UNIVERSIDADE FEDERAL DO PAMPA
PROGRAMA DE PÓS-GRADUAÇÃO EM CIÊNCIA ANIMAL

CASOS CLÍNICOS NEUROLÓGICOS DE CÃES E GATOS – ESTUDO RETROSPECTIVO (2016-2021)

DISSERTAÇÃO DE MESTRADO

ALINE DE MOURA JACQUES

Uruguaiana, RS, Brasil
2022

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Dissertação apresentada ao programa de Pós-graduação Stricto sensu em Ciência Animal da Universidade Federal do Pampa, como requisito parcial para obtenção do Título de Mestre em Ciência Animal.

Orientador: Prof. Dr. Diego Vilibaldo Beckmann

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J19c Jacques, Aline de Moura
CASOS CLÍNICOS NEUROLÓGICOS DE CÃES E GATOS – ESTUDO RETROSPECTIVO (2016-2021) / Aline de Moura Jacques.
97 p.

Dissertação(Mestrado)-- Universidade Federal do Pampa, MESTRADO EM CIÊNCIA ANIMAL, 2022.
"Orientação: Diego Vilibaldo Beckmann".

1. Neurologia de pequenos animais. 2. Clínica de pequenos animais. I. Título.

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Área de concentração: Cirurgia e Neurologia de Pequenos Animais

Dissertação defendida e aprovada em: 23 de fevereiro de 2022.
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AGRADECIMENTOS

Agradeço a Deus por ter criado os animais, seres dignos de todo meu respeito.

Agradeço a UNIPAMPA e as agências de fomento pela oportunidade de realizar este aprimoramento profissional.

Agradeço ao meu orientador Diego pela oportunidade de realizar esse mestrado e por apresentar-se sempre solicito quando precisei.

Agradeço a minha mãe Vanderleia e minha vó Ercilia que nunca mediram esforços para possibilitar minha formação e continuam me apoiando em todas as etapas.

Agradeço a minha família e aos meus amigos pelo carinho e compreensão nos momentos de ausência.

A todos o meu muito obrigada!

RESUMO

Os casos clínicos neurológicos em cães e gatos representam um relevante número de atendimentos e ainda exigem do médico veterinário um maior conhecimento acerca das particularidades de diferentes afecções e dos possíveis recursos auxiliares ao diagnóstico existentes. O objetivo dessa dissertação foi desenvolver um estudo retrospectivo de casos clínicos neurológicos de cães e gatos atendidos no hospital veterinário de uma instituição de ensino superior entre os anos de 2016 e 2021. Os estudos retrospectivos foram realizados por meio de uma revisão dos registros clínicos neurológicos e de exames radiográficos da coluna vertebral de cães e gatos atendidos no Hospital Universitário Veterinário (HUVet) da Universidade Federal do Pampa, campus Uruguaiana-RS. A partir do levantamento realizado, foram selecionados três casos clínicos de síndrome vestibular periférica associados ao stress em cães; um caso clínico de um cão submetido à mielografia com extensa área sugestiva de mielomalácia e extravasamento de contraste extradural seguindo a raiz nervosa de L4; e exames radiográficos da coluna vertebral realizados em cães e gatos com suspeita clínica de lesão medular. O primeiro manuscrito forneceu um questionamento para o aparecimento de sinais clínicos vestibulares periféricos em cães após o estresse. A partir do segundo manuscrito, a mielografia foi capaz de identificar lesões degenerativas da raiz nervosa e medula espinhal, indicando um prognóstico ruim. Por fim, a partir do terceiro manuscrito foi possível concluir que a avaliação de forma sistemática da coluna vertebral permite maximizar os benefícios de métodos auxiliares ao diagnóstico ainda utilizados na medicina veterinária, tais como os exames radiográficos simples e contrastados.

Palavras-chave: Neurologia. Doenças neurológicas. Radiografia. Mielografia. Mielomalacia. Síndrome vestibular.

ABSTRACT

Neurological clinical cases in dogs and cats represent a relevant number of visits. Still, they require a greater knowledge of the veterinarian's particularities of different conditions and possible auxiliary resources to the current diagnosis. The objective of this dissertation was to develop a retrospective study of neurological clinical cases of dogs and cats treated at the veterinary hospital of a higher education institution between 2016 and 2021. Retrospective studies were conducted by reviewing neurological clinical records and radiographic examinations of the spine of dogs and cats treated at the Veterinary University Hospital (HUVet) of the Federal University of Pampa, Uruguaiana-RS. From the survey, three clinical cases of a peripheral vestibular syndrome associated with stress in dogs were selected; a clinical case of a dog submitted to myelography with an extensive area suggestive of myelomalacia and extradural contrast extravasation following the nerve root of L4; and radiographs exams of the spine performed in dogs and cats with clinical suspicion of spinal cord injury. The first manuscript provided a question about the appearance of peripheral vestibular clinical signs in dogs after stress. From the second manuscript, myelography was able to identify degenerative lesions of the nerve root and spinal cord, indicating a poor prognosis. Finally, from the third manuscript, it was possible to conclude that the systematic evaluation of the spine allows for maximizing the benefits of auxiliary diagnostic methods still used in veterinary medicine, such as surveys and contrasted radiographic exams.
Keyword: Neurology. Neurologic diseases. Radiography. Myelography. Myelomalacia. Vestibular syndrome.

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1 INTRODUÇÃO

A significante casuística de afecções neurológicas em cães e gatos ainda exige do médico veterinário um maior conhecimento acerca das particularidades de cada doença e dos possíveis recursos auxiliares ao diagnóstico existentes. Tendo em vista que o aprimoramento do diagnóstico e entendimento de doenças neurológicas por parte do clínico deve ser baseado em evidências científicas, indica-se a realização de estudos retrospectivos ou prospectivos com o objetivo de determinar a prevalência, a lista de possíveis diagnósticos diferenciais (CHAVES et al., 2014b, 2018), e para perceber e compreender melhor os sinais clínicos e possíveis tratamentos a serem instituídos. Embora não seja considerado uma metodologia científica de alto nível de evidência, o relato de caso também é uma importante fonte de informação capaz de fornecer subsídios fundamentais para o melhor entendimento de determinada afecção e seus possíveis tratamentos (OLLHOFF, 2004; EL DIB, 2007).

Não obstante, dentre as afeções neurológicas mais comumente relatadas em pequenos animais, encontram-se as lesões da medula espinhal. E para a elaboração da lista de possíveis diagnósticos diferenciais durante o atendimento clínico de um animal com suspeita de lesão medular é essencial que a avaliação neurológica seja realizada, tendo-se como objetivo identificar a neurolocalização das lesões, e consequentemente, os exames complementares auxiliares ao diagnóstico a serem solicitados e a melhor conduta terapêutica (DEWEY; DA COSTA, 2016). Isso acarreta na necessidade de avaliar a coluna vertebral por diferentes exames de imagem que proporcionem a melhor identificação de estruturas para o momento, ou seja, a avaliação das estruturas ósseas através de exames radiográficos ou dos tecidos moles adjacentes através de tomografia computadorizada ou ressonância magnética. Embora a maioria das desordens medulares não possam ser caracterizadas com o uso de radiografias da coluna vertebral devido as limitações existentes nesse tipo de exame, essas sempre devem ser feitas antes dos métodos de imagem avançada.

Essa dissertação envolveu o estudo de casos clínicos neurológicos em cães e de exames radiográficos da coluna vertebral de cães e gatos com suspeita clínica de lesão medular. A pesquisa foi realizada por meio de revisão dos registros clínicos neurológicos e de exames radiográficos da coluna vertebral de cães e gatos atendidos no Hospital Universitário Veterinário (HUVet) da Universidade Federal do Pampa, campus Uruguaiana-RS. A partir do levantamento feito foram selecionados três casos clínicos de sinais clínicos vestibulares periféricos em cães relacionados ao stress, um caso clínico de extravasamento de contraste extradural durante a mielografia em um cão com mielomalacia ocasionada por lesão a medula espinhal pela presença de uma neoplasia extradural, e exames radiográficos simples e contrastados da coluna vertebral realizados em cães e gatos com suspeita clínica de lesão medular.

Deste modo, o objetivo do presente trabalho foi desenvolver estudo retrospectivo de casos clínicos neurológicos de cães e gatos atendidos no hospital veterinário de uma instituição de ensino superior entre os anos de 2016 e 2021.

2 REVISÃO DE LITERATURA

2.1 Síndrome vestibular

O sistema vestibular é responsável pela manutenção da postura e do equilíbrio em relação à cabeça e o corpo, e é divido em componentes centrais e periféricos (KENT; PLATT; SCHATZBERG, 2010; ROSSMEISL JR, 2010; DEWEY; DA COSTA, 2016). O sistema vestibular periférico é composto pelo VIII par de nervos cranianos (nervo vestibulococlear), seus receptores, gânglios, axônios (THOMAS, 2000) e está localizado na orelha interna, coletando informações e transmitindo ao sistema vestibular central (DE LAHUNTA; GLASS; KENT, 2014).

A doença vestibular é um distúrbio neurológico, de alta prevalência em pequenos animais (KENT; PLATT; SCHATZBERG, 2010; CHAVES et al., 2014a) causada por disfunção do sistema vestibular (ROSSMEISL JR, 2010; DEWEY; DA COSTA, 2016). Quando ocorre de forma periférica, são causadas principalmente por afecções otológicas ou de origem idiopática (ROSSMEISL JR, 2010; BONGARTZ et al., 2020). Podendo ocorrer também por ototoxicidade, hipotireoidismo (VITALE; OLBY, 2007; RUSGTON; LESCHNIK; NELL, 2013; UTSUGI; SAITO; SHELTON, 2014), congênita, por pólipos ou neoplásica (ROSSMEISL JR, 2010). Quanto aos sinais clínicos, geralmente são unilaterais e comumente incluem perda de equilíbrio, rolagem assimétrica, inclinação ou queda, ataxia, inclinação da cabeça, nistagmo e/ou estrabismo (THOMAS, 2000; BRANDT; STRUPP, 2005; DE LAHUNTA; GLASS; KENT, 2014; DEWEY; DA COSTA, 2016).

A síndrome vestibular idiopática (SVI) é uma desordem neurológica de causa desconhecida secundária a uma lesão que afeta os receptores vestibulares (ROSSMEISL JR, 2010; BONGARTZ et al., 2020), mais comumente relatada em cães com idade média de 12 anos (ROSSMEISL JR, 2010). O diagnóstico é baseado na ausência de qualquer doença estrutural, metabólica ou inflamatória detectável, bem como pela falta de evidência de doença vestibular central (DEWEY; DA COSTA, 2016). Por ser uma condição benigna, geralmente se resolve espontaneamente em algumas semanas (ROSSMEISL JR, 2010; BONGARTZ et al., 2020); no entanto, uma inclinação residual da cabeça pode persistir (ROSSMEISL JR, 2010).

Não há evidencias de que a terapia com anti-inflamatórios esteroidais e não-esteroidais influenciem na recuperação no paciente (ROSSMEISL JR, 2010), sendo indicado terapia de suporte aos animais que apresentam náuseas e vômitos associados a essa condição (ROSSMEISL JR, 2010; FOTH et al., 2021).

2.2 Mielomalacia

Mielomalacia hemorrágica progressiva (MHP) é um termo patológico que se refere ao infarto isquêmico e hemorrágico da medula espinhal resultante de necrose hemorrágica e liquefativa (MARQUIS et al., 2005; BALDUCCI et al., 2017), que pode ocorrer como sequela de uma lesão medular aguda (LU; LAMB; TARGETT, 2002), tais como extrusão do disco intervertebral, trauma medular e embolismo fibrocartilaginoso (BRAUND, 2003).

O mecanismo não é completamente compreendido, mas acredita-se ser o resultado de efeitos concussivos e compressivos na medula espinhal (MARQUIS et al., 2015; HENKE et al., 2016; BALDUCCI et al., 2017; CASTEL et al., 2017), ocasionados por trauma, isquemia e liberação de substâncias vasoativas, radicais livres de oxigênio e enzimas celulares (GEBARSKI et al., 1995). A MHP inicia-se no local da lesão e progride de forma ascendente e descendente (PLATT; MCCONNELL; BESTBIER, 2006; HENKE et al., 2016), refletindo envolvimento de extensas regiões da substância cinzenta da medula espinhal (OLBY et al., 2003).

O tempo de início é variável, no entanto, a maioria dos cães mostra sinais de mielomalacia dentro de 72 horas após a lesão (CASTEL et al., 2017). Os sinais clínicos iniciam-se com paraplegia aguda e reflexos espinhais aumentados nos membros pélvicos. Após 48 a 72 horas, a paraplegia torna-se flácida, com atonia dos músculos dos membros pélvicos, flacidez da cauda e dilatação do ânus, com ausência do reflexo perineal (DE LAHUNTA; GLASS; KENT, 2014). À medida que a lesão progride cranial e caudalmente, há tetraplegia, flacidez em musculatura abdominal e membros torácicos flácidos e presença de dor à manipulação em região torácica ou cervical. A respiração torna-se diafragmática e pode ocorrer síndrome de Horner bilateral. A síndrome medular identificada inicialmente se altera, sendo que uma lesão inicial diagnosticada como de neurônio motor superior (NMS) para os membros posteriores torna-se do tipo neurônio motor inferior (NMI) (SHARP; WHEELER, 2005). Com a progressão ascendente ocorre perda progressiva do reflexo cutâneo do tronco e os membros torácicos também passam a apresentar alterações compatíveis com lesão do tipo NMI (DENNY; BUTTERWORTH, 2006).

O diagnóstico de mielomalacia é baseado na história clínica; apresentação de sintomas neurológicos progressivos da coluna vertebral; achados de exames complementares, como mielografia, ressonância magnética e tomografia computadorizada; descobertas post-mortem; e o exame histopatológico (LU; LAMB; TARGETT, 2002; NEGRIN; SCHATZBERG; PLATT, 2009). Certos sinais mielográficos que sugerem mielomalácia podem ser observados durante a investigação da causa da paraplegia. O edema da medula espinhal (DUVAL et al., 1996) e o meio de contraste no parênquima da medula espinhal (ROBERTS; SELCER, 1993) foram descritos como sinais de mielomalácia (LU; LAMB; TARGETT, 2002).

Como nenhum tratamento para mielomalacia hemorrágica progressiva está disponível, o prognóstico é ruim (OLBY et al., 2016). Sendo que o óbito do animal ocorre de sete a dez dias a partir do início dos sinais e é causado por paralisia respiratória (BRAUND, 2003). Já a mielomalacia localizada não é acompanhada de sinais clínicos progressivos; e ainda que o prognóstico para estes pacientes possa ser ruim, a melhora da função neurológica é possível (PLATT; MCCONNELL; BESTBIER, 2006).

2.3 Exames de auxílio ao diagnóstico

2.3.1 Exame radiográfico simples

A radiografia simples é considerada uma rápida ferramenta de triagem para alterações ósseas óbvias (DEWEY; DA COSTA, 2016), sendo utilizada como forma de diagnóstico ou para excluir afecções (DENNIS et al., 2010; KEALY; MCALLISTER; GRAHAM, 2012; WIDMER; THRALL, 2014). No entanto, devido a sua incapacidade de definir tecidos moles, é necessário a utilização de meios de contrastes e exames de imagem mais avançados, tais como tomografia computadorizada e ressonância magnética (HECTH et al., 2009; KEALY; MCALLISTER; GRAHAM, 2012).

O exame radiográfico simples da coluna vertebral deve ser realizado em no mínimo duas projeções, e quando executado em paciente não anestesiado muitas vezes é considerado de qualidade diagnóstica questionável, em função do posicionamento ruim e de movimento do animal (BURK, 1989; DEWEY; DA COSTA, 2016). É indicado para o diagnóstico de luxações, fraturas, discoespondilite, doença articular degenerativa, colapso dos espaços intervertebrais, anomalias vertebrais congênitas e neoplasias vertebrais (GAVIN; LEVINE, 2015; DEWEY; DA COSTA, 2016).

Normalmente tumores de tecidos moles não são aparentes nesse tipo de exame, exceto no caso de tumores de bainha de nervo, onde o nervo espessado pode acarretar no aumento do tamanho do forame, e isto deve ser visto radiograficamente (BAGLEY; GAVIN; HOLMES, 2009; KEALY; MCALLISTER; GRAHAM, 2012; WIDMER; THRALL, 2014). Já os tumores epidurais invadem o corpo vertebral antes de atingir a medula espinhal, sendo a destruição vertebral identificada através da radiografia um elemento indicativo de uma neoplasia (BAGLEY; GAVIN; HOLMES, 2009).

2.3.2 Mielografia

A mielografia é um exame de diagnóstico por imagem invasivo, a qual consiste na obtenção de radiografias da coluna vertebral após a injeção de agente de contraste radiopaco no espaço subaracnoide da cisterna magna ou lombar (DEWEY; DA COSTA, 2016), entre L5-L6 (preferencialmente), L4-L5 ou L6-L7 (ONDANI; DE JESUS BRASIL; LATARO, 2011). É utilizada no diagnóstico de mielopatias (KEALY; MCALLISTER; GRAHAM, 2012; DEWEY; DA COSTA, 2016) e é indicada para localização, extensão e confirmação de lesão suspeita identificada anteriormente ou não em radiografias convencionais (ONDANI; DE JESUS BRASIL; LATARO, 2011; DEWEY; DA COSTA, 2016).

Para a realização da mielografia é imprescindível o uso de anestesia geral, portanto, devem ser verificados histórico de convulsões, reações anteriores a drogas anestésicas, estado geral do paciente, além do conhecimento das alterações hemodinâmicas proporcionadas pelos fármacos com a finalidade de escolher a associação mais segura para o animal (DENNIS et al., 2010; TRANQUILLI; THURMON; GRIMM, 2013; WIDMER; THRALL, 2014; DEWEY; DA COSTA, 2016). Ademais, independentemente do tipo anestésico utilizado, os animais submetidos a esse tipo de exame devem ser intubados e receberem um suporte de oxigênio durante todo o procedimento (GREENE; HARVEY; SIMS, 1999).

