to create a small path (< 1 cm) through skin, muscle, and supraspinous ligament along the path of the needle. A 3.6-mm-diameter introducer with dilator[b] was then placed into the epidural space over the guidewire and securely sutured to the skin. This introducer was cut to a length of 7.5 cm to allow visualization of the lumbosacral epidural space.

An endoscope was inserted into the introducer and advanced until the epidural space and the sacral nerves were visible. For the first 3 dogs, a fiberscope[c] with an internal diameter of 0.9 mm and length of 30 cm was used as the endoscope, whereas for the final 3 dogs, a videoscope[d] with an internal diameter of 2.8 (8.5F) mm and length of 70 cm was used.

A 1-L bag of saline solution was connected to the working channel of the endoscope with a 3-way stopcock between 2 fluid lines. A 20-mL syringe was connected to the stopcock and used to measure the amount of saline solution infused into the epidural space. Saline solution was gently and intermittently infused into the epidural space, and the endoscope was maneuvered to disconnect fat from anatomic structures. A metric tape was used to measure the total length of the endoscope prior to its introduction. Then, the distance from the proximal end of the introducer to the proximal end of the endoscope (part of the endoscope outside the cadaver) was measured. This value was subtracted from the total length of the endoscope to record the distance of a given structure from the end of the introducer **(Figure 1)**. The length of the introducer path between the skin puncture site and the epidural space entrance was also taken into account for these calculations.

After visibility had improved, the endoscope was advanced cranially to identify the cauda equina and to tentatively navigate to all 4 quadrants of the epidural space (dorsal, ventral, and right and left lateral). The operator tentatively identified every nerve root seen,

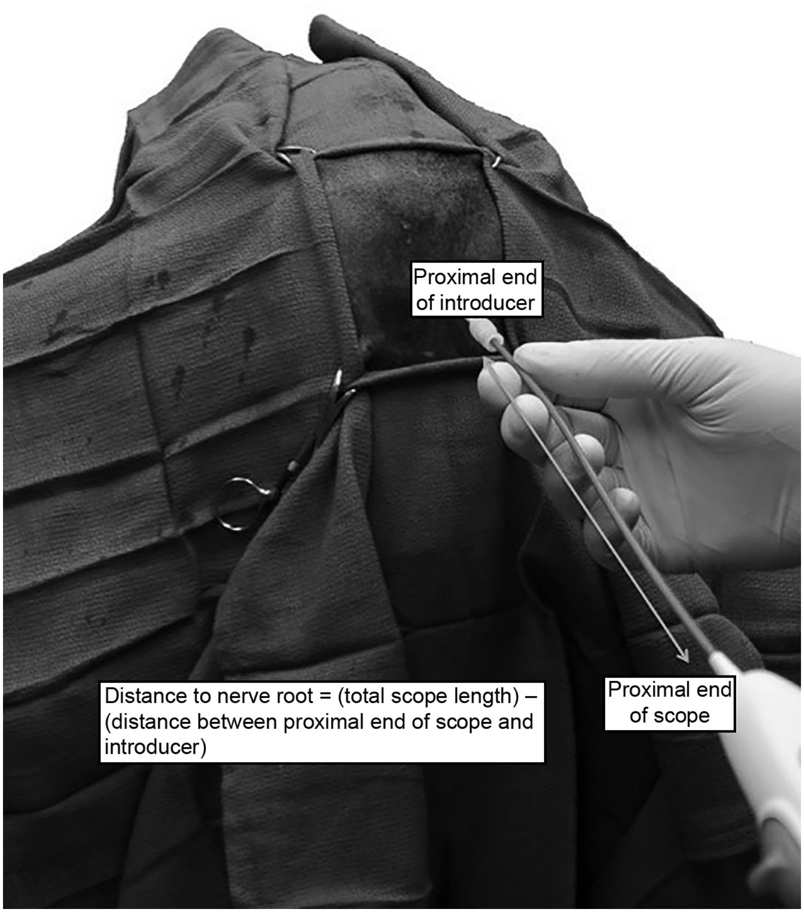

Figure 1—Photograph showing the method used to measure the distance between the nerve root and the introducer during epiduroscopy involving a canine cadaver.

and its distance to the port was recorded (eg, left L7 nerve root at 14 cm from the port). A list of structures to be visualized was used to guide the procedure, and the number of structures that could conceivably be identified within each quadrant (cauda equina, L1 to L7 nerve roots, epidural space, internal vertebral venous plexus, and nerve root ganglion) was recorded. A score was assigned to characterize the ease with which the endoscope could be moved and redirected within the epidural space and structures visualized **(Appendix)**. All procedures were photographed and videorecorded, particularly those involving the listed conceivably identifiable structures.

