CLINICAL, PATHOLOGIC, AND MAGNETIC RESONANCE IMAGING CHARACTERISTICS OF CANINE DISC EXTRUSION ACCOMPANIED BY EPIDURAL HEMORRHAGE OR INFLAMMATION

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Our aim was to characterize the magnetic resonance (MR) imaging features of canine disc extrusion accompanied by epidural hemorrhage or inflammation. We correlated the imaging characteristics of this type of disc extrusion in 46 dogs and compared these features with clinical signs and pathologic findings. Data from 50 control dogs with MR imaging features of a disc extrusion with no associated hemorrhage or inflammation, characterized by a T2-hypointense extradural mass, were used for comparison of the relative location of the two types of lesions and prognosis. Disc extrusion causing epidural hemorrhage or inflammation is more common in the caudal aspect of the lumbar spine than disc extrusions that do not cause signs of hemorrhage or inflammation ($P<0.05$) in MR images. In dogs with disc extrusion and associated epidural hemorrhage or inflammation, there was no association between MR imaging features and signalment, the presence or absence of hemorrhage, or pathologic findings. The appearance of the lesion created by disc extrusion with epidural hemorrhage and inflammation encompasses a wide variety of imaging features, likely related to the duration of the hemorrhage and associated inflammatory changes. In 10 of 46 dogs these secondary changes masked identification of the disc extrusion itself in the MR images. An awareness of the variety of MR imaging features of disc extrusion accompanied by extradural hemorrhage or inflammation is important to avoid making an incorrect diagnosis and to facilitate a proper surgical approach. The prognosis of dogs with disc extrusion accompanied by hemorrhage or inflammation does not appear to be different than for dogs with disc extrusion and without imaging signs of epidural hemorrhage or inflammation. © 2010 *Veterinary Radiology & Ultrasound, Vol. 52, No. 1, 2011, pp 17–24.*

Key words: dogs, neuroimaging, spinal cord disease.

Introduction

THORACOLUMBAR DISC DISEASE is commonly assessed using magnetic resonance (MR) imaging. The common MR imaging appearance of canine disc disease has been described as (1) bulging of the disc if there is circumferential, symmetric, uniform extension of the outer disc margin, (2) protrusion if the disc protrudes either to the right or left with focal disruption of the annulus, and (3) extrusion if the nucleus is herniated through the annulus and appears as a focal extradural mass. If a portion of the extruded disc is displaced from the outer annulus, it is referred to as a dispersed or migrated disc.[1] In humans, the term sequestrated disc is used when there is no connection between the extruded material and originating disc.[2]

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Received February 7, 2010; accepted for publication July 27, 2010.
doi: 10.1111/j.1740-8261.2010.01746.x

A complication associated with disc extrusion is laceration of the vertebral venous plexus leading to epidural hemorrhage,[3,4] hematoma formation,[5] and disc migration that can lead to sequestration.[6] An inflammatory process can also be present within the epidural space that may or may not be related to epidural hemorrhage.

Typically, MR imaging findings in dogs with disc extrusion include a polypoid asymmetric vertebral canal mass that has both T1- and T2-hypointensity, a lack of immediate contrast enhancement, and is continuous with the disc.[7] This is often associated with asymmetry of adjacent epidural fat and nerve roots or spinal cord morphology. Associated hemorrhage or inflammation may affect the MR imaging appearance of the disc extrusion. Some of these complications have been described, mainly considered as a consequence of hemorrhage,[8] but the specific MR imaging features of such complications have not been fully described.

Our aims were to (1) describe the MR imaging features of thoracolumbar disc extrusion in dogs that did not fit with the classical MR imaging appearance of disc extrusion on T2-weighted images; (2) determine if there was a correlation between the MR imaging characteristics and clinical presentation, pathologic findings, and prognosis and (3) compare lesion localization and prognosis of dogs with disc extrusion accompanied by epidural hemorrhage or inflammation with a cohort of 50 dogs with disc extrusion but no imaging signs of epidural hemorrhage or inflammation.

