Original Article

Journal of Feline Medicine and Surgery
2022, Vol. 24(6) 473–483

DOI: 10.1177/1098612X211028031
journals.sagepub.com/home/jfm

This paper was handled and processed by the American Editorial Office (AAFP) for publication in *JFMS*

SAGE

Outcome of thoracolumbar surgical feline intervertebral disc disease

Kayla M Fowler[1], Theresa E Pancotto[2], Stephen R Werre[3], Michaela J Beasley[4], William Kay Jr[5] and Casey P Neary[6]

Abstract

Objectives The aim of this study was to evaluate the outcome and prognosis of thoracolumbar feline intervertebral disc disease (IVDD) treated by surgical decompression.

Methods This was a multi-institutional retrospective study evaluating the age, breed, sex, body weight, presenting complaint, neuroanatomic diagnosis at presentation, diagnostic imaging results, surgery performed and the overall outcome at discharge and at recheck. Bivariable associations between variables were assessed using the Kruskal–Wallis test (age and grade of IVDD at presentation) and Fisher's exact test (grade of IVDD at presentation and outcome).

Results A total of 35 cats met the inclusion criteria for the study. The most frequently reported clinical sign was difficulty walking (54.2%). The majority of cats presented with an L4–S3 localization (57%). The most common site of intervertebral disc herniation (IVDH) was at L6–L7 (34%). The majority of feline patients that received surgery had a positive outcome at the time of discharge (62.5%; n = 20/32) and at the time of the 2-week recheck (91.3%; n = 21/23). No association was identified between the age of the patient and the grade of IVDD. No association was identified between the presenting grade of IVDD and the clinical outcome at the time of discharge or at the time of recheck evaluation.

Conclusions and relevance Cats undergoing spinal decompressive surgery for thoracolumbar IVDH appear to have a favorable prognosis independent of the initial presenting grade of IVDD. A larger sample size and a longer length of follow-up is necessary to obtain statistical associations between the presenting grade of IVDD and overall clinical outcome.

Keywords: Neurology; neurosurgery; surgery; intervertebral disc disease

Accepted: 6 June 2021

Introduction

Intervertebral disc disease (IVDD) has been infrequently reported in the felid species. Intervertebral disc protrusions have been documented as a common post-mortem finding in older, supposedly asymptomatic cats;[1] the true clinical prevalence is likely underestimated. The prevalence of clinically significant intervertebral disc herniation (IVDH) in the cat has been reported twice in the veterinary literature.[2,3] The prevalence of IVDH in one case series involving 10 cats was reported to be 0.12%.[2] In another study, the prevalence of IVDH in cats was reported to be 0.24%.[3] It has been suggested that purebred cats may experience a higher incidence of IVDH.[4] British Shorthairs and Persians were over-represented in one retrospective study evaluating thoracolumbar IVDH.[3]

A good-to-excellent outcome was described in 80% of cats in a retrospective study evaluating a total of six

[1]Department of Small Animal Clinical Sciences – Neurology, Virginia–Maryland College of Veterinary Medicine, Blacksburg, VA, USA
[2]Small Animal Clinical Sciences – Neurology, Auburn University College of Veterinary Medicine, Auburn, AB, USA
[3]Population Health Sciences, Virginia–Maryland College of Veterinary Medicine, Blacksburg, VA, USA
[4]Neurology Department, Mississippi State University College of Veterinary Medicine, Starkville, MS, USA
[5]Neurology Department, Garden State Veterinary Specialists, Tinton Falls, NJ, USA
[6]Neurology Department, Bush Veterinary Neurology Service, Atlanta, GA, USA

Corresponding author:
Kayla M Fowler DVM, Department of Small Animal Clinical Sciences – Neurology, Virginia–Maryland College of Veterinary Medicine, 205 Duck Pond Drive, Blacksburg, VA 24060, USA
Email: kmfowler@vt.edu

cats with lumbar intervertebral disc extrusion treated by hemilaminectomy.[5] In another study, six cats were noted to have a fair-to-excellent outcome following a dorsal laminectomy at the L7–S1 disc space.[6] A case report on a Siamese cat after an L6–L7 dorsal laminectomy had a positive outcome.[7] Another case series evaluated thoracolumbar intervertebral disc extrusion in six cats and 5/6 were noted to have an excellent outcome.[8] In a small case series involving three cats following a ventral slot procedure, 3/3 were determined to have neurologic improvement after surgery.[9]

To our knowledge, this is the largest retrospective study to compare the presenting clinical signs, imaging findings, type of surgery performed and clinical outcome in cats with a surgically decompressed thoracolumbar IVDH. It was hypothesized that cats would most frequently have a lumbar disc herniation, that the presenting grade would influence outcome and that cats would have a similar outcome as dogs with IVDD.

Materials and methods

This was a multicenter retrospective study that collected and evaluated cases from the Virginia – Maryland College of Veterinary Medicine (n = 13), Bush Veterinary Neurology Service (n = 11), University of Tennessee College of Veterinary Medicine (n = 5), Mississippi State University College of Veterinary Medicine (n = 3), Garden State Veterinary Specialists (n = 1), VCA Alameda East (n = 1) and VCA South Paws (n = 1) between the years of 1998 and 2019.

