

Cervical Vertebral Fractures in 56 Dogs: A Retrospective Study

The clinicopathological features of cervical fractures in 56 dogs were reviewed. "Hit by car" (HBC) was the most common inciting cause, and the axis and atlas were the vertebrae most frequently affected. Surgical treatment was associated with high (36%) perioperative mortality. However, all dogs that survived the perioperative period achieved functional recovery. Functional recovery was achieved in 25 (89%) of 28 nonsurgically treated dogs with adequate follow-up. Overall, severity of neurological deficits (nonambulatory status) and prolonged interval (five days or longer) from trauma to referral were associated with poorer outcome. Nonsurgical treatment is a viable therapeutic approach for many dogs with cervical fractures. Early neck immobilization and prompt referral are recommended, because delay in referral decreases the likelihood of functional recovery. *J Am Anim Hosp Assoc* 1999;35:135-46.

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Introduction

In dogs, cervical vertebral fractures occur less frequently than fractures of the thoracolumbar spine. Thoracolumbar fractures are well characterized with respect to epidemiology, anatomic distribution, and prognosis after surgical or nonsurgical treatment.¹⁻³ In contrast, cervical vertebral fractures of dogs are poorly characterized. The largest reported case series,⁴ published nearly 20 years ago, provided information on 12 dogs and reviewed 15 previously reported cases.⁵⁻¹⁰ Since then, seven reports have contributed data on an additional 21 cases.¹¹⁻¹⁷ The paucity of published information on cervical fractures in dogs, in particular the factors that influence functional outcome after nonsurgical treatment, prompted the authors to conduct this retrospective study.

The specific aims of this study were: 1) to characterize the clinicopathological features of 56 dogs with cervical vertebral fractures, and 2) to identify factors that were predictive of successful outcome in 46 dogs with adequate follow-up, including the subset of 28 dogs that underwent nonsurgical treatment. The results indicate that functional recovery often can be achieved with nonsurgical treatment. Surgical management of cervical vertebral fractures is associated with high perioperative mortality. Nonambulatory status and delayed referral are associated with decreased likelihood for a functional recovery.

Materials and Methods

Case Selection

Dogs with cervical vertebral fractures admitted to the Veterinary Teaching Hospitals of Purdue University and the University of Minnesota (1969 through 1992) were studied. Medical records were reviewed, and cases were selected for study if cervical radiographs, neurological examination findings, and treatment information were available. Fifty-six dogs satisfied these inclusion criteria. In all cases, diagnosis of cervical vertebral fracture was based upon radiographs, necropsy findings, or both. The following data was obtained from the medical record: signalment, inciting cause of fracture, onset and severity of neurological signs, concurrent injuries, and radiographic interpretation. The time interval from trauma to

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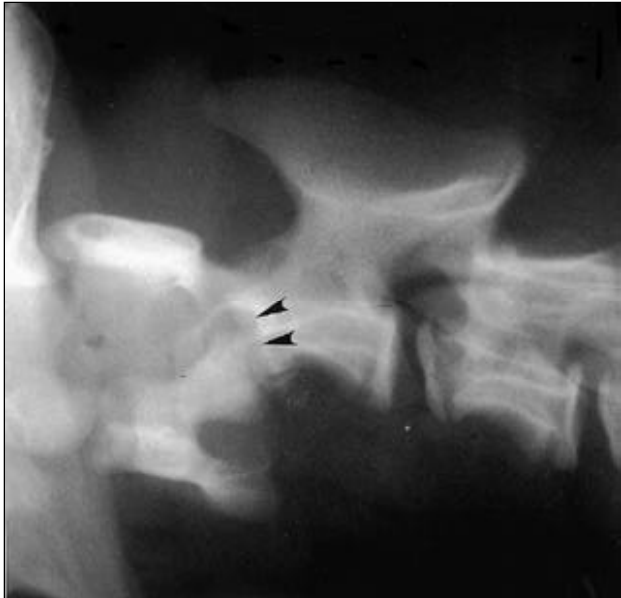


Figure 1—Lateral radiograph of a six-month-old chow chow with a second cervical (C_2) vertebral fracture (arrows) in the area of the synostosis of the dens and the body of the axis. There is dorsal displacement of the main portion of C_2 relative to the fractured fragment. The axis is the most common vertebra affected in dogs with cervical fracture.

presentation to the referral institution was recorded. Specific location of each fracture, treatment (surgical versus nonsurgical), and follow-up information also were recorded. Follow-up data was obtained from medical records or telephone questionnaires from the pet owner or referring veterinarian.