Materials and Methods

Medical records from August 2006 to March 2009 were reviewed to identify dogs suspected of having spinal cord disease localized between the T3 to S1 spinal segments and in which MR imaging was performed. Four hundred and sixty dogs with 1087 disc herniations, including disc protrusions and extrusions, were identified from a total population of 822 patients with T3–S1 spinal cord disease. If the site of disc extrusion was obvious but the lesion involved more than one disc space, it was defined as a migrated disc and was considered as an unique lesion. If there were multiple disc herniations in one patient they were considered independently. Patients with previous spinal surgery were not included. In 36 dogs with imaging evidence of an extruded disc, a distinct focal, extradural lesion that was not homogeneously T2-hypointense was found; these dogs were assumed to have disc extrusion with epidural hemorrhage or inflammation. In another 10 dogs with disc extrusion confirmed at surgery or postmortem examination, T2-hyperintense epidural lesions were found on the MR images but there were no imaging features that suggested disc extrusion. The lesions in these 10 dogs were originally attributed to other pathologic processes, such as a tumor or cyst. These 46 dogs formed the study group.

There were 29 males (63%) and 17 females (37%). Thirty-one (67%) dogs were chondrodystrophic with cocker spaniels being the most prevalent ($n = 13$; 28%). Other chondrodystrophic breeds were French Bulldog ($n = 5$), Dachshund ($n = 6$), Shih Tzu ($n = 3$), Maltese ($n = 2$), Beagle ($n = 1$), and Poodle ($n = 1$). The second most represented group was mixed-breed dogs ($n = 11$). Among the nonchondrodystrophic breeds, Labrador Retriever, Pitbull Terrier, German Braco, and Viszla were represented equally ($n = 1$). The mean age was 6 years (range 1–14 years).

The 46 dogs with disc extrusion and epidural hemorrhage and/or inflammation had 52 involved sites. In some dogs, the lesions affected two ($n = 4$) or three ($n = 1$) disc spaces and they were considered to be independent lesions. In 10 dogs (22%), although the lesion involved more than one disc space, the site of disc extrusion was obvious, and it was considered as one lesion with migrated disc material. These 46 dogs represented 5.6% of dogs suspected of having T3–S1 spinal disease and 10% of dogs with intervertebral disc disease.

Fifty other dogs with classic MR imaging features of disc extrusion, characterized by a T2-hypointense extradural mass, examined during the same time period were selected as a control group. Of these 50 dogs, six had two ($n = 5$) or three ($n = 1$) disc extrusions, and disc migration was present in seven dogs (14%).

The clinical signs at onset of the disease, neurologic status at the time of MR imaging, and the duration of clinical signs from onset to MR imaging and surgery were recorded. The rate of onset of clinical signs was defined as the time between the first appearance of signs and the worst preoperative status. Rate of onset was categorized as peracute (<1 h), acute (1–24 h), or gradual (>24 h). Animals were classified neurologically according to five different grades: I—spinal pain; II—ambulatory paraparesis and/or proprioceptive deficits; III—nonambulatory paraparesis; IV—paraplegia with deep-pain perception regardless of voluntary urinary continence; and V—paraplegia with no deep-pain perception.

Duration of clinical dysfunction was defined as the time from initial observation of clinical signs until surgical treatment. Time from initial clinical signs to imaging and surgery was recorded, and dogs were classified into three different groups, A (<48 h), B (2–7 days), and C (>7 days). The rationale for this classification was based on the known MR imaging signal changes of an evolving intracerebral hematoma.

MR imaging studies had been performed using a 0.5 T superconducting magnet.* Sagittal and transverse T2-weighted fast spin echo images (4000/110/16; TR/TE/echo train) were acquired in all dogs considered to have disc extrusion with epidural hemorrhage or inflammation ($n = 46$) and noncontrast T1-weighted spin echo sequences (500/14; TR/TE) were acquired in 32 of them. Gadolinium-dimeglumide (Gd)† enhanced T1-weighted spin echo images (0.1 mmol/kg) were acquired in 31 dogs, and 21 of them also had post-Gd fat-saturated T1-weighted images (SPIR) acquired in the transverse plane. In the 50 control dogs, only sagittal and transverse T2-weighted fast spin echo images were acquired because the lesion was characteristically hypointense in these sequences and other findings were typical of disc extrusion. The slice thickness was 3–4 mm for sagittal images with a 0.3–0.4 mm gap. The transverse slice thickness varied from 3 to 5 mm with a 0.2–0.5 mm gap depending on the size of the patient. The field of view was set to the size of the vertebral region.