Statistical analysis

A Bland-Altman–style plot was constructed to evaluate agreement between videoscopy and manual dissection for measurements of distance between the proximal end of the introducer and the nerve roots. The Mann-Whitney *U* test was used to compare navigation and visualization scores between the fiberscope and videoscope. Navigation and visualization scores, identities of the most cranial root visualized, and distance measurements were summed over all attempts in each subject and were not analyzed individually. Statistical software[e] was used for all analyses, and values of $P < 0.05$ were considered significant.

Results

Initial visualization of the epidural space after endoscope placement was successfully completed in all 6 canine cadavers with both endoscope types (fiberscope and videoscope). The introducer sheath needed to be transected and shortened to allow visualization of the cauda equina. Injection of saline solution was necessary in all procedures to obtain a clear image. Carbon dioxide insufflation (16 ± 1 mm Hg) was used in 3 attempts (once in one dog and twice in another dog) during videoscopy, and this hastened structural visualization. No CO_2 accumulation in the abdomen or thorax was observed after the procedures.

Epiduroscopy was performed 3 times in all 3 dogs in the fiberscope group and in 1 dog in the videoscope group (represented for reporting purposes as dogs 1, 2, and 3, in order of evaluation). For the other 2 dogs in the videoscope group, epiduroscopy was performed twice in 1 dog (dog 3) and only once in the remaining dog (dog 2). The reason epiduroscopy was performed only once in dog 2 was because the investigators were interested in whether epiduroscopy performed with a videoscope would be feasible in small subjects, and that dog weighed only 4.5 kg. However, the cadaver of that dog had been kept in the cooler for too long and the nerve tissue had lost its integrity. Consequently, epiduroscopy was performed in that dog only to confirm that the epidural space would be large enough to fit the videoscope and the videoscope was removed when lumbar nerve roots were seen. For the 3 dogs in the fiberscope group, after several attempts (3/dog), epiduroscopy was abandoned because no clear visualization of relevant structures was possible.

All epiduroscopic procedures performed with the fiberscope resulted in a visualization score of 5 (poor). In 2 of the 3 dogs examined with the videoscope, the procedure yielded good images and most structures were visible. The first attempt in 1 dog in which CO_2 insufflation hastened structure visualization (dog 1) was brief because the operator needed to familiarize himself with the new instrument. During the second attempt, all structures as cranial as the second lumbar nerve roots, including vertebral venous sinuses, bilateral nerve roots, and ganglions were visible and identified. Although videoscopy of the second dog in that group (dog 2) was performed only briefly, the epidural fat, cauda equina, and lumbar nerve roots from L5 to L7 were identified. Videoscopy of the third dog (dog 3) was performed twice, and all targeted structures as cranial as L4 were visible.

A navigation and visualization score of 1 was assigned for the 4 epiduroscopic procedures performed on dogs 1 and 3 in the videoscopy group. The first attempt in dog 1 and the attempt in dog 2 were not scored. Navigation and visualization scores differed significantly ($P = 0.045$) between endoscope types.

Manual dissection of the spinal cord was performed for 2 dogs/endoscope group after epiduroscopy, including dogs 1 and 3 in the videoscope group. No damage was grossly visible in the dura mater, nerve roots, or major blood vessels. In the videoscope group only, mean measurements of distances between visualized nerve roots and the insertion site of the videoscope were compared with the dissection measurements, revealing a mean difference between measurements of 1.43 ± 1.25 cm **(Figure 2)**. Distances had variable agreement between videoscopic and dissection measurements. The difference between sets

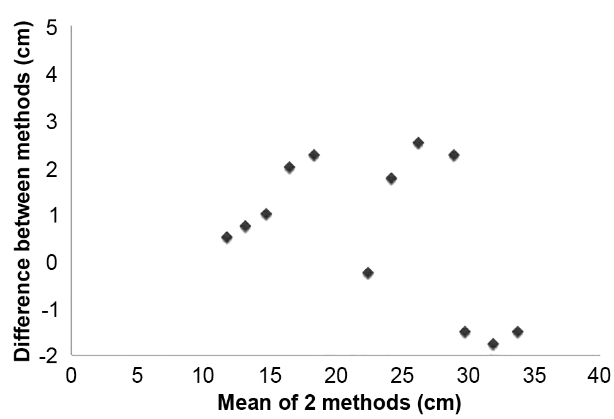

Figure 2—Bland-Altman–type plot of distances between nerve roots and the proximal end of an introducer as measured in 2 canine cadavers by videoscope and dissection. Data points represent 1 measurement on each dog. The mean ± SD difference for the 2 measurement techniques was 1.43 ± 1.25 cm; however, lines representing this value and the 95% limits of agreement, as would be typically provided in a Bland-Altman plot, are not shown because of the small number of dogs and measurements.

of measurements became larger as the videoscope moved cranially.

