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Motor deficit and urinary bladder dysfunction in cats with thoraco-lumbar vertebral fracture and luxation

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Abstract
The objective is to present motor deficit and type of neurogenic bladder dysfunction in cats with acute spinal cord injury at the time of presentation and on 60th day of follow up in 22 cats with thoraco-lumbar vertebral fracture and luxations. The differences in distribution of neurological dysfunction with respect to the site of spinal cord injury and association of spasticity in the hindlimbs in prediction of spasticity in bladder/sphincter were analyzed. Spastic neurological dysfunction in hindlimbs and bladder were associated with lesions in thoracolumbar segment (T3-L3) of spinal cord. Whereas, type of bladder dysfunction were either spastic, flaccid or mixed type with flaccid paraplegia in lesions of lumbosacral segment (L4-S3) of spinal cord. Prediction of spastic sphincter is more accurate in increased spinal reflexes than in normal or decreased spinal reflexes. There was no significant association between the site of vertebral lesion and recovery of motor deficit or neurogenic bladder dysfunction.

Keywords: Cats, vertebral fracture, vertebral luxation, thoraco-lumbar, neurological dysfunction

Introduction
Spinal trauma in cats is devastating. The resulting injury to spinal cord interrupts sensory, motor and autonomic fibers. So the function of various parts of the body controlled by spinal cord is altered. Lack of normal control of locomotion and urinary bladder function are of major concern in long term management of spinal patients. Vertebral fracture and luxation (VFL) are common in thoracolumbar junction (T10-L2) followed by lumbar region (L3-L7) in cats (Jeffery, 2010) [1]. Although plain spinal radiographs are sufficient to diagnose VFL, the extent of maximum vertebral displacement at the time of injury and severity of spinal cord injury may not be evident in radiographs, hence, radiographic evaluation are not replacement for neurological examination (Dewey, 2014) [2]. Neurological signs are usually related to focal lesion that can be seen on spinal radiograph in affected cats (Platt and Olby, 2004) [3]. However, type of neurological dysfunction depends on extent of interruption in co-ordination between upper motor neuron (UMN) and lower motor neuron (LMN). It is generally considered that lesions in thoracolumbar segment of spinal cord (T3-L3) results in spastic paraplegia with spastic bladder and lesions in lumbosacral segment of spinal cord (L4-S3) will result in flaccid paraplegia with urinary incontinence. However, according to De Lahunta (2015) [4], intact hypogastric nerve originating from lumbar segment can maintain a good sphincter tone in presence of a flaccid detrusor muscle in cats. Studies on clinical assessment of UMN, LMR or mixed lesions over hindlimbs and bladder related to vertebral lesions at various levels in cats is lacking. Since the prognosis and type of treatment management varies with type of neurological dysfunction, the present study was undertaken with the objective to assess motor deficits and type of neurogenic bladder dysfunction (NBD) in cats with thoraco-lumbar vertebral fracture and luxation, and to analyze prediction of spasticity of urinary bladder/sphincter with spasticity in hindlimbs.

Material and Methods
The study was conducted in cats presented for treatment of acute paraplegia at Teaching Veterinary Clinical Complex and Department of Veterinary Surgery and Radiology, College of Veterinary Science and Animal Husbandry, OUAT, Bhubaneswar, from January 2019 to February 2020. The cats with thoraco-lumbar vertebral fracture and luxation on lateral view

spinal radiography at the time of presentation were selected for the study. They were treated conservatively or surgically for spinal injury and cats which did not survived up to 60th post-treatment day were excluded from the study.

The basic data regarding age, breed, sex, aetiology, time elapsed before presentation and voiding of urine were collected from animal owners. Lateral view spinal radiographs were obtained to identify location and type of vertebral lesion at the time of presentation. Neurological examination and urinary bladder function were assessed on the day of presentation and on 60th post-treatment day follow up. Neurological examination in hindlimbs were observation of gait, deep pain sensation, muscle tonicity on palpation and spinal reflexes viz., patellar reflex and flexor reflex. Motor deficit in hindlimbs was then classified as spastic paraplegia and flaccid paraplegia. Standing and ambulation without support was considered functional limb. Bladder dysfunction was assessed by palpation of urinary bladder through abdominal wall and bladder expression test. Bladder dysfunction was then classified as spastic NBD with hyperreflexic bladder and sphincter; flaccid NBD with hyporeflexic or areflexic bladder and sphincter; and mixed type NBD with areflexic bladder and hyperreflexic sphincter. Voluntary voiding of urine in a continuous stream was considered normal.

Analysis of (1) difference in distribution of neurological deficit in hind limbs and NBD type with respect to site of spinal cord injury and (2) association of motor deficit and bladder dysfunction at the time of presentation with results of 60th day of follow up were done by Chi-square test.

