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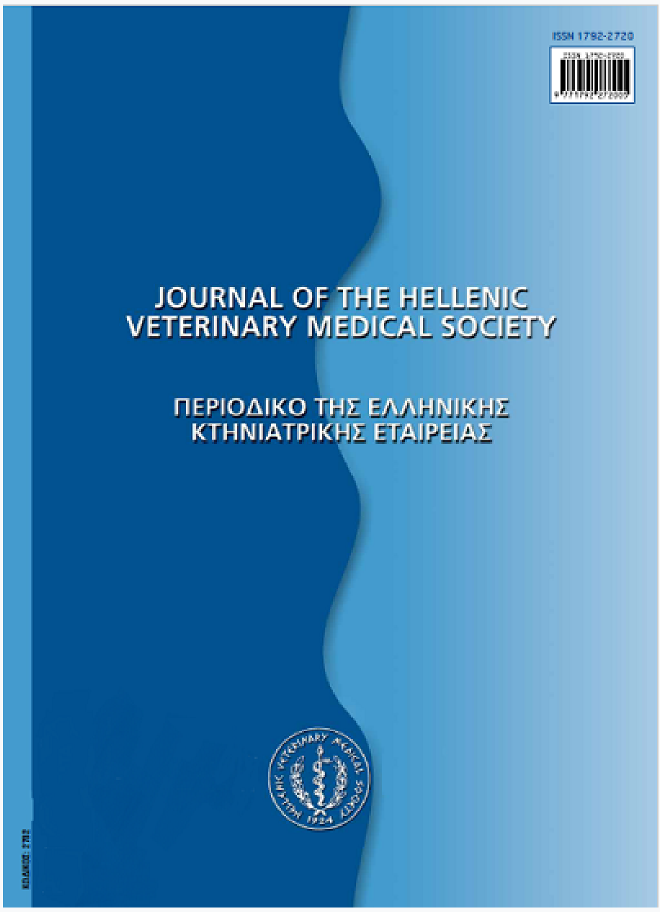

Cervical spondylomyelopathy in dogs

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Review article
Ανασκόπηση

Cervical spondylomyelopathy in dogs

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Οπίσθια αυχενική σπονδυλομυελοπάθεια στο σκύλο

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ABSTRACT. Cervical spondylomyelopathy (CSM) is the most common disease of the cervical spine in large and giant breed dogs. Its exact aetiology is not known and the relevant pathophysiology is not clear; two clinical entities are currently recognised: disc-associated and osseous-associated spinal cord compression. History and clinical signs are indicative of cervical spondylomyelopathy, although its neurologic manifestation can vary from cervical pain only to tetraparesis and respiratory compromise. Imaging of the spine is fundamental for definitive diagnosis and includes radiography, myelography, computed tomography and magnetic resonance imaging. It is also the cornerstone of surgical planning. This is usually based on the subjective concept of dynamic or static compressive lesions. Among the advanced imaging techniques, magnetic resonance imaging is superior to myelography for diagnosis of cervical spondylomyelopathy, although, at present, these techniques can be considered complementary. Furthermore, attention is drawn to the false positive interpretations of magnetic resonance findings, which are related to clinically irrelevant spinal cord compression. Hence, the degree of agreement between neuroanatomic localization and neuroimaging is of the outmost importance. Conservative treatment consists of strict restriction of the animal and the use of steroid or non-steroid anti-inflammatory drugs. Objective of surgical treatment is to decompress the spinal cord. However, the decision-making process of surgical treatment is more complicated, because a large number of different surgical techniques have been proposed. Adjacent segment disease is a controversial complication of the surgical treatment of disk-associated cervical spondylomyelopathy and recently introduced motion-preserving techniques are targeted on reducing its occurrence. Significant prognostic information for focal parenchymal damage may derive from magnetic resonance imaging studies, but this remains to be further clarified.

Keywords: cervical spondylomyelopathy, dog, wobbler.

