Clinical reasoning in canine cervical hyperaesthesia: which presenting features are important?

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Abstract

Background To evaluate whether clinical features from the history, presentation, physical and neurological examination of dogs with cervical hyperaesthesia are statistically predictive of the underlying diagnosis.

Methods Two hundred and ninety-eight dogs presenting with cervical hyperaesthesia between January 2010 and October 2018 were investigated. Only neurologically normal dogs with cervical hyperaesthesia on examination were included, while those with concurrent neurological deficits including gait abnormalities and proprioceptive deficits were excluded. Univariate analysis of clinical variables was performed and those associated with each diagnosis were retained for multivariable binary logistic regression models.

Results Ninety-five percent of cervical hyperaesthesia presentations were represented by eight conditions which included steroid-responsive meningitis arteritis (SRMA, n=100), intervertebral disc extrusion (IVDE, n= 78), syringomyelia (SM, n= 51), intervertebral disc protrusion (IVDP, n= 30), neoplasia (n=8), cervical spondylomyelopathy (CSM, n=7), immune mediated polyarthritis (IMPA, n= 5) and meningoencephalomyelitis of unknown aetiology (MUA, n=5). Younger age (p=0.003), pyrexia (p=0.003), and haematology abnormalities (p=0.03) comprising leucocytosis, neutrophilia or monocytosis, were associated with a diagnosis of SRMA.

Conclusions Easy-to-recognise clinical features can be used to identify the most likely differential diagnosis in neurologically normal dogs with cervical hyperaesthesia, which may aid the decision making of veterinary surgeons evaluating dogs with this presentation.

Abbreviations:

CSM: Cervical spondylomyelopathy
IMPA: Immune mediated polyarthritis
IVDE: Intervertebral disc extrusion
IVDP: Intervertebral disc protrusion
MUA: Meningoencephalomyelitis of unknown aetiology
SM: Syringomyelia
SRMA: Steroid responsive meningitis arteritis

Introduction

The assessment of dogs with cervical hyperaesthesia as the primary presenting characteristic is a common but potentially challenging occurrence for the veterinary practitioner. Signs of cervical discomfort can be identified from the patient's head carriage, response to palpation of the cervical musculature or resistance to manipulation of the head (1). While cervical hyperaesthesia may be appreciated, it is merely a clinical sign and not specific to an underlying diagnosis. Owing to the wide range of anatomic structures in the cervical region, the source of pain can be difficult to locate and is dependent upon the type of potential disease process and the structure affected (2). Although, the majority of conditions leading to signs of cervical hyperaesthesia are related to neurological structures in the neck, clinical signs secondary to intracranial neurological disease such as brain tumours and hydrocephalus, and non-neurological cervical conditions including subcutaneous abscessation and trauma have been reported (3). Several disorders causing cervical hyperaesthesia have been documented in dogs which are associated with different diagnostic approaches, treatment options and hence prognoses (2).

Degenerative disease of the intervertebral discs resulting in extrusion is widely regarded as one of the most frequent causes of cervical hyperaesthesia (4). It has been suggested that the larger diameter of the vertebral canal in this region means that affected dogs are more likely to present with signs of hyperaesthesia only, rather than paresis or ataxia commonly seen with intervertebral disc extrusion in the thoracolumbar region (5). Inflammatory conditions, specifically steroid responsive meningitis arteritis (SRMA) and meningoencephalomyelitis of unknown aetiology (MUA) are widely recognised causes of cervical hyperaesthesia, particularly within young animals (6-8). Other frequently reported conditions include anomalies such as syringomyelia (SM) typically associated with Chiari-like malformation, cervical spondylomyelopathy (CSM), atlantoaxial subluxation, neoplasia and spinal fracture and luxation (9-12).

Given the difficulty of narrowing down the underlying cause of cervical hyperaesthesia into a prioritised list of differential diagnoses, it is unsurprising that these cases are frequently referred to neurology specialists. However, referral and advanced diagnostics are not always an option, therefore the application of clinical reasoning to obtain a prioritised list of most likely diagnoses to guide investigation and treatment is of importance. Previous studies have shown that many canine and feline spinal disorders are statistically associated with characteristic combinations of clinical features (13, 14). The aim of this study was therefore to evaluate whether discrete clinical parameters from the history, presentation, physical and neurological examination of dogs presenting with cervical hyperaesthesia without concurrent neurological deficits could be used to statistically predict the most likely differential diagnoses. It was hypothesised that statistical models could be used to identify associations between discrete clinical characteristics and the most common diagnoses. This statistically validated information could be implemented by veterinary surgeons evaluating neurologically normal dogs with cervical hyperaesthesia to aid clinical decision making.