Por muito tempo utilizou-se a mielografia como exame diagnóstico padrão para identificar compressões medulares em cães, sendo considerada a principal modalidade de imagem utilizada para o diagnóstico de doença do disco intervertebral em pequenos animais com o objetivo de identificar quaisquer desvios que possam refletir o local de uma lesão medular (ROBERTSON; THRALL, 2011; WIDMER; THRALL, 2014). Por conseguinte, a possibilidade de uma visualização mais rápida e fácil de toda a medula espinhal e o seu menor custo são vantagens da mielografia sobre outros procedimentos de diagnóstico por imagem (DEWEY; DA COSTA, 2016). Todavia, essa técnica é contraindicada em casos de doença infecciosa e inflamatória, em casos de suspeita de aumento da pressão intracraniana, epilepsia e desidratação (KEALY; MCALLISTER; GRAHAM, 2012; DEWEY; DA COSTA, 2016). E possui como limitação a visualização de lesões lateralizadas ou intraforaminais (BRISSON, 2010) e na incapacidade de distinção de alterações do parênquima medular (COOPER et al., 2014).

Para realização da mielografia utiliza-se um meio de contraste hidrossolúvel, iodado e não iônico (BRAUND, 2003), sendo o ioexol e o iopamidol os mais comuns (DEWEY; DA COSTA, 2016). A punção realizada na cisterna magna possui como vantagens a facilidade na sua execução, o volume de líquor a ser coletado e o preenchimento do segmento cervical com o meio de contraste (PAITHANPAGARE et al., 2008). No entanto, depende-se da gravidade e do movimento do líquor cefalorraquidiano para ocorrer o preenchimento dos segmentos torácicos e lombares (PAITHANPAGARE et al., 2008), além do que, existe a possibilidade de o contraste não ultrapassar a lesão espinhal (GAVIN; LEVINE, 2015), assim como, a possibilidade de ocorrer deslocamento do mesmo em direção ao encéfalo e/ou, raramente, lesão da medula espinhal cervical ou tronco encefálico causada pela agulha de forma iatrogênica (DA COSTA; PARENT; DOBSON, 2011).

Já a punção lombar permite que o contraste se desloque cranialmente sob pressão e por esse motivo pode delimitar mais facilmente as lesões (PAITHANPAGARE et al., 2008), e muitas vezes resulta em uma imagem de melhor qualidade (DEWEY; DA COSTA, 2016). Porém é uma técnica que se exige mais treinamento, sendo usualmente associada a complicações, tais como, transfixação da medula espinhal e aplicação do contraste no espaço epidural (BRAUND, 2003; GAVIN; LEVINE, 2015), gerando uma imagem de epidurografia, a qual não delimita o exato local da lesão (SHARP; WHEELER, 2005).

A piora do estado neurológico pós-mielografia costuma ser ocasionada por mielite química transitória, secundária à injeção de contraste (DEWEY; DA COSTA, 2016). Outros efeitos adversos que podem ser observados são crises convulsivas reativas em cães submetidos ao procedimento (DEWEY; DA COSTA, 2016), assistolia e hemorragia subaracnóidea (BRISSON, 2010). Além disso, para a realização da projeção ventrodorsal da região cervical, existe a necessidade de extubação do paciente, colocando-o em risco anestésico (AESCHBACHER, 2010).

Em geral, as colunas de contraste correm paralelamente entre si e tomam a forma do canal vertebral, exceto na região da cauda equina, local onde o espaço subaracnóideo se afunila (DEWEY; DA COSTA, 2016). As lesões medulares visualizadas na mielografia são classificadas em: extradurais, intradurais-extramedulares e intramedulares (BRAUND, 2003). O padrão de lesão extradural caracteriza-se pela atenuação e desvio da coluna de contraste no local da lesão em direção ao centro do canal vertebral, o qual ocorre nos casos de protrusão/extrusão do disco intervertebral (BRISSO, 2010), fratura/luxação vertebral, anomalias vertebrais congênitas, hipertrofias de estruturas de tecidos moles e hemorragia extradural (DEWEY; DA COSTA, 2016). Já os desvios da coluna de contraste, em projeções laterolaterais, dentro do canal vertebral são indicativos de processo neoplásico (BAGLEY; GAVIN; HOLMES, 2009; BAGLEY, 2010).

No padrão intradural-extramedular, atribui-se a imagem chamada pino de golfe em projeções laterolaterais (BAGLEY, 2010), a qual é formada devido a uma falta de preenchimento de contraste associado a uma dilatação da coluna de contraste (MCCONNELL, 2012). É mais frequentemente associado a neoplasias, sobretudo meningiomas e tumores da bainha nervosa; e menos comumente, quando ocorre hemorragia intradural (DEWEY; DA COSTA, 2016). Além disso, lesões intradurais-extramedulares podem produzir uma tumefação da medula espinhal a ponto de excluir o contraste da região da massa, parecendo intramedular; nesses casos indica-se a realização da tomografia computadorizada para confirmar o diagnóstico (KEALY; MCALLISTER; GRAHAM, 2012; DEWEY; DA COSTA, 2016).

Por fim, no padrão intramedular há divergências das colunas de contraste, as quais ficam mais estreitas provocadas pelo aumento de volume da medula espinhal adjacente (MCCONNELL, 2012), tipicamente associado a edema medular, massas parenquimatosas expansivas ou hemorragia intraparenquimatosa (DEWEY; DA COSTA, 2016). Além da tumefação aparente da medula espinhal na mielografia, o extravasamento de contraste para o interior do parênquima medular pode ser visualizado em casos de mielomalacia (DEWEY; DA COSTA, 2016).

3 OBJETIVOS

3.1 Objetivo geral

Desenvolver estudo retrospectivo de casos clínicos neurológicos de cães e gatos atendidos no hospital veterinário de uma instituição de ensino superior entre os anos de 2016 e 2021.

3.2 Objetivos específicos

Os objetivos específicos do estudo retrospectivo consistem em:

1. Relatar três casos clínicos de síndrome vestibular periféricos associados ao stress em cães.
2. Relatar um caso atípico de extravasamento de contraste extradural durante a mielografia de um cão com mielomalacia causada por lesão indireta a medula espinhal pela presença de uma neoplasia extradural.
3. Avaliar e caracterizar as alterações radiográficas da coluna vertebral de cães e gatos com suspeita clínica de lesão medular no período de janeiro de 2016 a dezembro de 2021.
4. Colaborar com as futuras avaliações de exames radiográficos da coluna vertebral de cães e gatos através da utilização do formulário de avaliação sistemática da coluna vertebral.

4 MANUSCRITO 1

Should stress be associated with peripheral vestibular clinical signs in dogs?

Aline de Moura Jacques, Diego Vilibaldo Beckmann

(Artigo a ser submetido para publicação na revista **Research in Veterinary Science**)

Should stress be associated with peripheral vestibular syndrome in dogs?

Aline de Moura Jacques, Diego Vilibaldo Beckmann

Highlights

- Involvement of stress in canine idiopathic vestibular syndrome
- Stress-related to peripheral vestibular clinical signs in three dogs
- Stress-mechanism could be related to peripheral vestibular clinical signs in dogs
- Acute peripheral vestibular in dogs with resolution at 2-3 weeks
- Different sources of stress-related peripheral vestibular signs in dogs

Abstract

Dogs with peripheral vestibular clinical signs are commonly observed in veterinary practice. This short communication describes the acute peripheral vestibular clinical signs associated with stress in three dogs with fast, gradual, and spontaneous recovery without treatment. Three dogs were referred to the veterinary hospital with vestibular signs, such as ataxia, right head tilt, and nystagmus after stressful events. The lesion localization was peripheral vestibular, and the idiopathic vestibular syndrome (IVS) diagnosis was confirmed by combining clinical presentation, neurological examination findings, and complementary tests without alterations. Due to the similarity between the canine IVS and some PVS in humans associated with stress, the mechanism that occurred in the three dogs may have been similar. Finally, it is suggested that retrospective and prospective studies are needed to highlight this possible association.

Keywords: canine, stress hormones, peripheral nervous system, stressful event, vascular, idiopathic vestibular disease, peripheral vestibular syndrome, vestibular disease.

Peripheral vestibular syndrome (PVS) in dogs is characterized by a dysfunction of the peripheral components of the vestibular system responsible for maintaining equilibrium and balance (Radulescu et al., 2020). The clinical manifestations are head tilt, positional strabismus, pathological nystagmus, and vestibular ataxia (Foth et al., 2021a;).

The causes of PVS in dogs were idiopathic vestibular syndrome (IVS), otitis media/interna, neoplasia affecting the inner ear structures, congenital malformation/degeneration of the inner ear, hypothyroid-associated neuropathy, head trauma, and ototoxicity (Bongartz et al., 2020; Foth et al., 2021a). The relationship between human PVS (such as benign paroxysmal positional vertigo, Ménière's disease, vestibular neuritis, and idiopathic sudden sensorineural hearing loss) and stress is already established by stress hormonal action direct or ischemic injury indirect to the peripheral vestibular system (Bae et al., 2022; Canlon et al., 2007; Chae et al., 2021; Choi and Kim, 2021; Lee et al., 2002; Monzani et al., 2006; Saman et al., 2020; Söderman et al., 2004; Steenerson, 2021; Tigno et al., 2017; Yeo et al., 2018).

The four stress-related human PVS share similarities with canine IVS (Foth et al., 2021a). Thus, this short communication describes the acute peripheral vestibular clinical signs associated with stress in three dogs with fast, gradual, and spontaneous recovery without treatment.

Three dogs were referred to the University Veterinary Teaching Hospital presenting peripheric vestibular signs subsequently stressful events: dog 1 (13-year-old female German Shepherd) - exposure to the sun for a long period on a hot day with an abrupt temperature change; dog 2 (15-year-old male Mixed Breed) - running away from home during a stormy night due to recurring fear of thunderstorms and returning wet; and dog 3 (14-year-old male Maltese) - separation-related problem with decreased appetite due to absence of owner for four days.

On neurological examination, the dogs were alert, with the preserved proprioceptive evaluation, vestibular ataxia, right head tilt, and nystagmus (rotational in dog 1 and horizontal in dogs 2 and 3). The lesion localization was peripheral vestibular in the three dogs, which underwent hematological and serum biochemical tests, otoscopy, and careful inspection/palpation of the head, pharyngeal region, ears, and lymph nodes. No changes were found in the examinations performed, and the main clinical suspicion was IVS in the three dogs (Foth et al., 2021a).

The owners of the three dogs were instructed to observe their dogs at home and return immediately to the veterinary hospital in case of worsening clinical signs. Dogs 1 and 2 were medicated with ondansetron 1.6 mg/kg PO q 12 hours to relieve nausea for three and five days, respectively (Foth et al., 2021b). The dogs recovered fastly, gradually, and spontaneously. In dogs 1 and 2, the remission of vestibular signs was total in fourteen days and ten days, respectively, and dog 3 remained with a slight head tilt after three weeks.

The fast, gradual, and spontaneous recovery corroborated the IVS diagnosis (Foth et al., 2021a). According to recent telephone contact with the owners, dogs 1 and 3 died approximately one year after the IVS owed to bone marrow aplasia and unrelated disease/unknown causes, respectively. Dog 2 was alive and without neurological disorders at the telephone call time (two years after IVS). Furthermore, the owners were pleased since the animals had returned to their normal functions without neurological clinical manifestations afterward.

This case series described the occurrence of IVS in three dogs with acute peripheral vestibular clinical signs associated with stress. The clinical presentation, neurological findings, and complementary exams were used to diagnose the canine IVS for the three dogs (Bongartz et al., 2020; Boudreau et al., 2018; Foth et al., 2021a). Even if other more technological tests, such as MRI, had been performed, this diagnosis would not change. Moreover, the diagnosis of

IVS did not limit the importance of demonstrating the relationship of the acute vestibular clinical signs following stressful events, even if it is hard to confirm. Thus, the proposal was to bring dogs with PVS associated with stress with fast, gradual, and spontaneous recovery without treatment, regardless of the cause/diagnosis.

Human PVS associated with stress include benign paroxysmal positional vertigo, Ménière's disease, vestibular neuritis, and idiopathic sudden sensorineural hearing loss are similar to canine IVS (Foth et al., 2021a). The stress causes/triggers the PVS in humans through the secretion of stress hormones (cortisol, growth hormone, aldosterone, antidiuretic hormones [ADH], and adrenocorticotrophic hormone [ACTH]) which can interfere with the inner ear blood flow and result in anterior vestibular artery ischemia as a response to the stressful event (Bae et al., 2022; Canlon et al., 2007; Chae et al., 2021; Choi and Kim, 2021; Lee et al., 2002; Monzani et al., 2006; Saman et al., 2020; Söderman et al., 2004; Steenerson, 2021; Tigno et al., 2017; Yeo et al., 2018). Since this relationship exists in humans, the association of stress with peripheral vestibular clinical signs in the three dogs can be justified.

The term "stress" refers to a reaction of the organism to a stimulus or event that represents a potential threat and can negatively influence health, behavior, and longevity (Karatsoreos and McEwen, 2011; Landsberg et al., 2015). In dogs, stress has been related to different origins and clinical manifestations (Forsgård et al., 2019; Fox and Donovan, 2020). There are different stressful situations: extreme environmental conditions observed in cases where the animal is subjected to high ambient temperatures, such as heat stress suffered by dog 1 (Hall et al., 2020); noise sensitivity, where the dog 2 probably reacted to loud noises provoked by thunderstorms that stormy night (Tiira et al., 2016); the absence of the owner experienced by the dog 3 which is defined as physical, physiological, and/or behavioral signs of the distress exhibited (Overall, 2013). Furthermore, due to inadequate thermoregulation, elderly dogs are more prone to develop different clinical manifestations associated with heat stress (Mattin et al., 2015).

Some limitations of this short communication should be noted: (1) the small number of dogs; (2) and the impossibility of confirming the role of stress as a triggering mechanism, causative mechanism, or a consequence of peripheral vestibular clinical signs.

The diagnosis was established as IVS for the three dogs due to fast, gradual, and spontaneous recovery without treatment. This work brings the possible association of PVS to stress in dogs, regardless of the cause. Moreover, due to the similarity between the canine IVS and some PVS in humans associated with stress, the three dogs' peripheral vestibular clinical signs that occurred after stressful events may have been similar. Retrospective and prospective studies should be conducted in different centers with more dogs to clarify the relationship between vestibular clinical manifestations and stress.

Acknowledgments

The authors would like to thank the Brazilian governmental agencies CAPES (Coordenação de Aperfeiçoamento de Pessoal de Nível Superior) for financial support.

Conflicts of interest

The authors declare no conflict of interest.

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5 MANUSCRITO 2

Extradural contrast extravasation during the myelography in a dog with myelomalacia caused by chondrosarcoma

Aline de Moura Jacques, Diego Vilibaldo Beckmann

(Artigo a ser submetido para publicação na revista **Research in Veterinary Science**)

Extradural contrast extravasation during the myelography in a dog with myelomalacia caused by chondrosarcoma

Aline de Moura Jacques[1], Diego Vilibaldo Beckmann[1].

Highlights

- Survey spinal radiography in a dog
- Functional alteration or obstruction vascular of the spinal cord in a dog
- Nerve root degeneration in a dog
- Chondrosarcoma extradural in a dog

Abstract

A five-year-old mixed-breed paraplegic dog with loss of deep pain perception and spinal cord injury in the L4-S3 segment was referred to the veterinary hospital. The dog was undergoing myelography, which revealed edema, an area suggestive of myelomalacia, and contrast extravasation at the origin of the L4 nerve root. This atypical case of extradural contrast extravasation accompanying the anatomical region of the L4 nerve root indicated a degenerative process associated with the myelomalacia, resulting in a poor prognosis. Finally, necropsy confirmed these findings, probably caused by vascular changes related to extradural chondrosarcoma in the region of L5.

Key Words: canine; degeneration; spinal cord; ischemia; nerve root; vascular alteration.

Introduction

Myelography is a radiographic technique widely used imaging exam that allows for localization and extension of a spinal lesion (Bach et al., 2019; Bismuth et al., 2014; da Costa et al., 2020; Delamaide Gasper et al., 2014; Dewey and Da Costa, 2016). This exam can also identify compressive injuries directly or indirectly of the spinal cord caused by intervertebral disc disease, vertebral fracture/luxation, congenital vertebral anomalies, and neoplasms (Bagley, 2010; Brisson, 2010; Dewey and Da Costa, 2016).

Edema, hemorrhage, and myelomalacia are some of the changes found in myelography (Dewey and Da Costa, 2016; Robertson and Thrall, 2011). The divergences in the contrast columns, contrast extravasation into the spinal cord parenchyma, and apparent spinal cord swelling on myelography can be seen in cases of myelomalacia, which has vascular involvement and maybe hemorrhagic or ischemic in origin (de Lahunta et al., 2015; Dewey and Da Costa, 2016; Lu et al., 2002; McConnell, 2012).

Among them, spinal cord neoplasms can be evidenced in different patterns of myelography (Bagley, 2010; da Costa and Samii, 2010; Dewey and DaCosta, 2016). In extradural tumors, one or both contrast columns may be displaced towards the center of the vertebral canal, indicating spinal compression, especially when superimposed on a vertebral body (Bagley, 2010). Intradural-extramedullary patterns outline the tumor and expansion of the subarachnoid space (Rizzo et al., 2008). Finally, intramedullary tumors often cause spinal cord expansion and edema (Bagley, 2010).

This report describes an atypical case of extradural contrast extravasation extensive from the subarachnoid space of the right L4 nerve root and myelomalacia caused by a degenerative spinal cord process in a paraplegic dog submitted myelography.