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ΠΕΡΙΛΗΨΗ. Η οπίσθια αυχενική σπονδυλομυελοπάθεια του σκύλου αποτελεί την πιο συχνή πάθηση της αυχενικής μοίρας της σπονδυλικής στήλης σε μεγαλόσωμες και γιγαντόσωμες φυλές σκύλων. Η αιτιολογία της οπίσθιας αυχενικής σπονδυλομυελοπάθειας είναι άγνωστη και οι υποκείμενοι παθοφυσιολογικοί μηχανισμοί μη πλήρως κατανοητοί. Κεντρικό ρόλο στην παθοφυσιολογία της νόσου φαίνεται ότι κατέχουν ο βαθμός συμπίεσης του νωτιαίου μυελού και η ισχαιμία/υποξία που προκαλείται. Υπάρχουν δύο κλινικές οντότητες στην οπίσθια αυχενική σπονδυλομυελοπάθεια: συμπίεση του νωτιαίου μυελού που συνδέεται με εκφύλιση και προβολή του μεσοσπονδυλίου δίσκου τύπου ΙΙ και συμπίεση που συνδέεται με τη δημιουργία νέου οστού. Το ιστορικό και η κλινική εικόνα είναι ενδεικτικά της νόσου, αν και τα νευρολογικά συμπτώματα ποικίλουν από αυχενικό πόνο έως τετραπληγία και έκπτωση της αναπνευστικής λειτουργίας. Η απεικονιστική διερεύνηση της αυχενικής μοίρας της σπονδυλικής στήλης είναι απαραίτητη για τη διάγνωση της οπίσθιας αυχενικής σπονδυλομυελοπάθειας, περιλαμβάνει δε τα απλά ακτινογραφήματα, τη μυελογραφία, την αξονική και τη μαγνητική τομογραφία. Επιπλέον, είναι απαραίτητη για το σχεδιασμό της χειρουργικής θεραπείας. Η τελευταία βασίζεται συνήθως στον υποκειμενικό χαρακτηρισμό των συμπιεστικών αλλοιώσεων ως δυναμικών ή στατικών. Η μαγνητική τομογραφία υπερέχει έναντι της μυελογραφίας, αλλά προς το παρόν προτείνεται οι απεικονιστικές αυτές τεχνικές να εφαρμόζονται συμπληρωματικά. Επιπρόσθετα, τονίζεται ιδιαίτερα η αναγκαιότητα ύπαρξης συμφωνίας μεταξύ των κλινικών συμπτωμάτων και των απεικονιστικών ευρημάτων της μαγνητικής τομογραφίας, προς αποφυγή ψευδώς θετικών ευρημάτων. Πριν από την ανάληψη θεραπευτικής προσπάθειας, κρίνεται σκόπιμη η διερεύνηση του ζώου για συνυπάρχουσες παθολογικές καταστάσεις, οι οποίες μπορεί να επηρεάσουν την έκβαση του περιστατικού σε βάθος χρόνου. Η οπίσθια αυχενική σπονδυλομυελοπάθεια θεωρείται χειρουργικό νόσημα, ωστόσο η συντηρητική θεραπεία, που συνίσταται στον αυστηρό περιορισμό της κινητικής δραστηριότητας και στη χρήση στεροειδών ή μη στεροειδών αντιφλεγμονωδών φαρμάκων, μπορεί να υιοθετηθεί σε επιλεγμένα περιστατικά. Η χειρουργική θεραπεία αποσκοπεί στην αποσυμπίεση του νωτιαίου μυελού. Οι συμπιεστικές αλλοιώσεις στους γειτονικούς σπονδύλους αναφέρονται ως επιπλοκή της χειρουργικής θεραπείας, χωρίς όμως η αιτιολογία τους να είναι σαφώς προσδιορισμένη. Πρόσφατα, εφαρμόστηκαν τεχνικές αντικατάστασης του μεσοσπονδύλιου δίσκου με τεχνητό, σε περιστατικά με συμπίεση λόγω εκφυλιστικής δισκοπάθειας τύπου ΙΙ και τα πρώτα αποτελέσματα είναι ενθαρρυντικά. Τέλος, υπάρχουν σύγχρονες ενδείξεις ότι η μαγνητική τομογραφία μπορεί να χρησιμοποιηθεί για καθορισμό της πρόγνωσης σε περιστατικά μυελοπάθειας.

Λέξεις ευρετηρίασης: οπίσθια αυχενική σπονδυλομυελοπάθεια, σκύλος.

INTRODUCTION

Cervical spondylomyelopathy, widely known as ‘wobbler syndrome’, is probably the most common and controversial disease of the cervical spine in large and giant breed dogs (Chen et al., 2009; da Costa, 2010). Over the years, since the late 1960’s, 14 different names have been attributed to this disease and 21 different surgical techniques have been proposed for its treatment. The lack of consensus for the management of dogs with cervical spondylomyelopathy reflects the insufficient knowledge on its aetiology, the inherent difficulties in the diagnostic process and the difficulties in choice between medical or surgical treatment (da Costa et al., 2008). Absence of large, well-controlled clinical studies with adequate follow-up times and similar protocols poses difficulties in comparison of results reported. Lately, there is a concern about the clinical importance of the findings of computed tomography and magnetic resonance imaging in cervical spondylomyelopathy cases, showing that the experience in interpreting images of those modalities has to be increased (da Costa et al., 2006a). Objective of this review article is to inform clinical veterinarians about the current trends in diagnosis and the decision making process regarding dogs affected by this multifactorial neurological syndrome.

AETIOLOGY AND PATHOPHYSIOLOGY

The exact etiology of cervical spondylomyelopathy is still unknown, although genetic, congenital and nutritional factors along with the body conformation have been implicated (da Costa, 2010). However, it is well known that many factors, such as the degree of disc degeneration, disc protrusion and associated spinal cord compression, foramina stenosis, hypertrophied ligaments, vertebral body abnormalities, osteoarthritic changes, shape of the articular facets, proliferation of facet joint capsule, extradural synovial cyst formation, vertebral canal stenosis and ischaemic insult caused by those disorders, could participate in the pathophysiology of cervical spondylomyelopathy.