Methods

Ethical approval for this retrospective study was granted by the Royal Veterinary College Social Sciences Research Ethical Review Board (RVC; SR2018-1634). The digital medical database of the Small Animal Referral Hospital, Royal Veterinary College, was searched to retrieve the records of all dogs presenting with cervical hyperaesthesia between January 2010 and October 2018. Cases presenting with cervical hyperaesthesia in the absence of concurrent neurological deficits were included. These cases were localised as neurologically normal with cervical hyperaesthesia on neurological examination. Dogs presenting with evidence of a myelopathy, including proprioceptive deficits and gait abnormalities such as ataxia or tetraparesis, or those with neurological examination changes suggestive of a forebrain or brainstem neurolocalisation, including cranial nerve or mentation changes were excluded. Dogs with incomplete medical records or cases in which a diagnosis was not reached were excluded from the study.

Cases were required to have undergone a complete neurological examination with appropriate diagnostics to obtain a definitive diagnosis. The diagnostics performed were decided on an individual case basis by the attending board certified neurologist which included: spinal radiographs, CT, MRI, cerebrospinal fluid analysis, blood tests including haematology, biochemistry and infectious disease testing, cytology or histopathology if indicated. When performed, MRI, CT and radiographic studies were reviewed by a board-certified neurologist. CT was performed with a 16-slice helical scanner (PQ 500, Universal systems, Solon; GE Healthcare) under sedation or general anaesthesia. MRI was performed

with a high field unit (1.5 T, Intera; Phillips Medical Systems) under general anaesthesia. Guidelines for the MRI characterisation of intervertebral disc extrusion (IVDE)(15-18), intervertebral disc protrusion (IVDP)(17, 19), neoplasms (9, 20-22) and SM (23, 24) were used in making a radiological diagnosis. Cases of osseous-associated and disc associated cervical spondylomyelopathy (CSM) were grouped together and diagnosed based on previously reported MRI criteria (25, 26). Ancillary diagnostics tests, including CSF analysis and arthrocentesis, were performed when reaching a diagnosis of SRMA (6, 27), MUA (28, 29) and immune mediated polyarthritis (IMPA) (30) in accordance with previously reported diagnostic guidelines. Diagnoses with three or fewer cases, such as vertebral fractures, discospondylitis, atlantoaxial instability, subarachnoid diverticula, hydrated nucleus pulposus extrusion and myositis were grouped as 'other' for inclusion in statistical analysis.

For all cases the following information was collected from medical records: signalment including age, breed, sex, neuter status and weight, clinical history including onset and duration of clinical signs, disease progression, general physical and neurological examination abnormalities and findings from diagnostic investigations including blood tests and imaging. Onset of clinical signs was categorised into acute (<10 days) and chronic (>10 days). Progression of clinical signs was categorised into episodic, deteriorating, static or improving based upon the clinical history from the referring veterinary surgeon and owner. Clinical signs were termed lateralised when the board-certified neurologist deemed there to be an unequivocal difference in the severity of response to left and right lateral flexion of the neck. On physical examination, pyrexia was determined by a rectal temperature >39.2$_{o}$C. The presence of a leucocytosis (>17.1 x10^{9}/L), neutrophilia (>11.5 x10^{9}/L) or monocytosis (> 1.5 x10^{9}/L) on blood tests were grouped as haematological abnormalities (31).

Statistical analysis was performed using statistical software (SPSS V.25.0.0.1; IBM). Univariate analysis of all clinical variables was performed for each diagnosis. Variables with P <0.30 were retained and a logistic regression, using the forced entry method, performed for each of the most prevalent diseases. The small sample size of the majority of breeds limited the performance of logistic regression for this variable. Variables retained in the final models were considered significant with a P <0.05 (32). A false discovery rate for multiple comparisons was performed on the resultant P values (33). Sensitivity and specificity calculations were performed for the presence of haematological abnormalities and pyrexia in SRMA cases (34). Results are presented with odds ratios (OR) and 95 percent confidence intervals (CI) for each condition compared to the rest of the study population (controls were those not diagnosed with the condition being modelled) (32). Non-normally distributed continuous data are presented as median (range) while normally distributed data are presented as mean (Standard deviation).

Results

Three hundred and nineteen dogs presented with cervical hyperaesthesia without evidence of concurrent neurological deficits during the study period. Five dogs were excluded due to incomplete clinical records. A further sixteen dogs were excluded from the study due to a diagnosis not being reached. These dogs typically presented with mild presentations of cervical hyperaesthesia which had demonstrated significant improvement with symptomatic medical treatment prior to presentation and therefore further diagnostics were not performed.

Two hundred and ninety-eight dogs were therefore included in the study. The study population consisted of 170 males (104 neutered) and 128 females (87 neutered). The ages of these dogs ranged from 4 months to 14 years (median 3 years) while weights ranged from

2kg to 62.4 kg (median 12.5kg). The study population consisted of 54 different breeds with 38 cross breeds. The most prevalent breeds were Cavalier King Charles Spaniels (n=49), French Bulldogs (n=31), Beagles (n=27), Labradors (n=18) and Cocker Spaniels (n=10). Of the French Bulldogs within the study population, 84% (n=26) were diagnosed with IVDE while 88% (n=43) of Cavalier King Charles Spaniels studied were diagnosed with syringomyelia.

