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Cervical spondylomyelopathy in Great Danes: A magnetic resonance imaging morphometric study

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ABSTRACT

Morphometric investigations comparing normal and affected animals increase our understanding of spinal diseases in dogs. The aim of this study was to generate morphometric data for osseous-associated cervical spondylomyelopathy (CSM) in Great Danes (GDs). Magnetic resonance imaging (MRI) morphometric features of the cervical vertebral column of GDs with and without clinical signs of CSM were characterized and compared. Thirty client-owned GDs were prospectively enrolled, including 15 clinically normal and 15 CSM-affected GDs. All dogs underwent MRI of the cervical to thoracic vertebral column (C2-C3 through T1-T2). Areas of the cranial and caudal articular processes, and the height, width and areas of the vertebral canal and spinal cord were determined. Middle foraminal heights were measured. Intervertebral disc width was measured before and after traction. Intraobserver and interobserver agreement were calculated. CSM-affected GDs had larger areas of the caudal articular processes from C2-C3 through T1-T2. In CSM-affected GDs, the vertebral canal and spinal cord areas were significantly smaller at C5-C6 and C6-C7, the vertebral canal width was significantly narrower at C6-C7 and C7-T1, and the spinal cord width was significantly narrower at C5-C6 and C6-C7. Middle foraminal height was smaller in CSM-affected GDs from C3-C4 through C7-T1. Neutral intervertebral disc widths were smaller in CSM-affected GDs. It was concluded that the cervical vertebral canal dimensions are significantly different between normal and CSM-affected GDs. Absolute vertebral canal stenosis and severe foraminal stenosis involving the cervical vertebrae distinguish CSM-affected from clinically normal GDs. These findings are relevant to the pathogenesis of osseous-associated CSM and should be taken into consideration when performing imaging studies and planning surgery.

Introduction

Great Danes (GDs) with cervical spondylomyelopathy (CSM) are most frequently affected by the osseous-associated form, which is characterized by vertebral canal stenosis secondary to osseous proliferation of the vertebral arch, articular processes and/or pedicles (Trotter et al., 1976; Olsson et al., 1982; da Costa, 2010). Magnetic resonance imaging (MRI) is the imaging modality of choice for dogs with suspected CSM (Lipsitz et al., 2001; da Costa, 2010; Gutierrez-Quintana and Penderis, 2012).

The morphologic MRI features of GDs with osseous-associated CSM have been described retrospectively (Lipsitz et al., 2001; Gutierrez-Quintana and Penderis, 2012). These studies provided a qualitative description of MRI abnormalities in CSM-affected GDs with clinical signs, but no morphometric information was provided. Morphometric studies comparing anatomic measurements obtained from clinically normal and affected dogs help to establish normal values for healthy animals and increase the understanding of the pathologic changes associated with clinical signs (Herzog et al., 1991; da Costa et al., 2006).

Morphometry of the cervical vertebral column has been reported in asymptomatic human beings, as well as human patients with cervical spondylotic myelopathy, which is a chronic compressive myelopathy similar to canine CSM (Fujiwara et al., 1988; Boden et al., 1990; Sherman et al., 1990; Herzog et al., 1991; Okada et al., 1994; Tierney et al., 2002; Kato et al., 2012). Morphometric MRI studies of the cervical vertebral column have also been reported in Doberman dogs with and without signs of disc-associated CSM (da Costa et al., 2006; De Decker et al., 2012b). However, no equivalent studies are available for giant breed dogs with osseous-associated CSM. Despite some degree of overlap between disc-associated and osseous-associated CSM, the pathologic changes causing spinal cord compression in both forms of the disease are different, as well as the age and breed of the affected dogs.

The aim of this study was to prospectively characterize and compare the morphometric features of the cervical vertebral column of GDs with and without clinical signs of CSM using MRI. We hypothesized that the dimensions of the cervical vertebral canal structures would differ between clinically normal and CSM-affected GDs.

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Materials and methods

Animals

The investigation was conducted in accordance with the guidelines and with approval of the Ohio State University Clinical Research Advisory Committee and the Institutional Animal Care and Use Committee (2011A00000027). Written owner consent was obtained prior to study enrolment.