The inclusion criteria required cats to have been presented to a veterinary neurologist and to be diagnosed with an IVDH. Diagnosis could be made by MRI, CT myelography, radiographic myelogram or a combination. Two cats with cervical IVDH were excluded owing to the numbers being too small to make useful comparisons. Cats were required to be treated with surgical decompression to be included in this study. Therefore, any cat receiving medical management was excluded.

The following information was recorded: age, breed, sex, body weight, presenting complaint, neuroanatomic diagnosis at presentation, diagnostic imaging results, type of surgery performed, and the overall outcome at discharge and at postoperative rechecks. Clinical signs were graded using a five-point grading scale. Grade I represented a normal gait but with spinal hyperesthesia. Grade II represented ambulatory paraparesis. Grade III represented non-ambulatory paraparesis. Grade IV represented paraplegia with intact nociception and possible loss of urinary function. Grade V represented paraplegia with absent nociception and possible loss of urinary function. The grade was determined from the medical record and was confirmed to correlate with the description of the neurologic examination. Imaging findings were obtained from the radiology report from the date of the original examination. Images were not re-evaluated by the current investigators. A positive outcome was defined as any improvement in the neurologic examination at the time of discharge and/or at the time of the recorded recheck. A negative outcome was defined as either a static or worse neurologic examination at the time of discharge and/or recheck. See Table 1 for clinical data.

Statistical analysis

Normal probability plots showed that age and weight were skewed. Accordingly, age and weight were summarized as medians (range), while the categorical variables were summarized as counts and percentages. Bivariable associations between variables were assessed using the Kruskal–Wallis test (age and grade of IVDD at presentation) and Fisher's exact test (grade of IVDD at presentation and outcome). Statistical significance was set to $P < 0.05$. All analyses were performed using SAS version 9.4.

Results

A total of 35 cats were included for review in this study after having met the inclusion criteria. Two cats that received a ventral slot were excluded. Ten separate breeds were identified, including domestic shorthair (n = 24), domestic longhair (n = 3), Bengal (n = 1), Balinese (n = 1), Abyssinian (n = 1), Himalayan (n = 1), Maine Coon (n = 1), Manx (n = 1), Persian (n = 1) and Siamese (n = 1). There were 15 spayed females and 20 castrated males. The median age was 9 years (range 4–17). Median weight was 5.4 kg (range 2.7–8.6). The most frequent presenting complaint was difficulty walking (n = 19; 54.2%). Other less frequent presenting complaints included pain, difficulty with defecation and urination, and ataxia. Twenty cats (57%) presented with an L4–S3 neuroanatomic diagnosis. Twelve cats (34%) presented with a T3–L3 neuroanatomic diagnosis. Three cats (8.6%) presented with an S3–caudal neuroanatomic diagnosis.

Two cats (5.7%) presented with a grade I status. Twenty cats (57%) presented with a grade II status. Seven cats (20%) presented with a grade III status. Three cats (8.6%) presented with a grade IV status. Finally, three cats (8.6%) presented with a grade V status. There was no statistical significance when comparing the age of the cat and the grade of IVDD that they presented with ($P = 0.12$) (Figure 1).

When comparing the initial presenting grade of IVDD with the neurologic examination at the time of discharge, it was noted that one of the two grade I cats had shown improvement (50%) and the other cat remained static (50%). Of the grade II cats, 11 had shown improvement (55%), six were static (30%), one was unknown (5%) and two were worse (10%). Of the grade III cats, four were improved (57%), two were static (28.5%) and one died from cardiac arrest during recovery (14.2%). Of the grade IV cats, two were improved (66.6%) and one was

Table 1 Signalment, neuroanatomic diagnosis, MRI findings and clinical outcomes in 35 cats after surgical decompression of thoracolumbar intervertebral disc herniation (IVDH)