Results and Discussion

The study was conducted in 22 domestic short hair cats with thoracolumbar vertebral fracture and luxation which included 9 female and 13 male cats. The mean±SD age was 2.40±0.82 years. Cats were presented for acute paraplegia with urinary incontinence in 4 cats and absence of urination in 18 cats, since 1.38±0.82 days of duration. Automobile accident (50%) was major cause followed by fall from height (32%) and bite injury (18%). Vertebral fractures and luxations were recorded between T10 and L7. Thirteen cats (59%) had spinal cord injury in thoracolumbar segment (T3-L3) and 9 cats (41%) had spinal cord injury in lumbosacral segment (L4-S3). Twelve cats were able to move by dragging on hind limbs, 8 cats were laterally recumbent and 2 cats were stuporous with absence of deep pain perception at the time of presentation.

Distribution of motor deficit and NBD types in cats with thoraco-lumbar vertebral fracture and luxation at the time of presentation is shown in table 1. Motor deficit of spastic paraplegia was seen in 13 cats (59%) and flaccid paraplegia in 9 cats (41%). Muscle tone was normal in all the cats with spastic paraplegia. Among 13 cats with spastic paraplegia, increased response to patellar reflex and withdrawal reflex was noticed in 10 cats and other 3 cats had normal reflex. In cats with flaccid paraplegia, muscles of hindlimb were flabby on palpation (Figure 1). Response to patellar reflex and withdrawal reflex was decreased or absent in cats with lumbosacral cord lesions. The distribution of urinary bladder dysfunction were spastic in 15 cats (68%), flaccid in 4 cats (18%) and mixed type in 3 cats (14%) (Type of UBD appearance is shown in figure 2 only for demonstration and UBD cannot be diagnosed by radiography). Lesions in thoracolumbar spinal cord (T3-L3) results in spastic paraperesis or paraplegia with intact spinal reflexes and muscle tone. This is due to disruption in descending fibers of upper motor neuron (UMR) and intact lower motor neuron (LMR) innervations of hind limbs. The response to spinal reflexes and muscle tone in hind limbs may be increased due to lack of UMR modulation. The effect of continuous stimulation from LMR without UMR inhibition on urinary bladder innervation causes hyper-tonicity in detrusor muscle as well as internal and external sphincter. This prevents voiding of urine and manual expression is difficult or impossible in cats. Spastic UBD is characterized by an increased bladder size with hard and tonic walls, easily palpable in the abdomen and very difficult to squeeze. In case of lumbosacral intumescence (L4-S3) lesions, LMNs are damaged results in lack of voluntary locomotion due to flaccid paraplegia and muscle tone is flaccid. LMN innervation of internal sphincter, external sphincters and detrusor muscle are damaged, resulting in atonic sphincters and flaccid paralysis of the detrusor. In flaccid UBD, the bladder is relatively small, loose and easy to squeeze (Braund, 2010) [5]. However, in cats with intact hypogastric nerve originating from lumbar segment can maintain a good or exaggerated tone of the sphincter in presence of a flaccid detrusor muscle. In this bladder is soft but difficult to express and considered as mixed UBD. Overflow dribbling of urine may be seen in all types of NBD (De Lahunta, 2015) [4]. In the present study, the site of vertebral lesion affecting thoracolumbar segment (T3-L3) of spinal cord were associated with spastic neurologic or NBD, whereas, the site of vertebral lesion affecting lumbosacral segment (L4-S3) of spinal cord were associated with flaccid paraplegia and bladder only and not always associated with flaccid sphincter. Cats with flaccid paraplegia may have flaccid NBD or mixed NBD, thus NBD should not be assessed on clinical signs of dribbling of urine alone.

The role of hind limb spasticity to predict spasticity of bladder and sphincter is shown in table 2. The sensitivity, specificity, positive predictive value and negative predictive values of increased response to spinal reflexes in hind limb on bladder spasticity/sphincter spasticity were 66.67%/55.56%, 100.00%/100.00%, 100.00%/100.00% and 58.33%/33.33% respectively. On 60th day of follow up, NBD persisted in 7 cats and the sensitivity, specificity, positive predictive value and negative predictive values of increased response to spinal reflexes in hind limb on bladder spasticity/sphincter spasticity were 40.00%/33.33%, 100.00%/100.00%, 100.00%/100.00% and 40.00%/20.00% respectively. In humans, presence of ankle spasticity is highly accurate to predict spastic NBD after the acute stage of spinal cord injury (Chen *et al*., 2012) [6]. However, similar studies in animals is lacking. In the present study, prediction of spasticity in bladder and sphincter is more accurate in increased spinal reflexes in hindlimb in spastic paraplegia, whereas prediction of spasticity of sphincter is not very accurate in normal or decreased spinal reflexes in hindlimb in flaccid paraplegia. Thus, flaccid limbs does not always correlate with flaccid NBD. Further studies in large number of case is required as diagnosis and treatment of NBD varies with type of NBD.

At 60th day of follow up examination, 19 cats (86.36%) were ambulatory of which 5 cats had ataxia. Normal urinary bladder function was regained in 15 cats (68.18%). The distribution of ambulatory status and urinary bladder function at different injury sites is shown in table 3. Ambulation is a complicated motor act requiring coordinated movement of many muscles of the trunk and limbs, involving many joints.