Case report

A five-year-old intact female mixed-breed dog weighing 12.1 kg was presented to the hospital to investigate acute paraplegia for approximately 12 hours without trauma history. Four hours before the paraplegia, the owner observed lameness of the left pelvic limb. The neurological findings were flaccid paralysis with loss of deep pain perception and decreased patellar and withdrawal reflexes (lower motor neuron signs) in the pelvic limbs. For this reason, the localization of the spinal cord injury was in the lumbosacral segment (L4–S3) (Dewey and DaCosta, 2016).

The differential diagnoses included intervertebral disc disease, fibrocartilaginous embolic myelopathy, primary or secondary spinal tumor, and spinal trauma (fracture/luxation) (Dewey and DaCosta, 2016). Immediately to the neurologic examination, due to the severity of the clinical signs and considering the possibility of the spinal cord decompression surgery, the dog was anesthetized and underwent survey radiographs and myelography of the lumbosacral spine.

Survey radiographs (Figures 1A and 1B) reveal no compatible alterations with vertebral fractures or luxations in the lumbar spine. Myelography was performed via lumbar puncture (L5-L6) and iohexol contrast injection (Omnipaque®) into the subarachnoid space at the dose of 0.4 mL/kg (total volume 4.8 mL) (Dewey and DaCosta, 2016). A radiograph to confirm the spinal needle and the contrast into the subarachnoid space revealed contrast extravasation at the origin of the L4 nerve root (Figures 1C and 1D).

Lumbar spine radiographs (Figure 2) were obtained at the left lateral view (Figure 2A), ventrodorsal view (Figure 2B), and right and left ventrodorsal obliques views (Figures 2C and 2D) immediately after the injection of all contrast volume. Myelography revealed attenuation of contrast columns between T12 and L3, indicating edema in four vertebral bodies; extensive area suggestive of myelomalacia with the presence of contrast extravasation into the spinal cord parenchyma between L4-L6; and evidence of the continuous and homogeneous extradural contrast greater than two times the size of the vertebral body of L2 vertebra (Figure 2).

The myelography findings indicated a degenerative process of the spinal cord and a poor prognosis for functional recovery of the spinal cord since there is no effective clinical or surgical treatment (Balducci et al., 2017; Castel et al., 2017; Henke et al., 2016; Lu et al., 2002). The owner was informed of the diagnosis and the severity of the spinal cord injury, which may lead to fecal and urinary dysfunction later on (Balducci et al., 2017; Castel et al., 2017; Dewey and DaCosta, 2016). The owner decided to take care of the animal for emotional reasons, even aware of the essential intensive care.

The owner brought the animal to euthanasia a week later owing to the difficulty in performing home care such as manual bladder compression. The necropsy confirmed (1) extensive area of myelomalacia in the lumbar region between T12-L6 with edema areas, accentuated neuronal loss, and hemorrhage (Figures 3A and 3C); (2) degeneration and accentuated vacuolization of nerve roots and spinal branches (Figure 3A) and; (3) extradural chondrosarcoma, located on the ventral floor of the vertebral canal of the fifth lumbar vertebra, measuring 1.5x0.8x0.3 cm (Figures 3B and 3D). The extradural chondrosarcoma did not compress the spinal cord; however, it had sufficient consistency to promote the vascular degenerative process of the spinal cord and nerve roots.

Discussion

The present report reveals an atypical case of extradural contrast extravasation extensive from the subarachnoid space of the right L4 nerve root in a paraplegic dog with loss of deep pain perception submitted to myelography. The contrast extravasation accompanying the anatomical region of the L4 nerve root (De Lahunta et al., 2014) was greater than two times the size of the vertebral body of the L2 vertebra. Probably, this contrast extravasation was due to the degenerative process of the L4 nerve root, confirmed at necropsy.

The presence of contrast in the spinal cord parenchyma between L4-L6 corresponds to an extensive area of myelomalacia, and the attenuation of contrast columns between T12 and L3 indicates edema (Lu et al., 2002). When associated with the contrast extravasation, these alterations are related to severe spinal cord injuries and poor prognosis (Balducci et al., 2017; Castel et al., 2019; Hay and Muir, 2000; Lu et al., 2002; Olby et al., 2020). Slight contrast extravasation of the nerve root with tearing of the duramater and spinal cord hemorrhage was reported in a dog with a traumatic history (Hay and Muir, 2000). However, in our case, the extradural contrast extravasation showed more extensive with intact sheath nerves and duramater.

The lesions to the ventral spinal artery and/or from the lumbar artery's spinal branch were probably capable of promoting the degenerative process of the right L4 nerve root and myelomalacia. The ventral spinal artery in dogs supplies the ventral two-thirds of the lumbar spinal cord (Pais et al., 2007), which is irrigated by the ventral spinal branches of the lumbar artery (Fletcher and Kitchell, 1966), and analogous to the anterior spinal artery in humans (Castel et al., 2017; Pais et al., 2007). Functional alteration or obstruction of the anterior spinal artery promoted myelomalacia in humans (Bahadır et al., 2020; Reynolds et al., 2014) and ischemic degeneration and apoptosis of nerve roots in rabbits experimental models (Kanat et al., 2017; Kilic et al., 2018; Ozturk et al., 2015; Turkmenoglu et al., 2017).

Besides, ischemic myelopathy was reported in humans due to injury to the Adamkiewicz artery, which supplies the anterior two-thirds of the spinal cord in the thoracolumbar region (Koshino et al., 1999; Rodriguez-Baeza et al., 1991). The Adamkiewicz artery is considered equivalent to the great ventral medullary artery present in approximately 50% of dogs (Caulkins et al., 1989; Pais et al., 2007). However, the great ventral medullary artery cannot be identified in our patient due to anatomical changes caused by neoplasm located precisely in the region of the great ventral medullary artery, which originates between the L4 and L6 vertebrae, most often to the left of the L5 spinal artery, and supplies the ventral spinal artery (Caulkins et al., 1989; Pais et al., 2007). Therefore, damage to the great ventral medullary artery can also trigger ischemia at the site of the ventral spinal artery, causing the cycle of vascular injury that results in myelomalacia (Balducci et al., 2017; De Lahunta et al., 2014).

The compression did not cause a direct injury to the spinal cord, but this occurs by the alteration in the elastic capacity of the ventral spinal artery or spinal branch of the lumbar artery, or both, leading to ischemia and necrosis (Balducci et al., 2017; De Lahunta et al., 2014; Fingeroth and Thomas, 2015). The ischemic mechanism relating neoplasm with myelomalacia was previously reported in a horse with epidural lymphosarcoma (Rousseaux et al., 1989) and a human with peripheral nerve sheath tumor (Zaninovich et al., 2019). However, the association of extradural neoplasm, myelomalacia, and extensive contrast extravasation in literature was not found in myelography in dogs.

Conclusion

Myelography was able to identify extradural contrast extravasation accompanying the anatomical region of the L4 nerve root and myelomalacia caused by a degenerative process of the spinal cord as a result of probable vascular changes. Studies relating to the possible vascular changes of the spinal cord with myelomalacia are already being performed (Balducci et al., 2017; Castel et al., 2019; De Lahunta et al., 2014). Therefore, research about these alterations evidenced in myelography is essential and allows the supply of relevant information to veterinary clinicians who still use this imaging method.

Acknowledgments

The authors would like to thank the Brazilian governmental agencies CAPES (Coordenação de Aperfeiçoamento de Pessoal de Nível Superior) for financial support.

Conflicts of interest

The authors declare no conflict of interest.

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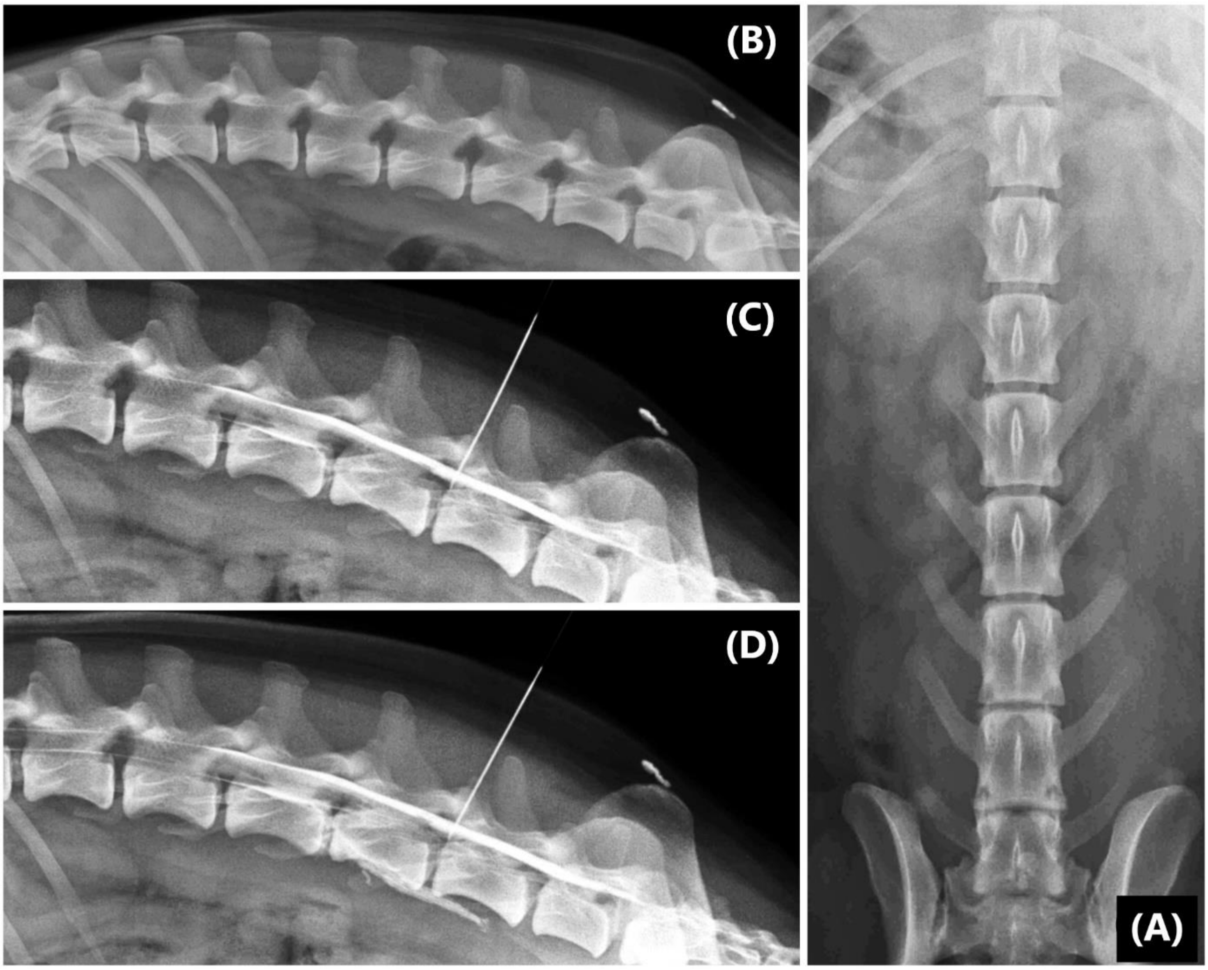

Figure 1. A radiographic exam on a dog with paraplegia. A and B, Plain film radiographic views of the spine were typical. C and D, Myelographic views during the application of contrast: contrast extravasation in the region of the L4 nerve root on the right side (arrow) and needle presence.

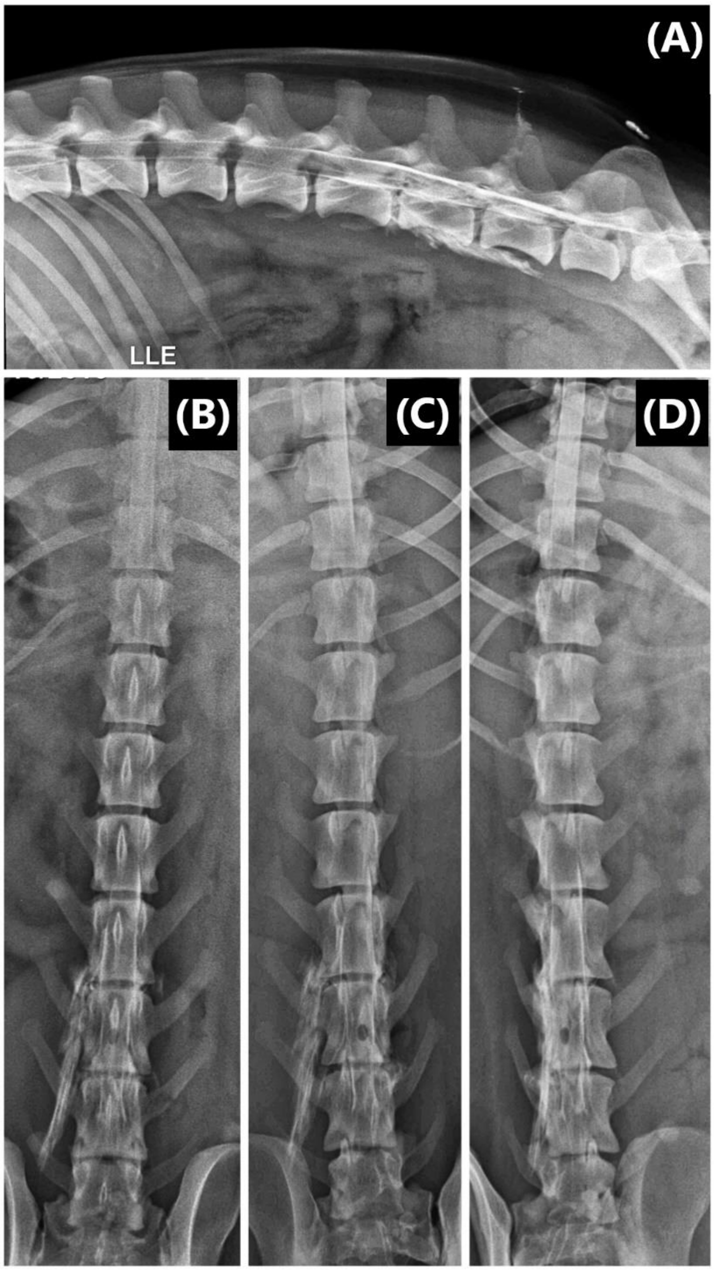

Figure 2. Myelographic images of the left lateral (Figure 2A), ventrodorsal (Figure 2B), right and left ventrolateral obliques views (Figures 2C and 2D) of the lumbar spine of a paraplegic dog. Myelography revealed edema between T12 and L3 vertebrae, extensive area suggestive of myelomalacia between L4-L6, and extradural contrast extravasation from the subarachnoid space to the origin of the L4 nerve root into the epaxial musculature.

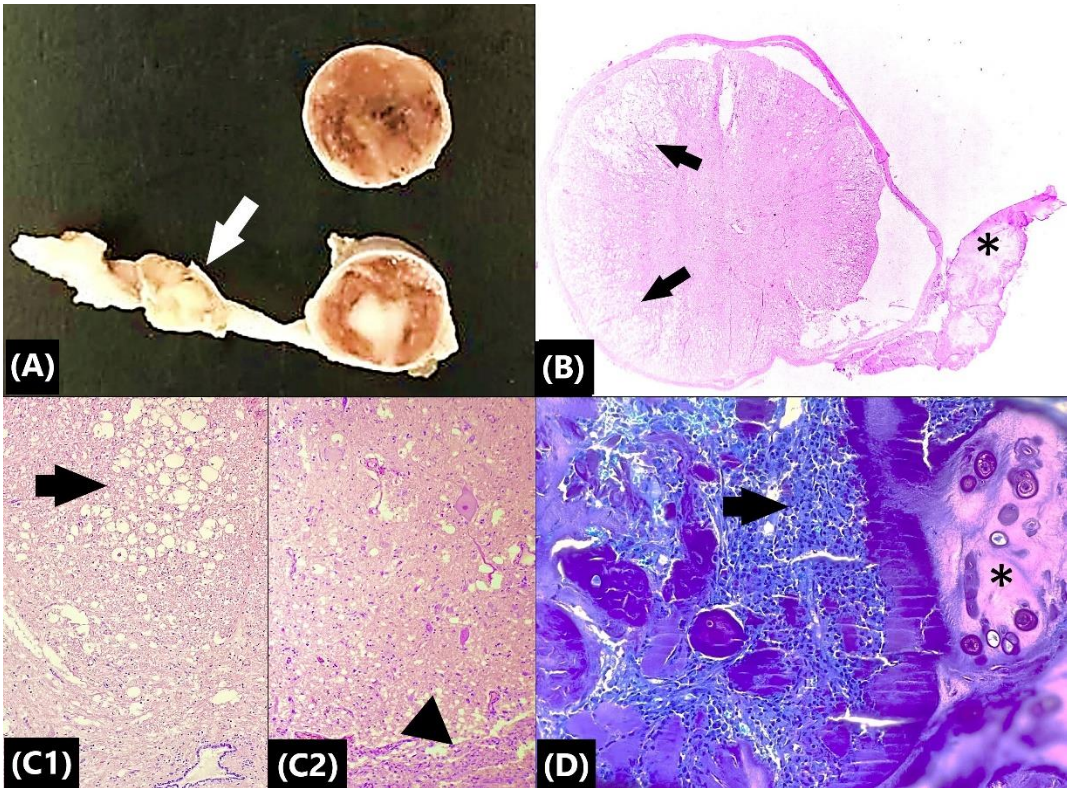

Figure 3. Cross-sections of the lumbar spinal cord of the dog. A, Transverse sections of the formalin-fixed spinal cord. The duramater in both fragments delimits an extensive brown area in the middle of the neuronal tissue. The edema may have thickened the spinal nerve root and ventral branch in the inferior fragment. B, Hematoxylin and eosin stain, cross-sectional submacroscopic photomicrograph of a lumbar spinal segment showing asymmetry due to compression caused by an extradural neoplastic mass rich in hyaline cartilage (*) compatible with chondrosarcoma. Intense vacuolization of the neuropil can be observed, especially of the white matter in the dorsal and ventral funiculi (arrows). C, Hematoxylin and eosin stain, 200× magnification, lumbar spinal cord segment. The left image shows intense vacuolization of the neuropil (arrow) and axonal spheroids in an area of malacia (C1). Note also irregularity in the structure of the central canal of the medulla (*). In the image on the right (C2), gray matter vacuolization near neurons and an extensive area of malacia in white matter can be seen with an intense infiltrate of "gitter" cells (activated microglia) (arrowhead). D, Proliferation of malignant neoplastic cells with abundant cytoplasm. Islands of the neoformed chondroid matrix (*) amidst this proliferation, highlighted in the Toluidine Blue stain, can be noted (400× magnification).