There are two well recognized clinical entities of cervical spondylomyelopathy: (a) disc-associated compression (DAC) which is the consequence of type II disc degeneration and protrusion and (b) osseous-associated compressions which are the consequence of absolute vertebral canal stenosis while the disc appears normal. The final result in each entity is compression of sub-arachnoid space, cord parenchyma and nerve roots, in various combinations and degrees of severity. Compression leads to decreased blood flow at a microvascular level, which contributes to increasing severity of clinical signs (Seim and Withrow, 1982).

Dogs with cervical disc-associated compression (Dobermans included) now far outnumber those admitted with other forms of spondylomyelopathy; the process is encountered mainly in middle aged large breed dogs (McKee and Sharp, 2003; da Costa et al., 2008; De Decker et al., 2009a). In those cases, there is gradual ventral compression of the spinal cord caused by the dorsal bulging of the *annulus fibrosus* and dorsal longitudinal ligament. This is sometimes complicated with a dorsolateral compression caused by the hypertrophied *ligamentum flavum*. In Doberman breed dogs, it has been reported that intervertebral disc degeneration and cord compression demonstrated in magnetic resonance imaging is not always associated with clinical signs (da Costa 2006a; De Deckeret al., 2010). This is in accord with studies performed in Bernese Mountain dogs, which suggests that compressive lesions detected in imaging may not be the sole mechanism in the pathogenesis of disc associated cervical spondylomyelopathy (Eagleson et al., 2009; De Decker et al., 2010). It is also reported that intervertebral disc degeneration and disc-associated compression of the spinal cord demonstrated in imaging in clinically normal Dobermans and Foxhounds were significantly associated with the older age category (>5 years), implying that these lesions are part of the aging process in dogs. Furthermore, it is suggested that, as long the cross sectional area of the spinal cord is preserved, despite obvious deformation of its shape in longitudinal series at the same level, clinical signs may not occur, due to compensation mechanism of spinal cord in relatively wider vertebral canal (De Decker et al., 2012a).

Dobermans may be predisposed to cervical disc-associated compression due to congenital or acquired minor vertebral canal stenosis. Acquired stenosis is usually the result of a relative redundancy of hypertrophic ligamentus structures. Minor canal stenosis does not cause neural compression, but lowers the threshold at which cumulative effects of the various encroaching structures of the spinal cord can cause compression, increasing the risk of the animal to developing myelopathy (da Costa et al., 2006a).

A compressive lesion is called dynamic when the degree of compression changes in the stressed position of traction, flexion or extension (De Decker et al., 2009a). This concept has been used extensively in the surgical planning, but there is no standardized method for assessment of those lesions. Moreover, this characterisation is subjective and lesions may appear static in myelography and simultaneously dynamic in magnetic resonance imaging or vice-versa (da Costa et al., 2006b).

The most common site of spinal cord compression is the region of the intervertebral disc space at C5-C6 and/or C6-C7 (da Costa et al., 2008; Trotter, 2009), although other sites can also be affected. In a retrospective study, it has been noticed that the most common site of disc extrusion (type II) in large breed dogs was the C6-C7 intervertebral disc space (Cherrone et al., 2004). A significant percentage of dogs (13-20%) are presented with both C5-C6 and C6-C7 lesions at the time of initial diagnosis (De Decker et al., 2009a; Trotter, 2009; De Decker et al.,2010). The more caudal the cervical site affected, the more severe the compression of the spinal cord appeared to be (De Decker et al., 2010). This is possibly due to concavity of the articular facets in the caudal cervical region, which facilitates axial rotational motion, leading to intervertebral disc degeneration and spinal cord compression. In a recent biomechanic study in cadavers, it has been found that motion patterns differ significantly between cranial and caudal cervical spine, with greater mobility in the caudal cervical spine (Johnson et al., 2011).

Osseous-associated compressions are almost exclusively seen in giant breed dogs younger than 2 years of age. In a study which included 224 affected dogs, 42 Great Danes younger than 2 years participated therein (Lewis, 1989). Affected dogs exhibit absolute vertebral canal stenosis, which is the result of malformed vertebrae and osteoarthritic changes of the articular facets (Sharp et al., 1992). The latter may be responsible for extradural synovial cysts formation, which furthermore compress the spinal cord (Levitski et al., 1999). The most common sites of osseous associated spinal cord compression are the areas of intervertebral disc space at C6-C7, C5-C6 and/or C4-C5 (Levitski et al., 1999), although other sites may also be affected (da Costa et al., 2011b).

DIAGNOSIS

History findings and clinical signs

Cervical spondylomyelopathy affects mainly dogs of large or giant breeds. Middle-aged Doberman breed animals are over-represented in cohorts of affected dogs, but other large breed dogs, e.g., Rottweiler, Dalmatian or Great Dane breeds, can also be frequently affected.

The most common presentation in dogs affected by disc-associated compression may be a slowly progressive pelvic limb ataxia and paresis (Sharp and Wheeler, 2005; De Decker et al., 2009a) or neck pain (da Costa et al., 2008). Cervical hyperaesthesia may be manifested as low carriage of the head or screaming. Neurologic dysfunction, which may range from neck pain to tetraplegia, and respiratory compromise may be present (De Risio et al., 2002). Progress of clinical signs is usually long, but, sometimes, minor traumatic episodes can exacerbate subclinical problems and lead to acute manifestation of the disease.