Diagnoses
The most commonly diagnosed condition was SRMA (n= 100; 33.6%), followed by IVDE (n= 78; 26.2%), SM (n= 51; 17.1%), IVDP (n= 30; 10.1%), neoplasia (n=8; 2.7%), CSM (n=7; 2.3%), IMPA (n= 5; 1.7%) and MUA (n=5; 1.7 %). Of the remaining dogs three were diagnosed with atlantoaxial instability or luxation and hydrated nucleus pulposus extrusion respectively, two dogs were diagnosed with cervical vertebral fractures, cervical myopathies and discospondylitis respectively. A single dog was diagnosed with a bacterial meningitis and another with a spinal arachnoid diverticulum (Table 1).

Age
Age was significantly associated with diagnoses of IVDP, neoplasia and SRMA. A diagnosis of IVDP or neoplasia was associated with older age, while dogs with SRMA were more likely to be younger (Table 2).

Sex/ Neuter status
Neuter status was associated with a diagnosis of IVDE, with the diagnosis being significantly more likely in male neutered and female neutered dogs (Table 2).

Weight
The weight of the patient was significantly associated with diagnoses of IVDE, SM and CSM. A diagnosis of SM was associated with dogs <10kg, IVDE was more likely in dogs weighing 10-25kg while CSM was more likely in dogs >40kg (Table 2).

Onset and progression of clinical signs
Onset of clinical signs was associated with diagnoses of IVDE, SM, IVDP and CSM, while the progression of clinical signs was associated with MUA. Dogs with IVDE more likely had an acute onset of clinical signs, while dogs diagnosed with IVDP, CSM and SM were more likely to have a chronic disease course. Progression of clinical signs was significantly associated with MUA which was more likely to be deteriorating (Table 2).

Body Temperature
The presence of pyrexia was significantly associated with SRMA with a sensitivity of 81 percent and specificity of 97.5 percent for the diagnosis. Dogs with IVDE were significantly less likely to have a pyrexia on examination (Table 2).

Blood test findings
Compared with other diagnoses, dogs with SRMA and IMPA were more likely to have abnormal haematological values including leucocytosis, neutrophilia or monocytosis. Conversely, dogs with IVDE were significantly less likely to have such abnormalities on blood work (Table 2). The presence of leucocytosis, neutrophilia or monocytosis grouped as haematology abnormalities was found to have 65 percent sensitivity and 92.9 percent specificity for an SRMA diagnosis. When combined with the presence of pyrexia, the specificity increased to 99.5 percent with a decrease in sensitivity to 55 percent.

Table 1: Summary of presentation, neurological examination and investigation findings for diagnoses with 5 or more cases

