Clinical reasoning in feline spinal disease: which combination of clinical information is useful?

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Abstract

Objectives: To evaluate if a combination of discrete clinical characteristics can be used to identify the most likely differential diagnoses in cats with spinal disease.

Methods: 221 cats referred for further evaluation of spinal disease were included and categorised into the following disease categories: non-lymphoid neoplasia (n=44), intervertebral disc disease (n=42), fracture/luxation (n=34), ischaemic myelopathy (n=22), feline infectious peritonitis virus myelitis (n=18), lymphoma (n=16), thoracic vertebral canal stenosis (n=11), acute non-compressive nucleus pulposus extrusion (n=11), traumatic spinal cord contusion (n=8), spinal arachnoid diverticula (n=7), lumbosacral stenosis (n=5) and spinal empyema (n=3). Information retrieved from the medical records included signalment, clinical history and clinical presentation. Univariate analyses of variables (clinical history, breed, age, gender, general physical examination findings, onset, progression, spinal hyperaesthesia, asymmetry, ambulatory status and neuroanatomical localisation) were performed, and variables were retained in a multivariate logistic regression model if $P<0.05$.

Results: Multivariate logistic regression revealed that intervertebral disc disease most often occurs in middle-aged, purebred cats with a normal general physical examination and an acute onset of painful and progressive clinical signs. Ischaemic myelopathy occurs most often in older cats with a stable or improving, non-painful, lateralising, C6-T2 myelopathy. Spinal fracture/luxation occurs most often in younger cats and results most often in a peracute onset, painful, non-ambulatory neurological status. Concurrent systemic abnormalities or abnormal findings detected on general physical examination was significantly associated with feline infectious peritonitis virus myelitis, spinal lymphoma or spinal empyema.

Conclusions and relevance: This study suggests that using easily identifiable characteristics from the history and clinical examination can assist in obtaining a preliminary differential diagnosis when evaluating cats with spinal disease. This information could aid veterinary practioners in clinical decision making.

Introduction

Assessment of cats with suspected spinal disease can be daunting for veterinary practioners. Neurophobia is the fear of neuroscience and clinical neurology which was first recognised in medical students and young physicians.[1] It is associated with the belief that neurology is a complex subject that is academically challenging and difficult to apply in clinical practice. It results in decreased confidence and the inability to apply basic knowledge into clinical practice, essentially leading to paralysis of analysis or 'paralysis of thinking'.[1-3] Following a surge in veterinary neurology research in the last 15 years, neurological diseases are more frequently recognised. Despite the accompanying rise in understanding of neurological disorders, the 'neurophobia' phenomenon remains prevalent particularly among young veterinarians.[4,5]

A variety of spinal disorders has been recognised in cats, which are associated with different diagnostic approaches, treatment options and varying prognoses.[6-8] Infectious disorders, specifically feline infectious peritonitis (FIP) virus myelitis, has historically been considered the most common feline spinal disorder, followed by neoplastic disease, primarily lymphoma.[6,8] Other commonly diagnosed feline spinal disorders are spinal fracture and luxation, intervertebral disc disease and ischaemic myelopathy.[6-8] With such an extensive list of differential diagnoses, it is not surprising that cats with spinal disease are commonly referred to neurology specialists. Advanced diagnostic tests commonly performed in the referral setting, such as magnetic resonance imaging (MRI) and cerebrospinal fluid (CSF) collection, can however be invasive and financially prohibitive.[9] Furthermore, not all cat owners will be able or prepared to accept referral to neurology specialists. It is therefore necessary for veterinarians to apply their knowledge and clinical reasoning skills to

obtain a likely diagnosis and subsequently consider the necessity, specific advantages, expectations and limitations of a potential referral to a specialist referral centre.