Analysis of Possible Prognostic Factors

Data from 46 dogs with adequate follow-up was analyzed to determine if particular factors were associated with functional recovery. Ten dogs that were lost to follow-up after nonsurgical treatment were excluded from this analysis. A separate analysis was performed to identify factors predictive of outcome in the subset of 28 dogs that underwent nonsurgical treatment. Functional recovery was defined as pain-free ambulation with urinary and fecal continence. The following potential prognostic factors were evaluated: inciting cause (HBC versus other); level of affected vertebra (first cervical [C_1] and second cervical [C_2] versus other); multiplicity (single versus multiple vertebrae); time interval from trauma to presentation to referral institution (less than five days versus five or more days); severity of neurological deficits on presentation (nonambulatory versus ambulatory); concurrent head trauma; and surgical versus nonsurgical treatment. Two by two tables were constructed, and chi-square (χ^2) or Fisher's exact tests were used to determine the association between these factors and functional recovery. Whenever possible, odds ratio (OR) and 95% confidence intervals were calculated.¹⁸ Odds ratio provides an estimate of the relative risk that a patient with a

particular characteristic will have a certain outcome (e.g., functional recovery in this study). Odds ratios were considered statistically significant if the 95% confidence interval did not include 1.0.

Results

Signalment and Inciting Cause

The clinicopathological features of 56 dogs with cervical fractures are summarized in Table 1. Median age was two years (range, 4 mos to 14 yrs), and there was an equal sex distribution. Median body weight was 18 kg (range, 1 to 50 kg). Twenty-six (46%) of 56 dogs with cervical fractures were HBC. Other inciting causes included a big dog/little dog fight ($n=8$); collision/rough play ($n=6$); a door slam ($n=4$); a gunshot injury ($n=2$); a fall into a hole or down stairs ($n=3$); blunt trauma ($n=1$); a leash injury ($n=1$); and a tumor-associated pathological fracture ($n=1$). In four cases, there was no history of trauma.

Concurrent Injuries

Concurrent injuries were noted in 27 (48%) of 56 dogs. Hit by car was the inciting cause of vertebral fracture in 17 (63%) of 27 dogs that had concurrent injuries. These included fractures of long bones ($n=3$), mandible ($n=2$), scapula ($n=2$), rib ($n=1$), occiput ($n=2$), and thoracolumbar vertebrae ($n=2$). Soft-tissue wounds, usually associated with gunshot injuries or animal bites, were found in eight dogs. Three dogs had thoracic trauma (e.g., pneumothorax, lung contusions). Clinical signs of head trauma (e.g., hemorrhage from the nose or mouth, seizures, loss of consciousness) were reported in nine dogs.

Severity and Progression of Neurological Deficits

Severity of neurological deficits upon presentation to the referral institution was variable [Table 1]. Thirty-two (57%) of 56 dogs were nonambulatory. However, loss of voluntary motor function (i.e., tetraplegia) was noted in only four dogs, and none of these dogs had complete sensorimotor loss. Eight (14%) of 56 dogs had cervical pain as the only abnormality on neurological examination.

In many cases, diagnosis of cervical vertebral fracture was not made immediately, and a decline in neurological status noted days to weeks after the traumatic event prompted reevaluation. Median interval from trauma to presentation at the referral institution was five days (range, 2 hrs to 2 mos). Deterioration in neurological status was documented in 13 (48%) of 27 dogs for which detailed histories were available.

Anatomic Distribution

The axis (C_2) was the most commonly affected vertebra [Figure 1]. Twenty-nine (52%) of 56 dogs had C_2 fractures, which accounted for 29 (36%) of 81 fractures. Twenty-five percent of dogs had C_1 fractures. Nineteen (34%) of 56 dogs had multiple cervical vertebrae af-

Table 1
Summary of Clinicopathological Features of 56 Dogs With Cervical Fractures