6 MANUSCRITO 3

Survey spinal radiographs and myelographies used in the evaluation of dogs and cats with suspected spinal cord injury: A retrospective study

Aline de Moura Jacques Diego Vilibaldo Beckmann

(Artigo a ser submetido para publicação na revista **Ciência Rural**)

Survey spinal radiographs and myelographies used in the evaluation of dogs and cats with suspected spinal cord injury: A retrospective study

Exames radiográficos simples e contrastados utilizados na avaliação de cães e gatos com suspeita de lesão em medula espinhal: Um estudo retrospective

Aline de Moura Jacques **Diego Vilibaldo Beckmann**

ABSTRACT

Spinal cord injuries often occur in the small animal clinic. Therefore, when used judiciously, imaging of the spine reveals important findings in spinal cord injuries' clinical suspicions. This study aimed to evaluate and characterize survey spinal radiographs exams and myelographies performed in dogs and cats with a clinical suspicion of spinal cord injury and present a form to aid the evaluation of the spine. Spinal radiographs of dogs and cats treated at the Veterinary University Hospital of a Higher Education Institution were carried out between January 2016 and December 2021. Out of the selection criteria, 31/65 survey spinal radiograph exams of dogs, 6/65 survey spinal radiograph exams of felines, and 14/65 survey spinal radiograph exams and myelographies of dogs with digital images and clinical records (history, physical examination, and possible location of lesion) were selected. A professional evaluator evaluated all radiographic examinations and submitted them to an evaluation protocol through a systematic evaluation form elaborated from different literature for this study. At the end of the evaluation, the data obtained were submitted for descriptive analyses. The spine region with the highest frequency of radiographic alterations found on simple radiographic examination was the lumbar spine with sacral, totaling 117/212 alterations (55.1%). The comparison between the two analyses identified the importance of existing a methodology of analysis of radiographic exams to avoid low agreements and identify all the alterations present. Finally, it was concluded that spinal radiographs exams are an auxiliary method to the diagnosis, and it is still widely used in veterinary medicine. For this reason, it is necessary to maximize the use of the evaluation systematically of the vertebral column from imaging exams.

Keywords: canine, feline, myelography, neurology, radiography, spine.

RESUMO

Lesões medulares ocorrem frequentemente na clínica de pequenos animais. Por conseguinte, exames de imagem da coluna vertebral quando utilizados de forma criteriosa permitem revelar achados importantes nas suspeitas clínicas de lesões medulares. Este estudo teve como objetivo avaliar e caracterizar os exames radiográficos simples e contrastados realizados em cães e gatos com suspeita clínica de lesão medular, bem como apresentar um formulário de auxílio a avaliação da coluna vertebral. Foi realizado um levantamento de exames radiográficos da coluna vertebral de cães e gatos atendidos no Hospital Universitário Veterinário de uma Instituição de Ensino Superior, no período entre janeiro de 2016 a dezembro de 2021. Como critérios de inclusão foram selecionados 45/65 exames radiográficos simples da coluna vertebral de cães, 6/65 exames radiográficos simples da coluna vertebral de felinos, e 14/65 mielografias de cães que possuíam imagens em formato digital e prontuários clínicos (histórico, exame físico e possível localização de lesão). Todos os exames radiográficos foram avaliados por um avaliador profissional e submetidos a um protocolo de avaliação através de um formulário de avaliação sistemática elaborado a partir de diferentes literaturas para esse estudo. Ao final da avaliação, os dados obtidos foram submetidos a análises descritivas. A região da coluna vertebral com a maior frequência de alterações radiográficas encontradas no exame radiográfico simples foi a coluna lombar com sacral, perfazendo 117/212 alterações (55,1%). A comparação entre as duas análises identificou a importância de existir uma metodologia de análise de exames radiográficos para evitar baixas concordâncias e identificar todas as

alterações presentes. Por fim, concluiu-se que os exames radiográficos da coluna vertebral são um método auxiliar ao diagnóstico, sendo ainda amplamente utilizados na medicina veterinária. Por isso, é necessário maximizar o uso da avaliação sistemática da coluna vertebral a partir de exames de imagem.

Palavras-chave: canino, felino, mielografia, neurologia, radiografia, coluna vertebral.

INTRODUCTION

Spinal cord injuries often occur in the small animal clinic, and for more accurate diagnosis, spinal evaluations are required by different imaging diagnostic methods (DENNIS et al., 2010; DEWEY; DACOSTA, 2016; FARROW, 2003; KEALY; MCALLISTER; GRAHAM, 2012; KIRBERGER; MCEVOY, 2016; MUHLBAUER; KNELLER, 2013; WIDMER; THRALL, 2014). In addition, a survey radiography exam of the spine should be the examination of choice before advanced imaging methods (KEALY; MCALLISTER; GRAHAM, 2012; WIDMER; THRALL, 2014).

Although many myelopathies, including intervertebral disc disease and spinal neoplasia, cannot be fully characterized using radiographs (WIDMER; THRALL, 2014). This exam is a simple tool to evaluate the spine, allowing the screening of bone changes, and can be used as a diagnostic form or to exclude other conditions (DEWEY; DACOSTA, 2016; KEALY; MCALLISTER; GRAHAM, 2012; WIDMER; THRALL, 2014).

Radiography of the spine, when performed in an unanesthetized patient, is often considered of questionable diagnostic quality due to poor positioning and/or possible movement during image capture (DEWEY; DACOSTA, 2016; HECHT et al., 2009; KEALY; MCALLISTER; GRAHAM, 2012; WIDMER; THRALL, 2014). Furthermore, this examination cannot define soft tissues (DEWEY; DACOSTA, 2016; KEALY; MCALLISTER; GRAHAM, 2012), so it is necessary to use contrast media or more advanced images, such as myelography, computed tomography (CT), and magnetic resonance imaging (MRI) (KEALY; MCALLISTER; GRAHAM, 2012; WIDMER; THRALL, 2014).

On the other hand, myelography is an auxiliary alternative to the diagnosis of myelopathies and allows the visualization of the entire spine (DENNIS et al., 2010; DEWEY; DACOSTA, 2016; FARROW, 2003; KEALY; MCALLISTER; GRAHAM, 2012; KIRBERGER; MCEVOY, 2016; MUHLBAUER; KNELLER, 2013; WIDMER; THRALL, 2014). This exam consists of obtaining radiographs of the spine after injection of a radiopaque contrast medium in the subarachnoid space and is indicated for localization, extension, and confirmation of spinal cord injuries (BRAUND, 2003; BRISSON, 2010; DEWEY; DACOSTA, 2016; KEALY; MCALLISTER; GRAHAM, 2012; WIDMER; THRALL, 2014).

This study aimed to evaluate and characterize the survey spinal radiographs and myelographies performed in dogs and cats with clinical suspicion of spinal cord injury and present a form to aid the evaluation of the spine.

MATERIALS AND METHODS

Radiography exams of dogs and cats with clinical suspicion of spinal cord injury treated at the Veterinary University Hospital of a Higher Education Institution were reviewed between January 2016 and December 2021. As inclusion criteria, radiographs exams were selected with digital images of dogs and cats with a spinal injury and who had clinical records (history, physical examination, and possible lesion location) (Figure 1). In addition, all spinal radiographs exams were performed with conventional radiology equipment, *Philips Medical Systems*, 125kV and 200mA, and a mobile model Áquilla Plus 300, in digital format.

Radiographic examinations of the spine were grouped and classified according to the type of examination (simple or contrasted), regions of the spine (cervical, thoracic, thoracic with lumbar, and lumbar with sacral), and the radiographic findings obtained in the report prepared immediately after the examination. Information about the species, race, gender, age, weight, clinical signs, neurological examination, main clinical suspicion, and the purpose of requesting radiographic examination (survey or myelography) were obtained from the clinical records of each animal.

After selecting radiography exams, each image was evaluated by a professional evaluator with experience in the area using software for viewing images in format DICOM (*Onis™ 2.5.1.6 Free edition, 2009-2013*). To standardize the radiographic findings, we chose to develop a systematic evaluation form (supplementary archive 1). This form used Röntgen radiographic signals as evaluative criteria, i.e., geometric changes (location and alignment, size, shape, number, margin), opacity, and function of the spine of small animals were sought (DENNIS et al., 2010; DEWEY; DACOSTA, 2016; FARROW, 2003; KEALY; MCALLISTER; GRAHAM, 2012; KIRBERGER; MCEVOY, 2016; MUHLBAUER; KNELLER, 2013; WIDMER; THRALL, 2014).

Data analysis

The data obtained were submitted to descriptive analyses. To determine the agreement and reliability between the radiographic findings reported in the report and the form, the Kappa test was used, introduced by Cohen (1960) and categorized as: poor (≤0), superficial (0-0.2), reasonable (0.21-0.4), moderate (0.41-0.6), substantial (0.61-0.8) and excellent (0,81-1) (LANDIS; KOCH, 1977).

RESULTS

During the study period (2016-2021), 45/65 (69.23%) survey spinal radiographic exams were performed in dogs, 6/65 (9.23%) survey spinal radiographic exams in felines, and 14/65 (21.54%) myelographies in dogs. Among the 45 dogs submitted to survey radiographic exams of the spine, 31/45 dogs performed only this exam, and 14/45 dogs also performed myelography. We highlight some periods in which radiographic images were not in digital format and radiographic equipment was not available, contributing to the low number of radiographs exams performed.

The radiographs findings observed in 48/51 survey spinal radiographic exams of dogs and cats are shown in table 1.

The spine region with the highest frequency of findings on survey radiographs exams was the lumbar spine with sacral, totaling 117/212 alterations (55.1%). The main finding was deforming spondylosis (Figures 2A and 2B), totaling 70/212 alterations (33.0%). In addition, the radiographic images present in figures 3A and 3B exemplify some radiographs alterations found, such as block vertebra (0.4% = 1) and discospondylitis (0.4% = 1).

Radiographs findings related to spinal trauma in dogs and cats in this study were (Figure 3C and 3D) vertebral body fracture (2.3% = 5), luxation (1.8% = 4), bone fragments within the vertebral canal (1.4% = 3), blade fracture (0.4% = 1), joint process fracture (0.4% = 1), spinous process fracture (0.4% = 1), transverse process fracture (0.4% = 1), and poor alignment of the vertebral canal floor (0.4% = 1). Moreover, reduction of intervertebral space (25.9% = 55), intervertebral disc calcification (8.4% = 18), wedge-shaped intervertebral space (6.1% = 13), calcified material in intervertebral foramen (0.9% = 2), alteration and loss of the contour of the intervertebral foramen (0.9% = 2), and endplate sclerosis (0.4% = 1) were alterations also observed in the survey spinal radiographs exams analyzed, and may be suggestive of intervertebral disc disease in dogs (Figure 4).

All myelographies of this study (14/14) presented alterations (Table 2). Based on the alterations found, it was possible to identify lesions suggestive of extradural medullary compressions in 11/14 myelographies (Figure 5A, 5B, and 5C), characterized by an attenuation of the ventral contrast column between two vertebrae (2/33 = 6%), dorsal deviation of the ventral contrast column between two vertebrae (13/33 = 39.3%), and failure of the ventral contrast column between two vertebrae (8/33 = 24.2%).

The values of agreement and reliability (Kappa) between the findings of the form and the findings present in the reports issued above are described in Table 3.

Data related to the epidemiology of the forty-five dogs and six felines will be described below. Of the dogs included in the study, 24/45 (53.33%) were female, and 21/45 (46.67%) were males. As for cats, 4/6 (66.67%) were female, and 2/6 (33.33%) were males. Regarding the breeds of dogs, 13/45 (28.89%) were mixed breed, and 32/45 (71.11%) were poodle (5/45), Dachshund (4/45), Boxer (3/45), French Bulldog (3/45), Labrador retriever (3/45), German Shepherd (3/45), Australian cattle Dog (2/45), Yorkshire (2/45), and only one specimen of border collie breeds, Bull terrier, Cane Corsican, Cocker Spaniel, Dogo Argentino, Shih-Tzu, and Pekingese. The 6 (100%) felines in this study were mixed breed.

Data related to the age and weight of the animals were also collected. The age of dogs ranged from 8 months to 17 years, with a mean age of 7.33 ± 4.39 years, and in a dog, this information was unknown. In cats, age ranged from 4 months to 10 years, with a mean age of 4.38 ± 3.80 years. The weight of the dogs was not reported in three medical records, and in the others ranged from 2.3 kg to 47.9 kg, with an average weight of 15.88 ± 11.44 kg. The weight of the felines ranged from 1.3 kg to 4.7 kg, with an average weight of 2.93 ± 1.12 kg.

Information about clinical signs, neurological examination, main clinical suspicion, and the main purpose of the exam request of all animals submitted to the survey radiographic exams are arranged in supplementary archive 2.

DISCUSSION

Survey spinal radiographic exams in dogs and cats

Deforming spondylosis was the main finding of survey radiographic exams in this study. This finding is characterized as a common bone formation in the cranioventral and caudoventral aspects of vertebral bodies on the margins of intervertebral disc spaces (DENNIS et al., 2010; KEALY; MCALLISTER; GRAHAM, 2012). However, these findings were not extended to the point of resulting in the involvement of the nerve root and, consequently, did not produce clinical manifestations (DENNIS et al., 2010; KEALY; MCALLISTER; GRAHAM, 2012; MCCONNELL, 2012).

In a mixed breed dog at three years of age and paraplegic, it was possible to observe a hemivertebra in the region of the lumbar spine with sacral, resulting from the failure of the vertebral body to develop completely (KEALY; MCALLISTER; GRAHAM, 2012; KIRBERGER; MCEVOY, 2016; WIDMER; THRALL, 2014). This type of congenital malformation is common in the thoracic spine of dogs of breeds with "screw tails," such as the bulldog, French Bulldog, and Boston Terrier (DENNIS et al., 2010; WIDMER; THRALL, 2014). However, even if this amendment justified spinal compression (DENNIS et al., 2010; KEALY; MCALLISTER; GRAHAM, 2012), the myelography performed later revealed significant alterations of extradural lesion suggestive of intervertebral disc extrusion, which was confirmed through surgical treatment.

Since birth, another congenitally originated alteration found in a paraplegic dog was the block vertebra. This find consists of a fusion of two vertebral bodies (DENNIS et al., 2010; KEALY; MCALLISTER; GRAHAM, 2012). Although this genetic alteration has little clinical significance, as it is usually an accidental finding during radiographic evaluations, it may predispose to extrusion of the intervertebral disc in adjacent vertebrae (DENNIS et al., 2010; KEALY; MCALLISTER; GRAHAM, 2012; WIDMER; THRALL, 2014). Due to its presence and other associated radiographic alterations, such as scoliosis and kyphosis in the thoracic spine region, a relationship with the paraplegia of the animal was suggested (DENNIS et al., 2010).

Changes suggestive of intervertebral disc disease in observed dogs were not interpreted alone in this study. Although studies present a high sensitivity of simple radiographic examination for the diagnosis of thoracolumbar DDIV, these results are not as promising for cervical DDIV (HECHT et al., 2009; LU; LAMB; TARGETT, 2002; SOMERVILLE et al., 2001). The fact that there are alterations suggestive of DDIV does not necessarily imply the association with the clinical manifestations of the animal (BRISSON, 2010; JENSEN et al., 2008; KEALY; MCALLISTER; GRAHAM, 2012; MURAKAMI et al., 2014; ROSENBLATT; BOTTEMA; HILL, 2014; WIDMER; THRALL, 2014). Therefore, the most important use of simple radiographic examination in animals with signs of IVDD is to exclude other bone disorders (DEWEY; DACOSTA, 2016; WIDMER; THRALL, 2014).

In only 1/51 simple radiographic examination, it was impossible to rule out the trauma hypothesis. Because there are situations in which conventional radiography may not reveal incomplete misalignments and fractures, or even due to the need for animal sedation for specific positioning to be executable (BAR-AM et al., 2008; DENNIS et al., 2010; DEWEY; DACOSTA, 2016; WIDMER; THRALL, 2014). It is reiterated that animals with suspected spinal trauma may also present concomitantly suspected head trauma and, for this reason, should not be sedated/anesthetized for imaging (DEWEY; DACOSTA, 2016; LORENZ; COATES; KENT, 2011).

Although the radiographic examinations performed on the dogs and cats of this study had specific purposes, the analysis of the images through previously established criteria (supplementary archive 1) allowed us to investigate all the existing alterations in each image associated or not with clinical manifestations (DENNIS et al., 2010; KEALY; MCALLISTER;

GRAHAM, 2012; KIRBERGER; MCEVOY, 2016; MUHLBAUER; KNELLER, 2013; WIDMER; THRALL, 2014).