By considering the signalment, obtaining a thorough clinical history, performing a general physical examination, a complete neurological examination and obtaining a neuro-anatomical localisation it is possible to identify key factors that can be vital in clinical decision making.[9-11] It has been identified that most canine spinal diseases are statistically associated with distinct characteristic combinations of clinical variables.[9] It is currently however unknown if such a statistical model could also be used to guide a clinical reasoning approach in feline spinal disease. The aim of this study was therefore to evaluate if discrete clinical characteristics, such as clinical history, general physical examination findings, signalment, onset, progression, symmetry of clinical signs, spinal hyperaesthesia, ambulatory status, and neuro-anatomical localisation can be used to statistically predict the most likely differential diagnoses in cats with spinal disease. We hypothesised that statistical models could be used to identify associations between the most common feline spinal disorders and specific combinations of clinical variables. This information could aid in determining the most likely differential diagnoses when assessing cats with spinal disease and hence improve clinical decision making for veterinary practitioners.

Materials and Methods

This retrospective study was approved by the ethics and welfare committee of the Royal Veterinary College (RVC, SR2018-1663). The digital medical database of the small animal referral hospital, RVC was searched for all records of cats referred for

further evaluation of suspected spinal disease between 2 August 2007 and 3 January 2018. Cats were included if they underwent a complete neurological examination and appropriate further diagnostics to obtain a definitive or presumptive diagnosis of an underlying spinal condition. Further diagnostics could include one or a combination of the following; spinal radiographs, computed tomography (CT), MRI, CSF analysis, infectious disease testing, cytology or histopathology. Cats with sacrocaudal luxation were not included in this study. Cats were excluded if the medical records or imaging studies were incomplete or not available for review or if a final clinical or presumptive diagnosis was not reached. Although cats were only included if they presented for further evaluation of spinal disease, they were not excluded if the neurological examination revealed abnormalities suggestive for intracranial involvement. All medical records and imaging studies were reviewed by a board-certified neurologist (SDD) and cats were allocated to one of the following 12 disease categories: presumptive non-lymphoid spinal neoplasia, degenerative intervertebral disc disease, spinal fracture/luxation, ischaemic myelopathy, FIP virus myelitis, spinal lymphoma, thoracic vertebral canal stenosis, traumatic spinal cord contusion, spinal arachnoid diverticula, lumbosacral stenosis, and spinal empyema. Cases were grouped into a disease category when a diagnosis was made in more than two cats. Cats that suffered from spinal conditions that were made only once or twice in the study period were therefore not included in this study. For the purpose of this study, a diagnosis of FIP was made when a diagnosis was confirmed by histopathology or detection of feline coronavirus in CSF by real-time reverse transcriptase polymerase chain reaction (real-time RT-PCR).[12,13] A diagnosis of lymphoma was made when a histopathological diagnosis was made or when MRI was suggestive for a neoplastic spinal condition and cytological evaluation of CSF or extraneural tissue was

suggestive for lymphoma.[14] A diagnosis of presumptive non-lymphoid spinal neoplasia was made when neoplastic disease other than lymphoma was histopathologically confirmed or if cytological evaluation of CSF or extraneural tissues did not reveal any indications for lymphoma. A diagnosis of thoracic vertebral canal stenosis was defined as a focal osseous vertebral canal stenosis. Diagnostic criteria for the other spinal disease categories were based on previously published literature.[15-23]

For all included cases, the following information was retrieved from the medical records: clinical history with emphasis on the occurrence of other clinical signs such as lethargy, anorexia and weight loss; signalment; onset; duration; type; and severity of clinical signs; general physical and neurological examination findings, including lateralisation of clinical signs and presence of spinal hyperaesthesia. Age was classified as younger (<3 years), middle aged (3–9 years), and older (>9 years). Onset of clinical signs was categorised into peracute (<2 days), acute (2-5 days), subacute (5-14 days) and chronic (>14 days). Progression of clinical signs was categorised into deteriorating, static or improving clinical signs before presentation at the RVC. This assessment was based on the notes from the referring veterinary surgeon and owner's perception. Severity of clinical signs was categorised into ambulatory or non-ambulatory neurological status on presentation. Spinal hyperaesthesia was considered to be present when a painful response could be elicited on spinal palpation by the attending clinician or when obvious spinal pain was reported by the referring veterinary surgeon or owner of the cat. Neurological signs were considered to be lateralised when there was an unequivocal difference in the severity of neurological deficits between the left and right side of the cat. The neuro-anatomical localisation

was categorised into disorders affecting the C1-C5, C6-T2, T3-L3 or L4-S3 spinal cord segments or multifocal with intracranial involvement.