At clinical examination, findings may often be normal. A broad-based hind limb stance can be noticed and elbow abduction with internal rotation of the digits (toe in posture) is often seen. The thoracic limb gait can appear spastic or has a pseudo-hypermetric appearance. Some degree of shoulder muscle atrophy (e.g., *supraspinatus*) that indicates chronicity could be evident. Level of consciousness is expected to be normal and neurologic examination can reveal proprioceptive deficits and upper motor neuron signs (e.g., increased muscle tone and normal to increased spinal reflexes) in all four limbs. However, withdrawal reflex in the thoracic limbs may appear depressed, due to the increased muscle tone (upper motor nerve effect to the thoracic limbs) or due to the involvement of musculocutaneous nerves from C6-C8 spinal cord segments. Usually the rear limbs are affected first, followed by various degrees of involvement of the thoracic limbs. It is interesting that in cervical spondylomyelopathy, the grey matter is often spared (Parent, 2010), leading to upper motor signs in all four limbs without lower motor signs in the thoracic limbs, even if the lesion is at the level of cervical enlargement (C6-T2).

Interpretation of findings of neurological examination may be misleading, especially when the offending lesion is at the level of C5-C6 intervertebral disc space. In such a case, the C6 spinal cord segment is spared, which implies that the upper motor neurons that control the radial nerve (those neurons originate mainly from C8 and T1 segment, more caudally than the other nerves of the brachial plexus) are more affected than those controlling the flexion of the front limb. Consequently, the front limb is thrown forward in extension in the protracted phase of the gait. This extension may be erroneously attributed to a lesion at C1-C5 spinal cord segments, when in fact derives from the release over the inhibitory effect on the antigravity extensor muscles innervated by the radial nerve (Parent, 2010).

Imaging of the vertebral column

Radiography

Plain radiographs in lateral and dorsoventral projections (usually under general anaesthesia) can contribute mainly to rule out some possible diagnoses, e.g., trauma, osseous neoplasia, discospondylitis, vertebral osteomyelitis. Apparent vertebral tipping (tilting of the craniodorsal edge in a dorsal direction), malformation of the shape of the vertebrae (ranging from a flattened cranioventral epiphysis to triangular shaped vertebra), stenotic vertebral canal and spondylosis deformans are changes associated with bone. Loss of the joint space between facets and new bone formation in those joints are especially common in Great Danes (Sharp et al., 1992). Other associated findings, but still not definitive for diagnosis, include narrowing of the disc space and mineralisation of the disc.

Myelography

Myelography can identify the site of compressions, unlike plain X-rays (Lewis, 1991), and has been the technique of choice for initial evaluation of dogs with suspicion of caudal cervical spondylomyelopathy (Sharp et al., 1995). A potential complication is post-myelographic seizures with an incidence risk of 10% in dogs weighing over 20 kg (da Costa et al., 2011a). Precautions to decrease incidence risk of the adverse reaction are use of water-soluble contrast media (e.g., iohexol), slow injection in the subarachnoid space, warm-up of the contrast medium to room temperature prior to injection and upward lifting of the animal's head after the end of procedure (Barone et al., 2002). Ventral extradural compression is usually related to the intervertebral disc protrusion (Sharp et al., 1992). In such cases, ventral contrast column may be elevated, arrested or manifest 'splitting', when an asymmetrical compression exists. Multiple compressions are not uncommon. Dorsal extradural compressions are usually caused by *ligamentum flavum* (interarcuate ligament) or lesions associated with the synovial joints. Compression caused by articular facets may be more obvious in ventrodorsal projections, contrary to the compression caused by *ligamentum flavum*, which is apparent on lateral projections (Sharp et al., 1992). Hourglass compression results from degenerative joint disease or malformation of the articular processes and associated hypertrophy of the *ligamentum flavum* and annulus fibrosus (De Risio et al., 2002).

Compressive lesions that do not change in stressed positions of traction, flexion or extension are termed 'static', whilst those that change are termed 'dynamic'. Dynamic lesions can be further subdivided by whether or not they respond to traction (traction-responsive or traction-unresponsive) and by whether or not they change during flexion and extension (positional).The practice of applying traction to the spinal column by stretching the head with a weight tightened to the maxilla has been used extensively, in order to differentiate a static from a dynamic lesion ('stressed myelography'). This differentiation is considered fundamental for surgical planning, as traction-responsive lesions may benefit from a distraction-stabilization surgery, whereas traction-unresponsive lesions are most likely to respond to ventral slot or dorsal decompression (Sharp and Wheeler, 2005). Unfortunately, there are no clear criteria to determine whether a lesion is static or dynamic and it has never been established how much traction should be used and how it should be performed. It is reported as unecessary to exert traction forces over 25% of the patient`s weight (da Costa et al., 2006b), although a 16 kg water-filled plastic container has been used as a weight in a 31 kg Doberman, in order to reduce the dynamic lesion (Penderis et al.,2004). Stressed views of extension and flexion of the neck have the risk for neurological deterioration of the animal, due to exacerbated compression and further injury to the spinal cord (Sharp et al., 1992).Thus, their use is limited to cases where traction does not provide sufficient information, keeping in mind that the neck should be positioned in mild extension for as short a time as possible (Sharp and Wheeler, 2005).