	n	%	*Age (years, median and range)*	*Sex / Neuter status*	*Weight*	*Presentation*		*Examination*		*Investigation*
						Onset	*Progression*	*Lateralisation*	*Presence of pyrexia*	*Haematology abnormalities*
Steroid Responsive Meningitis Arteritis (SRMA)	100	33.6	0.9 (0.3-5.0)	**ME: 38 (38.0%)** MN: 21 (21.0%) FE: 23 (23.0%) FN: 18 (18.0%)	S: 34 (34.0%) **M: 57 (57.0%)** L: 8 (8.0%) XL: 1 (1.0%)	**A: 90 (90.0%)** C: 10 (10.0%)	**D: 89 (89.0%)** S: 8 (8.0%) E: 3 (3.0%) I: 0 (0.0%)	0%	81%	65%
Intervertebral Disc Extrusion (IVDE)	78	26.2	5.0 (1.0-14.0)	ME: 10 (12.8%) **MN: 35 (44.9%)** FE: 4 (5.1%) FN: 29 (37.2%)	S: 23 (29.5%) **M: 46 (59.0%)** L: 9 (11.5%) XL: 0 (0.0%)	**A: 58 (74.4%)** C: 20 (25.6%)	**D: 65 (86.0%)** S: 0 (0.0%) E: 13 (16.7%) I: 0 (0.0%)	9%	3%	3%
Syringomyelia (SM)	51	17.1	4.0 (0.5-11.0)	ME: 9 (17.6%) **MN: 18 (35.3%)** FE: 11 (21.6%) FN: 13 (25.5%)	**S: 33 (64.7%)** M: 17 (33.3%) L: 1 (2.0%) XL: 0 (0.0%)	A: 7 (13.7%) **C: 44 (86.3%)**	D: 14 (27.5%) S: 0 (0.0%) **E: 37 (72.5%)** I: 0 (0.0%)	4%	0%	6%
Intervertebral Disc Protrusion (IVDP)	30	10.1	6.0 (1.0-11.0)	ME: 2 (6.7%) MN: 12 (40.0%) FE: 1 (3.3%) **FN: 15 (50.0%)**	**S: 15 (50.0%)** M: 9 (30.0%) L: 6 (20.0%) XL: 0 (0.0%)	A: 10 (33.3%) **C: 20 (66.7%)**	**D: 16 (53.3%)** S: 2 (6.7%) E: 12 (40.0%) I: 0 (0.0%)	13%	0%	3%
Neoplasia	8	2.7	9.0 (7.0-12.0)	ME: 1 (12.5%) MN: 3 (37.5%) FE: 0 (0.0%) **FN: 4 (50.0%)**	S: 0 (0.0%) M: 3 (37.5%) **L: 4 (50.0%)** XL: 1 (12.5%)	A: 2 (25.0%) **C: 6 (75.0%)**	**D: 6 (75.0%)** S: 0 (0.0%) E: 2 (25.0%) I: 0 (0.0%)	25%	0%	0%
Cervical Spondylomyelopathy (CSM)	7	2.3	7.0 (2.0-11.0)	ME: 1 (14.3%) **MN: 4 (57.1%)** FE: 0 (0.0%) FN: 2 (28.6%)	S: 0 (0.0%) M: 2 (28.6%) L: 2 (28.6%) **XL: 3 (42.9%)**	A: 1 (14.3%) **C: 6 (85.7%)**	D: 2 (28.6%) S: 0 (6.1%) **E: 5 (71.4%)** I: 0 (0.0%)	43%	14%	0%
Meningoencephalomyelitis of unknown aetiology (MUA)	5	1.7	3.0 (2.0-8.0)	ME: 0 (0.0%) MN: 2 (40.0%) FE: 0 (0.0%) **FN: 3 (60.0%)**	**S: 4 (80.0%)** M: 1 (20.0%) L: 0 (0.0%) XL: 0 (0.0%)	**A: 4 (80.0%)** C: 1 (20.0%)	**D: 3 (60.0%)** S: 2 (40.0%) E: 0 (0.0%) I: 0 (0.0%)	0%	0%	40%
Immune mediated polyarthritis (IMPA)	5	1.7	2.0 (1.0-5.0)	ME: 0 (0.0%) MN: 1 (20.0%) FE: 1 (20.0%) **FN: 3 (60.0%)**	S: 0 (0.0%) **M: 5 (100.0%)** L: 0 (0.0%) XL: 0 (0.0%)	**A: 5 (100.0%)** C: 0 (0.0%)	**D: 5 (100.0%)** S: 0 (0.0%) E: 0 (0.0%) I: 0 (0.0%)	0%	40%	80%
Other	14	4.7	5.5 (0.4-8.0)	ME: 5 (35.7%) **MN: 8 (57.1%)** FE: 1 (7.1%) FN: 0 (0.0%)	S: 3 (21.4%) **M: 6 (42.9%)** L: 3 (21.4%) XL: 2 (14.3%)	**A: 10 (71.4%)** C: 4 (28.6%)	**D: 10 (70.5%)** S: 0 (0.0%) E: 4 (28.6%) I: 0 (0.0%)	14%	0%	14%

ME= Male Entire, MN= Male Neutered, FE= Female Entire, FN= Female Neutered, S = <10kg, M= 10-25kg, L = 25-40kg, XL= >40kg, A = Acute, C = Chronic, D= Deteriorating, S= Static, E = Episodic, I= Improving, NN = Neurologically normal with cervical hyperaesthesia C1 = C1-C5, C6= C6-T2, FB = Forebrain/ Brainstem

Table 2: Logistical regression analysis of presentation and neurological examination characteristics of leading cervical hyperaesthesia diagnoses with 5 or more cases

	n	*Age*	*Sex / Neuter Status*	*Weight*	*Body Temperature*	*Onset*	*Progression*	*Blood Tests*
Steroid Responsive Meningitis Arteritis (SRMA)	100	Younger 6.3 (2.9-13.7) *P* = 0.003	-	-	Pyrexia 63.0 (8.0-500.0) *P* =0.003 cf. unremarkable	-	-	Abnormal 6.0 (1.3-27.0) *P* = 0.03 cf. normal
Intervertebral Disc Extrusion (IVDE)	78	-	Male Neutered 2.9 (1.1-7.6) *P* = 0.04 cf. male entire Female Neutered 4.4 (1.6-12.0) *P*= 0.04 cf. male entire	10-25kg 2.8 (1.3-5.9) *P* = 0.006 cf >40kg	Normal 24.3 (5.2-113.0) *P* =0.003 cf. pyrexia	Acute 5.5 (2.3-13.3) *P* = 0.003 cf. chronic	-	Normal 17.4 (3.6-82.7) *P* =0.003 cf. abnormal
Syringomyelia (SM)	51	-	-	<10kg 3.2 (1.4-7.4) *P* = 0.006 cf. 10-25kg 30.3 (3.6-250.0) *P*= 0.03 cf. 25-40kg	-	Chronic 13.0 (4.3-38.5) *P* =0.003 cf. acute	-	-
Intervertebral Disc Protrusion (IVDP)	30	Older 1.2 (1.1-1.4) *P* = 0.003	-	-	-	Chronic 2.9 (1.3-6.6) P= 0.02 cf. acute	-	-
Neoplasia	8	Older 2.4 (1.4-4.2) *P*= 0.004	-	-	-	-	-	-
Cervical spondylomyelopathy (CSM)	7	-	-	>40kg 83.3 (6.5-1000.0) *P* = 0.003 cf. 10-25kg 29.4 (2.0-500.0) *P* = 0.02 cf. 25-40kg	-	Chronic 17.6 (1.3-237.1) *P* = 0.04 cf. acute	-	-
Meningoencephalomyelitis of unknown aetiology (MUA)	5	-	-	-	-	-	Deteriorating 13.9 (2.1-90.9) *P* = 0.01 cf. static	-
Immune mediated polyarthritis (IMPA)	5	-	-	-	-	-	-	Abnormal 19.5 (1.8-210.6) *P* = 0.02 cf. normal