Cat	Age (years)	Sex	Breed	Weight (kg)	Neurolocalization	Neurologic grade	Imaging findings	Surgery	Outcome at discharge	Outcome at recheck	Anesthetic protocol	Postoperative pain management
1	5	MC	DSH	5	L4–S3	IV	CT: L5–L6 IVDH	L5–L6 dorsal laminectomy	Positive	Unknown	Premedication: oxymorphone (0.05 mg/kg IV) Induction: ketamine (5 mg/kg) and diazepam (0.2 mg/kg IV)	Buprenorphine (0.01 mg/kg TM q8h)
2	4	MC	DSH	6.8	T3–L3	III	Radiographic myelogram: L2–L3 extradural lesion	L2–L3 left hemilaminectomy	Positive	Unknown	Premedication: oxymorphone (0.05 mg/kg IV) Induction: ketamine (6 mg/kg) and diazepam (0.3 mg/kg IV)	Buprenorphine (0.01 mg/kg TM q8h)
3	5	MC	Abyssinian	6.8	L6–L7	III	CT: L6–L7 IVDH	L6–L7 dorsal laminectomy	Positive	Positive – normal	Premedication: ketamine (2 mg/kg IM), butorphanol (0.2 mg/kg IM) Induction: medetomidine (20 µg/kg IV)	Meloxicam (0.1 mg/kg PO q24h for 5 days) and buprenorphine (0.01 mg/kg IV q8h)
4	6	FS	DSH	3	L4–S3	IV	Radiographic myelogram: L5–L6 extradural lesion	L4–L6 hemilaminectomy – no lesion identified	Negative – euthanized	–	Premedication: oxymorphone (0.05 mg/kg IV) Induction: ketamine (5 mg/kg IV) and diazepam (0.2 mg/kg IV)	–
5	6	MC	Persian	4.2	T3–L3	II	MRI: L2–L3 and L3–L4 IVDH	L1–L4 left hemilaminectomy	Positive	Unknown	Premedication: midazolam (0.2 mg/kg IV) and oxymorphone (0.05mg/kg IV) Induction: propofol (5mg/kg IV)	Prednisone (1 mg/kg q24h for 5 days)
6	10	MC	DSH	5.4	L4–S3	II	MRI: L6–L7 IVDH	L6–L7 dorsal laminectomy	Static	Positive	Premedication: medetomidine (14 µg/kg IM) and ketamine (3 mg/kg IM) Induction: 6 mg/kg IV	Tramadol (2.5 mg/kg q8h for 7 days)

(continued)

Table 1 (continued)

Cat	Age (years)	Sex	Breed	Weight (kg)	Neurolocalization	Neurologic grade	Imaging findings	Surgery	Outcome at discharge	Outcome at recheck	Anesthetic protocol	Postoperative pain management
7	17	FS	DSH	3.6	L4–S3	II	MRI: L5–L6, L6–L7 and L7–S1 IVDH	L5–L6 and L7–S1 dorsal laminectomy	Static	Initially positive, re-presented 3 months later for an articular facet fracture	Premedication: acepromazine (0.05 mg/kg IM) and butorphanol (0.2 mg/kg IM) Induction: propofol (4 mg/kg IV)	Prednisolone (0.5 mg/kg PO q24h for 4 days), buprenorphine (0.01 mg/kg PO q8h for 5 days)
8	4	FS	DSH	5.5	L4–S3	III	MRI: L5–L6 IVDH	L5–L6 right hemilaminectomy	Positive	Positive	Predmedication: none Induction: propofol (6 mg/kg IV)	Unknown
9	8	MC	DSH	2.7	L4–S3	V	CT: L4–L5 IVDH	L4–L5 right hemilaminectomy	Static	Static	Premedication: acepromazine (0.05 mg/kg IM) and butorphanol (0.5 mg/kg IM) Induction: propofol (5 mg/kg IV)	Buprenorphine (0.01 mg/kg TM q8h for 3 days)
10	10	FS	DLH	3.5	T3–L3	II	MRI: T8–T9, T9–T10, T10–T11 IVDH	T7–T10 continuous dorsal laminectomy	Static	Static	Premedication: oxymorphone (0.05 mg/kg IV) and diazepam (0.2 mg/kg IV) Induction: propofol (5 mg/kg IV)	Buprenorphine (0.01 mg/kg TM q8h for 3 days)
11	4	FS	DSH	7.9	L4–S3	III	MRI: L4–L5 IVDH, mild protrusion at L7–S1	L4–L5 right hemilaminectomy	Positive	Positive	Premedication: diazepam (0.2 mg/kg IV), methadone (0.5 mg/kg IV) Induction: alfaxalone (2 mg/kg IV)	Gabapentin (3 mg/kg PO q12h for 7 days), buprenorphine (0.01 mg/kg TM q12h for 5 days)
12	10	FS	Siamese	3.2	L4–S3	III	MRI: L5–L6 IVDH	L5–L6 left hemilaminectomy	Static	Euthanized for bladder management	Premedication: midazolam (0.2 mg/kg IV) and butorphanol (0.2 mg/kg IV) Induction: alfaxalone (2 mg/kg IV)	Buprenorphine (0.02 mg/kg TM q6h) and gabapentin (10 mg/kg PO q12h)

(continued)

Table 1 (continued)