Computed tomography was performed with a 16-slice helical CT scanner (PQ 500, Universal Systems, Solon; GE Healthcare), under sedation or general anaesthesia. After completion of the transverse CT study, sagittal, dorsal and 3-dimensional reconstructions were made. Magnetic resonance imaging was performed under general anaesthesia with a high-field unit (1.5T, Intera, Philips Medical Systems) and imaging studies included a minimum of T1- and T2-weighted sagittal and transverse images.

Statistical analysis was performed by one of the authors (TJC) and data were analyzed using statistical software (SPSS; Statistical Package for the Social Sciences V.21.0.1).

Univariate analyses of potential explanatory variables for each condition were performed. Variables were considered for inclusion in multivariate logistic regression if $P<0.30$ and retained in the final model if $P<0.05$, based on the likelihood ratio test. Multivariate logistic regression was carried out using a forced entry method (where all variables are entered into the equation in a single step) to examine associations between included variables with a significance level of $P<0.05$.[24] Results are presented with odds ratios (OR) and 95 per cent confidence intervals (CI) for each condition versus the overall spinal disease population.[24] Following multivariate logistic regression for each disease variables retained in the final model ($P<0.05$) included: purebred status, age (signalment), concurrent abnormalities in the clinical history or general physical examination, median time to presentation, progression of clinical signs, ambulatory status, spinal hyperaesthesia, asymmetry in neurological deficits and neuroanatomical localisation. Non-normally distributed data were

presented as median value with the range. Normally distributed data were presented as means and standard deviation (sd) (means±sd).

Results

Two-hundred and twenty-six cats were diagnosed with a spinal condition in the study period. Five cats were excluded because their diagnosis occurred only once or twice. These five cats were diagnosed with traumatic intramedullary haemorrhage (n=2 cats), suspected poliomyelitis, Toxoplasmosis and vertebral malformation caused by mucopolysaccharidosis (n= 1 cat for each diagnosis).

Two-hundred and twenty-one cats were therefore included in this study. This group consisted of 143 males (131 neutered) and 78 females (67 neutered) between two months and 18 years of age. The most commonly diagnosed condition was presumptive non-lymphoid neoplasia (n=44 cats; 19.9% of cats), followed by degenerative intervertebral disc disease (42 cats; 19%), spinal fracture and luxation (34 cats; 15.4%), ischaemic myelopathy (22 cats; 10%), FIP virus myelitis (18 cats; 8.1%), lymphoma (16 cats; 7.2%), thoracic vertebral canal stenosis (11 cats; 5.0%), acute non compressive nucleus pulposus extrusion (11 cats; 5.0%), traumatic spinal cord contusion (8 cats; 3.6%), spinal arachnoid diverticulum (7 cats; 3.2%), lumbosacral stenosis (5 cats; 2.3%) and spinal empyema (3 cats; 1.4%). A summary of the clinical presentation of cats affected by these disorders is presented in Table 1.

The 44 cats with presumptive non-lymphoid neoplasia included 15 cats with contrast enhancing intramedullary mass lesions. Serum Toxoplasma titers were negative and CSF analysis was within normal limits in all these 15 cats. Thirteen cats had vertebral masses of which five were histopathologically confirmed to be osteosarcoma and one

205 was confirmed to be a plasmacytoma, six cats had histopathologically confirmed
206 meningioma, two cats histopathologically confirmed glial cell tumors, two had
207 unspecified extradural mass lesions, and each of the following diagnoses were made
208 in one cat: vascular hamartoma, fibrosarcoma, solitary giant cell tumor of soft tissue,
209 histiocytic sarcoma, peripheral nerve sheath tumor, and metastatic neoplasia.

210

211 **Age**

212 Older age was associated with a diagnosis of presumptive non-lymphoid neoplasia,
213 ischaemic myelopathy, and lumbosacral stenosis (Table 2). Cats with degenerative
214 intervertebral disk disease were more likely middle aged and cats with spinal fracture
215 and luxation, FIP virus myelitis, and traumatic spinal cord contusion were more likely
216 younger (Table 2).