Case No.	Breed	Age (yrs)	Weight (kg)	Site*	Cause†	Trauma to Referral Interval	Neurological Findings and Diagnostics‡	Treatment¶	Other Injuries #	Outcome **
1	Shepherd	0.5	14	C ₃	BDLD	<1 day	NAT	Tracheostomy	Dyspnea, tracheal tear	Arrested after presentation; necropsy (hemorrhax, lung contusions)
2	Beagle	5	22	C ₂ , C ₆	HBC	5 days	NAT; cervical pain	None	Bilateral mandibular fx	Euthanized; no necropsy
3	Newfound-land	7	50	C ₂ , C ₃	HBC	12 days	CP deficits (LF, RF); nonweight-bearing lameness (RH)	None	Rlb, femoral fx; partial brachial plexus avulsion	Euthanized; no necropsy
4	Labrador retriever	8	34	C ₇	Unknown	2 mos	NAT; progressive ataxia; myelogram, C ₇ pathologic fx with compression	None	None	Euthanized; necropsy (osteosarcoma, no evidence of metastasis)
5	Doberman pinscher	9	41	C ₄ , C ₆	No known trauma	2 days	NAT; weak VM (all limbs); cervical pain; myelogram, C ₅ -C ₆ compression	None	None	Euthanized; necropsy (focal axonal compression C ₄ -C ₇)
6	Cocker spaniel	3	8	C ₂	Fell (bath)	<1 day	NAT; torticollis; intact deep pain; myelogram	None	None	Euthanized; necropsy (fx dens, meningitis, malacia C ₁ -C ₂)
7	German shepherd dog	0.5	40	C ₁ , C ₃ , C ₄ , C ₅	HBC	1 day	NAT; cervical pain	None	Epistaxis	Arrested; necropsy (epidural hemorrhage)
8	Chow chow	0.5	9	C ₂	Door slam	6 days	NAT; cervical pain	Dorsal suture stabilization, postop splint; 4 days postop, suture broke; wire stabilization	None	7 days: ambulatory; 5 yrs: normal
9	Miniature pinscher	1.5	NA ^s	C ₂	HBC	8 days	NAT; extreme cervical pain; spastic cervical musculature	Dorsal wire stabilization; 3 days postop, seizes	Skull fracture	4 days: died; necropsy (cerebral necrosis, cervical cord demyelination)
10	Mixed-breed dog	1	3.5	C ₅ , C ₇	BDLD	6 days	NAT; absent VM (forelimbs)	Dorsal laminectomy/facet wiring (C ₆ , C ₇); hemilaminectomy (T ₁₃ -L ₁)	Puncture wounds; T ₁₃ -L ₁ disk herniation	Perioperative arrest; necropsy (demyelination of cervical spine)

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Table 1 (Cont' d)

Case No.	Breed	Age (yrs)	Weight (kg)	Site*	Cause†	Trauma to Referral Interval	Neurological Findings and Diagnostics †	Treatment †	Other Injuries #	Outcome **
11	American eskimo	1	9	C ₁ , C ₂	HBC	5 days	Severe cervical pain; minimal ambulation; hyporeflexia (forelimbs)	Dorsal wiring and neck brace	None	2 wks: ambulatory
12	Labrador retriever	1	27	C ₂	Fell (10-foot deep hole)	5 days	NAT; intact deep pain (all limbs); absent VM in forelimbs	Dorsal suture stabilization; whirlpool	None	6 wks: ambulating, ataxic; 14 mos: normal
13	Mixed-breed dog	6	14	C ₂	HBC	8 days	NAT; intact VM and CP deficits (all limbs); opisthotonos	Dorsal stabilization with wire of C ₁ -C ₂ ; decompression of caudal aspect of skull	None	Perioperative arrest; necropsy (contusion/laceration of dura/spinal cord beneath wires around atlas, focal malacia of brain stem)
14	Shetland sheepdog	0.5	11	C ₁	HBC	9 days	NAT; hyporeflexia (LH, LF); CP deficits (all limbs); cervical pain; cranial nerve deficits	Dorsal laminectomy of C ₁	Scapular and occipital condylar fx	24 hrs postop: arrested; necropsy (myelomalacia at base of cerebellum)
15	Chihuahua	6	2.5	C ₅ , C ₆	BDLD	<1 day	NAT; hyperreflexia (all limbs)	Dorsal laminectomy C ₄ -C ₇	Hornet's syndrome	10 mos: CP deficit (RF)
16	Samoyed	1.5	15	C ₂	HBC	<1 day	Cervical pain; decreased VM (forelimbs); CP deficits (all limbs)	Screws/methylmethacrylate; neck cast	None	5 days: mild ataxia; 22 mos: normal
17	Pit bull	1.5	20	C ₂	Collision (truck bed)	1 day	NAT; cervical pain; absent VM (all limbs); superficial pain present	Reduction; stabilization; methylmethacrylate implant around 3 bone screws	None	8 days: mild ataxia
18	Miniature schnauzer	1	10	C ₂	HBC	1 day	NAT; intact VM	Partial left hemilaminectomy; tubra plate; neck brace	None	3 wks: normal

Table 1 (Cont' d)