Where statistically significant ($P \leq 0.05$) data presented include Odds Ratios with 95% confidence intervals (CI) indicated in parentheses and the comparison group for categorical data. Characteristics with no statistically significant bias are indicated with '-'

Discussion

While cervical hyperaesthesia is frequently appreciated on clinical examination, formulating a diagnostic and treatment plan can be daunting, owing to the extensive list of differential diagnoses and numerous anatomic structures within the region (2). Using clinical information from the patient's presentation in a problem-orientated approach has been advocated to provide a framework for clinical decision making (35). With the innate variability of presentations in veterinary medicine the approach to managing patients with cervical hyperaesthesia can never be reduced to a simple algorithm. However, the benefits of a clinical reasoning-based approach in the management of neurological presentations has been previously documented in canine and feline spinal disease and epilepsy (13, 14, 36, 37).

This study evaluated whether discrete clinical features can be used to identify the most likely differential diagnoses in neurologically normal dogs presenting with cervical hyperaesthesia. Our results suggest that the most frequent causes of canine cervical hyperaesthesia are associated with discrete clinical characteristics obtained from the patient's signalment, clinical history, general physical and neurological examinations. Although a wide range of diagnoses were evident within the study population, the eight most prevalent causes of cervical hyperaesthesia represented 95% of presentations. Furthermore, three quarters of dogs within the population were diagnosed with one the three most prevalent diagnoses, SRMA (34%), IVDE (26%), and SM (17%), which is consistent of the findings of previous research (3).

A diagnosis of SRMA was associated with younger age, 63 times the odds of presenting with pyrexia and 6 times the odds of presenting with leucocytosis, neutrophilia or monocytosis on haematology. The predisposition of SRMA in juvenile dogs is not unexpected with the typical age of onset reported to be younger than 24 months of age (38, 39). The association of SRMA with pyrexia supports the findings of previous research in which SRMA was the most frequently diagnosed condition in a study of juvenile dogs with pyrexia (40). Haematology changes consistent with inflammation, including neutrophilia and leucocytosis, have been previously reported in the literature in association with SRMA (6, 41). The association with these clinical features is unsurprising, given the recognised definition of SRMA as a systemic immune disorder that is characterised by inflammatory changes of the leptomeninges and the associated vasculature (6).

In the current study population, the presence of pyrexia had a higher sensitivity (81%) and specificity (97.5%) for a diagnosis of SRMA, than the presence of haematology abnormalities. When considering dogs presenting with a combination of pyrexia and haematology abnormalities the specificity for a diagnosis of SRMA further increased (99.5%), with a concurrent decrease in sensitivity (55%). Therefore, in dogs presenting with cervical hyperaesthesia and a combination of pyrexia and haematology abnormalities the clinician should be highly suspicious of an underlying diagnosis of SRMA. This information can be utilised to guide clinical reasoning including the formulation of an appropriate diagnostic and treatment plan for these patients. This can be particularly important in situations with financial constraints where a diagnosis can be reached with targeted diagnostics without performing costly advanced imaging. Although, the high specificity of these clinical variables means that the risk of reaching a false positive diagnosis is low, confirmatory diagnostics tests should be performed prior to treatment. This is important when considering the prolonged course of immunosuppressive corticosteroid treatment required with SRMA and the potential side effects of the medication. While pyrexia and haematology

abnormalities are useful clinical variables for SRMA, the low sensitivity means that a diagnosis of SRMA cannot be excluded in cases presenting without pyrexia or haematology abnormalities.