Advanced imaging techniques (computed tomography, computed tomography-myelography, magnetic resonance imaging)

Advanced imaging techniques are helpful in the decision-making process regarding surgical planning, especially when more than one compressive lesion is revealed during myelography. Furthermore, they could provide information on prognosis of the problem, which in turn may have an impact on the choice of therapeutic method. In humans affected by cervical spondylomyelopathy, it has been reported that specific alterations in the intra-medullary spinal cord signal intensity observed in magnetic resonance imaging results indicate irreversible damage and a poor prognosis (Mastronardi, 2007). Similar results in dogs affected by cervical spondylomyelopathy would render surgical intervention not a rational option. Both computed tomography and magnetic resonance imaging allow transverse imaging of the spinal cord, which provides the most accurate visualization of compression in a 360° orientation surrounding the spinal cord (Bagley et al., 2009), although significant disadvantages include increased and difficulties in availability.

Considerable variation in interpretation of imaging results, depending on observers and between the various imaging techniques has been reported (De Decker et al., 2011a). These authors also indicated that the advanced imaging techniques should be used complementary to each other.

Computed Tomography is better suited for imaging bones, thus it appears to be more valuable in evaluating dogs with severe osseous changes causing marked vertebral canal stenosis. It is of smaller diagnostic value than cervical myelography (Sharp et al., 1995) and non-contrast computed tomography cannot be used as the sole diagnostic test for the diagnosis of cervical spondylomyelopathy (da Costa and Samii, 2010). Compared to magnetic resonance imaging, computed tomography is a faster imaging technique with reduced requirements in anaesthetic procedures, as well as of smaller cost to the animal's owner. Computed tomography may also be used intra- or post-operatively, in order to reveal inadvertent spinal canal violation by metal implants and is considered superior to radiographic assessment. In a recent study with cadavers, the sensitivity of the technique in detecting complete canal penetration by Steinmann pins has been found to reach 100% (Hettlich et al., 2010).

Computed tomography-myelography can be performed after conventional myelography, in order to rule out other causes of myelopathy and to define precisely the region of interest (Sharp et al., 1992, 1995). Abnormalities observed in computed tomography-myelography include compression of the spinal cord from extradural mass(es), sub-arachnoid space attenuation and spinal cord atrophy. Spinal cord atrophy in dogs has been found to be identical to that disorder (Sharp et al., 1992), although its prognostic significance in dogs is unknown. In a study performed in Doberman Pinchers, computed tomography-myelography compared with conventional myelography provided increased information on the exact location and degree of compression, as myelography failed to distinguish spinal cord compression from spinal cord atrophy (Sharp et al., 1995). In the same study and according to a proposed classification scheme, central cord deformity was the most common computed tomography-myelographic appearance in the examined dogs.

Magnetic Resonance Imaging is considered to be superior to other techniques in evaluating soft tissue structures. The variables that can be assessed by means of this technique include the degree of disc degeneration, disc-associated compression, vertebral body abnormalities, new bone formation, the degree of foramina stenosis and intra-parenchymal signal changes. Contrary to myelography and computed tomography-myelography, magnetic resonance imaging is non-invasive and allows the detection of signal changes in the spinal cord and, thus, assessment of cord parenchyma (da Costa et al., 2006a). In a study on 18 Dobermans with clinical signs suggestive of cervical spondylomyelopathy, da Costa et al. (2006b) found that magnetic resonance imaging appeared to have been more accurate in predicting site, severity and nature of the spinal cord compression compared to cervical myelography. Moreover, it has recently been shown that presence of alterations in intra-spinal signal intensity can be considered a reliable indicator of clinically relevant spinal cord compression, at least in disc-associated compression (De Decker et al., 2011b), even though it has been shown that changes in intra-spinal signal intensity had the lowest interobserver agreement (De Deckeret al.,2011b). Nevertheless, caution must be exercised when attributing clinical signs to structural abnormalities seen on magnetic resonance imaging, since relevant abnormalities have also be seen in normal dogs, underlying the possibility for erroneous positive clinical interpretations (da Costa et al., 2006a; De Decker et al., 2010). So, confidence that an abnormality observed in magnetic resonance imaging is responsible for the clinical signs depends primarily on the degree of correspondence between the site of the lesion and the neuroanatomical localization (Viteet al., 2011). In medicine, overinterpretation of abnormal imaging findings is termed 'VOMIT', which stands for 'victims of modern imaging technology' and is a constant source of anxiety for patients and doctors, along with the wealth of medical information gathered on the internet by the patients (Hayward, 2003).These data may indicate that increased experience in interpreting magnetic resonance imaging images is necessary, in order to distinguish between clinically relevant and irrelevant findings. Prognostic significance of magnetic resonance imaging findings in cases of cervical spondylomyelopathy is still unclear in dogs, but the correlation of spinal cord signal changes on magnetic resonance imaging and histopathology has been well described in affected humans (da Costa, 2010). Furthermore, there is growing evidence that magnetic resonance imaging can provide prognostic information in canine spinal patients (Robertson et al., 2011). Consequently, further studies are necessary for correlation of spinal cord abnormalities observed on magnetic resonance imaging with the clinical signs and ultimately with the functional integrity of the spinal cord and the consequent prognosis. Assessment of motor evoked potentials latency may be used in order to provide a sensitive assessment of spinal cord function (da Costa et al., 2006c), but their use in clinical setting is often difficult because of the limited availability of the appropriate equipment. Use of traction magnetic resonance imaging, in order to evaluate dynamic lesions has also been reported (Penderis et al., 2004), although its significance is questionable if the cement distraction- stabilization technique is to be used, as this technique is appropriate for nearly all types of lesions (dorsal, traction non-responsive, positional and traction-responsive) (Sharp and Wheeler, 2005). Finally, another important finding in magnetic resonance imaging is the assessment of degree of the foramina stenosis, which, apart from neck pain or hyperesthesia, may also cause local neuroischaemia (da Costa et al., 2006a).