The comparison between the form and the report regarding fulfilling the purpose of the imaging examination request was considered substantial (LANDIS & KOCH, 1977). This result may be explicated due to the homogeneity of the study samples. The other Kappa values analyzed indicated a superficial or poor agreement and reliability. These results may have been interfered with due to the sensitivity and specificity of the test, as it has already been found that the Kappa coefficient may be reduced the more homogeneous the sample (BOUDREAU et al., 2018).

Myelographies in dogs

Contrast injection via the magna cistern is considered easy to perform (MCCONNELL, 2012; PAITHANPAGARE et al., 2008); however, complications such as poor contrast miscegenation (1/14) are more likely to occur and, consequently, hinder the evaluation (KEALY; MCALLISTER; GRAHAM, 2012). Concerning lumbar puncture, it is not uncommon to be associated with the application of contrast in the epidural space (BRAUND, 2003; DENNIS et al., 2010; GAVIN, LEVINE, 2015; SHARP; WHEELER, 2005), and even though it occurred in 3/14 myelographies, it did not impair the evaluation performed for this study.

The extradural compressive lesions observed in myelography helped diagnose seven dogs with intervertebral disc extrusion confirmed by surgical treatment (5/14) or presumptive with clinical treatment institution (2/14). These lesions may also occur in cases of cervical spondilomyelopathy (Wobbler syndrome) due to malformation of the caudal cervical vertebrae and/or anomalous stabilization playing a role in the manifestation of clinical signs (DENNIS et al., 2010; MCCONNELL, 2012; WIDMER; THRALL, 2014); and were evidenced in a dog in this study submitted to decompressive surgery with confirmation of the diagnosis. In addition, these lesions may also occur in intervertebral disc protrusions, vertebral fracture/dislocation, congenital vertebral anomalies, soft tissue hypertrophy, and extradural hemorrhage (BRISSON, 2010; DEWEY; DACOSTA, 2016).

All the purposes for requesting the 14 myelography belonging to this study were to assist in diagnosing myelopathies (DEWEY; DACOSTA, 2016). Considering that in 2/14 myelographies, it was impossible to assist in the diagnosis, it was possible to conclude that these tests were deemed inconclusive in these two cases. It is recalled that this technique has limitations in the visualization of lateralized or intraforaminal lesions and the inability to distinguish alterations of the medullary parenchyma (BRISSON, 2010; COOPER et al., 2014).

Despite the reduced number of myelographies in this study, there were no worsening or complications in any of the fourteen dogs submitted to this test. It is known that it is not uncommon to have a worsening of the neurological state after myelography due to transient chemical myelitis secondary to contrast injection; or even other adverse effects such as seizures, asystole, and subarachnoid hemorrhage (BRISSON, 2010; DEWEY; DACOSTA, 2016; MCCONNELL, 2012; NYKAMP, 2017).

Study limitations

The data collection verified that during three months of 2016, five months of 2017, and one month of 2019, radiographic examinations were not performed digitally due to the unavailability of radiographic equipment. In addition, there was no radiographic examination in the years 2020 to 2021 (the period of the COVID-19 pandemic) because the hospital was closed and without clinical care.

CONCLUSION

It is concluded that both survey radiography and myelography are tools capable of fulfilling the purposes of their requests satisfactorily. The comparison between the two analyses identified the importance of existing a methodology of analysis of radiographic exams to avoid low agreements and identify all the alterations present. Finally, because the use of radiographic examination as an auxiliary method to the diagnosis is still used in veterinary, it is necessary to maximize the use of the evaluation systematically of the spine.

ACKNOWLEDGEMENTS

The authors would like to thank the Brazilian governmental agencies CAPES (Coordenação de Aperfeiçoamento de Pessoal de Nível Superior) for financial support.

DECLARATION OF CONFLICT OF INTEREST

We have no conflict of interest to declare.

AUTHORS’ CONTRIBUTIONS

All authors contributed equally to the conception and writing of the manuscript. All authors critically revised the manuscript and approved the final version.

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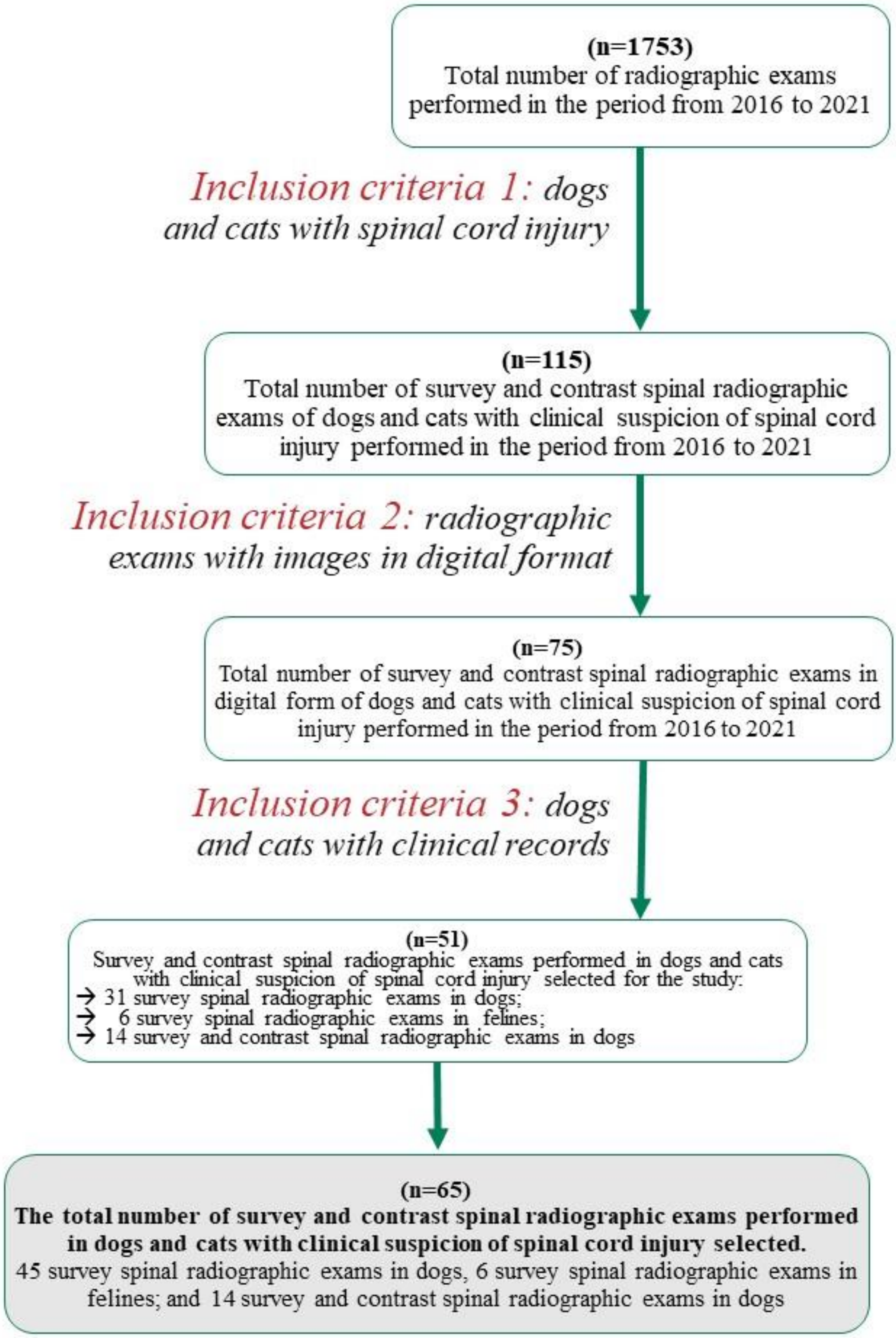

Figure 1: Flowchart of research and selection of radiographic examinations of the spine of dogs and cats with suspected spinal cord injury treated at the veterinary university hospital of an institution between 2016 and 2021.

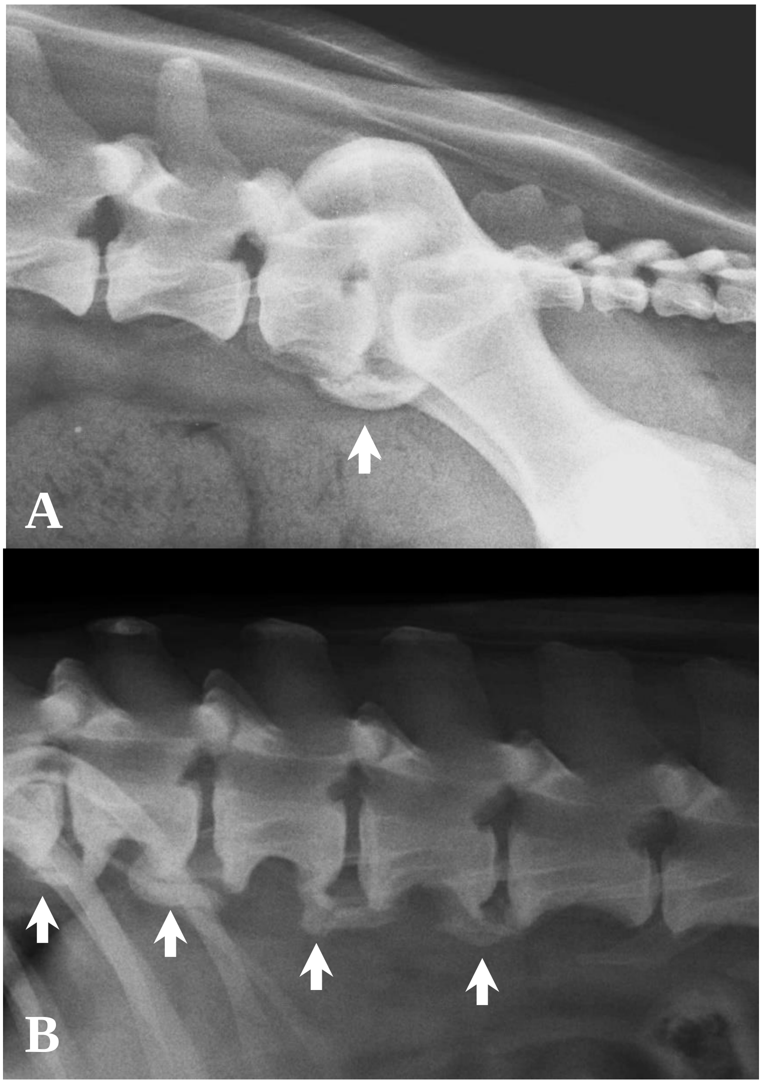

Figure 2: A. Radiographic image of ankylosing spondylosis (arrow) at the lumbosacral junction (L7-S1), during survey spinal radiographic exam, in a 14-year-old labrador dog. Pronounced, hook-like bone projection is observed in the flow aspect of L7 towards the vertebral body of S1. B. During the survey spinal radiographic exam, a radiographic image of deforming spondylosis (arrows) in an 11-year-old German Shepherd dog. Bone projections are observed in the cranial aspects of the l1, L2, L3, and L4 vertebrae proliferating ventrocranially towards the respective previous vertebrae, and bone projections in the caudal aspects the vertebrae T13, L1, L2, L3 proliferating ventrocaudally towards the subsequent vertebrae. Source: radiology sector of the veterinary university hospital of a higher education institution.

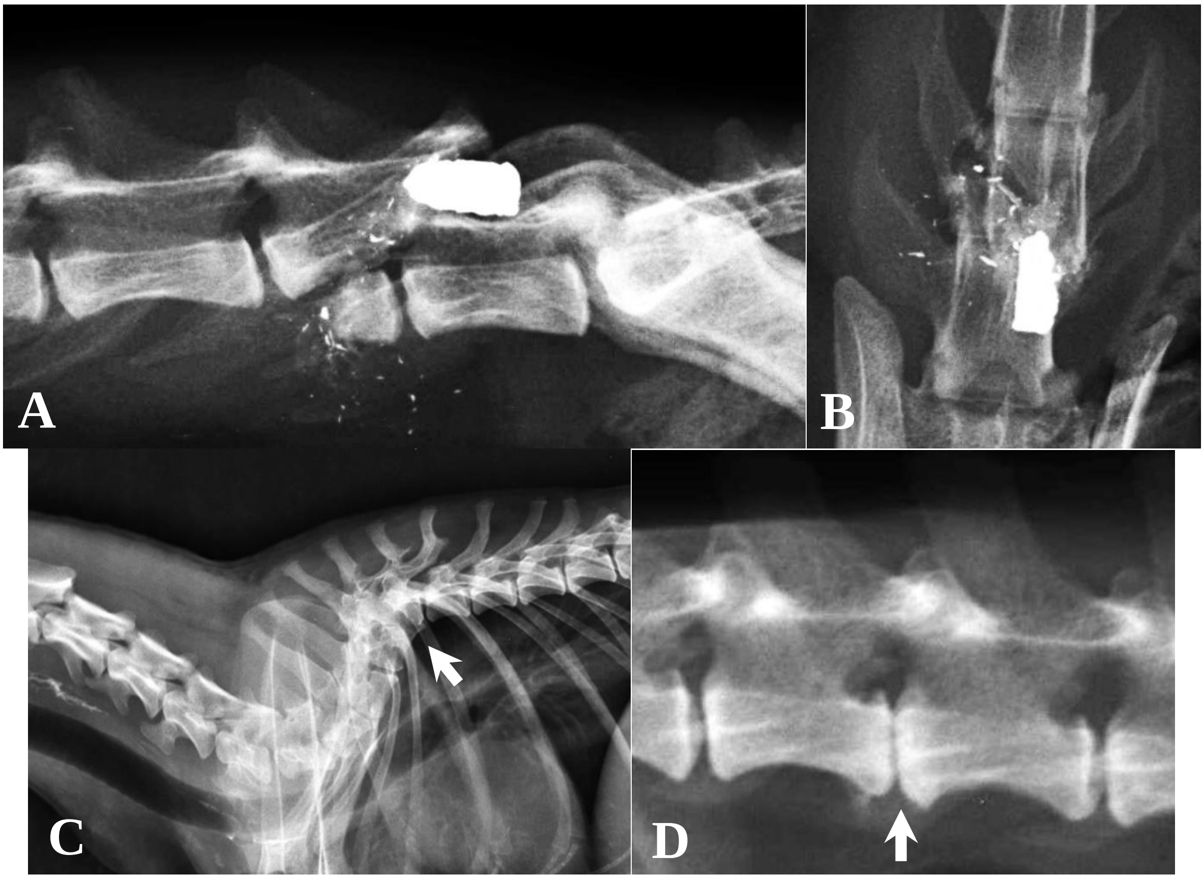

Figure 3: A and B. Radiographic images of vertebral trauma alterations during the survey spinal radiographic exam of a feline without a defined race at four years of age. A. It is observed in lateral projection: Dislocation between the L6-L7 vertebrae; Bone fragments within the lumbosacral vertebral canal; Foreign body (projectile) in the vertebral canal of L6; Fracture of the transverse process, lamina, and vertebral body of L6. B. It is observed in ventrodorsal projection, and other previously reported alterations: dislocation between the L6-L7 vertebrae. C. Radiographic image of T4-T5 vertebrae in block (arrow), during the survey spinal radiographic exam of a 5-year-old poodle paraplegic dog from birth. The fusion of the vertebral bodies of T4 and T5 is observed, with abnormal angulation of the spine due to the presence of scoliosis (lateral curvature) and kyphosis (dorsal curvature). The company of these alterations confirmed the purpose of requesting a survey spinal radiographic exam (congenital vertebral anomaly). D. Radiographic image with alteration suggestive of discospondylitis (arrow), during the survey spinal radiographic examination, in a 12-year-old poodle dog. There is a reduction in the intervertebral space and bone lysis in the vertebral terminal plates between the L2-L3 vertebrae. Source: radiology sector of the veterinary university hospital of a higher education institution.