Case No.	Breed	Age (yrs)	Weight (kg)	Site*	Cause [†]	Trauma to Referral Interval	Neurological Findings and Diagnostics [‡]	Treatment [¶]	Other Injuries [#]	Outcome ^{**}
19	Golden retriever	7	36	C ₂	Collision (side of car)	5 days	NAT; no deep pain following casting	Neck cast	None	6 days: arrested while rolling over; no necropsy
20	Golden retriever	0.5	27	C ₂	HBC	5 days	NAT; absent VM (LH, RH)	Cage rest	None	3 mos: euthanized due to residual paresis (RH, LH)
21	St. Bernard	2	48	C ₃ , C ₄	HBC	5 days	NAT; deep pain absent (LF); EMG - left median nerve lesion	Cage rest	T ₂ fracture	2 wks: euthanized due to no improvement; necropsy (epidural hemorrhage C ₂ -T ₃)
22	Great Dane	2	55	C ₂ , C ₃	HBC	2 days	CP deficits (all limbs)	Neck cast	Hemorrhage from nose/ears	5 wks: slight CP deficits (LF, LH); 4 mos: normal
23	Doberman pinscher	1.5	32	C ₂	Playing	1 day	Severe cervical pain; hyperreflexia (all limbs)	Neck brace	None	2 mos: no cervical pain
24	Mixed-breed dog	0.5	18	C ₂	Chain	6 days	NAT; CP deficits and hyperreflexia (all limbs); cervical pain	Neck brace	None	4 wks: normal
25	Mixed-breed dog	0.5	14	C ₂	HBC	10 days	Cervical pain; CP deficits (LH, RH)	Plaster neck brace	Mandibular fx	5 wks: normal
26	Mixed-breed dog	2	21	C ₃	Gunshot	2 days	Ataxia; CP deficits (RF, LH, RH)	Cardboard neck brace	Bullet wound	2 wks: CP deficits (LH, RH)
27	Labrador retriever	5	32	C ₁	HBC	10 days	Cervical pain	Neck brace	Temporal muscle atrophy	5 mos: normal
28	Yorkshire terrier	1	1.5	C ₁	Door slam	2 days	NAT; CP deficits (all limbs); hyperreflexia (LH)	Neck brace	None	3 wks: normal
29	Mixed-breed dog	2	6	C ₂	Playing-dogs	1 month	Muscle tremors (RF/neck); myelogram (normal)	Neck brace	None	4 wks: mild ataxia
30	Australian shepherd	5	16	C ₁	HBC	1 day	Seizures; blindness; ataxia	Neck bandage	Pneumothorax, scleral hemorrhage	6 wks: normal except blind in right eye
31	Mixed-breed dog	NA	3.5	C ₁	Unknown	1 day	NAT; CP deficits (LH, LF)	Neck splint	None	2 wks: weak in LR
32	Miniature poodle	2	9	C ₅	HBC	2 days	NAT; absent VM (RF); cervical pain; myelogram (disk herniation C ₅ -C ₆)	Neck brace	Herniated disk C ₅ -C ₆	34 mos: slight LF weakness

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Table 1 (Cont' d)

Case No.	Breed	Age (yrs)	Weight (kg)	Site*	Cause [†]	Trauma to Referral Interval	Neurological Findings and Diagnostics [‡]	Treatment [¶]	Other Injuries [#]	Outcome ^{**}
33	Flat-coated retriever	1.5	23	C ₂	HBC	1 day	NAT; CP deficits (RH, RF); torticollis	Neck cast; bone plate (left radius)	Radius/ulna fx	3 days: standing; 3 yrs: normal; low head carriage
34	Toy poodle	0.5	2	C ₆	Fell down stairs	1 day	Ataxia; CP deficits (RF, LF)	Neck brace	None	2 wks: ataxic; 4 yrs: mild gait abnormality
35	Chihuahua	4	1.5	C ₃	Hit by door	<1 day	Cervical pain; ataxia	Neck splint	None	10 days: mild ataxia
36	Dalmatian	1	19	C ₂ , C ₃	Unknown	14 days	Cervical pain (episodic, 3x/day)	Neck cast	None	4 wks: normal
37	Cocker spaniel/poodle	13	NA	C ₁	BDLD	1 day	NAT; minimal VM (LF, LH)	Neck bandage	None	3 mos: ambulatory, weak (LH); 2 yrs: normal
38	Doberman pinscher	3	28	C ₁ , C ₂	Blunt object to head	1 day	Cervical pain	Neck cast	None	7 wks: normal
39	German shepherd dog	0.5	27	C ₂	HBC	7 days	NAT	Neck cast	None	3 days: assisted ambulation; 6 wks: minimal ataxia
40	Toy poodle	3	3	C ₂ , C ₅ , C ₆	BDLD	3 days	NAT	Neck splint	None	1 yr: LF weakness
41	Poodle mix	5	18	C ₄ , C ₅	HBC	<1 day	NAT; cervical pain	Neck cast	None	5 wks: CP deficits (LF)
42	Whippet	5	17	C ₆	Collision (racing)	<1 day	Ambulatory tetraparesis; cervical pain	Neck cast	None	6 wks: normal except hyperreflexia (LH, RH)
43	Brussel Griffon	3	3.5	C ₂	BDLD	<1 day	NAT	Neck splint	Puncture wounds	2 wks: assisted ambulation; 1 yr: normal
44	German shepherd dog	0.5	23	C ₁	HBC	<1 day	Vestibular signs; nystagmus; ataxia; shock	Cage rest	Epistaxis	5 days: normal
45	Mixed-breed dog	0.5	10	C ₆ , C ₇	HBC	<1 day	Cervical pain; RF lameness	Cage rest	Scapular fx	10 mos: normal
46	Keeshond	3	18	C ₄ , C ₅	HBC	5 days	NAT; absent VM/decreased sciatic reflex (LH)	Cage rest; external fixation of femoral fx	Femoral/T ₁ fx, epistaxis	18 mos: normal
47	Mixed-breed dog	1	18	C ₅ , C ₆	HBC	4 days	NAT; CP deficits and hyperreflexia (all limbs); myelogram (no compression)	Neck brace	Pneumothorax, contusions, concussion	No follow-up