DIFFERENTIAL DIAGNOSIS

A large number of diseases, including trauma, intervertebral disc disease type I, discospondylitis, meningitis, spinal neoplasia and spinal arachnoid cysts or pseudocysts, should be considered in large and giant breed dogs in cases with neck pain, proprioceptive ataxia and paraparesis or tetraparesis. It is important to differentiate orthopaedic from neurologic disorders. Orthopaedic disorders occur frequently in geriatric patients, often co-existing with neurologic diseases; however, they would never cause proprioceptive ataxia or increased spinal reflexes. Laboratory tests (haematological and blood biochemical examination, urine examination) and additional ancillary diagnostics tests are useful to rule out the various possible diagnoses and commonly co-existing diseases. Cerebrospinal fluid testing is useful for differentiation of cervical spondylomyelopathy from inflammatory diseases, a cardiac ultrasound can be employed to detect dilated cardiomyopathy and, finally, screening for hypothyroidism should be considered.

TREATMENT

Conservative (non-surgical) treatment

Although surgery has been recommended as the method of choice for treatment of cervical spondylomyelopathy, non-surgical treatment can be also a viable option in dogs presented with mild symptoms, in dogs considered to be at risk for administration of anaesthesia or when financial constraints of the owner do not allow the pursuit of more sophisticated methods of treatment. In a retrospective study of 104 patients, there was no statistically significant difference in survival time between dogs treated surgically or not; moreover, no significant differences were recorded in owner-reported improvement of the animal's condition and in score for quality of life (da Costa et al., 2008). A time period of 6 to 12 months was considered critical to evaluate the results of conservative treatment, which indicates the significance of following up animals for a long period (De Decker et al., 2009b). In accord with that, new compressive lesions or changes in intra-spinal signal intensity were not seen in Dobermans treated conservatively, which may indicate that progression of clinical signs and abnormalities observed during magnetic resonance imaging is slow in this breed in cases of conservative treatment (da Costa and Parent, 2007).

Conservative treatment consists of strict confinement of the animal with concurrent use of steroids. Anti-inflammatory dosages of prednisolone are often used (0.5-1 mg kg^{-1} every 12-24 h), progressively tapering the dose over a period of 2 to 3 weeks. Despite the potential benefits associated with corticosteroid treatment, long-term use of these drugs is associated with various adverse reactions, including gastrointestinal ulceration, risk for infection, diabetes mellitus and iatrogenic hyperadrenocorticism. In cases with neck pain only, non-steroid anti-inflammatory drugs can be used instead. The response to conservative management can be used to indirectly assess the degree of reversible spinal cord damage (De Decker et al., 2012b). The concurrent treatment of diseases unrelated to disc-associated compression, e.g., hypothyroidism in geriatric patients, is useful, as it will improve strength and energy of the animal.

Surgical treatment

Objective of surgical treatment is to decompress the spinal cord. Pre-surgical evaluation of buccal mucosal bleeding time (BMBT) is essential in breeds with a known predilection to von Willebrand disease. However, on the grounds that blood products and desmopressin are available, abnormal buccal mucosal bleeding time values (>4 min) are not considered an absolute contra-indication to surgery even in such breeds.