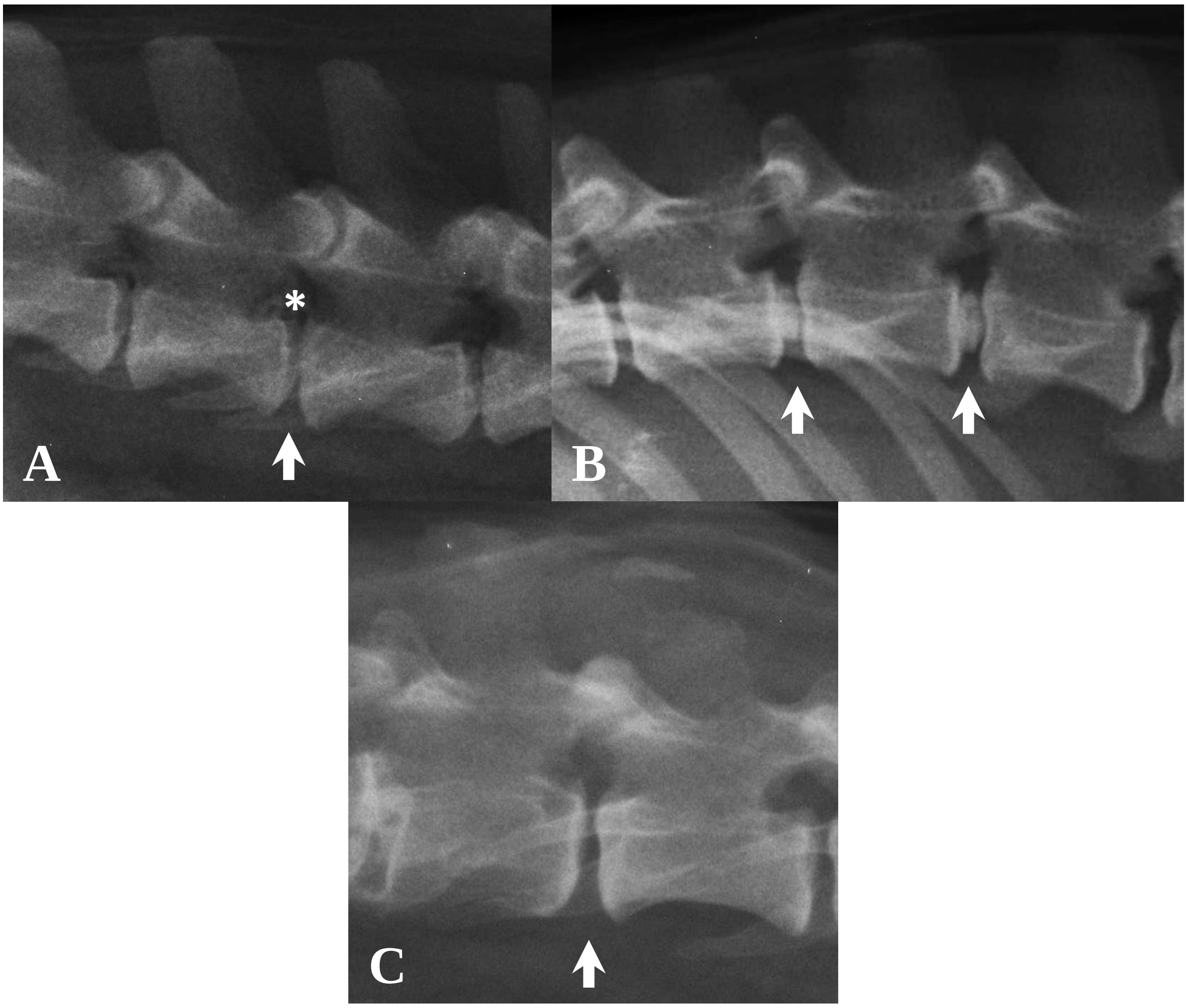

Figura 4: During the survey spinal radiographic exam, radiographic images of alterations that may be clinically related to DDIV in dogs. A. Reduction of the intervertebral space between L3-L4 (arrow) and calcified material within the intervertebral foramen between L3-L4 (*). B. Calcification of the intervertebral disc between T13-L1 and L1-L2 (arrows). C. Wedge-shaped intervertebral space between L4-L5 (arrow). Source: radiology sector of the veterinary university hospital of a higher education institution

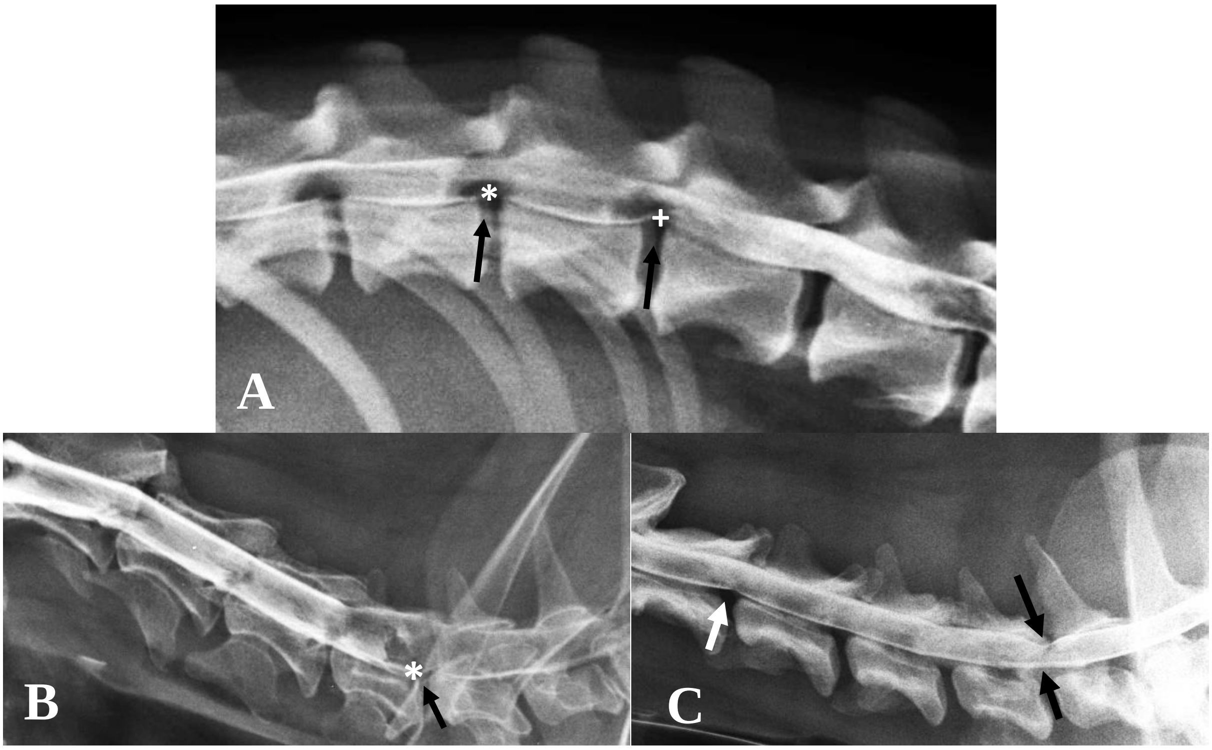

Figure 5: A. Radiographic image of alterations suggestive of extradural medullary compression during myelography performed in dogs. It is observed, in laterolateral projection: Dorsal deviation of the contrast column between T13-L1 and L1-L2 (arrows); Failure of the ventral contrast column between T13-L1 (*); Attenuation of the ventral contrast column between L1-L2 (+). B. Radiographic image of alterations suggestive of extradural medullary compression in myelography of the cervical spine performed in a dog, with no defined breed of 12 years of age, with suspected extrusion of the intervertebral disc. It is observed, in lateral projection: Dorsal deviation of the ventral contrast column between C5-C6 (arrow); Ventral contrast column failure between C5-C6 (*). The suspicion of intervertebral disc extrusion was confirmed during the surgical treatment instituted (ventral slot decompressive surgery between C5-C6). C. Radiographic image of alterations suggestive of extradural medullary compression in cervical myelography performed in a 10-year-old Australian Cattle Dog with suspected caudal cervical spondylomyelopathy (Wobbler syndrome). A dorsal deviation of the ventral contrast column and ventral deviation of the dorsal contrast column between C6-C7 (black arrows), indicating extradural medullary compression, are observed. Suspicion of Wobbler syndrome was confirmed during the surgical treatment instituted (decompressive surgery through dorsal laminectomy between C6-C7). In addition, dorsal deviation of the ventral contrast line between C3-C4 (white arrow) can be observed, also indicating extradural medullary compression. Source: radiology sector of the veterinary university hospital of a higher education institution.

Table 1: Relative and absolute frequencies of radiographic alterations observed in different spine regions in the 51 simple radiographic examinations performed in dogs and cats with suspected spinal cord injury treated at the veterinary university hospital between January 2016 and December 2021.

	Cervical		**Thoracic with lumbar**		**Lumbar with sacral**		**TOTAL**	
	N	%	N	%	N	%	**N**	**%**
Vertebral body alteration	0	0.0	0	0.0	4	3.4	**4**	**1.8**
Increased opacity in the intervertebral foramen	0	0.0	0	0.0	4	3.4	**4**	**1.8**
Increased opacity in the cranial and caudal aspects of the vertebral body	0	0.0	0	0.0	1	0.8	**1**	**0.4**
Calcification of the intervertebral disc	0	0.0	10	10.8	8	6.8	**18**	**8.4**
Kyphosis	0	0.0	1	1.1	0	0.0	**1**	**0,4**
Foreign body (projectile) present in the vertebral canal	0	0.0	0	0.0	1	0.8	**1**	**0.4**
Curvature between vertebrae	0	0.0	2	2.17	1	0.8	**3**	**1.4**
Poor alignment of the vertebral canal floor	0	0.0	0	0.0	1	0.8	**1**	**0.4**
Discospondylitis	0	0.0	0	0.0	1	0.8	**1**	**0.4**
Ssclerosis in the vertebral endplates	0	0.0	0	0.0	1	0.8	**1**	**0.4**
Scoliosis	0	0.0	3	3.26	1	0.8	**4**	**1.8**
Wedge-shaped intervertebral disc space	0	0.0	9	9.78	4	3.4	**13**	**6.1**
Deforming spondylosis	1	33.3	23	25.0	46	39.3	**70**	**33.0**
Bone fragments inside the vertebral canal	0	0.0	0	0.0	3	2.5	**3**	**1.4**
Vertebral lamina fracture	0	0,0	0	0.0	1	0.8	**1**	**0.4**
Vertebral body fracture	0	0.0	1	1.1	4	3.4	**5**	**2.3**
Fracture of the vertebral joint process	0	0.0	1	1.1	0	0.0	**1**	**0.4**
Fracture of the vertebral spinous process	0	0.0	1	1.1	0	0.0	**1**	**0.4**
Fracture of the vertebral transverse process	0	0.0	0	0.0	1	0.8	**1**	**0.4**
Hemivertebra	0	0.0	0	0.0	1	0.8	**1**	**0.4**
Luxation	0	0.0	1	1.1	3	2.5	**4**	**1.8**
Bone lysis in endplates	0	0.0	0	0.0	1	0.8	**1**	**0.4**
Malformation of the vertebral body	0	0.0	0	0.0	6	5.1	**6**	**2.8**
Calcified material within the intervertebral foramen	0	0.0	1	1.1	1	0.8	**2**	**0.9**
Loss of ventral resolution of the vertebral body	0	0.0	0	0.0	4	3.4	**4**	**1.8**
Alteration and loss of the contour of the intervertebral foramen	0	0.0	0	0.0	2	0.8	**1**	**0.4**
Pin inserted into vertebral body	0	0.0	0	0.0	2	1.7	**2**	**0.9**
Narrowed of intervertebral disc space	2	66.7	38	41.3	15	12.8	**55**	**25.9**
Block vertebrae	0	0.0	1	1.1	0	0.0	**1**	**0.4**
TOTAL	**3**	**100.0**	**92**	**100.0**	**117**	**100.0**	**212**	**100.0**

Table 2: Relative and absolute frequencies of radiographic alterations observed in the 14 myelography performed in dogs with suspected spinal cord injury treated at the veterinary university hospital between January 2016 and December 2021.

	Radiographic changes	**N**	**%**
Extradural	Attenuation of the ventral contrast column between two vertebrae	2	6.0
	Dorsal deviation of the dorsal contrast column between two vertebrae	1	3.0
	Dorsal deviation of the ventral contrast column between two vertebrae	13	39.3
	Expansion of the dorsal contrast column under a vertebra	1	30
	Extradural contrast extravasation of the subarachnoid space following the L4 nerve root	1	3.0
	Failure of the dorsal contrast column between two vertebrae	8	24.2
Intramedullary	Spinal cord edema	1	3.0
	Extensive area suggestive of myelomalacia	1	3.0
Other	Epidurography	3	9.0
	Change in the appearance of the dorsal contrast column	1	3.0
	Poor contrast miscegenation	1	3.0
	TOTAL	**33**	**100.0**

Table 3: Analysis of agreement and reliability (Kappa) of simple radiographic examinations obtained between the radiographic analysis of this study and the radiographic research present in the report of the image prepared immediately after the exam, performed in dogs and cats with suspected spinal cord injury treated at the veterinary university hospital between January 2016 and December 2021.

	Kappa (k)	**Intensity of agreement**	**p**
The purpose of the image exam request	Substantial	90%	0.00
General radiographic changes	Superficial	69%	0.01
Radiographic changes in the lumbar spine with sacral	Poor	56%	0.05
Radiographic changes related to vertebral form	Poor	43%	0.02

1

Supplementary archive 1 - Form of systematic evaluation of the spine

☐ Survey radiographic exam ☐ Myelography

Registration No.: _______ Species: ______________ Race: ____________ Sex: _______ Age: __________
Historic: ____
Clinical suspicion: ____

PART 1 - SURVEY SPINAL RADIOGRAPHIC EXAM EVALUATION PROTOCOL

A. X-rayed region:

☐ **One region**	☐ **Two regions**	☐ **Three regions**	☐ **Four regions**
☐ Cervical vertebral column ☐ Thoracic vertebral column ☐ Lumbar vertebral column ☐ Sacral vertebral column	☐ Cervical and thoracic vertebral column ☐ Thoracic and lumbar vertebral column ☐ Lumbar and sacral vertebral column	☐ Cervical and thoracic, and lumbar vertebral column ☐ Thoracic and lumbar and sacral vertebral column	☐ Cervical and thoracic and lumbar and sacral vertebral column

B. Views:

☐ Laterolateral ☐ Ventrodorsal ☐ Dorsoventral ☐ Oblique

C. Image quality assessment:

☐ It was possible to evaluate, and there were radiographic alterations.
☐ It was possible to evaluate, and there were no radiographic changes.
☐ It was not possible to evaluate due to image quality and/or poor positioning/movement of the animal.

The systematic evaluation of the spine uses Röntgen radiographic signals as evaluative criteria, i.e., changes in geometric signals (location and alignment, size, shape, number, margin), opacity signals, and functional signals are sought.

Each change found must be reported, along with its respective location.

1) Location and alignment of the vertebral column:

To evaluate vertebral orientation and alignment, it should be possible to "trace" the floor and ceiling along the vertebral canal without any evident change in angulation. The floor of the vertebral canal of the adjacent vertebrae should form a continuous line, straight to slightly curved. Although the vertebral canal extends between C6-T2 and L3-L6 to accommodate the cervical and lumbar intumescences of the spinal cord, this transition should be smooth. In ventrodorsal incidences, evaluate whether the pedicles should be evenly spaced and parallel. Assess whether all spinous processes are aligned. (Main changes: *Angulation in the spine; Abnormal angulation/curvature between vertebrae; Increased distance between the spinous process of C1 and axis of C2; Kyphosis (dorsal curvature); Lordosis (ventral curvature); Scoliosis (lateral curvature); Dislocation; Subluxation; Subluxation of the joint process (cranial/caudal); Misalignment of the vertebral canal floor)*.

Changes found:____.

2) Number of vertebrae of each x-section (Cervical: 7 vertebrae; Thoracic: 13 vertebrae; Lumbar: 7 vertebrae; Sacrals: 3 vertebrae):

The number of vertebrae of each x-be-x-by-side region should be evaluated. It is recalled that numerical changes may be genuine or accompanied by other congenital vertebral anomalies, resulting in apparent changes in the vertebral number (e.g., transition vertebrae). (Main change: *Reduction in the number of vertebrae*).

Changes found:____.

3) Size of the spine, vertebra, intervertebral foramen, intervertebral space, and joints of the joint process:

a) To evaluate the size of the spine, the diameter of the vertebral canal should be evaluated, which is evaluated between the dorsal face of the vertebral body and the ventral face of the lamina. (Main changes: *Increased vertebral canal; Stenosis of the vertebral canal*).

Changes found:____.

b) To evaluate the size of each vertebra, one should evaluate the spinous process, the joint process, the odontoid process, the accessory process, the vertebral body, and the endplates in isolation, respecting the particularities of each region of the spine. (Main changes: *Shortened vertebra; Increased or decreased spinous process; Increased or decreased cranial joint process; Increased or decreased caudal joint process; Hypoplasia of the axis odontoid process; Increased or decreased vertebral body; Increased or decreased vertebral terminal plaque*).

Changes found:____.

c) Evaluate the size of each intervertebral foramen, intervertebral space, and joints of the joint process. (Main changes: *Increase or reduce intervertebral foramen; Increase or reduce intervertebral space: Increase or reduce joint space of the joint process*).

Changes found:____.

4) Shape of the spine, vertebra, intervertebral foramen, intervertebral disc, joint joints, and soft tissues:

a) Assess the shape of the spine in its general scope. (Main changes: *Spina bifida [incomplete fusion of the vertebral arch]; Bone fragments inside the vertebral canal*).

Changes found:____.

b) To evaluate the shape of each vertebra, one should evaluate the spinous process, the joint process, the odontoid process, the accessory process, the vertebral body, and the terminal plates in isolation, respecting the particularities of each region of the spine. (Main changes: *Block-shaped vertebra; Butterfly-shaped vertebra; Crack-shaped vertebra; Vertebral malformation; Misform vertebra; Wedge-shaped vertebra; Hemivértebra [triangular or wedge-shaped vertebra]; Transition vertebra [Cervicalization/Toracalization/Lumbarization/Sacralization]; New periosteal bone formation; Foreign body present in vertebra; Fracture of the odontoide process of the axis; Absence of axis odontoide process; Spinous process fracture; Absence of spinous process; Incomplete separation of the spinous process; Joint process fracture (cranial/caudal); Bone proliferation in the joint process (cranial/caudal); Presence of osteophytes in the joint process (cranial/caudal); Accessory process fracture; Vertebral lamina fracture; Incomplete separation of the vertebral dorsal lamina; Transverse process fracture; Vertebral body fracture; Flattening of the vertebral body; Pin inserted into vertebral body; Malformation of the vertebral body; Rotation of vertebral body; Vertebral body inclination; Vertebral terminal plate fracture; Destruction of the vertebral terminal plate; Separation of the terminal plate from the vertebral body; Vertebral end plate spondylitis; Deforming spondylosis [ankylosing] in the vertebral body; Schmorl nodules [concave defect in the terminal plate of the vertebral body]*.

Changes found:____.

c) Evaluate the shape of each intervertebral foramen, intervertebral disc, and joints of the joint process. (Main changes: *Change in the shape of the intervertebral foramen; Discsponditis; Change in the shape of the joint space of the joint process*).

Changes found:____.

d) Evaluate the shape of paravertebral soft tissues. (Main changes: *Edema; Presence of foreign body).*

Changes found:____.

5) Vertebral margins:

Assess vertebral margins. (Main changes: *Discontinuity of cortical margins by fracture; Altered vertebral margins due to the presence of lesions; Loss of contour of the intervertebral foramen).*

Changes found:____.