Consistent with previous literature, IMPA was also found to be significantly associated with the presence of abnormalities on haematology (30). When faced with compatible haematological abnormalities, in the presence or absence of pyrexia, the clinician is well advised to thoroughly examine the patient for evidence of joint pain or swelling as an indicator of IMPA. This is particularly prudent as previous reports have documented the prevalence of concurrent SRMA and IMPA to be as high as 46% (42). Identification of joint changes, therefore enabling a diagnosis to be obtained from arthrocentesis, can be less technically challenging for the clinician and represent a reduced risk to the patient compared with cerebrospinal fluid collection. IVDE was most frequently evident in smaller dogs, weighing between 10-25kg, most commonly with an acute onset of clinical signs, which reflects the findings of previous studies (13, 43). Dogs presenting with IVDE were typically systemically well with the diagnosis associated with 24 times the odds of having a normal body temperature and 17 times the odds of having normal blood work. There was no consistent lateralisation of signs noted. Increased odds for a diagnosis of IVDE was evident in both male and female neutered dogs. This finding aligns with the results of previous research which reported an increased risk of IVDE in neutered dogs, particularly when gonadectomy was performed at an early age (44, 45). Data regarding the age at which neutering was performed was not consistently available for our study population which limited further investigation into the impact of neutering timing. Of the French Bulldogs presented with cervical hyperaesthesia, 84% were diagnosed with IVDE, which is consistent with results of a previous studies (46).

CSM, IVDP and SM all presented with a chronic onset of clinical signs. Unsurprisingly, dogs presenting with CSM typically weighed >40kg while SM patients were typically <10kg. This finding is expected given the known breed predispositions of both diseases (10, 11, 47). Further support is given by the fact that 88% of Cavalier King Charles Spaniels presenting with cervical hyperaesthesia during the study period were diagnosed with SM. SM was most commonly episodic in its progression. Although, the most obvious clinical signs to the owner such as phantom scratching or vocalisation may be intermittent or episodic, recent research has identified that persistent signs of discomfort including reduced activity, reluctance to jump or climb stairs, emotional changes and aversions to being touched are common in dogs with Chiari-like malformation and SM (48). There was no statistical association between CSM and age in this study. Age predilections of osseous and disc associated CSM have been reported in the literature, however it is likely that there were not evident within this study as CSM was not separated into osseous or disc associated forms for analysis (25, 49).

This study is invariably limited by its retrospective design. The study focused on clinical reasoning in dogs which were neurologically normal with cervical hyperaesthesia, with stringent exclusion of dogs that presented with concurrent neurological signs such as ataxia or tetraparesis. The study population therefore represents a specific clinical presentation and as a result the prevalence of each diagnosis and clinical reasoning findings correlate to neurologically normal dogs with cervical hyperaesthesia. The clinical reasoning outcomes may not be representative of dogs presenting with a myelopathy or neck problems in general. The exclusion of cases without a diagnosis aimed to provide accurate statistical results but may have selected against mild disease presentations which demonstrate improvement with symptomatic treatment. However, those cases which resolve with symptomatic medical

treatment are not typically the cases in which a clinical reasoning approach or framework are required by the clinician. It must be considered that the study population represents cases presented to a referral hospital. This is inherently biased to more severe clinical presentations or conditions where specialist input is deemed necessary and therefore is unlikely to be representative of the disease prevalence seen in general practice. There is currently no information within the literature to compare prevalence of disorders causing cervical hyperaesthesia in this study to those seen in first opinion practice. All cases presented for cervical hyperaesthesia within the study window that met the criteria were included which meant that some conditions were represented in greater numbers than others. This approach meant that the least prevalent diagnoses could not be included within the statistical model which inherently leads to bias of results to the most prevalent conditions. While less prevalent conditions such as atlantoaxial instability, myopathies and vertebral fractures could not be statistically analysed they should still be considered by the clinician when presented cases of cervical hyperaesthesia. Although the variance in diagnosis prevalence within the study population is statistically accounted for within the logistic regression model, it does mean that the less prevalent conditions may lack the statistical power of the most prevalent disorders and thus associations with the variables studied may have been missed. In addition, the analysis of each diagnosis against the remainder of the study population is not characteristic of real-life clinical scenarios which could result in some statistical associations being overstated. Statistical based clinical reasoning can undoubtedly aid clinicians in identifying the most likely differential diagnosis for the most prevalent disorders. However, the clinical reasoning approach is limited in unusual disease presentations or uncommon disorders meaning that these remain difficult to identify in clinical practice.

Conclusions

Easy-to-recognise clinical characteristics from the history, physical and neurological examinations of dogs presenting with signs of cervical hyperaesthesia without concurrent neurological deficits can be evaluated to construct a prioritised list of differential diagnoses. Due to the innate variability of veterinary medicine the approach to managing patients presenting with cervical hyperaesthesia can never be reduced to a simple algorithm. However, it is hoped that the use of information from this study can be implemented by veterinary surgeons to improve the timeliness and accuracy of diagnosis in dogs with cervical hyperaesthesia. Utilising clinical reasoning from the presenting features of the patient to produce a prioritised list of differential diagnoses, can assist the clinician in deciding upon the most appropriate diagnostic tests, treatment options and the potential need for referral in each patient.

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References

1. Thomas WB. Initial assessment of patients with neurologic dysfunction. Vet Clin North Am Small Anim Pract. 2000;30(1):1-24, v.