Cat	Age (years)	Sex	Breed	Weight (kg)	Neurolocalization	Neurologic grade	Imaging findings	Surgery	Outcome at discharge	Outcome at recheck	Anesthetic protocol	Postoperative pain management
13	5	FS	DSH	3.9	S1–S3/caudal	II	MRI: L6–L7 nerve root compression, transitional L7 vertebra	L6-L7 dorsal laminectomy	Positive	Positive	Premedication: butorphanol (0.3 mg/kg IM), midazolam (0.2 mg/kg IM), alfaxalone (2 mg/kg IM) Induction: alfaxalone (0.5 mg/kg IV)	Onsior (1.5 mg/kg PO q24h for 2 days) and buprenorphine (0.02 mg/kg TM q8h for 3 days)
14	7	MC	Manx	6.9	L4–S3	IV	MRI: L5–L6, L6–7 IVDH	L5–L6 right hemilaminectomy	Negative – died from cardiopulmonary arrest	–	Premedication: acepromazine (0.01 mg/kg IV), hydromorphone (0.1 mg/kg IV) Induction: propofol (6 mg/kg IV)	–
15	14	MC	DLH	4.5	L4–S3	II	MRI: L7–S1 IVDH	L7–S1 dorsal laminectomy	Static	Unknown	Premedication: dexmedetomidine (2 μg/kg IV), methadone (0.4 mg/kg IV) Induction: propofol (3mg/kg IV), fentanyl CRI (3 μg/kg/h)	Buprenorphine (0.01 mg/kg TM q8h)
16	12	FS	Himalayan	3.5	T3–L3	II	MRI: T13–L1 IVDH	T13–L1 right hemilaminectomy	Negative – worse paraparesis	Positive	Premedication: dexmedetomidine (1 μg/kg IV), methadone (0.25 mg/kg IV) Induction: propofol (3 mg/kg IV)	Buprenorphine (0.01 mg/kg TM q8h)
17	5	FS	DSH	6.3	T3–L3	III	MRI: L3–L4 IVDH	L3–L4 left hemilaminectomy	Static	Positive	Unknown	Unknown
18	5	MC	DSH	5.5	L4–S3	II	CT: L4–L5 IVDH	L4–L5 left hemilaminectomy	Positive	Positive	Unknown	Gabapentin and buprenorphine – unknown dosages
19	6	MC	DSH	8.2	T3–L3	V	Radiographic myelogram: L3–L4 extradural lesion	L2–L3 and L3–-L4 left hemilaminectomy	Positive	Unknown	Unknown	Gabapentin, buprenorphine, and clavamox – unknown dosages
20	11	FS	DSH	5.6	L4–S3	II	MRI: L7–S1 IVDH	L7–S1 dorsal laminectomy, bilateral L7 foraminotomy	Positive	Unknown	Premedication: acepromazine, butorphanol Induction: diazepam, ketamine and fentanyl CRI	Buprenorphine and hydromorphone in hospital, no medications discharged

(continued)

Table 1 (continued)

Cat	Age (years)	Sex	Breed	Weight (kg)	Neurolocalization	Neurologic grade	Imaging findings	Surgery	Outcome at discharge	Outcome at recheck	Anesthetic protocol	Postoperative pain management
21	9	FS	DSH	3.9	T3–L3	II	Radiographic myelogram: L5–L6 extradural compression	L5–L6 left hemilaminectomy	Unknown	Unknown	Unknown	Buprenorphine, gabapentin and amantadine – unknown dosages
22	10	FS	Balinese	3.4	S1–S3/caudal	II	MRI: L6–L7 IVDH	L6–L7 dorsal laminectomy	Static	Positive	Premedication: acepromazine, butorphanol, glycopyrrolate Induction: ketamine	None
23	6	MC	DSH	4.7	T3–L3	II	MRI: T13–L1 IVDH	T13–L1 right hemilaminectomy	Static	Positive	Premedication: midazolam (0.5 mg/kg IV), fentanyl (10 µg/kg IV) Induction: propofol (3 mg/kg IV)	Buprenorphine and onsior for 1 week, gabapentin for 2 weeks – unknown dosages
24	13	MC	DSH	6.1	L4–S3	II	MRI: L6–L7 IVDH, transitional L7 vertebra	L6–L7 dorsal laminectomy	Positive	Positive	Premedication: midazolam (0.5 mg/kg IV), fentanyl (10 µg/kg IV) Induction: propofol (3 mg/kg IV)	Methylprednisolone for 5 days, tramadol for 1 week and gabapentin for 2 weeks – unknown dosages
25	10	MC	Bengal	7.2	L6–S2	II	MRI: L6–L7 IVDH	L6–L7 right hemilaminectomy	Positive	Positive	Premedication: midazolam (0.5 mg/kg IV), fentanyl (10 µg/kg IV) Induction: propofol (3 mg/kg IV)	Prednisolone for 5 days, amantadine for 1 week and gabapentin for 2 weeks – unknown dosages
26	12	FS	DSH	5.4	T3–L3	IV	MRI: L1–L2 IVDH	L1–L2 left hemilaminectomy	Positive	Positive	Premedication: midazolam (0.5 mg/kg IV), fentanyl (10 µg/kg IV) Induction: propofol (3 mg/kg IV)	Tramadol for 5 days, methylprednisolone for 7 days and gabapentin for 10 days – unknown dosages
27	13	FS	DSH	3.5	L4–S3	III	MRI: L1–L2 IVDH	L1–L2 right hemilaminectomy	Positive	Negative – died secondarily to congestive heart failure	Premedication: midazolam (0.5 mg/kg IV), fentanyl 10 µg/kg IV) Induction: propofol (3 mg/kg IV)	Prednisolone for 5 days, buprenorphine for 7 days and gabapentin for 11 days – unknown dosages

(continued)

Table 1 (continued)