217

218 **Breed**

219 33% of cats in this study were purebred (n=55) and 67% were non-purebred (n=166).
220 The group of non-purebred cats consisted of domestic shorthair (n=143 cats),
221 domestic longhair (n=19) and domestic medium hair cats (n=4). The most common
222 purebred cat was the British shorthair (n= 11), followed by the Bengal (n=9), Persian
223 (n=8), Maine Coon (n=7), Sphinx and Siamese (n=3 for both), Russian Blue,
224 Chinchilla, Tonkinese and Ragdoll (n=2) and six breeds were represented by only one
225 cat. Purebred status was significantly associated with a diagnosis of presumptive non-
226 lymphoid neoplasia, degenerative intervertebral disc disease and thoracic vertebral
227 canal stenosis. Cats with degenerative intervertebral disc disease and thoracic

vertebral canal stenosis were more likely purebred cats, while cats with presumptive non-lymphoid neoplasia were more likely non-purebred cats (Table 2).

Concurrent clinical signs and general physical examination findings

Compared to other diagnoses, cats with FIP virus myelitis, lymphoma and spinal empyema had more often concurrent clinical signs, such as lethargy, anorexia and weight loss, or abnormalities on their general physical examination, such as pyrexia and lymphadenomegaly. Cats with degenerative intervertebral disk disease had significantly less often concurrent clinical signs or abnormalities on their general physical examination (Table 2).

Onset and progression of clinical signs

Onset of disease was significantly associated with diagnoses of degenerative intervertebral disk disease and vertebral fracture and luxation. Cats with degenerative intervertebral disk disease had more likely an acute onset of clinical signs, while cats with vertebral fracture and luxation had more likely a peracute onset of clinical signs (Table 2). Progression of clinical signs was significantly associated with diagnoses of presumptive non-lymphoid neoplasia, degenerative intervertebral disc disease and ischaemic myelopathy. Cats with presumptive non-lymphoid neoplasia and degenerative intervertebral disc disease had more likely deteriorating clinical signs, while cats with ischaemic myelopathy demonstrated more likely static or improving clinical signs (Table 2).

Neurological examination findings

Neuro-anatomical localisation

The neuro-anatomical localisation was significantly associated with diagnoses of ischaemic myelopathy and FIP virus myelitis. Cats with ischaemic myelopathy had more likely a lesion localised to the C6-T2 spinal cord segments, while cats with FIP virus myelitis had more likely a multifocal neuro-anatomical localisation with intracranial involvement (Table 2).

Ambulatory status

Ambulatory status was significantly associated with diagnoses of spinal fracture and luxation and acute non-compressive nucleus extrusion. Cats with spinal fracture and luxation or acute non-compressive nucleus pulposus extrusion were more likely not ambulatory at the time of presentation (Table 2).

Presence of spinal hyperaesthesia

Presence of spinal hyperaesthesia was significantly associated with diagnoses of degenerative intervertebral disk disease, spinal fracture and luxation, ischaemic myelopathy and thoracic vertebral canal stenosis. Cats with degenerative intervertebral disk disease, spinal fracture and luxation, and thoracic vertebral canal stenosis demonstrated more likely spinal hyperaesthesia, while cats with ischaemic myelopathy demonstrated less likely spinal hyperaesthesia (Table 2).

Lateralisation of clinical signs

Presence of obviously lateralised clinical signs was significantly associated with diagnoses of ischaemic myelopathy and thoracic vertebral canal stenosis. Cats with ischaemic myelopathy and thoracic vertebral canal stenosis were more likely to demonstrate lateralisation of their clinical signs (Table 2).