Signal intensity of lesions was graded subjectively as hypointense, isointense, hyperintense, or heterogeneous relative to the intensity of the normal spinal cord. The enhancement pattern was classified as peripheral, central, or diffuse and the grade as mild, moderate, or intense. Transverse T2-weighted images were used to assess

*Gyroscan T5-NT, Philips, Best, the Netherlands.

†Magnograf 0.5 mmol/ml solución inyectable; Schering España, Madrid, Spain.

intramedullary spinal cord changes. Sagittal and transverse T2-weighted images were used as a reference to determine the location of the lesion, which was confirmed either surgically or by postmortem examination.

All dogs that underwent decompressive surgery (40 dogs with disc extrusion and epidural hemorrhage or inflammation and the 50 control dogs) had a hemilaminectomy. In the dogs wherein histopathology was performed, samples were fixed in 10% buffered formalin and paraffin embedded. Sections 4 μm thick were stained with hematoxylin and eosin.

The location of the lesion was verified at surgery ($n = 40$) or necropsy ($n = 6$) and the diagnosis was confirmed histopathologically in 15 dogs. When histopathologic confirmation was not possible, the diagnosis was made on the basis of surgical findings.

Follow-up information was obtained by reexamination 30 days after surgery in 33 dogs with disc extrusions and epidural hemorrhage or inflammation and in the 50 control dogs. Outcome evaluation was only determined in dogs with a follow-up of 30 days. A successful outcome was defined as unsupported ambulation with only mild residual ataxia and no residual pain (neurologic grades 0–II), and improvement of at least one grade in neurologic status. An unsuccessful outcome was defined as a neurologic grade of III or higher or euthanasia because of the disc extrusion.

Chi-squared test was used in control and study groups to examine associations between intervertebral disc space and the presence or absence of an epidural lesion. Other statistical analyses were performed only in the 46 dogs with disc extrusion and epidural hemorrhage or inflammation. Descriptive statistics are reported as mean and minimum and maximum values. Kruskal–Wallis test was used to examine for associations between breed, age, time to imaging, rate of onset, and pathologic examination groups and the MR imaging findings. This same test was used to determine if prognosis was affected by rate of onset, breed, time to surgery, pathologic findings, or MR imaging findings. Mann–Whitney *U*-test was used to examine associations between presence of intramedullary spinal cord changes and prognosis. Results were considered significant at $P < 0.05$. All data were processed using a commercial statistical package.‡

Results

Twenty-three of 52 (44%) disc extrusions with epidural hemorrhage or inflammation were located between L2 and L5, with the most prevalent location being L4–L5 (11 of 52 lesions; 21%). In the 50 control dogs, 41 of 57 (72%) disc extrusions were located between T12 and L2 and the most affected site was T12–T13 (22 of 57 lesions; 38.6%) (Fig. 1). The location of the lesion was significantly different between groups. The T12–T13 disc space was affected more commonly in dogs with conventional disc extrusion ($P < 0.001$), whereas the L4–L5 disc space was affected more commonly in dogs with disc extrusion and epidural hemorrhage or inflammation ($P = 0.001$). The clinical onset of signs was predominantly acute (23 of 46 dogs; 50%), but some dogs had hyperacute signs (15 of 46 dogs; 33%) or a gradual (8 of 46 dogs; 17%) onset.

The relative T2-signal and T1-signal of the lesion in 32 of the 46 dogs with disc extrusion and epidural hemorrhage or inflammation were as follows: (1) T2-hyperintense and T1-isointene or T1-hypointense ($n = 10$, four of them without evidence of disc material, Fig. 2); (2) T2-hyperintense and T1-hyperintense ($n = 3$, two of them without evidence of disc material, Fig. 3); (3) T2-heterogeneity and T1-isointene or T1-hypointense ($n = 15$, in two of them without evidence of disc material, Fig. 4); and (4) T2-heterogeneity and T1-hyperintensity ($n = 4$, in two of them without evidence of disc material, Fig. 5). In the other 14 dogs, only T2-weighted images were available and the lesion was hyperintense in all 14. In 36 dogs the lesions were adjacent to an extruded disc but there was no accompanying MR imaging evidence of a herniated disc in the other 10 (Figs. 2 and 3).