Cat	Age (years)	Sex	Breed	Weight (kg)	Neurolocalization	Neurologic grade	Imaging findings	Surgery	Outcome at discharge	Outcome at recheck	Anesthetic protocol	Postoperative pain management
28	11	FS	DLH	4.2	T3–L3	II	MRI: L1–L2 IVDH with mild compression at L7–S1	L1–L2 left hemilaminectomy	Positive	Positive	Premedication: midazolam (0.5 mg/kg IV), fentanyl (10 µg/kg IV) Induction: propofol (3 mg/kg IV)	Prednisolone for 5 days, buprenorphine for 7 days and gabapentin for 10 days – unknown dosages
29	6	MC	DSH	4.68	T3–L3	V	MRI: L3–L4 IVDH	L3–L4 left hemilaminectomy	Positive	Positive	Premedication: midazolam (0.5 mg/kg IV), fentanyl (10 µg/kg IV) Induction: propofol (3 mg/kg IV)	Methocarbamol for 5 days, gabapentin for 10 days – unknown dosages
30	11	MC	DSH	6.2	L4–S3	II	MRI: L6–L7 IVDH	L6–L7 dorsal laminectomy	Negative – worse CP placement	Positive	Premedication: midazolam (0.5 mg/kg IV), fentanyl (10 µg/kg IV) Induction: propofol (3 mg/kg IV)	Prazosin for 5 days, prednisolone for 1 week and gabapentin for 2 weeks – unknown dosages
31	10	MC	DSH	8.6	L4–S3	II	MRI: L6–L7 IVDH	L6–L7 right hemilaminectomy	Positive	Positive	Premedication: midazolam (0.5 mg/kg IV), fentanyl (10 µg/kg IV) Induction: propofol (3 mg/kg IV)	Buprenorphine for 1 week and gabapentin for 2 weeks – unknown dosages
32	16	MC	DSH	5.7	L4–S3	II	MRI: L7–S1 IVDH	L7–S1 dorsal laminectomy	Positive	Negative – died secondarily to aspiration pneumonia	Premedication: midazolam (0.5 mg/kg IV), fentanyl (10 µg/kg IV) Induction: propofol (3 mg/kg IV)	Meloxicam for 5 days and gabapentin for 2 weeks – unknown dosages
33	12	MC	Maine Coon	7.7	L4–S3	II	MRI: L5–L6 IVDH	L5–L6 left hemilaminectomy	Static	Positive	Premedication: midazolam (0.5 mg/kg IV), fentanyl (10 µg/kg IV) Induction: propofol (3 mg/kg IV)	Dexamethasone for 5 days, tramadol for 7 days and gabapentin for 10 days – unknown dosages
34	8	MC	DSH	5.9	L6–sacral	II	MRI: L6–L7 IVDH	L6–L7 right hemilaminectomy	Positive	Positive	Unknown	Prednisone, gabapentin, tramadol and clavamox – unknown dosages
35	7	MC	DSH	7.9	T3–L3	II	MRI: L3–L4 IVDH with material extending to L1 and L5	L2–L3 and L3– L4 left hemilaminectomy	Positive	Positive, normal	Unknown	Unknown

MC = male castrated; DSH = domestic shorthair; TM = transmucosally; FS = female spayed; DLH = domestic longhair; CRI = constant rate infusion; CP = conscious proprioception

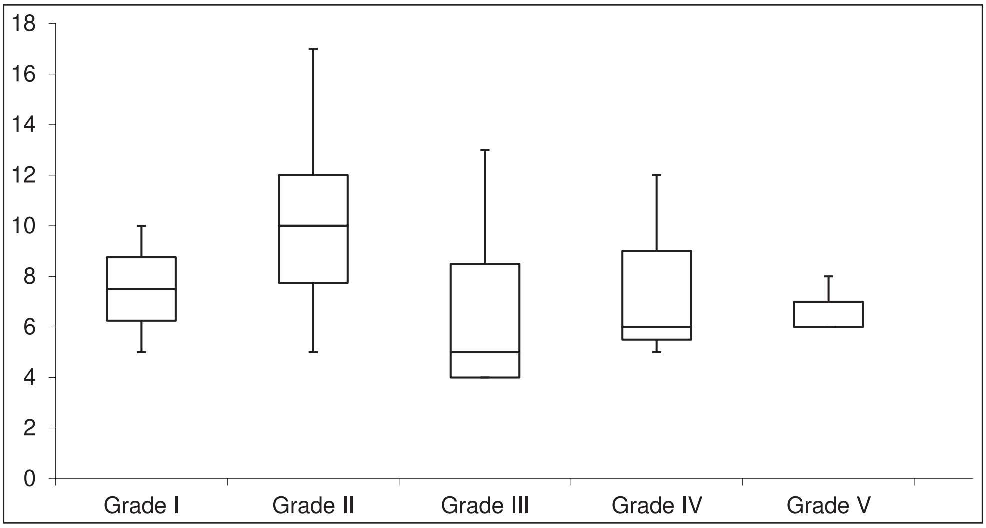

Figure 1 Box plot showing the distribution of the age of the cats (y-axis [years]) presenting with intervertebral disc disease grades I–V

euthanized when a significant compressive lesion was not identified in surgery (33.3%). Of the grade V cats, two were improved (66.6%) and one was static (33.3%). A Fisher's exact test was performed to test the association between the grade of IVDD and the outcome at the time of discharge. This was determined to not be statistically significant ($P = 1.00$).