Discussion

This study evaluated if discrete clinical characteristics can be used to aid in identifying the most likely differential diagnoses in cats with spinal disease. Our results suggest that the most common feline spinal disorders are statistically associated with discrete variables obtained from the clinical history, signalment, and general physical and neurological examinations. Due to the extensive list of possible diagnoses and the associated variation in prognoses of cats with spinal disease, achieving a 'most likely' differential diagnosis before carrying out further diagnostics is invaluable, particularly in the first opinion setting where finances can be a major concern. In agreement with our findings, previous studies evaluating canine spinal disease and canine and feline epilepsy highlighted how problem-based clinical reasoning enabled a diagnostic process which was focused at the level of the signalment, history, clinical signs, and neurological examination.[9-11] Clinical reasoning can be considered a thinking process in which we collect and process multiple fragments of clinical information, come to an understanding of a patient's clinical problem, and use this integrated information to plan further diagnostic and therapeutic interventions. Following this approach can help breaking down complex and potentially overwhelming clinical presentations into logical and manageable

297 cases.[25] We therefore hope that the results of this study will improve clinical decision
298 making for veterinary surgeons managing cats with spinal disease.

299 The most common feline spinal disorders in this study were presumptive non-
300 lymphoid neoplasia, followed by intervertebral disc disease, fracture and luxation, and
301 ischaemic myelopathy. Feline infectious peritonitis virus myelitis was only the fifth
302 most common spinal disorder. This finding is different from previous data suggesting
303 that FIP virus myelitis should be considered the most common spinal disorder in
304 cats.[6,8] This difference can potentially be explained by geographical differences in the
305 prevalence of spinal disorders and infectious diseases in particular. Another
306 contributing factor could be the different inclusion criteria used in studies. A previous
307 study evaluating the prevalence of spinal disorders in cats included cases for which a
308 histopathological diagnosis was available.[6] Although this inclusion criterion has the
309 clear advantage that only cases with a definitive diagnosis were included, a
310 histopathological diagnosis is typically only obtained after completion of a necropsy.
311 This inclusion criterion could therefore potentially favour the selection of cases with a
312 poor prognosis, such as FIP virus myelitis and spinal neoplasia. It should further be
313 emphasised that our study only included cats that presented for further evaluation of
314 spinal disease. Although we did not exclude cases for which the neurological
315 examination revealed abnormalities suggestive for intracranial involvement, we did
316 not include cats for which spinal disease was part of a more complex and multifocal
317 neurological presentation. Although it is possible that our study therefore represents a
318 more accurate reflection of the prevalence of feline spinal disorders in a referral
319 clinical setting, a major limitation is the lack of a definitive diagnosis in several cases.
320 This is especially true for the group of non-lymphoid spinal tumors, which was

considered the most common diagnosis in our study. This diagnosis was more common in older, non-purebred cats with deteriorating clinical signs.

For the purpose of this study, we grouped cats with spinal lymphoma into a separate disease category. The reasons for this were that spinal lymphoma has historically been considered one of the most common feline spinal disorders and that spinal lymphoma has been associated with different clinical characteristics compared to other feline spinal tumors. Lymphoma has been suggested to be the most common spinal tumor in cats, representing up to 39% of spinal tumors in this species.[26] Compared to cats with other spinal tumors, cats with lymphoma have been suggested to be younger, have a more rapid progression of clinical signs, have more often lateralised or asymmetrical neurological deficits and have more often clinical signs localised to the thoracic or lumbosacral spinal segments.[26-28] Our results however suggest that it is difficult to differentiate lymphoma from other feline spinal disorders without further diagnostics. The only clinical variable significantly associated with a diagnosis of spinal lymphoma was the presence of concurrent clinical signs and abnormalities on general physical examination. These findings are in agreement with previous suggestions that spinal lymphoma may be difficult to differentiate from other spinal disorders and that non-specific signs such as anorexia, lethargy and weight loss commonly precede neurological signs.[29] It is well-known that some common feline neurological conditions are expressions of systemic disease, which is illustrated by the fact that lymphoma, FIP virus myelitis and, spinal empyema were significantly associated with concurrent clinical signs and abnormalities on the general physical examination. The presence of such abnormalities was associated with more than thirty times the odds for the diagnoses of spinal lymphoma and FIP virus myelitis. A diagnosis of FIP virus

345 myelitis was further associated with a young age and a multifocal neuro-anatomical
346 localisation, which is in agreement with previous studies.[12,13]