6) Opacity of the spine:

Evaluate changes in spinal opacity. (Main changes: *Increased or decreased radiopacity; Localized increase or decrease in radiopacity [one or more vertebrae]; Mixed radiopacity (one or more vertebrae]; Reduction of bone opacity due to decreased bone mass [Osteopenia/Osteoporosis]; Reduction of bone opacity due to bone destruction [osthelysis]; Increased bone opacity due to bone remodeling or osteopetrosis/osteosclerosis or osteoproliferation; Alteration in radiopacity due to vertebral neoplasia; Calcified or mineralized material within the vertebral canal; Loss of definition of the vertebral body; Sclerosis in vertebral terminal plaque; Increased opacity in the intervertebral foramen; Calcified/mineralized material within the intervertebral foramen; Gas within the intervertebral space [spinal vacuum phenomenon]; Increased radiopacity or radiolucency of the intervertebral disc; Calcification of the disc; Alteration of radiopacity of the joint of the joint process; Gas accumulation in paravertebral soft tissues; Increased bone opacity in paravertebral soft tissues; Metallic foreign body in paravertebral soft tissue; Soft tissue mineralization).*

Changes found:____.

7) Functionality of the spine:

Evaluate the functionality of the spine. In addition, a three-compartment model can be used to assess the stability of spinal fractures when existing: each vertebra is divided into a dorsal compartment (joint processes, spinous processes, slides, pedicles, soft tissues), a middle compartment (dorsal longitudinal ligament, dorsal part of the fibrous ring, dorsal aspect of the vertebral body) and a ventral compartment (vertebral body, fibrous ring, nucleus pulposus, and ventral longitudinal ligament). If two of the three compartments are damaged, the fracture is unstable. (Main changes: *Instability; Rupture of the odontoid ligament, leading to abnormal mobility).*

Changes found:____.

E. Location of radiographic changes found:

☐ Cervical (C1-C2-C3-C4-C5-C6-C7)

☐ Thoracic (T1-T2-T3-T4-T5-T6-T7-T8-T9-T10-T11-T12-T13)

☐ Lumbar (L1-L2-L3-L4-L5-L6-L7)

☐ Sacral (S1-S2-S3)

F. Indication of a new imaging examination:

☐ No.

☐ Yes, new survey spinal radiographic exam.

☐ Yes, contrast spinal radiographic exam.

☐ Yes, CT or MRI.

G. Conclusion of the evaluation of the survey spinal radiographic exam:

☐ Inconclusive.

☐ Ruled out/confirmed spinal trauma.

☐ Ruled out/confirmed vertebral neoplasia.

☐ Ruled out/confirmed congenital vertebral anomalies.

PART 2 - CONTRAST SPINAL RADIOGRAPHIC EXAM EVALUATION PROTOCOL

A. Radiopaque contrast agent in the subarachnoid space injected via:

□ Magna Cistern □ Lumbar

B. X-rayed region:

□ **One region**	□ **Two regions**	□ **Three regions**	□ **Four regions**
□ Cervical vertebral column □ Thoracic vertebral column □ Lumbar vertebral column □ Sacral vertebral column	□ Cervical and thoracic vertebral column □ Thoracic and lumbar vertebral column □ Lumbar and sacral vertebral column	□ Cervical and thoracic, and lumbar vertebral column □ Thoracic and lumbar and sacral vertebral column	□ Cervical and thoracic and lumbar and sacral vertebral column

C. Views:

□ Laterolateral □ Ventrodorsal □ Dorsoventral □ Oblique

D. Image quality assessment:

□ It was possible to evaluate, and there were radiographic alterations.
□ It was possible to evaluate, and there were no radiographic changes.
□ It was not possible to evaluate due to image quality and/or poor positioning/movement of the animal.

Each change found must be reported, along with your location.

Estimate the location, extent, and severity of spinal lesions.

1. Filling and aligning contrast columns

Evaluate the fill and alignment of the dorsal contrast column. (Main changes: *Mitigation; Dorsal deviation; Failure; Increase*).

Changes found:____.

Evaluate the filling and alignment of the ventral contrast column. (Main changes: *Mitigation; Dorsal deviation; Failure; Increase*).

Changes found:____.

2. Contrast medium in relation to the spinal cord and vertebral canal:

Evaluate the contrast medium in relation to the spinal cord and vertebral canal. (Main changes: *Change in contrast within the vertebral canal; Presence of contrast within the parenchyma of the spinal cord [Syingomyelia]; "Golf pin" sign; Extradural contrast extravasation; Contrast outside the subarachnoid space [epidurography]; Poor miscegenation of contrast with cerebrospinal fluid; Enlarged and contrast filled vertebral canal [Hidromyelia]).*

Changes found:____.

3. Various radiographic changes:

Evaluate and report possible changes related or not to the animal's condition. (Main changes: *Air bubbles within the vertebral canal; Contrast injection into the parenchyma or central canal of the spinal cord; Irregular opacification [suggestive of myelomalacia]).*

Changes found:____.

E. Location of radiographic changes found:

□ Cervical (C1-C2-C3-C4-C5-C6-C7)

□ Thoracic (T1-T2-T3-T4-T5-T6-T7-T8-T9-T10-T11-T12-T13)

□ Lumbar (L1-L2-L3-L4-L5-L6-L7)

□ Sacral (S1-S2-S3)

F. Spinal cord compression:

□ No findings suggestive of spinal cord compression.
□ There are findings suggestive of extradural spinal cord compression.
□ There are findings suggestive of intradural/extramedullary spinal cord compression.
□ There are findings suggestive of intramedullary spinal cord compression.

G. Indication of a new imaging examination:

□ No.

□ Yes, new contrast spinal radiographic exam.

□ Yes, CT or MRI.

H. Conclusion of myelography evaluation:

- □ Inconclusive.
- □ Suggestive of myelopathy.
- □ ____.

Supplementary archive 2 - Table with the distribution and identification of 45 dogs, 31 dogs submitted to survey spinal radiographic exam, 14 dogs underwent both simple radiographic examination and myelography, and 06 cats with clinical suspicion of spinal cord injury submitted to survey spinal radiographic exam of the spine attended at the veterinary university hospital of an institution between January 2016 and December 2021.

No.	Identification (Race, gender, age, weight)	Main clinical sign	Neurological examination	Major clinical suspicion	Reason for the radiographic exam (discard or confirm)	Radiographic alterations found	Radiographic changes, according to the report	Purpose of the examination according to: New analysis	Purpose of the examination according to: Report	Indication of a new imaging examination
Survey spinal radiographic exams in dogs										
1	Labrador retriever, M, 14 years old, *	Paraparesis	No	Vertebral neoplasia	Trauma, vertebral neoplasia.	Deforming spondylosis in the vertebral body of L2, L3, L4, L5, L7, S1; Vertebral body alteration of L2, L3, L4, L5.	Deforming spondylosis in the vertebral body of L7 and S1; Sclerosis of endplates between L7-S1; Increased opacity in the L7-S1 segment of the vertebral canal.	Yes: - Ruled out trauma.	Yes: - Ruled out trauma.	Yes, myelography.
2	Poodle, M, 5 years, 2.3 kg	Paraplegia (from birth)	No	Congenital vertebral anomaly	Trauma; Congenital vertebral anomaly.	Escoliose e cifose na região toracolombar; Vértebras T4-T5 em bloco.	Scoliosis and kyphosis; T4-T5 vertebrae in a block.	Yes: - Ruled out trauma; - Confirmed congenital vertebral anomaly.	Yes: - Ruled out trauma; - Confirmed congenital vertebral anomaly.	Yes, myelography.
3	Mixed breed, M, 5 years, 8.6 kg	Paraplegia	Yes	IVDD	Trauma.	Deforming spondylosis in the vertebral body of L2 and L3.	Increased intervertebral disc opacity between L7-S1.	Yes: - Ruled out trauma.	Yes: - Ruled out trauma.	Yes, myelography.
4	Poodle, F, 17 years old, 2.5 kg	Paraplegia	No	IVDD	Trauma; Neoplasia vertebral.	Reduction of intervertebral space between T12-T13, T13-L1, and L3-L4.	No changes.	Yes: - Ruled out trauma.	Yes: - Ruled out trauma.	Yes, myelography.
5	Mixed breed, M, 4	Paraplegia	No	IVDD	Trauma.	Increased opacity in the intervertebral foramen between L1-L2; Increased	Reduction of intervertebral space between T13-L1.	Yes: - Ruled out trauma.	Yes: - Ruled out trauma.	Yes, myelography.

	years, 17.7 kg					intervertebral space between T13-L1 and L1-L2.				
6	Dogo Argentino, F, 5 years old, 41 kg	Paraparesis	Yes	IVDD	Trauma	Deforming spondylosis in the vertebral body of T10, T11, T12, L5, L6; Reduction of intervertebral space between L3-L4.	Deforming spondylosis in the vertebral body of T10, T11, T12, L5, L6, and L7.	Yes: - Ruled out trauma.	Yes: - Ruled out trauma.	Yes, myelograph y.
7	Mixed breed, F, 17 years, 5,7 kg	Unilateral RPL claudication	No	Discospond ylitis	Discospondyli tis; Deforming spondylosis.	Intervertebral space between L4-L5 wedge-shaped; Deforming spondylosis in the vertebral body of T11, T12, T13, L1, L2, L3, and L4; Increased opacity in the intervertebral foramen between L3-L4; Reduction of intervertebral space between T12-T13 and T13-L1.	Deforming spondylosis in the vertebral body of T12, T13, L1, L2, L3, and L4; Increased intervertebral disc opacity between L3-L4.	Yes: - Ruled out discospondylitis ; - Confirmed deforming spondylosis.	Yes: - Ruled out discospondylitis ; - Confirmed deforming spondylosis.	No
8	Cane corso, M, 9 years, 47.9 kg	Tetraparesis	No	IVDD	Trauma.	Deforming spondylosis in the vertebral body of T3, T4, and T5; Reduction of intervertebral space between C6-C7, T3-T4, T4-T5, and T5-T6.	Deforming spondylosis in the vertebral body of T3, T4, T5, and T6; Reduction of intervertebral space between T2-T3, T3-T4, T4-T5, and T5-T6; Reduction of the space between the articular interlines of the joint processes between L1-L2 and L2-L3; Sclerosis of endplates between T2-T3, T3-T4, T4-T5 and T5-T6.	Yes: - Ruled out trauma.	Yes: - Ruled out trauma.	Yes, myelograph y.
9	Pekingese, M, 10 years old, 7.8 kg	Paraparesis	No	IVDD	Trauma; Neoplasia vertebral.	Calcified material within the intervertebral foramen between L3-L4; Reduction of intervertebral space between L3-L4.	Calcified material within the intervertebral foramen between L3-L4; Reduction of intervertebral space between L2-L3 and L3-L4; Reduction of the	Yes: - Ruled out trauma.	Yes: - Ruled out trauma.	Yes, myelograph y.

							space between the joint's articular interlines L4-L5 and L5-L6; Irregular shape of the joint process of L5 and L6.			
10	Mixed breed, F, 3 years, 16,8 kg	Paraparesis	No	IVDD	Trauma	Deforming spondylosis in the vertebral body of L7 and S1.	Deforming spondylosis in the vertebral body of L7, S1	Yes: - Ruled out trauma.	Yes: - Ruled out trauma.	Yes, myelography.
11	Mixed breed, M, 3 years, 26 kg	Paraplegia	No	IVDD	Trauma	No changes	No changes	Yes: - Ruled out trauma.	Yes: - Ruled out trauma.	Yes, myelography.
12	Labrador retriever, M, 8 years old, 27.7 kg	Paraplegia	Yes	Fibrocarylaginous embolism	Trauma	Intervertebral space between T13-L1 wedge-shaped; Deforming spondylosis in the vertebral body of T4, T5, and T6; Reduction of intervertebral space between T4-T5.	Deforming spondylosis in the vertebral body of T4, T5, and T6; Reduction of intervertebral space between T4-T5.	Yes: - Ruled out trauma.	Yes: - Ruled out trauma.	Yes, myelography.
13	Border collie, F, 2 years, 22 kg	Bilateral claudication of PLs	No	Cauda equina syndrome	Trauma	Intervertebral space between L6-L7 wedge-shaped; Increased intervertebral foramen opacity between L7-S1.	No changes	Yes: - Ruled out trauma.	Yes: - Ruled out trauma.	Yes.
14	Boxer, M, 10 years, 25.4 kg	Paraparesis	Yes	Cauda equina syndrome	Trauma; Neoplasia vertebral.	Deforming spondylosis in the vertebral body of L7.	Deforming spondylosis in the vertebral body of L7 and S1; Enthesophyte fracture of the vertebral body of L7 and S1.	Yes: - Ruled out trauma.	Yes: - Ruled out trauma.	Yes, myelography (was performed)
15	Bull terrier, M, 1 year, 13.8 kg	Paraparesis	No	Trauma	Trauma; Congenital vertebral anomaly.	Reduction of intervertebral space between T13-L1; Vertebral body malformation of L2, L3, L4, L5, and L6.	No changes	Yes: - Ruled out trauma; - Confirmed congenital vertebral anomaly.	Yes: - Ruled out trauma; - Ruled out the congenital vertebral anomaly.	Yes, myelography.
16	Australian cattle dog, M, 8 months, 12.6 kg	Paraplegia	Yes	IVDD	Trauma; congenital vertebral anomaly.	Calcification of the intervertebral disc between T11-T12, T13-L1, L1-L2, and L4-L5.	No changes.	Yes: - Ruled out trauma.	Yes: - Ruled out trauma.	Yes, myelography.

17	Poodle, F, 8 years old, 4.2 kg	Paraplegia	No	IVDD	Trauma.	Reduction of intervertebral space between T12-T13 and L1-L2; Increased opacity in the cranial and caudal aspects of the vertebral body of L2.	Reduction of intervertebral space between L1-L2; Increased opacity of the intervertebral foramen between L1-L2; Increased opacity in the cranial and caudal aspects of the vertebral body.	Yes: - Ruled out trauma.	Yes: - Ruled out trauma.	Yes, myelography.
18	Cocker spaniel, F, 15 years old, 15.4 kg	Bilateral claudication of PLs	No	IVDD	Trauma; Neoplasia vertebral.	Deforming spondylosis in the vertebral body of L1, L2, L3, and L4; Calcification of the intervertebral disc between L5-L6; Reduction of intervertebral space between L5-L6; Increased opacity in the intervertebral foramen between L4-L5.	Deforming spondylosis in the vertebral body of L1, L2, L3, L4, and L5; Reduction of intervertebral space between L5-L6 and L6-L7; Increased opacity in the intervertebral foramen between L5-L6 and L6-L7.	Yes: - Ruled out trauma.	Yes: - Ruled out trauma.	Yes, myelography.
19	Mixed breed, F, 7 years, 7 kg	Paraparesis	Yes	IVDD	Trauma.	Intervertebral space between T12-T13 wedge-shaped; Reduction of intervertebral space between T12-T13 and L1-L2; Calcification of the intervertebral disc between T12-T13.	Reduction of intervertebral space between T11-T12; Increased opacity in the intervertebral foramen between T12-T13; Increased opacity in the T12-T13 segment of the vertebral canal; Irregular contour of the caudal vertebral body of L2; Deforming spondylosis in the vertebral body of L2; Calcification of the intervertebral disc between T12-T13.	Yes: - Ruled out trauma.	Yes: - Ruled out trauma.	Yes, myelography.
20	Poodle, F, 12 years, 4.2 kg	Paraparesis	Yes	IVDD	Trauma; Neoplasia vertebral.	Scoliosis in the thoracolumbar region; Reduction of intervertebral space between T12-T13 and L2-	Reduction of intervertebral space between L2-L3; Increased intervertebral disc opacity between L2-L3; Deforming spondylosis in	Yes: - Ruled out trauma.	Yes: - Ruled out trauma.	Yes, myelography.