Table 1 (Cont' d)

Case No.	Breed	Age (yrs)	Weight (kg)	Site*	Cause†	Trauma to Referral Interval	Neurological Findings and Diagnostics‡	Treatment¶	Other Injuries #	Outcome**
48	Doberman pinscher	2	30	C ₂	Collision	5 days	Cervical pain	Cardboard neck brace	None	No follow-up
49	Chihuahua mix	14	9	C ₂ , C ₃ , C ₄ , C ₅	BDLD	2 days	Ataxia; cervical pain	Neck cast; wound management	Bite wounds	No follow-up
50	German shepherd dog	1	18	C ₂	HBC	18 days	Cervical pain	Activity restriction	None	No follow-up
51	German shepherd dog	1	NA	C ₂ , C ₃	Unknown	6 wks	Left hemiparesis (especially LH)	Activity restriction	None	No follow-up
52	Basset hound	2	30	C ₄	HBC	9 days	NAT; minimal VM (RF, LF)	Cage rest	None	No follow-up
53	Labrador retriever	3	27	C ₁	Gunshot	<1 day	Nonambulatory left hemiplegia; extensor rigidity (LH)	Cage rest	Puncture wound (neck)	No follow-up
54	Beagle	0.5	NA	C ₁	HBC	<1 day	Comatose/concussion; then ambulatory tetraparesis	Shock therapy; cage rest	Shock	No follow-up
55	Chihuahua	8	3	C ₁	BDLD	5 days	NAT; myelogram (normal)	None	Puncture injury	No follow-up
56	Doberman pinscher	4	38	C ₂ , C ₃ , C ₄	Hit by gate	<1 day	No neurological deficits	None	Neck laceration	No follow-up

* C₁=first cervical vertebra; C₂=second cervical vertebra; C₃=third cervical vertebra; C₄=fourth cervical vertebra; C₅=fifth cervical vertebra; C₆=sixth cervical vertebra; C₇=seventh cervical vertebra

† BDLD=big dog/little dog fight; HBC=hit by car

‡ NAT=nonambulatory tetraparesis; CP=conscious proprioception; LF=left forelimb; RF=right forelimb; RH=right hind limb; fx=fracture; VM=voluntary motor; LH=left hind limb; EMG=electromyogram