When comparing the initial presenting grade of IVDD with the clinical outcome at the time of the final documented recheck it was noted that both grade I cats had improved (100%). Of the grade II cats, 14 had shown improvement (70%), five were lost to follow-up (25%) and one had an unchanged examination (5%). Of the grade III cats, three had improved (50%) and one was lost to follow-up (50%). Of the grade IV cats, one had improved (50%) and the other was lost to follow-up (50%). The grade IV cat that was lost to follow-up had shown improvement at the time of discharge. Of the grade V cats, one was improved (33.3%), one was static (33.3%) and one was lost to follow-up (33.3%). The grade V cat that was lost to follow-up had shown improvement at the time of discharge. A Fisher's exact test was performed to test the association between the grade of IVDD and the outcome at the time of recheck; this was determined to not be statistically significant ($P = 0.56$). See Table 2 for bivariable associations between the grade of IVDD and clinical outcome at discharge and recheck.

Imaging

Imaging modalities used for the diagnosis of IVDH in this population included MRI, CT with or without a myelogram, and radiographic myelography. Twenty-six cats had MRI (74%), five cats (14.2%) had CT and four cats (11.4%) had radiographic myelography. The most commonly diagnosed site of IVDH was at L6–L7, which occurred in 12 cats (34%).

Table 2 Bivariable associations between the grade of intervertebral disc disease (IVDD) and the outcome at discharge and recheck

Variable	Category*	n	Grade of IVDD					*P* value
			I	II	III	IV	V	
Response at discharge	0	1	0 (0.0)	1 (5.0)	0 (0.0)	0 (0.0)	0 (0.0)	1.0000
	1	20	1 (50.0)	11 (55.0)	4 (57.3)	2 (66.7)	2 (66.7)	
	2	10	1 (50.0)	6 (30.0)	2 (28.5)	0 (0.0)	1 (33.3)	
	3	2	0 (0.0)	2 (10.0)	1 (14.2)	1 (33.3)	0 (0.0)	
Response at recheck	0	7	0 (0.0)	5 (25.0)	3 (50.0)	1 (50.0)	1 (33.3)	0.5699
	1	21	2 (100.0)	14 (70.0)	3 (50.0)	1 (50.0)	1 (33.3)	
	2	2	0 (0.0)	1 (5.0)	0 (0.0)	0 (0.0)	1 (33.3)	

Data are n (%) unless otherwise indicated
*0 = unknown; 1 = improved; 2 = static; 3 = worsened or euthanized

Surgery

Anesthetic, surgical and postoperative pain management protocols varied greatly depending on the specific patient's needs, the drug availability at the time of surgery, and the individual clinician preference at each hospital. Owing to the variability in protocols, meaningful comparisons were not able to be made. See Table 1 for the anesthetic protocols and postoperative pain management used in each cat.

The cats in this population were treated by hemilaminectomy, dorsal laminectomy, continuous dorsal laminectomy or combined approaches according to the surgeon's preference. Twenty-three cats (65.7%) were treated via hemilaminectomy; 12 were right-sided and 11 were left-sided. Seventeen cats (73.9%) had a positive outcome following their hemilaminectomy. Five cats (21.7%) had a negative outcome for the following reasons: one cat developed congestive heart failure after surgery; one cat showed no improvement and was fitted for a cart; one cat was euthanized when a compressive lesion could not be identified in surgery; one cat experienced cardiac arrest in recovery; and one cat was euthanized after discharge for bladder management, despite being ambulatory. This last cat had shown resolution of spinal hyperesthesia, as well as improved mobility, and was expected to make a positive recovery; however, the owners were unable to manage bladder expression at home. Ten cats (27%) received a dorsal laminectomy. Nine cats (90%) had an initial positive outcome. One cat developed aspiration pneumonia and died. One cat did well for 3 months after its L5–S1 dorsal laminectomy for a disc herniation, resulting in dorsal spinal cord compression, but it then re-presented for an L5 left-sided articular facet fracture after a traumatic event where a bottle fell on the cat. Finally, one cat (2.7%) received a continuous dorsal laminectomy at T8–T9 and T9–T10, and had a positive outcome.

Overall outcome

A total of 32 cats had a repeat examination documented at the time of discharge. The majority of the cats had an improved neurologic examination by the time of discharge (62.5%). Ten cats had repeat neurologic examinations that were considered unchanged (31.3%). Two cats (6.2%) appeared worse at the time of discharge; both of these cats had worsening paraparesis. The improvement that was noted at the time of discharge included various degrees of the resolution of spinal hyperesthesia and improvement in the ability to walk, which had been documented in the medical record.