There was no association between time to imaging or the rate of onset and the MR imaging group ($P = 0.25$ and 0.62, respectively). Contrast enhancement was found in 18 of the 31 dogs in which contrast enhanced images were acquired (six of the dogs with contrast enhancement belonged to the group of dogs without evidence of disc material). The contrast enhancement was peripheral, central, and diffuse in six, one, and 11 dogs, respectively. The grade of contrast enhancement was mild in eight dogs, moderate in seven, and intense in three dogs. In the 21 dogs

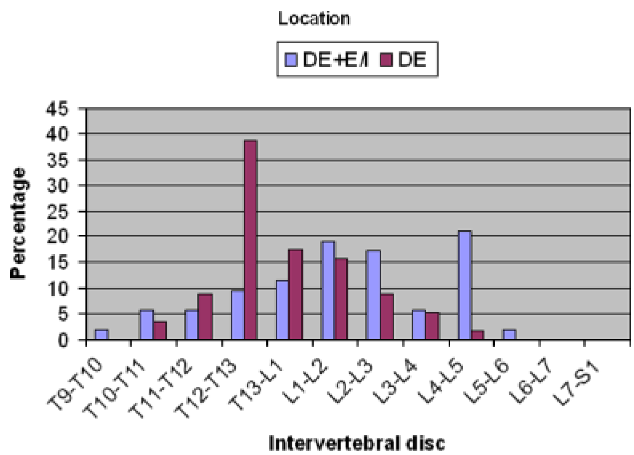

FIG. 1. Affected intervertebral disc space in dogs with thoracolumbar disc extrusion with epidural involvement (DE + E/I) and conventional disc extrusions (DE), expressed in percentages of the total in each group.

‡mul;, Statistical /mul;, Statistical Package for the Social Sciences v. 14.0.1; SPSS Inc., Chicago, IL.

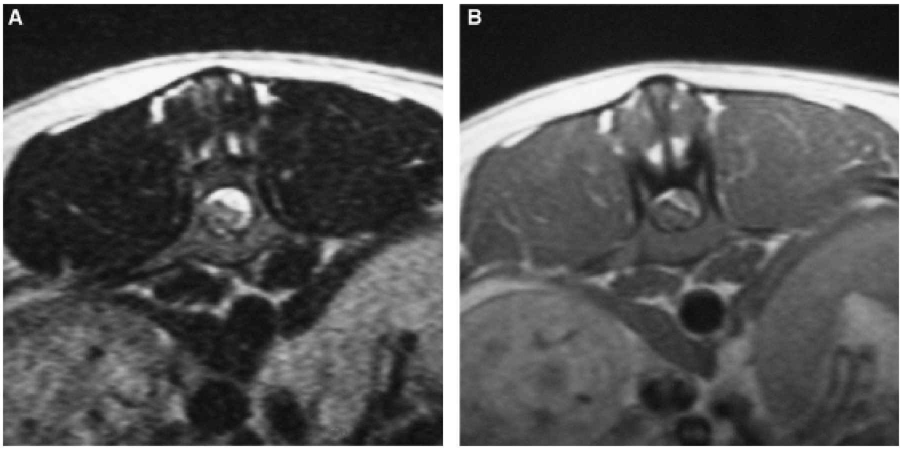

FIG. 2. Transverse images through L2. (A) T2-weighted image. There is a left dorsal hyperintense lesion displacing the spinal cord. (B) T1-weighted image. Note the isointensity of the lesion compared with the spinal cord.

in which fat-saturated images were available, the lesion was hyperintense in 16 dogs, confirming that fat was not a predominant component of the lesion. In eight dogs, there was negligible contrast enhancement in T1-weighted images but obvious hyperintensity was observed in the SPIR sequences after contrast medium administration (Fig. 6). As SPIR images were routinely acquired after the postcontrast T1-weighted images this finding may indicate delayed contrast enhancement. An intramedullary T2-hyperintense lesion, was present in 32 dogs.

Epidural hemorrhage was observed macroscopically in 36 of 46 dogs (78%) when hemilaminectomy was performed. Pathologic examination of the material obtained from the vertebral canal in 15 dogs was characterized by one of three different patterns: (1) presence of cartilaginous material without associated foreign body reaction ($n = 4$); (2) extradural hyaline cartilaginous material acting as a foreign body with associated pyogranulomatous reaction containing neutrophils and mononuclear cells, and basophilic necrotic foci with dispersed chondrocytes and fibrin debris ($n = 6$); and (3) foreign body reaction in which the main cell population was macrophages and lymphocytes ($n = 5$). There was no histologic evidence of neoplasia. Evidence of hemorrhage within the pathologic sample was observed only in five dogs, probably because the surgery site and the disc material was irrigated before the fixation process.