347 Although the prevalence of degenerative intervertebral disc disease in the overall
348 feline population should be considered low [20,30], this was the second most common
349 spinal disorder in our study. This condition was significantly associated with middle
350 aged, purebred cats with no abnormalities detected on general physical examination
351 that developed an acute onset of progressive and painful clinical signs (Table 2).
352 These findings are in agreement with previous studies that have reported spinal
353 hyperaesthesia and progressive clinical signs in the majority of cases [20,30,31] and have
354 suggested that purebred cats, in particular Persians and British shorthairs are
355 predisposed for intervertebral disc disease.[20] Previous studies have also suggested that
356 most cats are young to middle-aged [31] with a mean age at the time of diagnosis
357 ranging from 9.5 to 9.8 years.[20,30]

358 In agreement with previous findings, spinal fracture and luxation was a common
359 cause of spinal disease in this study.[6,15] This is not surprising given the partial
360 outdoors lifestyle of most cats. This condition was associated with young cats that
361 presented with a peracute onset of a non-ambulatory neurological status and spinal
362 hyperaesthesia. Spinal fracture and luxation can be considered a severe spinal
363 emergency in cats. Surgical treatment is technically challenging, expensive and can be
364 associated with an uncertain prognosis.[15,17,32,33] It is important to realise that cats that
365 are involved in a traumatic incident can also suffer from other spinal conditions.
366 Acute non-compressive nucleus pulposus extrusion and spinal cord contusion, two
367 conditions often associated with external trauma, were also considered common
368 spinal conditions in this study.[19,21] Treatment of both conditions does not involve

surgery, and this illustrates that multiple differential diagnoses should be considered when a cat is presented after suspected spinal trauma.

Ischaemic myelopathy was the fourth most common feline spinal disorder and was, in agreement with previous studies, associated with a characteristic clinical presentation. Cats with ischaemic myelopathy were typically older and presented with stable or improving, non-painful, lateralised clinical signs.[16,34] The presence of improving clinical signs was considered the strongest clinical indicator for a diagnosis of ischaemic myelopathy (Table 2). This condition was also associated with a C6-T2 neuro-anatomical localisation, which is in agreement with previous findings.[16]

The main limitations of this study were its retrospective study design and the inclusion of cases without a histopathologically confirmed diagnosis. Although for most disease categories a diagnosis was based on previously published criteria and a board-certified neurologist reviewed all diagnostic studies, it is possible that some cases might have been incorrectly classified. It is possible that this methodology enabled inclusion of disorders with a more favourable prognosis and provided therefore a more accurate reflection of the overall caseload seen in a tertiary referral population. It should however also be emphasized that all included cats were indeed referred to a specialist referral hospital and all underwent advanced diagnostics. It is therefore possible that the prevalence of spinal disorders reported in this study cannot be reliably extrapolated to a first opinion setting. It is possible that easy to diagnose spinal conditions, such as spinal fracture/luxation, and conditions with mild clinical signs are less likely referred for further evaluation by specialists. It should further be emphasized that cats with sacrocaudal luxation or ‘tail pull injury’ were not included in his study. Although this is a commonly encountered condition, sacrocaudal

393 luxation is associated with specific clinical characteristics[35], which can be considered
394 distinct from those of cats suffering from 'other' spinal disease.

395

396 **Conclusions**

397 Variables from the clinical history, signalment, general physical and neurological
398 examinations can be systematically evaluated to construct a focused and prioritised
399 list of differential diagnoses, allowing the implementation of an appropriate
400 diagnostic and treatment approach. Not only does this help with guiding clients and
401 their expectations but can also help clinicians increasing their confidence and
402 decreasing stress when evaluating cats with suspected spinal disease.

403

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406 **Conflict of Interest**

407 The authors do not have any potential conflicts of interest to declare.

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411 **Ethical Approval**

412 This study was approved by the ethics and welfare committee of the Royal Veterinary
413 College (SR2018-1663).

Informed consent

Although no specific informed consent was required for this study, all clients had signed an informed consent during the initial consult that allowed use of the medical notes for research purposes.

