Pathogenesis

Hoerlein determined that intervertebral disc disease (IVDD) accounted for 2.02% of all diseases diagnosed in dogs (Hoerlein 1952). Incidence of IVDD peaks at 4 to 6 years of age in chondrodystrophic breeds and at 6 to 8 years in nonchondrodystrophic breeds (Priester 1976). The Dachshund had the highest frequency followed in succession by the Pekingese, Welsh corgi, Beagle, Lhasa Apso and miniature poodle (Hoerlein 1952). Hansen first classified IVDD as type I and type II (Hansen 1951). Hansen type I is herniation of the nucleus pulposus through the annular fibers and extrusion of nuclear material into the spinal canal. Hansen type I IVDD is typically associated with chondroid disc degeneration and has an acute onset. The disc extrudes through the dorsal annulus, causing dorsal, dorsolateral or circumferential compression of the spinal cord. Acute disc extrusion is characterized by the presence of soft disc material within the vertebral canal and extradural hemorrhage. Chronic disc extrusion is characterized by extradural fibrous adhesions around the herniated disc material that has often become a hard mineralized mass. The thoracolumbar junction (T12-13 to L1-2) accounted for the highest incidence of all disc lesions (Hoerlein 1987). Large nonchondrodystrophic breeds of dog such as the Doberman pinscher and Labrador retriever may also be affected with Hansen type I IVDD (Cudia 1997). The most common site in large breed dogs is the interspace between L1 and L2 (Cudia 1997).

Clinical Signs

Onset of neurologic signs in dogs with type I IVDD may be peracute (less than 1 hour), acute (less than 24 hours), gradual (greater than 24 hours) and chronic (Coates 2000). Dogs presented with peracute or acute thoracolumbar disc extrusions may manifest clinical signs of spinal shock or Schiff-Sherrington postures. These indicate acute and severe spinal cord injury but do not determine prognosis. The degree of neurologic dysfunction is variable and affects prognosis. Clinical signs vary from spinal hyperesthesia only to paraplegia with or without pain perception. Dogs with back pain only are usually reluctant to walk and may show kyphosis. Dogs with back pain alone and no neurologic deficits often have myelographic evidence of substantial spinal cord compression. Neuroanatomic localization for thoracolumbar lesions is determined by intact (T3-L3) or hyporeflexive (L4-S3) spinal reflexes and by site of paraspinal hyperesthesia. Asymmetry of neurologic deficits to localize the side of the disc extrusion is less reliable (Schulz 1998).

Diagnosis

The initial diagnosis of thoracolumbar IVDD is obtained from the signalment, history and neurologic examination. Diagnosis of thoracolumbar disc extrusion/protrusion is confirmed by imaging techniques and surgery. Survey spinal radiography can help to determine the diagnosis and site of thoracolumbar disc extrusion if roentogenic signs are well defined and consistent with neuroanatomic localization. In studies of dogs with surgically confirmed thoracolumbar IVDD, survey radiography had an accuracy of 68-72% in identifying the site of disc extrusion; whereas, accuracy of myelography was higher (Kirberger 1992; Olby 1994). Myelography is performed with isotonic, water soluble contrast. Myelographic contrast injection at the caudal lumbar region is preferred over the cerebellomedullary cistern for demonstrating thoracolumbar disc extrusion. Longitudinal lesion localization by
myelography for thoracolumbar IVDD varies in accuracy but in most cases is close to 90% (Kirberger 1994; Olby 1994).

Cross sectional imaging using MRI and CT has surplanted the use of myelography for the evaluation of animals with suspected IVDD. **Computed tomography** can be an adjunctive procedure to myelography to further delineate lateralization of the extruded IVD material or used as the sole technique for detecting intervertebral disk extrusion. Imaging the spine using CT alone is noninvasive and performed more quickly with fewer complications than myelography but experience is needed for accurate interpretation (Olby 1999). The lesion extent and lateralization of IVD material can be more distinct on CT than with myelography alone. Mineralized disk material and acute hemorrhage are identified in the vertebral canal using noncontrast-enhanced CT. The attenuation (brightness) of the disk material increases with the degree of mineralization. Acutely extruded IVD material typically is recognized as a heterogeneous and hyperattenuating extradural mass from a combination of disk material and hemorrhage.

MRI is superior in the recognition of intraparenchymal pathology and is the standard of care for assessment of acute spinal cord injury (SCI) in animals. Standardized MRI protocols for intervertebral disk disease use T1- and T2-weighted sagittal and axial images over areas of interest. MRI is also is ideal for early recognition of in-situ disk degeneration based on decrease in signal intensity (relative blackness) within the nucleus pulposus on T2-weighted images. Focal signal void (blackness) within the intervertebral disk space or spinal canal may represent mineralization or extruded mineralized nucleus pulposus. Acute pathologies of spinal cord tissue recognized as high-signal intensity on T2-weighted images (relative whiteness) include necrosis, inflammation and edema. However, it is difficult to distinguish amongst these specific types of pathology. MRI may provide better clarity than other imaging techniques in detecting hemorrhage associated with IVD herniation. However, timing of MRI in relation to onset of the lesion can confound interpretation of signal intensity since rapid changes can occur within areas of hemorrhage in the early stages after injury (Tidwell 2002).

