



Recovery of stepping and coordination in dogs following acute thoracolumbar intervertebral disc herniations

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ABSTRACT

Prospective data on the recovery of coordination in dogs suffering acute thoracolumbar intervertebral disc herniations (TL-IVDH) are limited. The purpose of this study was to use treadmill based and open field scores (OFS) to quantify recovery of stepping ability and forelimb, hindlimb coordination in the 6 weeks following surgical decompression of dogs with TL-IVDH. Sixty-three dogs were grouped at presentation as grades 3 (non-ambulatory paraparetic), 4 (paraplegic) or 5 (paraplegic without pain sensation) and were evaluated 2, 4, and 6 weeks post-operatively. Stepping scores and Regularity Index (RI), a measure of coordination, were calculated from treadmill walking, and an OFS incorporating supported and unsupported walking was assigned. Outcomes for the three measures were compared between groups and correlation between scoring methods was assessed.

Grade 3 and 4 dogs recovered ambulation by 2 weeks, reaching median stepping scores of 96 and 90% by 6 weeks, respectively. Recovery of coordination differed between groups 3 and 4 with median RI scores of 93.9% and 63%, respectively, by 6 weeks. Eight grade 5 dogs failed to recover independent ambulation by 6 weeks. Nine dogs recovered with scores that were significantly worse than the grade 3 and 4 dogs at 6 weeks for stepping score ($P < 0.001$) and RI ($P < 0.001$). OFS correlated closely with stepping and RI scores and each group was significantly different using this ordinal scale. In conclusion, recovery of coordination was incomplete in dogs that showed good recovery of stepping. The data generated could be used for clinical trial design.

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Introduction

Acute intervertebral disc herniations (IVDH) occur at a high rate in chondrodystrophoid breeds of dog, causing acute loss of pelvic limb function that varies in severity from mild paresis to paraplegia with lack of pain perception (Wheeler and Sharp, 1994). The high frequency with which IVDH occurs and the potential for chronic disability highlight the need to evaluate therapies in prospective clinical trials. Such trials require outcome measures that capture neurologic recovery in an accurate and relevant fashion. Moreover, in order to design a trial with adequate statistical power, baseline data on recovery of the study population are needed.

Dogs with thoracolumbar (TL) spinal cord injuries are graded clinically using the modified Frankel score (MFS) from grade 5 (paraplegic with no pain sensation), to 0 (normal; Table 1; Wheeler and Sharp, 1994). IVDH can be treated conservatively but in general, decompressive surgery to remove extruded disc material is recommended

for dogs that are non-ambulatory paraparetic or paraplegic (grades 3 through 5; Brisson, 2010; Coates, 2013). Recovery of locomotion and continence occurs rapidly in dogs presenting with MFS grades 3 and 4 signs following surgery (Ferreira et al., 2002; Olby et al., 2004). However, data on recovery of forelimb, hindlimb coordination are limited and if recovery of coordination is incomplete, it may represent a meaningful therapeutic target. Dogs presenting with MFS grade 5 signs fare less well, with only 30–60% recovering motor function after surgery (Duval et al., 1996; Scott and McKee, 1999; Olby et al., 2003; Ito et al., 2005; Aikawa et al., 2014). Again, data on recovery of forelimb, hindlimb coordination are lacking.

Several different scoring systems have been developed to evaluate recovery of locomotion in dogs with TL spinal cord injuries, but few evaluate coordination in an objective manner. The most straightforward outcome measure is a categorical classification of the ability to walk or not, in many cases determined by telephone follow-up. Ordinal scales of gait such as the MFS and an expanded scale (Olby et al., 2001) are used commonly and combination ordinal scales have been developed to encompass gait, proprioception, and pain perception (Borgens et al., 1999; Levine et al., 2009). However, none of these scales evaluate forelimb, hindlimb coordination

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Table 1
Modified Frankel scale used clinically to grade dogs with thoracolumbar myelopathies.