References

1 Jozefowicz RF. **Neurophobia: the fear of neurology among medical students.** *Arch Neurol* 1994; 51: 328–329.

2 Abushouk AI, Duc NM. **Curing neurophobia in medical schools: evidence-based strategies**. *Med Educ Online* 2016; 21: 32476.

3 Shiels L, Majmundar P, Zywot A, et al. **Medical students attitudes and educational interventions to prevent neurophobia: a longitudinal study**. *BMC Med Educ* 2017; 17: 225.

4 Lin YW, Volk HA, Penderis J, et al. **Development of learning objectives for neurology in a veterinary curriculum: part I: undergraduates.** *BMC Vet Res* 2015; 11: 2. Doi 10.1186/s12917

5 Lin YW, Volk HA, Penderis J, et al. **Development of learning objectives for neurology in a veterinary curriculum: part II: postgraduates**. *BMC Vet Res* 2015; 11: 10. Doi:10.1186/s12917-014-0314-4.

6 Marioni-Henry K, Vite CH, Newton AL, et al. **Prevalence of disease of the spinal cord of cats**. *J Vet Intern Med* 2004; 18: 851–858.

435 7 Gonçalves R, Platt SR, Llabrés-Díaz FJ, et al. **Clinical and magnetic resonance**
436 **imaging findings in 92 cats with clinical signs of spinal cord disease**. *J Feline Med*
437 *and Surg* 2009; 11: 53–59.

438 8 Marioni-Henry K. **Feline spinal cord diseases**. *Vet Clin North Am Small Anim*
439 *Pract* 2010; 40: 1011–1028.

440 9 Cardy TJA, De Decker S, Kenny PJ, Volk HA. **Clinical reasoning in canine spinal**
441 **disease: what combination of clinical information is useful?** *Vet Rec* 2015; 177:
442 171.

443 10 Armasu M, Packer RM, Cook S, et al. **An exploratory study using a statistical**
444 **approach as a platform for clinical reasoning in canine epilepsy**. *Vet J* 2014; 202:
445 292–296.

446 11 Stanciu GD, Packer RMA, Pakozdy A, et al. **Clinical reasoning in feline**
447 **epilepsy: Which combination of clinical information is useful?** *Vet J* 2017; 225: 9–
448 12

449 12 Doenges SJ, Weber K, Dorsch R, et al. **Detection of feline coronavirus in**
450 **cerebrospinal fluid for diagnosis of feline infectious peritonitis in cats with and**
451 **without neurological signs.** *J Feline Med Surg* 2016; 18: 104–109.

452 13 Crawford AH, Stoll AL, Sanchez-Masian D, et al. **Clinicopathologic features and**
453 **magnetic resonance imaging findings in 24 cats with histopathologically**
454 **confirmed neurologic feline infectious peritonitis**. *J Vet Intern Med* 2017; 31:
455 1477–1486.

14 Rosin A. **Neurological diseases associated with lymphosarcoma in ten dogs.** *J Am Vet Med Assoc* 1982; 181: 50–53.

15 Bali MS, Lang J, Jaggy A, et al. **Comparative study of vertebral fractures and luxations in dogs and cats.** *Vet Comp Orthop Traumatol* 2009; 22: 47–53.

16 Theobald A, Volk HA, Dennis R, et al. **Clinical outcome in 19 cats with clinical and magnetic resonance imaging diagnosis of ischaemic myelopathy (2000-2011)**. *J Feline Med Surg* 2013; 15: 132–141.

17 Vallefuoco R, Manassero M, Leperlier D, et al. **Surgical repair of thoraco-lumbar vertebral fracture-luxations in eight cats using screws and polymethylmethacrylate fixation**. *Vet Comp Orthop Traumatol* 2014; 27: 306–312.

18 Adams RJ, Garosi L, Matiasek K, et al. **Acquired cervical spinal arachnoid diverticulum in a cat**. *J Small Anim Pract* 2015; 56: 285 – 288.

19 Wessmann A, McLaughlin A, Hammond G. **Traumatic spinal cord injury caused by suspected hyperflexion of the atlantoaxial joint in a 10-year-old cat**. *JFMS Open Rep* 2015; 12: 2055116915589839.