No association was found between the presence or absence of contrast enhancement of the lesion or the presence of an inflammatory reaction ($P = 0.56$). Also, no association was found between the presence of hemorrhage in the pathologic sample and the appearance (purely hyperintense or heterogeneous) of the lesion on T2-weighted images ($P = 0.37$) and T1-weighted images ($P = 0.94$).

Only 33 dogs having surgery were followed for at least 30 days. A successful outcome was achieved in 30 of the 33

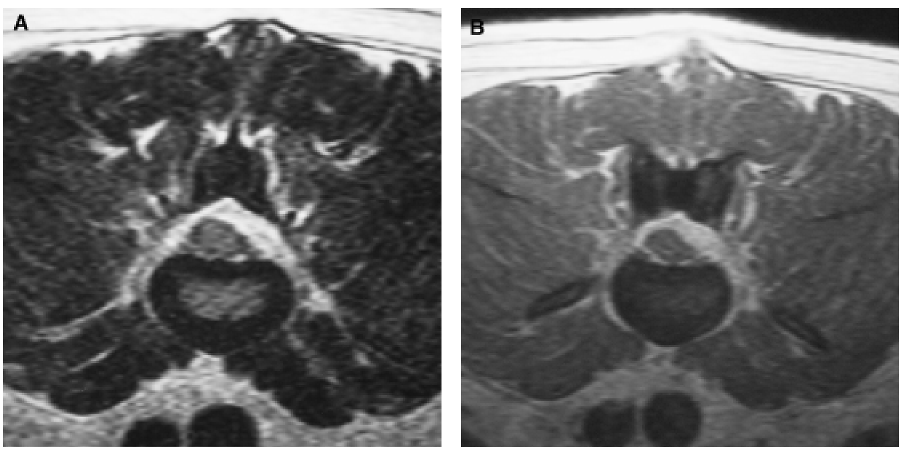

FIG. 3. Transverse images at the L4–L5 intervertebral disc space. Note the left dorsal lesion that is hyperintense in both (A) T2-weighted and (B) T1-weighted images.

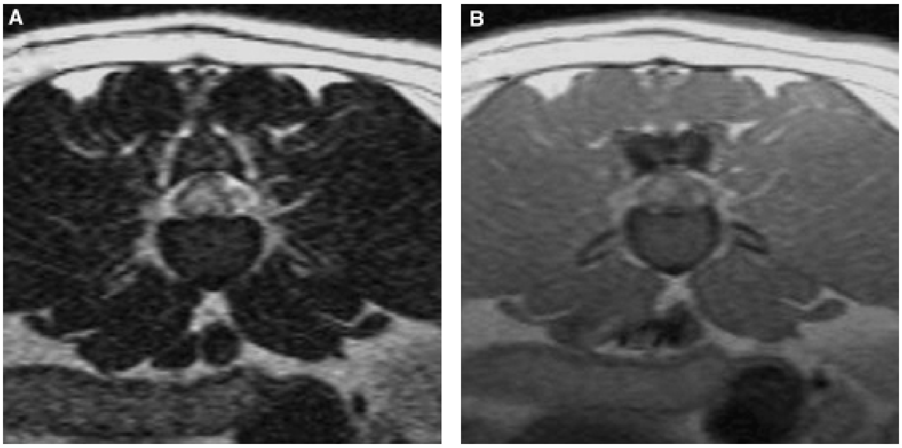

FIG. 4. Transverse images at the L4–L5 intervertebral disc space (A) T2-weighted image. Note a heterogeneous left lesion displacing the spinal cord. (B) T1-weighted image. Note the isointensity of the lesion compared with the spinal cord.

dogs (90.9%) with a mean improvement in neurologic grade of 1.69 (minimum = 0 and maximum = 4, Table 1). after 30 days. In dogs in which deep-pain perception was intact, the success rate was 96.5%. In the control dogs, a successful outcome was achieved in 43 dogs (91.5%) with a mean improvement in neurologic grade of 1.68 (minimum = 0 and maximum = 4, Table 2) after 30 days. Excluding dogs without deep-pain perception, the success rate increased to 93.3%. In dogs with disc extrusion and epidural hemorrhage or inflammation, no association was found between neurologic improvement and breed, gender, age, rate of onset, time to surgery, presence of intramedullary T2-hyperintensity, MR findings grouping, or pathologic group. Intramedullary T2-hyperintensity was observed in 22 dogs in which the mean neurologic grade was 3.4. Dogs without intramedullary T2-hyperintensity ($n = 11$) had a mean neurological grade of 2.5, but this difference was not statistically significant. Neurological status after treatment remained worse in dogs that had intramedullary T2-hyperintensity (1.68 vs. 1).