2. Webb AA. Potential sources of neck and back pain in clinical conditions of dogs and cats: a review. Vet J. 2003;165(3):193-213.
3. De Strobel F, Paluš V, Vettorato E, Cherubini GB. Cervical hyperaesthesia in dogs: an epidemiological retrospective study of 185 cases. J Small Anim Pract. 2019.
4. Cherrone KL, Dewey CW, Coates JR, Bergman RL. A retrospective comparison of cervical intervertebral disk disease in nonchondrodystrophic large dogs versus small dogs. J Am Anim Hosp Assoc. 2004;40(4):316-20.
5. Coates JR. Intervertebral disk disease. Vet Clin North Am Small Anim Pract. 2000;30(1):77-110, vi.
6. Tipold A, Schatzberg SJ. An update on steroid responsive meningitis-arteritis. J Small Anim Pract. 2010;51(3):150-4.
7. Tipold A, Stein VM. Inflammatory diseases of the spine in small animals. Vet Clin North Am Small Anim Pract. 2010;40(5):871-9.
8. Cornelis I, Volk HA, De Decker S. Clinical presentation, diagnostic findings and long-term survival in large breed dogs with meningoencephalitis of unknown aetiology. Vet Rec. 2016;179(6):147.
9. Pancotto TE, Rossmeisl JH, Zimmerman K, Robertson JL, Werre SR. Intramedullary spinal cord neoplasia in 53 dogs (1990-2010): distribution, clinicopathologic characteristics, and clinical behavior. J Vet Intern Med. 2013;27(6):1500-8.
10. da Costa RC. Cervical spondylomyelopathy (wobbler syndrome) in dogs. Vet Clin North Am Small Anim Pract. 2010;40(5):881-913.
11. Rusbridge C, Carruthers H, Dubé MP, Holmes M, Jeffery ND. Syringomyelia in cavalier King Charles spaniels: the relationship between syrinx dimensions and pain. J Small Anim Pract. 2007;48(8):432-6.
12. Slanina MC. Atlantoaxial Instability. Vet Clin North Am Small Anim Pract. 2016;46(2):265-75.
13. Cardy TJ, De Decker S, Kenny PJ, Volk HA. Clinical reasoning in canine spinal disease: what combination of clinical information is useful? Vet Rec. 2015;177(7):171.
14. Mella SL, Cardy TJ, Volk HA, De Decker S. Clinical reasoning in feline spinal disease: which combination of clinical information is useful? J Feline Med Surg. 2019:1098612X19858447.
15. Bersan E, McConnell F, Trevail R, Behr S, De Decker S, Volk HA, et al. Cervical intervertebral foraminal disc extrusion in dogs: clinical presentation, MRI characteristics and outcome after medical management. Vet Rec. 2015;176(23):597.
16. Züger L, Fadda A, Oevermann A, Forterre F, Vandevelde M, Henke D. Differences in Epidural Pathology between Cervical and Thoracolumbar Intervertebral Disk Extrusions in Dogs. J Vet Intern Med. 2018;32(1):305-13.
17. Besalti O, Pekcan Z, Sirin YS, Erbas G. Magnetic resonance imaging findings in dogs with thoracolumbar intervertebral disk disease: 69 cases (1997-2005). J Am Vet Med Assoc. 2006;228(6):902-8.
18. Jeffery ND, Levine JM, Olby NJ, Stein VM. Intervertebral disk degeneration in dogs: consequences, diagnosis, treatment, and future directions. J Vet Intern Med. 2013;27(6):1318-33.
19. da Costa RC, Samii VF. Advanced imaging of the spine in small animals. Vet Clin North Am Small Anim Pract. 2010;40(5):765-90.
20. Binanti D, De Zani D, Fantinato E, Allevi G, Sironi G, Zani DD. Intradural-extramedullary haemangioblastoma with paraspinal extension in a dog. Aust Vet J. 2015;93(12):460-5.
21. Bagley RS. Spinal neoplasms in small animals. Vet Clin North Am Small Anim Pract. 2010;40(5):915-27.