Discussion

The present study provided preliminary evidence of the feasibility of epidural videoscopy as a tool for visual identification of anatomic structures in the lumbosacral and thoracic epidural space in dogs, by use of canine cadavers. Additional studies involving live dogs are needed to confirm the potential usefulness of the technique for clinical diagnostic and therapeutic purposes in dogs.

Preparation for the procedure began with placement of an introducer into the lumbosacral intervertebral space. This step was fairly easy to perform, given that the operator was experienced in epidural injections. Confirmation that the Tuohy needle has entered the epidural space is important to achieve prior to placement of the guidewire and introducer sheath. The introducer sheath was shortened to allow for visualization of the lumbosacral epidural space. This made introduction of the sheath more difficult because the edges of the introducer were no longer smooth. Also, while the 2.8-mm-diameter videoscope was moved back and forth, the integrity of the introducer was lost and ridges could be seen on the images. Ridges were also appreciated by an increasingly greater resistance to the passage of the videoscope.

Ultimately, damage was noticed on the videoscope cover sheath as well as on the steering mechanism. Perhaps a rigid operating sheath (trocar) with an oblique end at the distal aspect would have minimized these problems. On the other hand, use of a malleable vascular introducer would be less likely to cause tissue damage while entering the epidural space, which is the reason it was used in the present study.

After several attempts with the 0.9-mm-diameter fiberscope, use of this instrument was abandoned. This endoscope was primarily designed for minimally invasive arthroscopies. However, because of its small diameter, it does not have a working channel or steering capabilities. These functions can be added by use of a steerable sheath (diameter, 2.7 mm). Another problem was the poor quality and size of the images obtained, making anatomic recognition of structures difficult. Furthermore, the length of the fiberscope (30 cm) made it a poor choice to reach the thoracolumbar epidural space. Although the cadavers in which the fiberscope was used were manually dissected after epiduroscopy, dissection was performed only to confirm the placement of the endoscope in the epidural space and that no gross damage had been generated by the procedure. Measurement of the distance between nerve roots and the proximal end of the introducer was not established by use of this type of endoscope.

In the authors' opinion, use of the videoscope rather than fiberscope for epiduroscopy represented a considerable improvement to the epiduroscopy technique. Although the videoscope had a much larger diameter than the fiberscope, it was easily passed through the 3.6-mm-diameter introducer. Additionally, this endoscope allowed navigation (270° deflection up or down), had a working channel to provide saline solution flushes, and was longer (70 cm) than the fiberscope, and the images obtained were clear. However, use of the vascular introducer caused increasingly greater resistance to the passage of the videoscope as the procedure was carried out.

After initial visualization of the epidural space, infusion of saline solution was imperative before any structure could be identified, largely because of the presence of adipose tissue. A mean of 15 minutes elapsed before fat was sufficiently dissected away. Navigation with the videoscope always began in a dorsolateral direction, so nerve roots could be visualized and then counted. Several minutes elapsed during attempts to visualize each segmental nerve root bilaterally because the videoscope needed to be withdrawn several centimeters before it could be maneuvered to the contralateral side of the epidural space. Navigation through all 4 epidural space quadrants and identification of nerve roots bilaterally prolonged the procedure, explaining the additional attempts made on the same cadavers. During second and third attempts, the operator was able to advance faster only through 1 lateral quadrant, identifying and confirming nerve roots until other previously unseen nerve roots were visible. Therefore, in live dogs in which the specific area of interest is known, the duration of epiduroscopy should be briefer than in the present study. Also, use of fluoroscopy is advisable given that recognition of nerve roots during epiduroscopy was not always correct.

Although the videoscopy technique evaluated in the present study appeared feasible for epiduroscopic evaluation of dogs with diseases of the spinal canal, it still requires some refinement. The use of a vascular introducer was not ideal; this introducer needed to be shortened, creating sharp edges that damaged the endoscope, which needed repair. A metal or hard plastic scope port could potentially be a good alternative to the vascular introducer. The technique also needs to be evaluated in live dogs to ensure it is safe and would yield no functional damage.