§ NA=not available

¶ T₁₃=thirteenth thoracic vertebra; L₁=first lumbar vertebra

T₂=second thoracic vertebra; T₁=first thoracic vertebra

** T₃=third thoracic vertebra

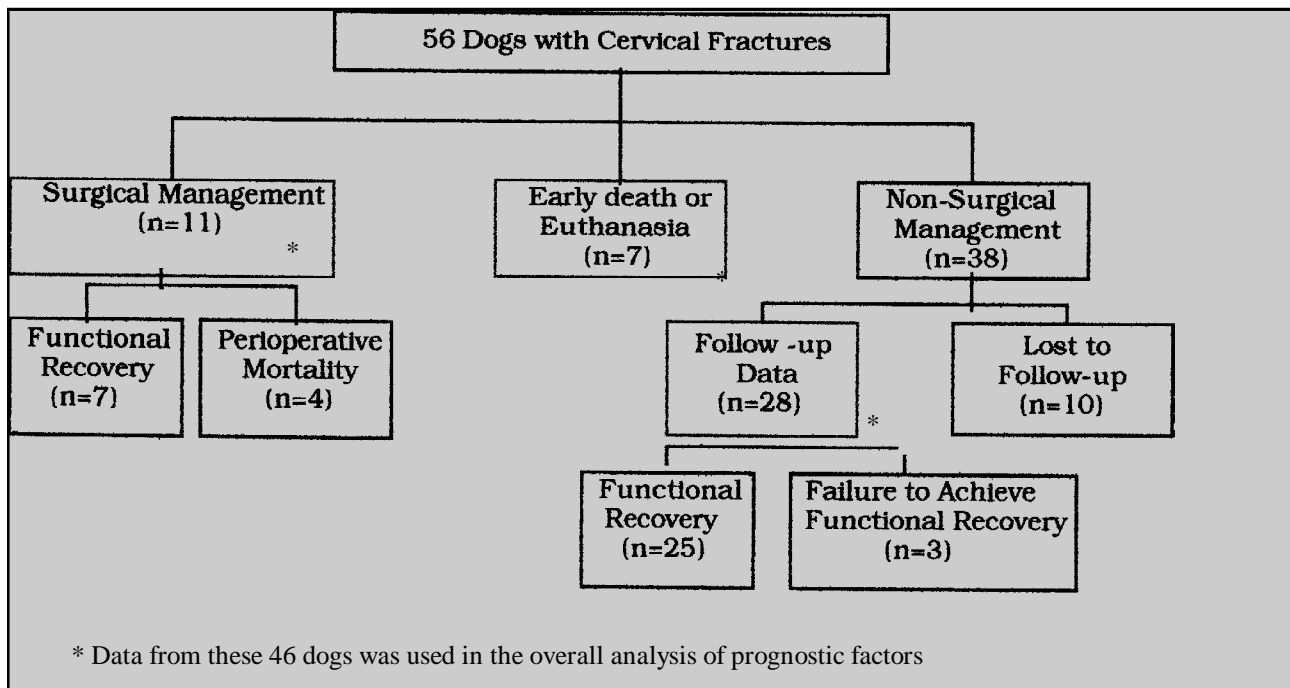


Figure 2 Subclassification of 56 dogs with cervical fractures based upon treatment, follow-up data, and outcome.

fractured. When the third cervical, fourth cervical, or fifth cervical vertebra was fractured, a single vertebra was affected in only 15% of the cases. A big dog/little dog fight and unknown trauma were the only subgroups in which fractures of the third through the seventh cervical vertebrae outnumbered fractures of C₁ and C₂.

Treatment and Outcome

Fifty-six dogs with cervical fractures were subdivided into three groups based upon treatment/outcome: 1) dogs that died or were euthanized within 24 hours of referral; 2) dogs that received surgical treatment; and 3) dogs that received nonsurgical treatment [Figure 2].

Seven dogs died or were euthanized within 24 hours of referral. Two of these seven dogs suffered cardiopulmonary arrest, and two dogs were euthanized within hours after presentation due to the severity of systemic injuries. Three dogs were euthanized after myelography due to the severity of injuries or anesthetic complications.

Eleven dogs received surgical treatment for their cervical vertebral fractures. Nine of 11 dogs had C₁ or C₂ lesions. Preoperative neurological status in nine of 11 dogs was nonambulatory tetraparesis. Surgical management consisted of dorsal suturing/wiring with or without dorsal laminectomy (n=5), dorsal laminectomy alone (n=2), screw fixation/stabilization using methylmethacrylate via a ventral approach (n=2), or hemilaminectomy with plastic dorsal spinous process plating (n=1). Surgical treatment was associated with high perioperative mortality; four (36%) of 11 surgically treated dogs died. Cardiopulmonary arrest occurred in three dogs within 24 hours after surgery, while the fourth dog had

cardiopulmonary arrest on the fourth postoperative day. All dogs that survived the perioperative period achieved functional recovery.

Thirty-eight dogs received nonsurgical treatment consisting of a neck brace/splint with activity restriction (n=26) or activity restriction alone (n=12). Follow-up data was available for 28 dogs that underwent nonsurgical treatment. Twenty (71%) of these 28 dogs had C₁ or C₂ lesions, and 14 were nonambulatory at the time of referral. In contrast to surgically treated patients, only three (11%) of 28 dogs died or were euthanized. One dog was euthanized after respiratory arrest and resuscitation two days after neck cast application. Two dogs that were treated with activity restriction were euthanized because of residual deficits at two weeks and three months, respectively. Twenty-five (89%) of the 28 nonsurgically treated dogs achieved functional recovery. Four of 25 dogs that achieved functional recovery had mild residual neurological deficits (median follow-up, 3.5 wks).