Discussion

The most common mass-like soft-tissue lesions that have a T2-signal intensity similar to that of spinal cord or hyperintense to spinal cord are neoplasia,[9] cysts,[10–12] hematomas,[5–13] abscesses,[14] and sequestrated discs.[6,15] All dogs in the current study had epidural lesions with a hyperintense or heterogeneous signal on T2-weighted images and were confirmed as having disc extrusions with a variable spectrum of hemorrhage and inflammation. This epidural hemorrhage or inflammation from disc extrusion was most common in chondrodystrophic breeds (67%); but this was expected because these breeds are prone to thoracolumbar disc extrusion.[16,17] Gender and mean age at presentation were comparable with reported dogs with disc extrusions.[16]

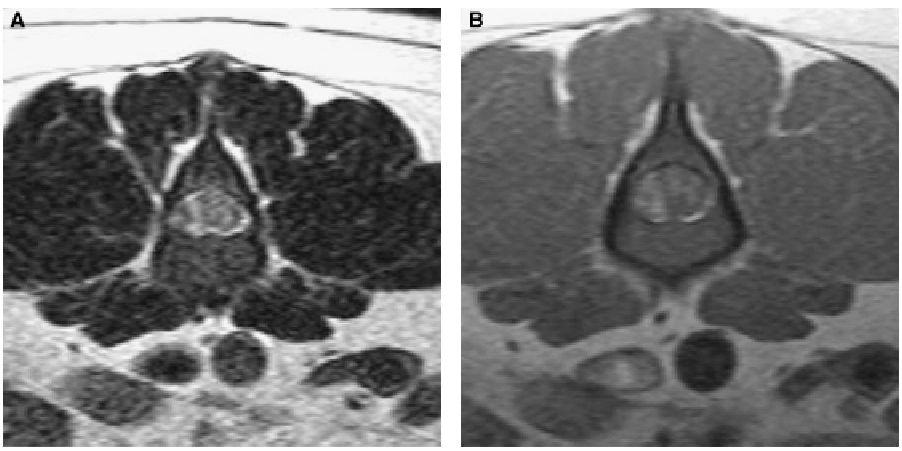

FIG. 5. Transverse images at the L3–L4 intervertebral disc space. (A) T2-weighted image. Note the right heterogeneous lesion displacing the spinal cord. (B) T1-weighted image. The lesion is hyperintense to spinal cord.