A total of 23 cats had a documented postoperative recheck. Twenty cats (87.0%) had a recheck between 2 and 4 weeks postoperatively. Three cats (13.0%) had a recheck between 1 and 3 months postoperatively. Twenty-one cats (91.3%) had an improved neurologic examination by the time of their recheck. Two cats (8.7%) had an unchanged neurologic examination at the time of their recheck; these two cats had also had an unchanged neurologic examination at discharge. Seven cats (20%) cats did not have a documented repeat neurologic examination; therefore, it is not possible to say if they improved or worsened after surgery. The two cats that had worsening paraparesis immediately after surgery continued to improve at home and were improved at the time of their 2-week recheck.

A total of two cats (5.7%) from the original study population of 35 cats were euthanized. Of these two cats, one was euthanized after receiving an L5–L6 left-sided hemilaminectomy owing to the owners being unwilling to manage the cat's bladder expression and one cat was euthanized intraoperatively when a compressive lesion could not be identified. A total of three cats (8.6%) died spontaneously after surgery. One cat developed aspiration pneumonia and died 6 days after a L7–S1 dorsal laminectomy; this cat had no change in its neurologic examination during that time. The second cat died from cardiopulmonary arrest in recovery after a right-sided L5–L6 hemilaminectomy; this third cat died from congestive heart failure 4 days after a right-sided L1–L2 hemilaminectomy; this cat was 13 years of age and did not have a documented cardiology evaluation prior to surgery.

Six cats were reportedly normal with no neurologic deficits at the time of their recheck. Four cats had a normal examination by 2 weeks after surgery. One of these cats had initially presented with a grade I status, two cats had presented with a grade II status and one cat had presented with a grade III status. One cat had a normal neurologic examination 1 week following an L6–L7 dorsal laminectomy for a disc herniation resulting in dorsal spinal cord compression; this cat originally presented with a grade II status. Lastly, one cat became normal within 4 weeks following a T13–L1 hemilaminectomy; this cat originally presented with a grade II status.

Discussion

This study evaluated the presenting clinical signs, severity, neuroanatomic diagnosis and outcome of surgically treated thoracolumbar feline IVDHs. This is the largest retrospective study to evaluate feline IVDD treated by surgical decompression. This study confirms that IVDH is a clinical problem in the felid species and should be considered as a differential in adult cats that present with spinal hyperesthesia, difficulty walking, ataxia and the inability to urinate and defecate. We identified a total of 35 cases over a 21-year period between seven separate veterinary referral hospitals. It is possible that the low prevalence of feline IVDH is secondary to veterinary neurologists emphasizing a worse prognosis in cats than in dogs, the difficulty assessing pain and discomfort in cats by owners and/or financial limitations of owners. This prevalence may rise with increasing awareness about the disease and less discouraging information regarding prognosis for neurologic cats.

The most frequently diagnosed IVDH in this population was at the L6–L7 disc space. L7–S1 has been previously reported to be the most frequently diagnosed site for IVDH in the cat.[10] Our findings are consistent with the majority of feline IVDH being present in the lumbar vertebral column.

A positive outcome was achieved in approximately 91.3% of cats that were presented for a postoperative recheck. This percentage may be higher when cats are evaluated with a longer follow-up interval. Including the cats that either died or were euthanized during or shortly after surgery, 75% of the cats improved postoperatively. In this retrospective study, seven cats (20%) did not have a documented neurologic examination at the time of their recheck and we were unable to determine if they had a positive or negative outcome. A larger study sample with a longer follow-up time is necessary to determine if the overall prognosis for improvement is actually greater than 91.3%. This study did not assess the difference between acute and chronic IVDH, which could have been determined at the time of surgery. This is a variable that could be evaluated in future studies to assess if the chronicity of the disc herniation has an effect on recovery time.

When compared with cats, there is a considerable amount of published research on the treatment and prognosis of canine IVDH. Previous studies have allowed the development of specific prognostic guidelines for grades of acute canine IVDH. Grades I–IV have an approximately 90–100% chance of improvement with decompressive surgery vs grade V; dogs will have an approximately 50–70% chance of improvement, with around 10–20% of grade V dogs progressing to develop myelomalacia.[11–13] The majority of cats in this study presented with grade II neurologic signs. There were only three cases of grade V IVDD in this population. Of those three cases, two showed improvement at the time of discharge (66.6%), which is similar to the improvement rate in dogs. There was no significant association between grade and outcome, which may be due to the low number of cases in each grade. Of the three cases that were deep pain negative in our study population, none was recorded to have developed myelomalacia.