Predictors of Functional Recovery

Follow-up (median, 1.5 mos; range, 0.5 to 77 mos) outcome data was available from the medical records or telephone questionnaires for 46 dogs [Table 1]. Functional recovery (i.e., pain-free ambulation, urinary and fecal continence) was achieved in 32 (70%) of 46 dogs. Overall, severe neurological deficits (OR, 13.00; 95% confidence interval, 1.52 to 111.47) and delayed interval from trauma to referral (OR, 5.50; 95% confidence interval, 1.38 to 21.85) were associated with a decreased likelihood for functional recovery [Table 2]. Thus, dogs with nonambulatory tetraparesis were 13 times less likely

Table 2
Predictors of Functional Recovery (FR) in 46 Dogs With Cervical Fractures*

Predictor	No. With FR	No. Without FR	Odds Ratio [†]	95% CI [‡]
Inciting cause				
Hit by car	15	8	0.66	0.15-2.78
Other	17	6	1.00	
Level of affected vertebrae				
C ₁ - C ₂	21	6	2.19	0.52-9.23
Other	8	5	1.00	
Single versus multiple vertebra				
Single	23	8	1.92	0.52-7.10
Multiple	9	6	1.00	
Trauma to referral interval				
<5 days	22	4	5.50	1.38-21.85
≥5 days	10	10	1.00	
Severity of neurological deficits				
Ambulatory	16	1	13.00	1.52-111.47
Nonambulatory	16	13	1.00	
Clinical signs of head trauma				
Absent	28	11	0.52	0.10-2.73
Present	4	3	1.00	
Surgical versus nonsurgical treatment				
Nonsurgical	25	10	0.70	0.17-2.93
Surgical	7	4	1.00	

* Ten of 56 dogs with cervical fractures were lost to follow-up after nonsurgical treatment; these dogs were excluded from this analysis.

[†] Odds ratio estimates the likelihood that an outcome is associated with a particular factor. For example, ambulatory dogs are 13 times more likely to achieve functional recovery than nonambulatory dogs. The aim of this study was to identify negative prognostic factors. Based upon this analysis, nonambulatory status is considered a significant predictor of poor outcome. The broad 95% confidence interval suggests that the "true" risk for poor outcome associated with nonambulatory tetraparesis is somewhere between 1.5 times and 111 times the risk for poor outcome associated with an ambulatory status.

[‡] 95% CI=95% confidence interval. Odds ratios were considered statistically significant if 95% CI did not include 1.0. For example, dogs with single fractures are 1.92 times more likely to have functional recovery than dogs with multiple fractures. However, because the 95% CI of 0.52-7.10 includes 1.0, the risk for poorer outcome in dogs with multiple fractures is not considered significant.

to have functional recovery compared to ambulatory dogs, whereas dogs with a trauma to referral interval of five days or longer were 5.5 times less likely to recover than dogs with a trauma to referral interval of less than five days. Analysis of prognostic factors for 28 nonsurgically treated dogs showed that delayed presentation to the referral institution (i.e., five days or longer) was significantly associated with a decreased likelihood for functional recovery when compared to dogs with a trauma to referral interval of less than five days (p=0.04) [Table 3]. No other factors were significantly associated with outcome.

Discussion

In contrast to thoracolumbar fractures, the clinicopathological features of cervical fractures in dogs have been poorly characterized. Previously reported data on func-

tional outcome after surgical or nonsurgical treatment is limited to 33 and 12 dogs, respectively.⁴⁻¹⁷ Importantly, no previous reports have evaluated prognostic factors that might predict functional outcome. The lack of information regarding patient outcome, in particular for those dogs that underwent nonsurgical treatment, prompted this study. The authors' results indicate that nonsurgical treatment (i.e., neck immobilization and activity restriction) can be used successfully in many dogs with cervical fractures. Furthermore, this study provides the first information that certain factors may predict the likelihood of functional recovery in dogs with cervical fractures.

Surgical treatment of cervical fractures was associated with high perioperative mortality. The 36% perioperative mortality rate is consistent with a previous report⁴ in which 37% of surgically treated dogs with cervical fractures did not survive the perioperative period [Table

Table 3

Predictors of Functional Recovery (FR) in 28 Nonsurgically Treated Dogs With Cervical Fractures

Predictor	No. With FR	No. Without FR	Odds Ratio*	95% CI	p value (Fisher's Exact Test)
Inciting cause					
Hit by car	10	2	0.33	0.1-5.82	p=0.56
Other	15	1	1.00		
Level of affected vertebrae					
C ₁ - C ₂	18	2	0.93	0.05-31.19	p=1.00
Other	7	1	1.00		
Single versus multiple vertebra					
Single	18	2	1.29	0.10-16.54	p=1.00
Multiple	7	1	1.00		
Trauma to referral interval					
<5 days	18	0	NA [†]	NA	p=0.04
≥5 days	7	3			
Severity of neurological deficits					
Ambulatory	14	0	NA	NA	p=0.09
Nonambulatory	11	3			
Clinical signs of head trauma					
Absent	21	3	NA	NA	p=1.00
Present	4	0			

* Odds ratio estimates the likelihood that an outcome is associated with a particular factor. For example, dogs with single vertebral fractures are 1.29 times more likely to achieve functional recovery than dogs with multiple vertebral fractures. Odds ratios were considered statistically significant if 95% confidence interval (95% CI) did not include 1.0. Because the 95% CI of 0.10-16.54 includes 1.0, the risk for poorer outcome in dogs with multiple fractures is not considered significant.