The various techniques available for surgical treatment are usually based on the concept of dynamic or static lesions. Dynamic traction-responsive lesions (e.g., protruded dorsal annulus, hypertrophied dorsal longitudinal ligament and *ligamentum flavum* or proliferated joint capsules) are expected to benefit from distraction stabilization techniques (Rusbridge et al., 1998) and static lesions (e.g., extruded disc material, malformed facets, deformed vertebral arches) from direct decompression techniques (ventral slot or dorsal laminectomy or hemi-laminectomy) (Trotter, 2009). Important information is considered to be the direction of the compression (dorsal, ventral, lateral), the source of compression (disc, osseous) and whether a single or multiple compressive lesions are present. In cases of disc-associated compression causing two sites of spinal compression, there is controversy on the number of lesions that should be addressed (one or both), because the decision concerning the clinically relevant compression might be difficult (De Deckeret al., 2010) and the incidence of complications is increased when the appropriate surgical procedure is performed in two adjacent intervertebral spaces (Platt and da Costa, 2012). In cases of multiple osseous-associated compressions, all lesions should be considered. Although there is no established way to prevent adjacent segment disease, it would seem reasonable to perform some sort of low risk non-invasive procedure on other high incidence disc space, immediately adjacent to the affected, either by cement plug or by forage and grafting (Sharp and Wheeler, 2005; Shamir et al., 2008; Trotter, 2009). Another factor that may influence the choice of surgical technique is the position of the lesion in the cervical spine, as caudal lesions (e.g., C6-C7) are less prone to surgical access and purchase of implants (Platt and da Costa, 2012). Generally, most of the techniques have a success rate of approximately 70% to 80% (Jeffery and McKee, 2001). Accurate symmetrical positioning of the animal in dorsal recumbency is critical to avoid rotation of the spine along the longitudinal axis during the procedure, especially when bicortical implants are to be used (Corlazzoni, 2008).

Ventral slot technique is usually performed in combination with discectomy and it should not exceed one-third of the vertebras length and width (Sharp and Wheeler, 2005). Ventral slot performed at the caudal aspect of the cervical spine could result in subluxation of the associated vertebras and impingement of the spinal cord (Lemarie et al., 2000), thus it should be combined with traction stabilization techniques. Despite the main indication for ventral slot being static lesions, the approach can be considered for any ventral compression, since there is no evidence that it is contra-indicated in dynamic lesions (Jeffery et al., 2001; Platt et al., 2012). Execution of a partial slot instead of a complete shot is also acceptable and a modified technique (inverted cone) has also been described (Goring et al., 1991). The procedure is sometimes completed by inserting bone graft obtained from the humerus into the slot to enhance fusion. Compared to distraction stabilization, ventral slot is much more time consuming, as it is a technically demanding technique. It is unclear if the defect generated leads to instability, as suggested by *in vitro* studies, because it is difficult to assess the compensative mechanisms in live animals (e.g., muscle contraction) (Lemarie et al., 2000; Agnello et al., 2010) or the expected secondary fibrosis at the treated site (Adamo et al., 2007).

Distraction-stabilization techniques are usually used in disc-associated compression. They incorporate the implantation of metal implants with or without polymethylmethacrylate, in combination with discectomy and partial or complete ventral slots. Inter-body polymethylmethacrylate can be used as a plug without metal implants and this technique is probably the only one that can be used independently of the number, location or nature of lesion(s) (Sharp and Wheeler, 2005). A major advantage of the technique compared to ventral slot is that it permits immediate enlargement of the intervertebral foramina that alleviates nerve root impingement and pain (McKee et al., 1999) and eliminates compression on the radicular vasculature. Some authors advocate use of bone grafts in various shapes, orientations and types or allografts with or without the concomitant use of intervertebral fusion cages (Steffen et al., 2011; De Decker et al., 2011c). Objective of these techniques is to stabilize the affected intervertebral space through vertebral fusion without long term reliance on implants (Queen et al., 1998; Bergman et al., 2008). This is based on the fact that intervertebral spaces can fuse after ventral decompression, even without grafting (Trotter, 2009). A major complication of using pins or screws is the inadvertent invasion to the spinal cord or the laceration of vertebral artery at the transverse foramina. Angle of insertion of the implants ranges from 30 to 35 ^{o}; however, that angle is influenced by the torsion of the animal and may carry a high risk for vertebral canal and intervertebral foramen violation, especially in the caudal cervical area (Corlazzoni, 2008). In the majority of examined vertebral bodies from C2 to C6, the width of the corridor preserving the transverse foramina was estimated to be smaller than 2.5 mm (Watine et al., 2006). However, the degree of implant penetration into the canal that will cause neurologic deficits and the consequences of vertebral artery laceration are unknown (Watine et al., 2006; Hettlich et al., 2010). Another matter of concern is how to obtain the initial and permanent distraction of the affected intervertebral disc space without the common complication of vertebral end plate failure-resorption and consequent loss of distraction (McKee et al., 1989; Rusbridge et al., 1998; McKee et al., 1999). The use of polymethylmethacrylate by itself carries a risk for complications, e.g., oesophageal eruption or thermal damage to the spinal cord. Additionally, application of polymethylmethacrylate in confined areas, such as the intervertebral disc space at C6-C7, may be challenging. There is clinical evidence (Trotter, 2009) that any violation of the end plates applied either from distractors (like modified Gelpi retractor) to the adjacent vertebras or from drilling holes for the accommodation of grafts and cement plugs, weakens significantly the end plates. Thus, use of a specially designed cervical distractor called Caspar and new designation plates used in human spinal surgery are proposed for their safety and ease of use (Matis, 2002; Bergman et al., 2008; Trotter, 2009). Their main disadvantages are the high cost and their questionable ability for distraction of more than one intervertebral disc spaces.