						L3; Discospondylitis between L2-L3.	the vertebral body of L2-L3.			
21	German Shepherd, F, 11 years, 34 kg	Bilateral claudication of PLs	No	Deforming spondylosis	Deforming spondylosis	Deforming spondylosis in the vertebral body of T13, L1, L2, L3, and L4; Reduction of intervertebral space between T13-L1.	Deforming spondylosis in the vertebral body of T13, L1, L2, L3, and L4.	Yes: - Confirmed deforming spondylosis.	Yes: - Confirmed deforming spondylosis.	No
22	French Bulldog, M, 3 years, 14 kg	Paraplegia	No	IVDD	Trauma; Congenital vertebral anomaly	Deforming spondylosis in the vertebral body of L3, L4, L5; Reduction of intervertebral space between T10-T11, T11-T12, T12-T13, and T13-L1.	No changes.	Yes: - Ruled out trauma.	Yes: - Ruled out trauma.	Yes, myelograph y (was performed)
23	German Shepherd, F, 11 years, 34 kg	Bilateral claudication of PLs	No	Deforming spondylosis	Alteration follow-up was previously found.	Deforming spondylosis in the vertebral body of T13, L1, L2, L3, and L4; Reduction of intervertebral space between T13-L1; Alteration of the shape of the intervertebral foramen between L7-S1.	Deforming spondylosis in the vertebral body of T10, T11, T12, T13, L1, L2, L3, L4, and L5.	Yes: - Confirmed deforming spondylosis.	Yes: - Confirmed deforming spondylosis.	No
24	Dachshund, F, 5 years, 7.3 kg	Paraparesis	Yes	IVDD	Trauma.	Intervertebral space in T13-L1 wedge-shaped; Intervertebral disc calcification between T11-T12 and T12-T13.	No changes.	Yes: - Ruled out trauma.	Yes: - Ruled out trauma.	Yes, myelograph y.
25	Shih-tzu, F, 4 years, 3.8 kg	Paraparesis	Yes	IVDD	Trauma.	Curvature between L2-L3; Calcified material within the intervertebral foramen between T13-L1; Reduction of intervertebral space between L2-L3; Calcification of the intervertebral disc between T12-T13.	It was not possible to evaluate due to image quality and/or poor positioning/movement of the patient.	Yes: - Ruled out trauma.	Inconclusive: - Could not rule out or confirm trauma.	Yes, myelograph y.
26	Yorkshire, F, 5 years, 4 kg	Paraparesis	Yes	IVDD	Trauma	Reduction of intervertebral space between T13-L1.	Reduction of intervertebral space between T13-L1.	Yes: - Ruled out trauma.	Yes: - Ruled out trauma.	Yes, myelograph y (was performed)

27	Dachshund, M, 12 years old, 13.3 kg	Paraparesis	No	IVDD	Trauma	Loss of ventral resolution of the vertebral body of L1, L2, L3, and L4; Deforming spondylosis in the vertebral body of T13 and L1; Reduction of intervertebral space between T9-T10 and T10-T11.	Loss of ventral resolution of the vertebral body of L1, L2, L3, and L4; Reduced intervertebral space between T9-T10 and T10-T11.	Inconclusive: - Could not rule out or confirm trauma.	Inconclusive: - Could not rule out or confirm trauma.	Yes, myelograph y.
28	Mixed breed, F, 2 years, 16,5 kg	Paraparesis	Yes	Trauma	Trauma	Misalignment of the floor of the lumbosacral vertebral canal; Bone fragments within the lumbar vertebral canal; L4-L5 dislocation; L4 vertebral body fracture; Loss of intervertebral foramen contour between L4-L5.	L5-L6-L7 dislocation; Fracture of the vertebral body of L4.	Yes: - Confirmed trauma.	Yes: - Confirmed trauma.	No
29	Mixed breed, F, 2 years, 16,5 kg	Paraparesis	Yes	Stabilized fracture	Post-surgical follow-up (fracture stabilization)	L4 vertebral body fracture; Bone fragments within the lumbar vertebral canal; Pin inserted in the vertebral bodies of L4 and L5.	L4 vertebral body fracture; Pin inserted in the vertebral bodies of L4 and L5.	Yes: - Confirmed fracture stabilization.	Yes: - Confirmed fracture stabilization.	No
30	German Shepherd, F, 5 years old, *	Paraparesis	Yes	IVDD	Trauma	L4 vertebral body malformation; Deforming spondylosis in the vertebral body of T5, T6, T12, and L4; Reduction of intervertebral space between T5-T6.	Deforming spondylosis in the vertebral body of T5, T6, T12, L2, and L3; Overlapping structures in the transverse processes of the vertebrae.	Yes: - Ruled out trauma.	Inconclusive: - Could not rule out or confirm trauma.	Yes, myelograph y.
31	Mixed breed, M, *, 8,2 kg	Paraplegia	No	Trauma	Trauma	Fracture of the spinous process of T11; Fracture of the articular process of T11.	Fracture of the spinous process of T11; Fracture of the vertebral body of T11; Overlap of T11 fracture to the vertebral canal.	Yes: - Confirmed trauma.	Yes: - Confirmed trauma.	No (Euthanasia)
Survey spinal radiographic exams in felines										
32	Mixed breed, F, 10 years, 3.5 kg	Paraparesis	No	Trauma	Trauma	L6 luxation.	L5-L6 luxation.	Yes: - Confirmed trauma.	Yes: - Confirmed trauma.	No

33	Mixed breed, F, 8 years, 2,7 kg	Paraparesis	No	Polyneuropathy	Trauma	Intervertebral space between T13-L1 and Wedge-shaped L2-L3.	No changes.	Yes: - Ruled out trauma.	Yes: - Ruled out trauma.	Yes, myelography
34	Mixed breed, M, 4 months, 1.3 kg	Paraparesis	No	Trauma	Trauma	Intervertebral space between T11-T12, T12-T13, and T13-L1 wedge-shaped; Deforming spondylosis in the vertebral body of T1; Reduction of intervertebral space between T10-T11.	No changes.	Yes: - Ruled out trauma.	Yes: - Ruled out trauma.	Yes, myelography
35	Mixed breed, F, 2 years, 2,5 kg	Paraplegia	No	Trauma	Trauma	Vertebral body fracture of T12 and L2.	Reduction of intervertebral space between T12-T13 and L2-L3; Reduction of vertebral body opacity of T12 and L1; Increased opacity in the T12 segment of the vertebral canal; Reduction of opacity in the L2 segment of the vertebral canal; Fracture of the L6 thorn process.	Yes: - Confirmed trauma.	Yes: - Confirmed trauma.	No
36	Mixed breed, M, 4 years, 4,7 kg	Paraplegia	Yes	Trauma	Trauma	L6-L7 luxation; Bone fragments within the lumbosacral vertebral canal; Foreign body (projectile) present in the vertebral canal of L6; Fracture of the Transverse Process of L6; L6 blade fracture; Fracture of the vertebral body of L6.	L6-L7 luxation; Foreign body (projectile) present in the vertebral canal of L6; Vertebral body fracture of L6 and L7.	Yes: - Confirmed trauma.	Yes: - Confirmed trauma.	No
37	Mixed breed, F, 2 years, 2,9 kg	Paraparesis	Yes	Feline ischemic myelopathy	Trauma	Intervertebral space of L2-L3 and L3-L4 in wedge format; Reduction of intervertebral space between T12-T13.	No changes.	Yes: - Ruled out trauma.	Yes: - Ruled out trauma.	Yes, myelography

Survey spinal radiographics exams performed moments before myelography in dogs

38	Mixed breed, M, 13 years, 17.7 kg	Paraplegia	Yes	IVDD	Trauma; Neoplasia vertebral	Deforming spondylosis in vertebral body of L1, L2 and L3; Reduction of intervertebral space between T13-L1 and L1-L2.	Reduction of intervertebral space between L1-L2 and L2-L3; Bone lysis in proximal terminal plate of L3; End plate sclerosis of the vertebral body of L1, L2 and L3; Deforming spondylosis in vertebral body of L1, L2 and L3; Osteophyte fracture in the vertebral body of L1 and L2.	Yes: - Ruled out trauma.	Inconclusive: - Could not rule out or confirm trauma.	Yes
39	Labrador, M, 8 years old, 27.7 kg	Paraplegia	Yes	Fibrocartylaginous embolism	Trauma	No changes.	No changes.	Yes: - Ruled out trauma.	Yes: - Ruled out trauma.	Yes
40	Boxer, M, 8 years, 40 kg	Paraparesis	Yes	IVDD	Trauma; Neoplasia vertebral	Deforming spondylosis in vertebral body of L1, L2, L3; Lysis on L1 terminal plate; Reduction of intervertebral space between T12-T13.	Deforming spondylosis in vertebral body of T6, T7, T13, L1, L2, L3 and L4; Projectile in the spine, dorsal at T7 and cranial at T11.	Yes: - Ruled out trauma.	Inconclusive: - Could not rule out or confirm trauma.	Yes
41	Boxer, M, 10 years, 25.4 kg	Paraparesis	Yes	Cauda equina syndrome	Trauma; Neoplasia vertebral	Deforming spondylosis in vertebral body of T12, T13 and L7.	No changes.	Yes: - Ruled out trauma.	Yes: - Ruled out trauma.	Yes
42	French Bulldog, M, 3 years, 14 kg	Paraplegia	Yes	IVDD	Trauma; Congenital vertebral anomaly	Calcification of the intervertebral disc between T11-T12, T13-L1, L1-L2 and L4-L5.	No changes.	Yes: - Ruled out trauma.	Yes: - Ruled out trauma.	Yes
43	French Bulldog, F, 3 years, 2.9 kg	Paraplegia	Yes	IVDD	Trauma; Congenital vertebral anomaly	Lumbar scoliosis; Deforming spondylosis in vertebral body of T11, L2, L3 and L4; Reduction of intervertebral space between T12-T13 and L1-L2; Calcification of the intervertebral disc between L4-L5, L5-L6 and L6-L7	No changes.	Yes: - Ruled out trauma.	Yes: - Ruled out trauma.	No (indicated surgical treatment)
44	Yorkshire, F, 5 years, 3 kg	Paraparesis	Yes	IVDD	Trauma	Reduction of intervertebral space between T11-T12 and T13-L1.	Reduction of intervertebral space between T13-L1.	Yes: - Ruled out trauma.	Yes: - Ruled out trauma.	No (surgical treatment)

45	Poodle, F, 3 years, *	Paraplegia	Yes	IVDD	Trauma	T10-T11 dislocation; Intervertebral space between T12-T13 wedge-shaped; Reduction of intervertebral space between T10-T11 and T12-T13; Calcification of the intervertebral disc between T9-T10 and T13-L1.	No changes.	Yes: - Confirmed trauma.	Yes: - Confirmed trauma.	Yes
46	Mixed breed, F, 5 Years, 12.5	Paraplegia	Yes	IVDD	Trauma	No changes.	No changes.	Yes: - Ruled out trauma.	Yes: - Ruled out trauma.	No (Euthanasia)
47	Mixed breed, F, 12 years, 9.9 kg	Tetraparesis	Yes	IVDD	Trauma; Neoplasia vertebral	Reduction of intervertebral space between C6-C7.	Variations in The Positioning of C6 were observed in different projections, suggestive of instability.	Yes: - Ruled out trauma.	Inconclusive: - Could not rule out or confirm trauma.	No (surgical treatment)
48	Australian cattle dog, M, 10 years, 26.8 kg	Tetraparesis	Yes	Cervical spondylom ylopathy	Trauma; Neoplasia vertebral[1]	Deforming spondylosis in vertebral body of C7 and T1.	No changes.	Yes: - Ruled out trauma.	Yes: - Ruled out trauma.	No (surgical treatment)
49	Dachshund, F, 10 years, 9.7 kg	Paraplegia	Yes	IVDD	Trauma; Neoplasia vertebral.	Scoliosis in T13-L1; Curvature between T10-T11; Deforming spondylosis in vertebral body of L2, L3; Reduction of intervertebral space between T10-T11, T12-T13, T13-L1 and L1-L2.	Reduction of intervertebral space between L1-L2; Curvature between T10-T11.	Yes: - Ruled out trauma.	Yes: - Ruled out trauma.	No (surgical treatment)
50	Dachshund, F, 11 years old, 10.4 kg	Paraparesis	Yes	IVDD	Trauma; Neoplasia vertebral	Curvature between T2-T3; Reduction of intervertebral space between T9-T10 and L2-L3.	Deforming spondylosis in vertebral body of T12, T13, L1, L2, L3; Decrease in intervertebral space between L2-L3.	Yes: - Ruled out trauma.	Yes: - Ruled out trauma.	No (surgical treatment)
51	Mixed breed, M, 3 years, 14.5 kg	Paraplegia	Yes	IVDD	Trauma	Hemivértebra in L1; Reduction of intervertebral space between T9-T10, T11-T12 and L1-L2.	Reduction of intervertebral space between T13-L1 and L1-L2.	Yes: - Ruled out trauma.	Yes: - Ruled out trauma.	No (surgical treatment)
Myelography performed after survey spinal radiographic exams in dogs										

52	Mixed breed, M, 13 years, 17.7 kg	Paraplegia	Yes	IVDD	Assist in the diagnosis of myelopathy	Dorsal deviation of the ventral contrast column between L2-L3; Epidurography	No changes.	Yes: - Suggestive of extradural spinal compression.	Inconclusive	Yes
53	Labrador, M, 8 years, 27.7 kg	Paraplegia	Yes	Fibrocarylaginous embolism	Assist in the diagnosis of myelopathy	Dorsal deviation of the ventral contrast column between L3-L4.	No deviation from contrast columns; It was not possible to evaluate the limit of the contrast lines in the final part of the column in region of L7-S1, due to the overlap of the wings of the ileos.	Yes: - Suggestive of extradural spinal compression.	Inconclusive	Yes
54	Boxer, M, 8 anos, 40 kg	Paraparesis	Yes	IVDD	Assist in the diagnosis of myelopathy	Poor contrast miscegenation.	Thinning of the ventral contrast column between T11-T12, T12-T13 and T13-L1; Radiographic findings are inconclusive due to the passage of contrast beyond the vertebrae.	Inconclusive	Inconclusive	Yes
55	Boxer, M, 10 anos, 25,4 kg	Paraparesis	Yes	Cauda equina syndrome	Assist in the diagnosis of myelopathy	Falha da coluna de contraste ventral entre L7-S1.	No changes.	Yes: - Suggestive of extradural spinal compression.	Inconclusive	Yes
56	French Bulldog, M, 3 years, 14 kg	Paraplegia	Yes	IVDD	Assist in the diagnosis of myelopathy	Contrast alteration within the medullary canal in the T12-T13 region.	No changes.	Inconclusive	Inconclusive	Yes
57	French Bulldog, F, 3 years, 2.9 kg	Paraplegia	Yes	IVDD	Assist in the diagnosis of myelopathy	Dorsal deviation of the ventral contrast column between L1-L2; Ventral contrast column failure between L1-L2.	No changes.	Yes: - Suggestive of extradural spinal compression.	Inconclusive	No (indicated surgical treatment)
58	Yorkshire, F, 5 years, 3 kg	Paraparesis	Yes	IVDD	Assist in the diagnosis of myelopathy	Dorsal deviation of the ventral contrast column between T11-T12, T13-L1 and L4-L5.	Ventral contrast column failure between T12-T13 and T13-L1; Dorsal contrast column failure between T13-L1.	Yes: - Suggestive of extradural spinal compression.	Yes: - Suggestive of extradural spinal compression.	No (surgical treatment)
59	Poodle, F, 3 years,*	Paraplegia	Yes	IVDD	Assist in the diagnosis of myelopathy	Dorsal deviation of the ventral contrast column between T12-T13; Ventral contrast column failure between T12-T13	No changes.	Yes: - Suggestive of extradural spinal compression.	Inconclusive	Yes

60	Mixed breed, F, 5 years, 12.5	Paraplegia	Yes	IVDD	Assist in the diagnosis of myelopathy	Medullary edema in four vertebral bodies between T12 and L3; Extensive area suggestive of myelomalacia; Extradural contrast extravasation of the subarachnoid space following the root of the L4 nerve in the epaxial musculature.	Contrast escape from the vertebral canal in the region of L5, L6 and L7; Higher contrast concentration in the vertebral canal in regions L5, L6 and L7.	Yes: - Suggestive of intramedullary compression.	Inconclusive.	No (Euthanasia)
61	Mixed breed, F, 12 years, 9.9 kg	Tetraparesis	Yes	IVDD	Assist in the diagnosis of myelopathy	Dorsal deviation of the ventral contrast column between C5-C6; Ventral contrast column failure between C5-C6.	Dorsal deviation of the ventral contrast column between C5-C6; Failure of the ventral contrast column between C5-C6.	Yes: - Suggestive of extradural spinal compression.	Yes: - Suggestive of extradural spinal compression.	No (surgical treatment)
62	Australian cattle dog, M, 10 years, 26.8 kg	Tetraparesis	Yes	Cervical spondylomylopathy	Assist in the diagnosis of myelopathy	Dorsal deviation of the ventral contrast column between C3-C4 and C6-C7; Dorsal deviation of the dorsal contrast column between C6-C7.	Dorsal deviation of the ventral contrast column between C6-C7.	Yes: - Suggestive of extradural spinal compression.	Yes: - Suggestive of extradural spinal compression.	No (surgical treatment)
63	Dachshund, F, 10 years, 9.7 kg	Paraplegia	Yes	IVDD	Assist in the diagnosis of myelopathy	Dorsal deviation of the ventral contrast column between T13-L1 and L1-L2; Attenuation of the ventral contrast column between L1-L2; Failure of the ventral contrast column between T13-L1; Epidurography.	Dorsal deviation of the ventral contrast column between L1-L2; Attenuation of the ventral contrast column between L1-L2.	Yes: - Suggestive of extradural spinal compression.	Yes: - Suggestive of extradural spinal compression.	No (surgical treatment)
64	Dachshund, F, 11 years old, 10.4 kg	Paraparesis	Yes	IVDD	Assist in the diagnosis of myelopathy	Failure of the ventral contrast column between T9-T10 and L3-L4; Epidurography	Ventral contrast column failure between T9-T10 and L3-L4.	Yes: - Suggestive of extradural spinal compression.	Yes: - Suggestive of extradural spinal compression.	No (surgical treatment)
65	Mixed breed, M, 3 years, 14.5 kg	Paraplegia	Yes	IVDD	Assist in the diagnosis of myelopathy	Dorsal deviation of the ventral contrast column between L1-L2; Failure of the ventral contrast column between L1-L2; Attenuation of the dorsal contrast column between L1-L2; Contrast dorsal column increase in L2.	Dorsal deviation of the ventral contrast column between L1-L2; Ventral contrast column failure between L1-L2.	Yes: - Suggestive of extradural spinal compression.	Yes: - Suggestive of extradural spinal compression.	No (surgical treatment)

* = information not found in the animal's medical records. C = cervical spine; T = thoracic spine; L = lumbar spine; S = sacral column; CT= cervical spine with thoracic; TL = thoracic spine with lumbar; LS = lumbar spine with sacral; CTL= cervical spine with thoracic spine with lumbar; TLS = thoracic spine with lumbar with sacral; CTLS = cervical spine with thoracic with lumbar with sacral. MPD = Right pelvic limb.

7 CONCLUSÃO

Apesar da crise sanitária iniciada em 2020 em decorrência do COVID-19, a qual possuía como medidas principais para evitar a disseminação do vírus o distanciamento social e a quarentena; e do objetivo primário deste mestrado em realizar um estudo experimental. Pode-se concluir que a presente pós-graduação permitiu desenvolver a pesquisa através de um formato diferente, mas não menos interessante, pois a partir dois relatos de casos e do estudo retrospectivo percebeu-se a relevância de realizar diferentes metodologias que, ainda assim, foram capazes de proporcionar resultados importantes para a comunidade científica.

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