Footnotes

a. 18-gauge, 8.75-cm Tuohy tip needle, Arrow International, Reading, Pa.
b. Avanti + introducer, Cordis, Miami, Fla.
c. BioVision Technologies, Golden, Colo.
d. Video-ureter-cystoscope (11278V), Karl Storz, Goleta, Calif.
e. NCSS 2007, NCSS LLC, Kaysville, Utah.

References

1. Sakai T, Aoki H, Hojo M, et al. Adhesiolysis and targeted steroid/local anesthetic injection during epiduroscopy alleviates pain and reduces sensory nerve dysfunction in patients with chronic sciatica. *J Anesth* 2008;22:242–247.
2. Shutse G, Kurtse G, Grol O, et al. Endoscopic method for the diagnosis and treatment of spinal pain syndromes [in Russian]. *Anesteziol Reanimatol* 1996;4:62–64.
3. Kallewaard JW, Vanelderen P, Richardson J, et al. Epiduroscopy for patients with lumbosacral radicular pain. *Pain Pract* 2014;14:365–377.

4. Vanelderen P, Van Boxem K, Van Zundert J. Epiduroscopy: the missing link connecting diagnosis and treatment? *Pain Pract* 2012;12:499–501.
5. Bosscher HA, Heavner JE. Incidence and severity of epidural fibrosis after back surgery: an endoscopic study. *Pain Pract* 2010;10:18–24.
6. Bosscher HA, Heavner JE. Lumbosacral epiduroscopy findings predict treatment outcome. *Pain Pract* 2014;14:506–514.
7. Prange T, Carr EA, Stick JA, et al. Cervical vertebral canal endoscopy in a horse with cervical vertebral stenotic myelopathy. *Equine Vet J* 2012;44:116–119.
8. Prange T, Derksen FJ, Stick JA, et al. Cervical vertebral canal endoscopy in the horse: intra- and postoperative observations. *Equine Vet J* 2011;43:404–411.
9. Prange T, Derksen FJ, Stick JA, et al. Endoscopic anatomy of the cervical vertebral canal in the horse: a cadaver study. *Equine Vet J* 2011;43:317–323.
10. Lee GW, Jang SJ, Kim JD. The efficacy of epiduroscopic neural decompression with Ho:YAG laser ablation in lumbar spinal stenosis. *Eur J Orthop Surg Traumatol* 2014;24(suppl 1):S231–S237.
11. Lee F, Jamison DE, Hurley RW, et al. Epidural lysis of adhesions. *Korean J Pain* 2014;27:3–15.
12. Jo DH, Kim ED, Oh HJ. The comparison of the result of epiduroscopic laser neural decompression between FBSS or not. *Korean J Pain* 2014;27:63–67.
13. Di Donato A, Fontana C, Pinto R, et al. The effectiveness of endoscopic epidurolysis in treatment of degenerative chronic low back pain: a prospective analysis and follow-up at 48 months. *Acta Neurochirurgica* 2011;108:S67–S73.
14. Garcia-Pereira FL, Hauptman J, Shih AC, et al. Evaluation of electric neurostimulation to confirm correct placement of lumbosacral epidural injections in dogs. *Am J Vet Res* 2010;71:157–160.
15. Garcia-Pereira FL, Sanders R, Shih AC, et al. Evaluation of electrical nerve stimulation for epidural catheter positioning in the dog. *Vet Anaesth Analg* 2013;40:546–550.
16. Fletcher TF, Kitchell RL. Anatomical studies on the spinal cord segments of the dog. *Am J Vet Res* 1966;27:1759–1767.

Appendix

Scoring system used to characterize the ease with which an endoscope could be navigated and used to visualize anatomic structures during epiduroscopy in canine cadavers.

Score	Navigation	Visualization
1 (Excellent)	Easy, with no damage or bleeding and minimal complication	Great visibility, with all structures clearly seen
2	Slightly difficult, with minor bleeding or some complication	Good to great visibility, with all or most structures seen but not clearly
3	Somewhat more difficult, with prolonged procedure duration or obvious bleeding	Good visibility, with half to two-thirds of structures seen with moderate clarity
4	Difficult, prolonged procedure or obvious bleeding and complications	Poor to adequate visibility, with less than half of structures visible and poor clarity
5 (Poor)	Very difficult, leading to termination of the procedure	Failure to identify most structures