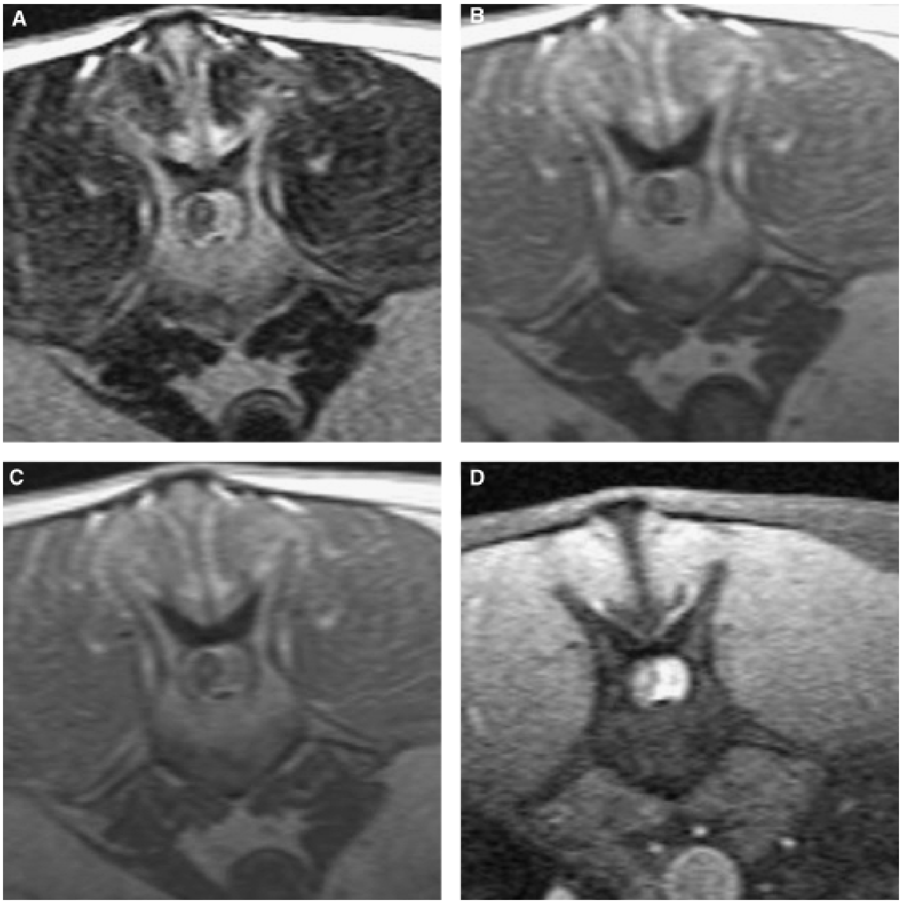

FIG. 6. Transverse images through the body of L2. (A) T2-weighted image. Note a heterogeneous left dorsal lesion displacing the spinal cord. (B) T1-weighted image. Note the slight hyperintensity of the lesion compared with the spinal cord. (C) Postgadolinium-enhanced T1-weighted image. There is no enhancement. (D) Fat-saturated T1-weighted (SPIR) image. The lesion is hyperintense.

Hyperacute onset of clinical signs is commonly seen in dogs with disc extrusion and associated epidural hemorrhage.[3] In our dogs, the clinical onset of signs was not predominantly hyperacute (33%), but acute (50%) according to the usual presentation of thoracolumbar disc extrusions.[16]

Topographically, disc extrusion with epidural involvement was more prevalent from L1–L2 to L4–L5, with the highest frequency at L4–L5. The dogs with disc extrusion but no epidural involvement had most lesions affecting T12–L2. Others have described a similar prevalence of disc extrusions in these intervertebral disc spaces (ranging from 60% to 86%).[8,16,17] This is in contrast to dogs with disc extrusion and epidural hemorrhage of inflammation where 21 of 52 lesions (46%) affected T12–L2. This indicates that epidural hemorrhage or inflammation from disc extrusion is more common in the more caudal aspect of the spine.

TABLE 1. Pre- and Postsurgical Neurologic Grade in 33 Dogs with Disc Herniation and Epidural Hemorrhage or Inflammation and Broken Down by Spinal Cord Appearance

	Presurgical			Postsurgical		
Neurological Grade	Intramedullary T2-Hyperintensity	Normal Spinal Cord	Total	Intramedullary T2-Hyperintensity	Normal Spinal Cord	Total
0	0	0	0	6	4	10
1	0	0	0	2	3	5
2	4	6	10	11	4	15
3	9	4	13	1	0	1
4	5	1	6	0	0	0
5	4	0	4	2	0	2
Mean neurologic grade	3.4	2.5	3.1	1.7	1	1.4

TABLE 2. Pre- and Postsurgical Neurologic Grade in the 50 Control Dogs

Neurologic Grade	Presurgical	30 Days Postsurgical
0	0	13
1	0	0
2	13	34
3	12	0
4	20	0
5	5	3
Mean neurologic grade	3.3	1.6

Dogs with disc extrusion and epidural hemorrhage or inflammation had a higher prevalence of disc migration compared with dogs with disc extrusion but no epidural hemorrhage or inflammation (22% vs. 14%). This suggests that migration of disc material in the vertebral canal may have a role in creating the associated epidural lesion. In humans, disc migration is more common in the lumbar region; however, the thoracic and cervical regions can be involved.[18] The sagittal septum is a ligamentous structure that in humans divides the posterior longitudinal ligament in two halves and is more prominent in the lower lumbar spine. This septum spans the posterior longitudinal ligament and the dorsal surface of the vertebrae and, therefore, disc migration is more likely to occur at this location due to the enlarged space.[18] The presence of this septum can also explain why in most humans the herniated disc material is disposed laterally, whereas a midline position is rare. Authors are not aware of a similar structure in dogs. Another cause (applicable also in animals) than can explain the higher frequency of disc migration in the lumbar region is related to the difference in the ratio of diameters of the spinal cord vs. the vertebral canal. This enlarged space can make disc migration easier.