The limitations of this study include the inherent nature of a retrospective study involving multiple institutions. Our case collection time period was wide (21 years) in order to obtain the largest number of cases possible. However, earlier cases were diagnosed with radiographic myelography, which is an outdated tool given the accessibility of MRI. Our cases also came from seven separate institutions, which prevents standardization of protocols and records, making comparisons more challenging. With this approach, there are various surgeons operating with various techniques and postoperative care regimens dependending on the supervising clinician. There was also a small sample size, which was possibly unavoidable owing to the infrequent occurrence of feline IVDH. This may be overcome with increasing recognition of a favorable prognosis associated with this disease. Finally, this study had a short follow-up time in the cases that had this information available. The majority of our study population had a length of follow-up limited to 2 weeks after the initial surgery. There were a few exceptions of cases that had a 6-week recheck and the cat that re-presented 3 months later for an articular facet fracture following a dorsal laminectomy. The postoperative complications, including aspiration pneumonia, cardiac arrest and congestive heart failure, were not suspected to be direct surgical complications, but a prospective study evaluating a single surgical technique with a longer follow-up time is necessary to eliminate this possibility. A thorough cardiac auscultation is recommended to assess the need for preoperative thoracic radiographs and echocardiogram to avoid these complications.

Conclusions

We described the outcome of cats undergoing surgery for IVDH. Cats undergoing spinal decompressive surgery appeared to have a favorable outcome independent of their presenting grade of IVDD. Owners should be made aware of the likelihood of a positive outcome when discussing the possibility of spinal surgery for the treatment of IVDH.

Acknowledgements The authors would like to thank Bush Veterinary Neurology Service, the University of Tennessee College of Veterinary Medicine, Mississippi State University College of Veterinary Medicine, Garden State Veterinary Specialists, VCA Alameda East, Ocean State Veterinary Specialists and VCA South Paws for their contribution of cases.

Conflict of interest The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding The authors received no financial support for the research, authorship, and/or publication of this article.

Ethical approval The work described in this manuscript involved the use of non-experimental (owned or unowned) animals. Established internationally recognized high standards ('best practice') of veterinary clinical care for the individual patient were always followed and/or this work involved the use of cadavers. Ethical approval from a committee was therefore not specifically required for publication in *JFMS*. Although not required, where ethical approval was still obtained, it is stated in the manuscript.

Informed consent Informed consent (verbal or written) was obtained from the owner or legal custodian of all animal(s) described in this work (experimental or non-experimental animals, including cadavers) for all procedure(s) undertaken (prospective or retrospective studies). No animals or people are identifiable within this publication, and therefore additional informed consent for publication was not required.

ORCID iD Kayla M Fowler https://orcid.org/0000-0003-1680-556X
Theresa E Pancotto https://orcid.org/0000-0003-4073-3607

References

1 King AS and Smith RN. **Disc protrusions in the cat: distribution of dorsal protrusions along the vertebral column.** *Vet Rec* 1960; 72: 335–337.
2 Munana KR, Olby NJ, Sharp NJ, et al. **Intervertebral disc disease in 10 cats.** *J Am Anim Hosp Assoc* 2001; 37: 384–389.
3 De Decker S, Warner AS and Volk HA. **Prevalence and breed predisposition for thoracolumbar intervertebral disc disease in cats.** *J Feline Med Surg* 2017; 4: 419–423.
4 Kathmann I, Cizinauskas S, Rytz U, et al. **Spontaneous lumbar intervertebral disc extrusion in six cats.** *J Feline Med Surg* 2000; 2: 207–212.
5 Hamilton-Bennett SE and Behr S. **Clinical presentation, magnetic resonance imaging features, and outcome in 6 cats with lumbar degenerative intervertebral disc extrusion treated with hemilaminectomy.** *Vet Surg* 2019; 48: 556–562.
6 Harris JE and Dhupa S. **Lumbosacral intervertebral disk disease in six cats.** *J Am Anim Hosp Assoc* 2008; 44: 109–115.
7 Sparkes AH and Skerry TM. **Successful management of a prolapsed intervertebral disc in a Siamese cat.** *Feline Pract* 1990; 18: 7–9.
8 Knipe MF, Vernau KM, Hornof WJ, et al. **Intervertebral disc extrusion in six cats.** *J Feline Med Surg* 2001; 3: 161–168.
9 Crawford AH, Cappello R, Alexander A, et al. **Ventral slot surgery to manage cervical intervertebral disc disease in three cats.** *Vet Comp Orthop Traumatol* 2018; 31: 71–76.
10 Farrell M and Fitzpatrick N. **Feline intervertebral disc disease.** In: Fingeroth JM and Thomas WB (eds). Advances in intervertebral disc disease in dogs and cats. Ames, IA: American College of Veterinary Surgeons Foundation and Wiley-Blackwell, 2015, pp 36–49.
11 Aikawa T, Fujita H, Kanazono S, et al. **Long-term neurologic outcome of hemilaminectomy and disk fenestration for treatment of dogs with thoracolumbar intervertebral disk herniation: 831 cases (2000–2007).** *J Am Vet Med Assoc* 2012; 12: 1617–1626.
12 Olby N, Levine J, Harris T, et al. **Long-term functional outcome of dogs with severe injuries of the thoracolumbar spinal cord: 87 cases (1996–2001).** *J Am Vet Med Assoc* 2003; 222: 762–769.
13 Fenn J, Hongyu R, Jeffery N, et al. **Association between anesthesia duration and outcome in dogs with surgically treated acute severe spinal cord injury caused by thoracolumbar intervertebral disk herniation.** *J Vet Intern Med* 2020; 34: 1507–1513.