Two groups of client-owned GDs were prospectively enrolled from April 2011 to October 2012. All dogs were examined by two of the investigators (PMV and RCdC). The first group included 15 GDs that were defined as clinically normal based on a normal neurologic examination and no prior history of neurologic disease. Only GDs 1 year of age or older were eligible for enrolment as normal dogs. The second group included 15 GDs with clinical signs and neurologic examination findings consistent with CSM. The time of onset of clinical signs was recorded.

Magnetic resonance imaging protocol

MRI of the cervical vertebral column was performed in all dogs under general anesthesia with a 3.0 T magnet (Achieva 3.0 Tesla, Philips Healthcare) and a surface coil. Dogs were positioned in dorsal recumbency, with the head and neck in a neutral position. Images were acquired using a turbo spin-echo technique. First, T1- and T2-weighted images (WI) were obtained in the dorsal, sagittal and transverse planes. After acquisition of all image sequences with the cervical area in the neutral position, T2-weighted sagittal images were acquired after applying linear traction by use of a neck harness and weight equivalent to 20% of the dog's body weight.

Repetition time (TR) and time to echo (TE) were set for T1-WI sagittal images (TR 700 ms, TE 8 ms), transverse and dorsal T1-WI (TR 650 ms, TE 8 ms), sagittal T2-WI in neutral and traction positions (TR 5000 ms, TE 110 ms) and transverse and dorsal T2-WI (TR 4000 ms, TE 120 ms). The field of view was 30 cm in the sagittal and dorsal planes, and 20 cm in the transverse plane. Slice thickness was set at 3 mm, with no interslice interval.

Seven intervertebral spaces (C2-C3 to T1-T2) were imaged in each dog and five transverse slices were obtained for each intervertebral space. The transverse slices were aligned parallel to the intervertebral disc and arranged to pass through the center of each intervertebral space, as well as the cranial and caudal end plates of the adjacent vertebral bodies, as described previously (da Costa et al., 2006).

Morphometric analysis of magnetic resonance images

All MRI images were evaluated and measurements obtained by two investigators (PMV and CGDL). Measurements were made using a software program for medical imaging analysis (ClearCanvas Workstation).

Transverse T1-WI at the center of the intervertebral space were used to measure the area of the caudal articular processes from the cranial vertebral body (dorsomedial position) and the area of the cranial articular processes from the caudal vertebral body (ventrolateral position) (Fig. 1). On transverse T2-WI, vertebral canal and spinal cord height, width and area were measured at three different levels for each intervertebral space, including the caudal aspect of the cranial vertebral body, the center of the intervertebral space and the cranial aspect of the caudal vertebral body (Fig. 2). The right and left middle foraminal heights were measured at the center of the intervertebral space also using transverse T2-WI (Fig. 2).

On mid-sagittal T2-WI, the spinal cord and vertebral canal height were measured at the caudal aspect of the cranial vertebral body, the center of the intervertebral space and the cranial aspect of the caudal vertebral body for each given space, as described previously (da Costa et al., 2006). Before and after application of traction, intervertebral disc width (IVDw) was measured on mid-sagittal T2-WI. Mid-sagittal T1-WI images were used to measure vertebral body length and height.

Intraobserver agreement was tested by repeating all the measurements three times in four randomly selected dogs (two clinically normal and two CSM-affected) at least 1 week apart by one observer (PMV). To assess interobserver agreement, the same measurements were performed on all 30 dogs by a second observer (CGDL), who was unaware of the clinical status of the dogs.

Statistical analysis

All measurements were compared for each intervertebral space between groups with a random-effects linear regression model using commercially available software (Stata version 12.1). Adjustments were made for age, sex, height and weight. Results were adjusted for multiple comparisons using the Sidak method to preserve the type I error at 0.05. Significance was set at a P value <0.05. Intraobserver agreement was estimated using the intraclass correlation (rho, ρ) among the three replicates of measurements that were obtained for four dogs using a variance component model based on a random effect linear regression analysis (Searle et al., 1992). Interobserver agreement was also evaluated using the intraclass correlation (ρ) between the two sets of measurements obtained by the two observers. If ρ is close to 1.0, the agreement is excellent, whereas a value of ρ close to 0 indicates lack of agreement.