Dorsal laminectomy is indicated for dorsal or dorsolateral compressions and has also been proposed for multiple sites of involvement. In one study (De Risio et al., 2002), the early post-operative morbidity was high (70%), which may be related to extensive muscle dissection that produces significant tissue trauma and post-operative oedema. This deterioration is usually transient, but challenging in relation to nursing care of the animals. It has also been attributed to reperfusion injury after removal of chronic compressive lesions (Rusbridge et al., 1998). The formation of post-laminectomy membrane with subsequent compression of spinal cord has also been reported as a potential complication. In order to minimize this risk, use of autogenous fat graft in the laminectomy site has been proposed, although its effectiveness remains questionable (De Risio et al., 2002).

Many controversies also exist regarding the best method of treatment, especially in relation to the ability to decrease recurrence rates in dogs affected by disc-associated compression, which are associated with the so called domino lesions in adjacent intervertebral disc spaces. However, Jeffery amd McKee (2001) found no apparent difference in recurrence rate (approximately 20%) between distraction-fixation and ventral slot procedure.

The indications, technique and associated complications of cervical total disk replacement are well established in human medicine (Salari and McAffe, 2012). In a meta-analysis of three different clinical trials carried out in human patients, cervical arthroplasty was associated with a lower rate of adjacent-level disease as compared to anterior cervical discectomy and fusion (Upadhyaya et al., 2012). However, in veterinary surgery cervical arthroplasty is still in its infancy. There is one report describing the successful use of cervical disk prosthesis in two Dobermans with disk associated cervical spondylomyelopathy (Adamo, 2011). However, studies that include large number of canine patients and long-term follow-up are necessary to investigate the potential beneficial effects of this technique.

Complications

Intra-operative complications are due to technical errors associated with the hardware used or with iatrogenic injury to soft tissues or vascular structures. Intra-operative haemorrhage from the vertebral venous plexus is a major and potential fatal complication of ventral slot, which may hinder the surgical procedure. In the post-operative period implant failure and post-operative morbidity are main complications, along with recurrence of clinical signs. Adjacent segment disease is the most controversial complication and is responsible for approximately 20% of recurrence cases in previously successfully treated dogs (da Costa, 2010). Adjacent segment disease has been reported to develop 5 to 48 months after stabilization (Bruecker et al., 1989). Use of cervical spine locking plates does not seem to influence this rate (Trotter, 2009). Domino lesions are believed to occur due to abnormal stress imposed on an intervertebral disc space by fixation of an interspace adjacent to it (Bruecker et al., 1989; McKee et al., 1999), although others believe that they reflect the natural progress of the disease, which is merely accelerated by surgical intervention (Trotter, 2009). Due to the high incidence of domino lesions, it has been reported that motion preservation at the surgery site may reduce the rate of this common complication. According to Adamo et al. (2007), ventral slot combined with an artificial disc prosthesis was better able to mimic the behavior of intact cadaver spines compared to ventral slot alone or the pin-polymethylmethacrylate technique.

Criteria for choice between medical and surgical treatment

The choice between medical or surgical treatment relies on the overall assessment of the case by the clinician. Therapeutic procedure has to be adapted on individual basis, depending on severity of clinical signs, degree of pain, short- and long-term expectations of the owner and presence of other orthopaedic (e.g., osteoarthritis of the hip or knee) or non-neurologic diseases (e.g., dilated cardiomyopathy) which may affect the long term outcome. Cervical spondylomyelopathy is a complex disease with a multifactorial pathogenesis and a poorly understood sequence of events, hence treatment decisions should be made on the basis of scientific evidence of the benefits and risks.

OUTCOME AND PROGNOSIS

In a recent retrospective study (da Costa et al., 2008), there was not a significant association between duration of clinical signs or ambulatory status (ambulatory or non-ambulatory patient) and outcome. Lewis (1991) assesed radiologically Dobermans and in a five-year long follow-up time found that 20 of 28 dogs with serious changes in plain radiographs developed clinical signs. In another study (De Decker et al., 2009b), outcome in dogs treated conservatively for disc-associated compression was influenced by type of neurological deficits and presence of malformed vertebra(e) in radiography and dorsal compression in myelography. There is no report associating escalation of findings from imaging and clinical manifestation or prognosis of the disease. Regardless of the method of treatment, it seems that the underlying process of caudal cervical spondylomyelopathy continues, despite clinical improvement after medical or surgical treatment, at least in Dobermans (da Costa and Parent, 2007). However, that study took into consideration spinal cord atrophy in subsequent magnetic resonance imaging examinations, the prognostic significance of which is still vague (da Costa, 2010).

CONCLUDING REMARKS

Cervical spondylomyelopathy in dogs continues to be a conundrum. Advanced imaging techniques are essential for accurate diagnosis, but clinicians should be aware of the potential pitfalls in cases of disk-associated spinal cord compression. Although surgery is opted for osseous associated spinal cord compression, poor understanding of the aetiology and natural progression of disk-associated cervical spondylomyelopathy implies that definitive recommendations regarding conservative as opposed to surgical treatment cannot be made. Unanimously accepted and standardised surgical techniques are still under investigation.

CONFLICT OF INTEREST STATEMENT

There is no conflict of interest of any author of this manuscript.

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