Grade 0	Normal
Grade 1	Painful back, no neurological deficits
Grade 2	Ambulatory paraparetic
Grade 3	Non-ambulatory paraparetic
Grade 4	Paraplegic with intact pain perception
Grade 5	Paraplegic with loss of pain perception

specifically. Detailed kinematic analysis has been used to quantify variability of coordination and stride length, but many centers do not have the required equipment (Hamilton et al., 2007, 2008; Gordon-Evans et al., 2009). More recently a treadmill based scoring system was validated to quantify stepping and forelimb, hindlimb coordination (Olby et al., 2014). The aim of the current study was to use this treadmill based scoring system in dogs that suffer acute TL-IVDH to describe their recovery of stepping and coordination over the 6-week period following surgery, in order to generate continuous baseline data that could be used in clinical trial design. Specifically, the study objectives were to quantify and compare the recovery of hindlimb stepping and coordination in dogs presenting with MFS grades 3, 4 and 5 at 2, 4 and 6 weeks following surgery.

Materials and methods

This was a prospective study in which data were collected on gait in dogs with an acute TL-IVDH at 2, 4 and 6 weeks post decompressive spinal surgery.

Dogs

Client-owned dogs that presented to the neurology service at North Carolina State University (NCSU) Veterinary Hospital between the years 2011 and 2014 were used in this study. In order to be included, dogs had to be acutely (onset over 2 days or less) non-ambulatory (MFS grades 3, 4 or 5) due to TL IVDH, to undergo decompressive surgery, and to return for rechecks 2, 4 and 6 weeks post-operatively to capture the typical recovery period (Olby et al., 2004). Participating dogs were enrolled in a clinical trial evaluating the efficacy of cranberry extract (Crananadin, Nutramax) at reducing urinary tract infections (UTIs) and additional exclusion criteria were applied for that trial. These included history of recurrent UTIs (more than two per year), presence of a UTI at presentation, or comorbidity that predisposed them to UTI (e.g. diabetes mellitus, hyperadrenocorticism, immunosuppressive therapy). All procedures were approved by NCSU Animal Use and Care Committee (IACUC number 11-009-0; 26 January, 2011) and dog owners signed an informed consent.

All dogs underwent a physical and neurological examination prior to surgery and were categorized as MFS grades 3, 4 or 5, based on the severity of presenting clinical signs. The site of disc herniation was identified with MRI (1.5 Tesla, Siemens Medical Solutions) or CT (64 slice scanner; Siemens Sensation, Siemens Medical Solutions) and all dogs underwent hemilaminectomy and fenestration (T11/12 – L2/3). The dogs underwent a neurological examination daily until time of discharge to their owners. Time of discharge depended on their neurological status and adequacy of pain control.

Gait evaluation

Dogs were re-evaluated at 2, 4 and 6 weeks post-operatively. Dogs underwent physical and neurological examinations and were videotaped walking on a treadmill and in an open field setting using previously published protocols (Olby et al., 2001, 2014). Briefly, during treadmill recordings, a video camera was placed to capture movements of all four limbs. A handler encouraged the dog to walk by using treats at the front of the treadmill and the pace of the treadmill was set to a comfortable walk for each dog. Dogs were recorded for a minimum of 50 continuous step cycles. Paraplegic dogs were not placed on the treadmill to avoid potential damage to their paws on the treadmill surface and a score of 0 was allocated for treadmill data. For open field scoring, dogs were videotaped from both sides and behind, twice each, walking along a 15-foot long non-slip floor mat both unassisted and, if unable to support their weight, with support by holding the base of the tail.