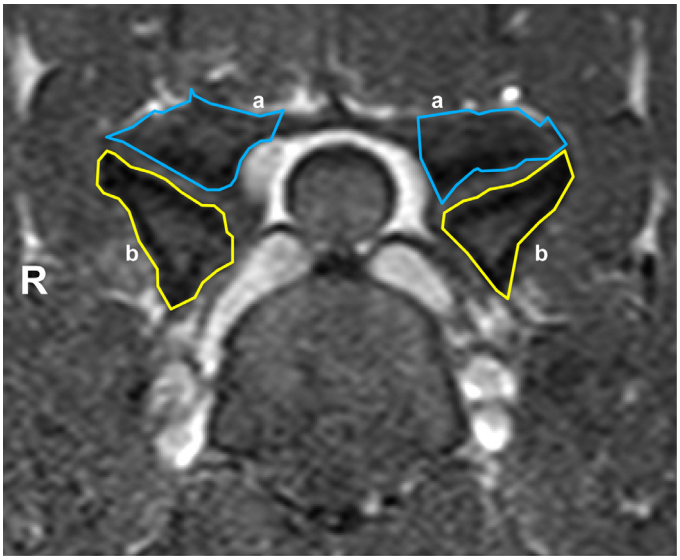

Fig. 1. Transverse T1-weighted image at the center of the C6-C7 intervertebral space of a clinically normal Great Dane, demonstrating the measurements obtained for the area of the articular processes. The caudal articular process of the cranial vertebral body is outlined in blue (a) and the cranial articular process of the caudal vertebral body is outlined in yellow (b). R, right side.

Results

Clinical data

The clinically normal GDs included seven females (six neutered, one intact) and eight males (seven neutered, one intact). The median age at the time of study enrolment was 2.3 years (range 1–6.4 years) and the median weight was 52 kg (range 40.5–73 kg). The group of CSM-affected GDs included two neutered females, 12 neutered males and one intact male. The median age at the time of enrolment was 4 years (range 1–7.2 years) and the median weight was 56.8 kg (range 42–79.3 kg). The median age at reported onset of clinical signs of CSM was 1.7 years (range 0.4–4.2 years) and

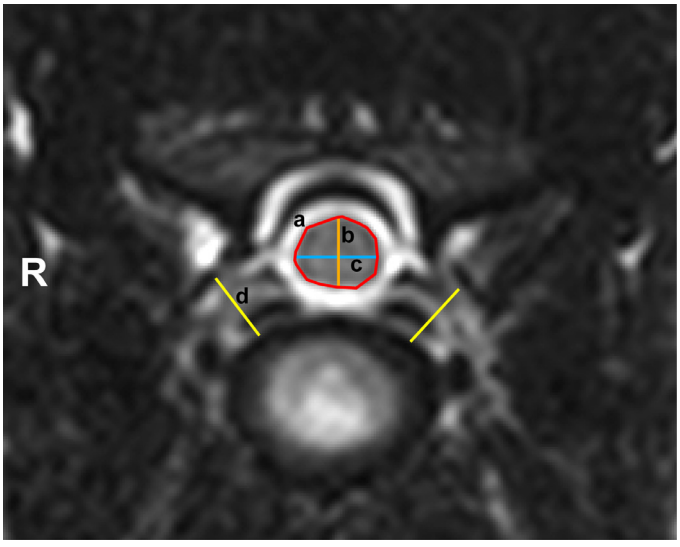

Fig. 2. Transverse T2-weighted image at the center of the C5-C6 intervertebral space of a clinically normal Great Dane, depicting the location of the following measurements: (a) spinal cord area (red), (b) spinal cord height (orange), (c) spinal cord width (blue) and (d) right and left middle foraminal heights (yellow). R, right side.