22. Palus V, Volk HA, Lamb CR, Targett MP, Cherubini GB. MRI features of CNS lymphoma in dogs and cats. Vet Radiol Ultrasound. 2012;53(1):44-9.
23. Rusbridge C, Greitz D, Iskandar BJ. Syringomyelia: current concepts in pathogenesis, diagnosis, and treatment. J Vet Intern Med. 2006;20(3):469-79.
24. Lu D, Lamb CR, Pfeiffer DU, Targett MP. Neurological signs and results of magnetic resonance imaging in 40 cavalier King Charles spaniels with Chiari type 1-like malformations. Vet Rec. 2003;153(9):260-3.
25. De Decker S, Gielen IM, Duchateau L, Volk HA, Van Ham LM. Intervertebral disk width in dogs with and without clinical signs of disk associated cervical spondylomyelopathy. BMC Vet Res. 2012;8:126.
26. Gasper JA, Rylander H, Stenglein JL, Waller KR. Osseous-associated cervical spondylomyelopathy in dogs: 27 cases (2000-2012). J Am Vet Med Assoc. 2014;244(11):1309-18.
27. Tipold A. Diagnosis of inflammatory and infectious diseases of the central nervous system in dogs: a retrospective study. J Vet Intern Med. 1995;9(5):304-14.
28. Cornelis I, Van Ham L, Gielen I, De Decker S, Bhatti SFM. Clinical presentation, diagnostic findings, prognostic factors, treatment and outcome in dogs with meningoencephalomyelitis of unknown origin: A review. Vet J. 2019;244:37-44.
29. Cherubini GB, Platt SR, Anderson TJ, Rusbridge C, Lorenzo V, Mantis P, et al. Characteristics of magnetic resonance images of granulomatous meningoencephalomyelitis in 11 dogs. Vet Rec. 2006;159(4):110-5.
30. Stull JW, Evason M, Carr AP, Waldner C. Canine immune-mediated polyarthritis: clinical and laboratory findings in 83 cases in western Canada (1991-2001). Can Vet J. 2008;49(12):1195-203.
31. Lumsden JH, Mullen K, McSherry BJ. Canine hematology and biochemistry reference values. Can J Comp Med. 1979;43(2):125-31.
32. Sperandei S. Understanding logistic regression analysis. Biochem Med (Zagreb). 2014;24(1):12-8.
33. Jafari M, Ansari-Pour N. Why, When and How to Adjust Your P Values? Cell J. 2019;20(4):604-7.
34. Trevethan R. Sensitivity, Specificity, and Predictive Values: Foundations, Pliabilities, and Pitfalls in Research and Practice. Front Public Health. 2017;5:307.
35. May SA. Clinical reasoning and case-based decision making: the fundamental challenge to veterinary educators. J Vet Med Educ. 2013;40(3):200-9.
36. Armaşu M, Packer RM, Cook S, Solcan G, Volk HA. An exploratory study using a statistical approach as a platform for clinical reasoning in canine epilepsy. Vet J. 2014;202(2):292-6.
37. Stanciu GD, Packer RMA, Pakozdy A, Solcan G, Volk HA. Clinical reasoning in feline epilepsy: Which combination of clinical information is useful? Vet J. 2017;225:9-12.
38. Scott-Moncrieff JC, Snyder PW, Glickman LT, Davis EL, Felsburg PJ. Systemic necrotizing vasculitis in nine young beagles. J Am Vet Med Assoc. 1992;201(10):1553-8.
39. Rose JH, Kwiatkowska M, Henderson ER, Granger N, Murray JK, Harcourt-Brown TR. The impact of demographic, social, and environmental factors on the development of steroid-responsive meningitis-arteritis (SRMA) in the United Kingdom. J Vet Intern Med. 2014;28(4):1199-202.
40. Black VL, Whitworth FJS, Adamantos S. Pyrexia in juvenile dogs: a review of 140 referred cases. J Small Anim Pract. 2019;60(2):116-20.
41. Rose JH, Harcourt-Brown TR. Screening diagnostics to identify triggers in 21 cases of steroid-responsive meningitis-arteritis. J Small Anim Pract. 2013;54(11):575-8.

42. Webb AA, Taylor SM, Muir GD. Steroid-responsive meningitis-arteritis in dogs with noninfectious, nonerosive, idiopathic, immune-mediated polyarthritis. J Vet Intern Med. 2002;16(3):269-73.
43. Hakozaki T, Iwata M, Kanno N, Harada Y, Yogo T, Tagawa M, et al. Cervical intervertebral disk herniation in chondrodystrophoid and nonchondrodystrophoid small-breed dogs: 187 cases (1993-2013). J Am Vet Med Assoc. 2015;247(12):1408-11.
44. Dorn M, Seath IJ. Neuter status as a risk factor for canine intervertebral disc herniation (IVDH) in dachshunds: a retrospective cohort study. Canine Genet Epidemiol. 2018;5:11.
45. Packer RM, Seath IJ, O'Neill DG, De Decker S, Volk HA. DachsLife 2015: an investigation of lifestyle associations with the risk of intervertebral disc disease in Dachshunds. Canine Genet Epidemiol. 2016;3:8.
46. Rossetti D, Ragetly GR, Poncet CM. High-Definition Video Telescope-Assisted Ventral Slot Decompression Surgery for Cervical Intervertebral Disc Herniation in 30 Dogs. Vet Surg. 2016;45(7):893-900.
47. da Costa RC, Parent JM, Holmberg DL, Sinclair D, Monteith G. Outcome of medical and surgical treatment in dogs with cervical spondylomyelopathy: 104 cases (1988-2004). J Am Vet Med Assoc. 2008;233(8):1284-90.
48. Rusbridge C, McFadyen AK, Knower SP. Behavioral and clinical signs of Chiari-like malformation-associated pain and syringomyelia in Cavalier King Charles spaniels. J Vet Intern Med. 2019.
49. de Albuquerque Bonelli M, da Costa RC. Clinical and magnetic resonance imaging characterization of cervical spondylomyelopathy in juvenile dogs. J Vet Intern Med. 2019.