The normal control of locomotion is a dynamic balance between different levels of the nervous system. In cats with a large lesion or even after a complete transection of the spinal cord can re-express locomotor movements due to remarkable ability of the spinal cord to optimize the locomotor functions within the remaining structures of the central nervous system. The spinal cord network is gradually modified and in this way the ability to express more or less appropriate locomotion is eventually regained (Rossignol *et al.*, 2002) [7]. Early recovery of urinary bladder function can be attributed to emergence of C-fiber-mediated segmental reflex in the micturition pathway, occurring within weeks to months after spinal cord injury (Al Taweel and Seyam, 2015) [8]. Bladder wall C-fiber afferents, which are usually functionally silent in spinal-intact animals, can become activated after suprasacral spinal cord injury (Palus, 2014) [9]. However, overall recovery of locomotion and bladder function is generally considered to be simultaneous and taking few weeks to three months or more. As a general rule, animals with upper motor neuron bladder problems tend to recover urinary function and are able to walk, whereas, animals with lower motor neuron bladder or pelvic nerve damage have a more guarded prognosis, and might need longer to recover the ability to control the micturition which could take weeks or months (Coates, 2004) [10]. In the present study, there was no significant association between the site of vertebral lesion and recovery of motor deficit or NBD. At the same time, recovery of hindlimb function was better than recovery of bladder function. The type of paraplegia and type of NBD, in cats which did not regained functional limb and bladder at 60th follow up examination, remained same as observed at the time of case presentation. Thus, location of spinal cord injury and extent of neural tissue damage determine the type of neurological dysfunction and its persistence as sequelae in surviving animals (Dewey, 2008) [11].

Table 1: Distribution of motor deficit and NBD types in cats with thoraco-lumbar vertebral fracture and luxation

Site of Vertebral lesion (n)	Motor deficit in hind limbs		NBD type		
	Spastic paraplegia *n*	Flaccid paralysis *n*	Spastic *n*	Flaccid *n*	Mixed *n*
Fracture in single vertebra					
T11 (3)	3	-	3	-	-
T13 (2)	2	-	2	-	-
L1 (1)	1	-	1	-	-
L2 (2)	2	-	2	-	-
L3 (1)	1	-	1	-	-
L6 (1)	-	1	-	-	1
L7 (5)	-	5	-	4	1
Fracture in multiple vertebrae					
T10 and T11 (2)	2	-	2	-	-
T13 and L1 (1)	1	-	1	-	-
T13, L1 and L2 (1)	1	-	1	-	-
Vertebral luxation					
L4-L5 (2)	-	2	2	-	-
L6-L7 (1)	-	1	-	-	1

Table 2: The hind limb spasticity on spasticity of bladder and sphincter in NBD

Spinal reflexes (n)	Bladder		Sphincter	
	Spastic n	Flaccid n	Spastic n	Flaccid n
At the time of presentation				
Increased (10)	10	-	10	-
Normal or decreased (12)	5	7	8	4
60th day of follow up				
Increased (2)	2	-	2	-
Normal or decreased (5)	3	2	4	1

Table 3: Ambulatory status and urinary bladder function on 60th day follow up.

Site of Vertebral lesion (*n*)	Ambulatory status		Urinary bladder function	
	Ambulatory n	Non-ambulatory n	Normal n	NBD n
Fracture in single vertebra				
T11 (3)	3	-	3	-
T13 (2)	1	1	1	1
L1 (1)	1	-	1	-
L2 (2)	2	-	1	1
L3 (1)	1	-	-	1
L6 (1)	-	1	-	1
L7 (5)	5	-	4	1
Fracture in multiple vertebrae				
T10 and T11 (2)	2	-	2	-
T13 and L1 (1)	1	-	-	1
T13, L1 and L2 (1)	-	1	-	1
Vertebral luxation				
L4-L5 (2)	2	-	2	-
L6-L7 (1)	1	-	1	-

Fig 1: Cats with spastic paraplegia with spastic NBD: tonic hindlimb muscles and tightly distended abdomen.

Fig 2: Cats with flaccid paraplegia with flaccid NBD: flabby hindlimb muscles, saggy distended abdomen and urinary incontinence (wet perineum).

Fig 2: Cats with flaccid paraplegia with Mixed NBD: flabby hindlimb muscles, tightly distended abdomen.

Conclusion

Thoracic and lumbar vertebral fracture and luxation resulting in thoracolumbar (T3-L3) segment spinal cord lesions caused spastic paraplegia with spastic NBD and in lumbosacral (L4-S3) segment spinal cord lesions caused flaccid paraplegia with either spastic NBD or mixed type of NBD in cats. Increased response to spinal reflexes in hindlimbs indicates spasticity of bladder and sphincter, whereas, normal or decreased response to spinal reflexes in hindlimbs will not indicate spastic sphincter in cats. Neurological assessment of hindlimbs and examination of urinary bladder are important tool for correct diagnosis and therapeutic approach in neurological dysfunction resulting from spinal trauma.

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