Scoring

The observer (CAR) scoring the videos did not assist in data collection and was unfamiliar with the dogs and their recovery. All videos were reviewed in Windows Movie Maker (Microsoft, Version 2012), slowed down to correctly identify steps when needed. Initially videos were evaluated for quality. They were excluded from scoring if distraction or reluctance to walk on the treadmill led to uneven, inconsistent

Video ID: _____

Support																			
None	RF																		
	RH																		
	LF																		
	LH																		

Fig. 1. An example of a scoring sheet for treadmill video. Each step is documented with a line in the corresponding box. Scoring begins with the right forelimb and each block of 4 columns represents one step cycle. Each step cycle contains a right and left forelimb step. RF, right forelimb; RH, right hindlimb; LF, left forelimb; LH, left hindlimb. A normal step cycle pattern is characterized by RF-LH-LF-RH (Olby et al., 2014).

stepping, or if all four limbs could not be clearly visualized irrespective of camera angle (this could be a problem in dogs with long hair coats or a high body condition score). Treadmill videos were then examined to identify the first sequence of 50 unsupported, continuous step cycles and the sequence of footsteps for these 50 step cycles was recorded on a chart (Olby et al., 2014; Fig. 1). The stepping score was calculated as the number of hindlimb steps divided by the number of forelimb steps. The regularity index (RI), a measure of coordination, was calculated as the total number of step cycles taken in a normal step cycle pattern (defined in Olby et al., 2014) multiplied by 4 and divided by the total steps taken (Koopmans et al., 2005). Open field scores (OFS) were generated from the videotapes of dogs walking on a non-slip surface as previously described (Olby et al., 2001), using a modified 12-point scale to exclude the evaluation of pain perception and voluntary tail wag such that the scale only applied to gait (Supplementary Table S1).

Statistical analysis

Data from dogs were grouped according to initial severity of signs (grades 3, 4 or 5) and summary statistics for each outcome measure at 2, 4, and 6 weeks were calculated for each group. Normality of data was evaluated with the Shapiro–Wilk test. A lack of treatment effect of cranberry extract on hindlimb function was first confirmed using Wilcoxon Rank Sum testing to compare outcomes in dogs treated with placebo vs. cranberry at each time point for each outcome measure. Following confirmation of this, outcome scores from all dogs were combined. To compare recovery between each MFS group at each time point, a linear model was fit for each outcome measure as a function of the MFS grade and the F ratio was calculated. When there was a significant difference between groups, least squares means were calculated to show the size and direction of the significant effect. Pearson correlation coefficients were calculated to determine the relationships between OFS, stepping score and RI in order to evaluate the accuracy with which the OFS, an ordinal scale, captured the recovery of hindlimb locomotion over the full range of disability. There was segregation of recovery of unsupported stepping in grade 5 dogs into two distinct groups (those that recovered and those that did not), with eight of the 15 dogs (53%) failing to show any recovery of unsupported stepping by 6 weeks (treadmill scores of 0). This led to difficulty in statistical analysis because of severe lack of normality. In order to determine whether grade 5 dogs that did recover had a significantly different recovery than grade 4 dogs, a post hoc analysis was performed to compare the recovery of grade 4 to that of grade 5 dogs, with the dogs scoring 0 on the treadmill removed.

All statistical calculations were performed in SAS (Version 9.4). *P* values less than 0.05 were regarded as statistically significant.

Results

Sixty-three dogs participated in this study (Table 2) with 23 each presenting with MFS grade 3 and 4 injuries, and 17 presenting with grade 5 injuries (Fig. 2). For the purposes of this study, dogs are grouped and referred to herein as their presenting MFS grade. Thirty-three dogs received placebo and 30 dogs received cranberry in the post-operative period, evenly distributed across the MFS grades. All dogs were discharged between 3 and 7 days after surgery. There was limited case attrition due to difficulty scheduling some rechecks (Fig. 2). Overall, dog compliance and the resulting quality of videotapes was excellent, with only 5% being excluded because they could not be analyzed. There was no difference in outcomes when dogs that received cranberry extract were compared to dogs that received placebo (Supplementary Table S2).

Stepping score

Stepping scores for all dogs are summarized in Table 3. Grade 3 dogs showed a rapid recovery of stepping score to a mean of 79.8%

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