† NA=not applicable

Table 4

Likelihood of Functional Recovery (FR) in Surgically Treated Dogs With Cervical Fractures

	All Dogs		Dogs That Survived Perioperative Period	
	No. of Dogs	% FR	No. of Dogs	% FR
Stone, <i>et al.</i> 1979 ⁴	8	63	5	100
Reviewed in reference 4	12	92	12	92
Veterinary literature (1980-1997) ¹¹⁻¹⁷	13	100	13	100
This series	11	64	7	100
Total	44	82	37	97

4]. However, the prognosis for functional recovery in perioperative survivors is excellent; 100% of dogs in the authors' series that survived the perioperative period had functional recovery. Collectively, 36 (97%) of 37 dogs in the authors' series and the literature that survived the perioperative period achieved functional recovery.⁴⁻¹⁷

An explanation for the high perioperative mortality in dogs with cervical fractures is not apparent, but this observation is consistent with previous reports of complications associated with cervical spinal surgery.¹⁹⁻²¹

Nonsurgical treatment resulted in functional recovery in 89% of dogs in the authors' series [Table 5]. The three

Table 5

Likelihood of Functional Recovery (FR) in Dogs With Cervical Fractures That Underwent Nonsurgical Treatment

	No. of Dogs	% FR
Stone, <i>et al.</i> 1979 ⁴	2	100
Reviewed in reference 4	2	100
Veterinary literature (1980-1997) ¹¹⁻¹⁷	8	100
This series	28	89
Total	40	93

dogs that did not achieve functional recovery died or were euthanized because of neurological deficits six days to three months after referral. Collectively, in the authors' series and the literature, functional recovery after nonsurgical treatment was seen in 37 (93%) of 40 cases.⁴⁻¹⁰ The authors conclude that many cervical fractures are amenable to nonsurgical treatment because this approach offers a high likelihood of success.

Definitive criteria for selection of dogs with cervical fractures that would benefit from surgical treatment (instead of nonsurgical treatment) have not been established. General indications for surgical treatment have been proposed, including vertebral displacement or comminution, deteriorating neurological status amidst conservative management, or persistent pain.^{4,13} A retrospective case review cannot provide definitive conclusions regarding the superiority (or inferiority) of surgical treatment compared to nonsurgical treatment of cervical fractures. Instead, the authors sought to identify a subset of cervical fractures that was associated with a poor outcome after nonsurgical treatment. If identified, these cases would have provided valuable insight into fracture characteristics that might render cases unsuitable for nonsurgical management. However, almost 90% of nonsurgically treated cases had functional recovery. As a result, particular types of cervical fractures that would mandate surgical treatment were not identified.

Several possible predictors (i.e., inciting cause, level of affected vertebra, multiplicity, time interval from trauma to referral, severity of neurological deficits on presentation, concurrent head trauma) of functional outcome were evaluated. Overall, nonambulatory dogs were 13 times less likely to have functional recovery than ambulatory dogs. However, severity of neurological deficits was not predictive of functional recovery in nonsurgically treated dogs. This may reflect that nonambulatory dogs in this series were more likely to be euthanized prior to treatment (perhaps due to concurrent non-neurological injury). Nonambulatory dogs may also have been more likely to undergo surgical treatment

which was associated with high perioperative mortality. Importantly, the results indicate that nonambulatory dogs with cervical fractures do not have a grave prognosis. In fact, once the decision was made to pursue nonsurgical treatment, there was no difference in prognosis for nonambulatory and ambulatory dogs.

A prolonged interval from trauma to referral was a consistent negative predictor of functional recovery. Overall, dogs with a trauma to referral interval of five days or more were 5.5 times less likely to achieve functional recovery than dogs referred less than five days after trauma. The strong negative association between trauma to referral interval and functional recovery also was seen in the 28 nonsurgically treated dogs. One possible explanation is that dogs with delayed referral may have an unstable vertebral fracture which results in progressive spinal cord damage. This instability may be related to the nature of the fracture or may reflect inadequate spinal stabilization during the post-traumatic period. Alternatively, it may reflect diminished owner enthusiasm to pursue treatment; lack of owner commitment ultimately leads to a less favorable outcome.

Conclusion

Dogs that undergo nonsurgical treatment of their cervical fractures have a high likelihood of functional recovery. Due to the high perioperative mortality associated with cervical spinal surgery, it is imperative that specific criteria be defined that justify surgical intervention. Delay in presentation to the referral institution decreases the likelihood of functional recovery. Accordingly, early neck immobilization, prompt referral, or both are recommended to increase the likelihood of successful outcome in dogs with cervical fractures.

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