20 De Decker S, Warner AS, Volk HA. **Prevalence and breed predisposition for thoracolumbar intervertebral disc disease in cats**. *J Feline Med Surg* 2017; 19: 419–423.

21 Taylor-Brown FE, De Decker S. **Presumptive acute non-compressive nucleus pulposus extrusion in 11 cats: clinical features, diagnostic imaging findings, treatment and outcome.** *J Feline Med Surg* 2017; 19: 21–26.

22 Guo S, Lu D. **Clinical presentation, diagnosis, treatment and outcome of spinal epidural empyema in four cats (2010 to 2016)**. *J Small Anim Pract* 2018; doi: 10.1111/jsap.12943.

23 Harris G, Ball J, De Decker S. **Lumbosacral transitional vertebrae in cats and its relationship to lumbosacral vertebral canal stenosis**. *J Feline Med Surg* 2018; doi.org:10.1177/1098612X18774449.

24 Tabachnick BG, Fidell LS. **Logistic regression**. In: *multivariate statistics. 5th Ed*. Allyn & Bacon. Boston, USA; 2007 pp: 437–499.

25 Maddison JE, Volk HA. **Introduction to problem-based inductive clinical reasoning.** In: *Clinical reasoning in small animal practice*. 1st Ed. Wiley-Blackwell; 2015, pp: 1-23.

26 Marioni-Henry K, Van Winkle TJ, Smith SH, et al. **Tumors affecting the spinal cord of cats: 85 cases (1980-2005)**. *J Am Vet Med Assoc* 2008;232:237–243.

27 Spodnick GJ, Berg J, Moore FM, et al. **Spinal lymphoma in cats: 21 cases (1976–1989)**. *J Am Vet Med Assoc* 1992; 200: 373–376.

28 Lane SB, Kornegay JN, Duncan JR, et al. **Feline spinal lymphosarcoma: a retrospective evaluation of 23 cats**. *J Vet Intern Med* 1994; 8:99–104.

29 Mandara MT, Motta L, Calò P. **Distribution of feline lymphoma in the central and peripheral nervous systems.** *Vet J* 2016; 2016: 109–116.

30 Munana KR, Olby NJ, Sharp NJH, et al. **Intervertebral disc disease in 10 cats**. *J Am Anim Hosp Assoc* 2001; 37: 384–389.

498 31 Knipe MF, Vernau KM, Hornof WJ, et al. **Intervertebral disc extrusion in six**
499 **cats**. *J Feline Med Surg* 2001; 3: 161–168.

500 32 Grasmueck S, Steffen F. **Survival rates and outcomes in cats with thoracic and**
501 **lumbar spinal cord injuries due to external trauma**. *J Small Anim Pract* 2004; 45:
502 284–288.

503 33 Vallefuoco R, Bedu AS, Manassero M, et al. **Computed tomography study of**
504 **the optimal safe implantation corridors in feline thoraco-lumbar vertebrae**. *Vet*
505 *Comp Orthop Traumatol* 2013; 26: 372–378.

506 34 Simpson KM, De Risio L, Theobald A, et al. **Feline ischaemic myelopathy with**
507 **a predilection for the cranial cervical spinal cord in older cats**. *J Feline Med Surg*
508 2014; 16: 1001-1006.

509 35 Tatton B, Jeffery N, Holmes M. **Predicting recovery of urination control in cats**
510 **after sacrocaudal injury: a prospective study**. *J Small Anim Pract* 2009; 50: 593–
511 596.

512

513 **Table captions:**

514 **Table 1:** Prevalence and clinical characteristics of 221 cats with spinal disease

515 **Table 2:** Multivariate logistic regression analysis of signalment, clinical presentation,
516 and clinical examination characteristics of feline spinal disorders with more than 2
517 cases.

518

519 **Table legends:**

520 **Table 1:** P = Peracute, A = Acute, S = Subacute, C = Chronic; D = Deteriorating, S =
521 Static, Imp = Improving

522 **Table 2:** Where statistically significant ($P \leq 0.05$) data presented include Odds Ratios
523 with 95% confidence intervals (CI) indicated in parentheses