The extruded disc, migrated or not, can damage the vertebral venous plexus and cause hemorrhage but the actual incidence and significance of this in dogs is unknown.[3,4,8] Epidural hemorrhage is more common in dogs than in humans. In dogs, the different pattern of disc degeneration may predispose to extradural hemorrhage, particularly with high-velocity extrusion. In the few reports of disc-associated epidural hemorrhage in human beings, factors such as violent Valsalva maneuvers with simultaneous lumbar flexion resulting in epidural venous engorgement have been implicated.[19]

The components of the evolving epidural hematoma are likely responsible for the variation in signal intensity seen in MR images.[20] The signal of the hematoma may change over time due to the biodegradation of hemoglobin. The temporal changes in signal intensity of intracerebral hemorrhage are well understood but it is not clear that these same patterns will apply to epidural hemorrhage. In fact we were not able to find a correlation between time to imaging and signal intensity of the lesion.

T1-hyperintensity is a classic feature of hematomas, in association with peripheral enhancement when an acute presentation occurs,[13] but inherent T1-hyperintensity was found in only seven of the 32 dogs (22%) in which T1-weighted images were acquired and was not related to the clinical onset or time to imaging. All these findings suggest that the presence of blood in the epidural space and changes associated with it are not the sole cause of the signal intensity of the epidural lesions presented here.

Besides hemorrhage, disc material in the vertebral canal produces inflammatory changes in the meninges, epidural fat and dorsal longitudinal ligament, and the extruded disc material itself.[21] These inflammatory reactions may be more extensive when disc migration occurs. Peripheral enhancement and a cyst-like appearance of the herniated disc/hematoma can be due to adherent vascularized epidural fat and by the inflammatory and vasogenic properties of the disc.[22] A variable histopathologic appearance of extruded disc material has been described[23] and it is similar to our findings. We hypothesized that the inflammatory changes induced by the extruded disc would be detectable based on contrast enhancement. Nevertheless, the inflammatory changes observed were unrelated to the onset of the disease, time to imaging, and presence and type of contrast enhancement.

In 10 dogs there was no imaging evidence of disc material adjacent to the epidural lesion and the diagnosis of disc extrusion with epidural hemorrhage or inflammation was made on the basis of surgery or postmortem examination. These dogs were clinically similar to the 36 dogs in which disc material was evident on MR imaging near the epidural lesion.

Regarding the outcome of dogs with disc extrusion and epidural hemorrhage or inflammation that were treated surgically and compared with the control group, mean improvement in neurologic status was similar at 30 days. A similar outcome in dogs with epidural hemorrhage and disc extrusion has been reported.[3]

Compression of the spinal cord can result in gliosis and myelomalacia and both cause intramedullary T2-hyperintensity.[24] Therefore, when intramedullary T2-hyperintensity is present the neurologic outcome may be worse[25,26] as was observed in our cases.

In conclusion, although the variable MR imaging appearance in dogs with disc extrusion and epidural hemorrhage or inflammation is likely associated with the age of the hemorrhage and the amount of associated inflammatory changes we were not able to find a temporal dependency of the signal of the epidural lesion. That may suggest that epidural hemorrhage may not follow the same degradation changes as seen in intracerebral hemorrhage. Also, the pattern of contrast enhancement was not related with the histopathologic appearance of the lesions. In some dogs the epidural lesion masked the MR imaging identification of the extruded disc material; this scenario could be confused with other conditions such as an epidural tumor or an intraspinal cyst. Awareness of this variable appearance of disc extrusion when there is epidural hemorrhage or inflammation is important to avoid the incorrect diagnosis and to select a proper surgical approach, avoiding conservative treatment. Outcome after decompressive surgery is excellent in most dogs, especially if deep-pain perception is intact

ACKNOWLEDGMENTS

The authors are greatly indebted to the editor and referees for the meticulous reading of the manuscript and their invaluable comments.

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