MRI has been used to predict prognosis in paraplegic dogs caused by intervertebral disk extrusion. Results of dogs undergoing MRI and surgery for IVDD suggested that an area of intramedullary spinal cord hyperintensity on sagittal T2-weighted MR images at least the L2 vertebral body had a poorer prognosis for functional recovery (Ito 2005). Success rate following surgery in dogs without hyperintensity of the spinal cord was 100% compared to 55% in those with areas of hyperintensity. Moreover, success rates reported for dogs with areas of hyperintensity and loss of pain perception was 31%, and the success rate in dogs with loss of pain perception and hyperintensity > 3 times the length of L2 vertebral body was 10% (1/10 dogs). Other (Levine 2009) also have found that intramedullary spinal cord hyperintensity on T2-weighted MR images was associated with the injury severity and also predictive of the recovery of the ability to walk long-term.

**Treatment**

**Medical/Conservative management**

Indications for nonsurgical treatment of thoracolumbar IVDD include a first time incident of spinal pain only or mild to moderate paraparesis and financial constraint of the client. Dogs can be managed with strict cage rest for four to six weeks combined with pain relief using anti-inflammatory drugs, opiates, and muscle relaxants. A recent retrospective study questioned the use of strict confinement by documenting lower ‘quality of life’ score (Levine 2007). Gastrointestinal protectants also may be necessary with use of anti-inflammatory therapies. Never use NSAIDs in combination with corticosteroids as gastric ulcers can result possibly leading to death. Acupuncture also has been advocated as a treatment for pain management. Dogs should be monitored closely for deterioration of neurologic status. If pain persists or neurologic status worsens, surgical management is recommended.
Success rates for conservative management of ambulatory dogs with pain only or mild paresis range from 82% to 100% (Funkquist 1978; Davies 1983). Recovery rates in nonambulatory dogs are lower and recurrence rates are higher in studies following conservative treatment. Recent retrospective studies documented 30 to 50% recurrence rates in dogs with minimally affected ambulatory status (Levine 2007; Mann 2007).

Methylprednisolone sodium succinate (MPSS) has been advocated as an adjunctive treatment of acute disc herniations causing paraplegia and loss of nociception; however, evidence-based studies are needed to provide efficacy. Therapy (30 mg/kg IV slow bolus) should be initiated within the first 8 hours of the trauma. However, use of MPSS in Dachshunds with acute IVDD also is associated with an increased post-operative complication rate and financial cost to the client. Fluid therapy also is important at the time of the injury in order to maintain spinal cord perfusion.

**Surgical**

Indications for surgical management of thoracolumbar IVDD include spinal pain or paresis unresponsive to conservative management, recurrence or progression of clinical signs, paraplegia with intact deep nociception, and paraplegia without deep nociception for less than 24-48 hours. Prolonged loss of deep nociception (> 48 hours) carries a poor prognosis and owners should be made aware of this prior to surgery. However, it is often difficult to determine when deep nociception is lost, and recoveries have been observed in dogs that had surgery more than 5 days after onset of paraplegia. In dogs that are nonambulatory paraparetic or paraplegic, decompressive surgery should be performed immediately. This recommendation is supported by several clinical and experimental studies that compared the time of onset (acute vs. chronic) and duration of spinal cord compression with the rate of recovery. Goals for surgical management of dogs with spinal cord injury include decompression, visual observation, and irrigation of the spinal cord. Surgical decompression also includes removal of extruded disc material. Chronicity of disc extrusion at the time of surgery may influence the ease with which extruded disc material can be removed.

Decompressive procedures for thoracolumbar IVDD are dorsal laminectomy (Funkquist 1970; Prata 1981), hemilaminectomy (Hoerlein 1956), and pediculectomy (also termed mini-hemilaminectomy) (Braund 1976; Bitetto 1987). There are advantages and disadvantages of each decompressive technique. Hemilaminectomy significantly improves retrieval of extruded disc material with minimal spinal cord manipulation: a clear advantage over dorsal laminectomy and pediculectomy. Pediculectomy is the least invasive and destabilizing technique but these advantages may not be clinically significant except in cases of a bilateral approach to the vertebral canal. Unilateral facetectomy and fenestration do not significantly destabilize the spine in lateral bending (Schultz 1996).

The type of decompressive procedure may not affect outcome; however, the ability to retrieve the disc material depends on the decompressive procedure. The primary purpose of decompressive surgery is to allow for adequate exposure for removal of disc material while minimizing spinal cord manipulation. Hemilaminectomy provides the same degree of decompression as dorsal laminectomy and is less frequently associated with a post-surgical constrictive laminectomy membrane. Radical bilateral dorsal laminectomy (removal of pedicle – Funkquist A) has an increased risk of constrictive laminectomy membrane formation. Hemilaminectomy allows easier access to extruded disc material and the dorsolateral approach allows access to disc spaces for fenestration. McKee reported retrieval of disc material in 93% of dogs that had hemilaminectomy compared with 40% of dogs that had dorsal laminectomy (McKee 1992), although initial neurologic recovery after hemilaminectomy was not significantly different compared with dorsal laminectomy.

_Durotomy_ is ineffective as a treatment for acute compressive spinal cord trauma. Durotomy does
allow for visualization of the spinal cord parenchyma to determine extent of swelling and presence of myelomalacia. Absence of visual evidence of myelomalacia does not guarantee functional recovery; conversely, functional recovery may still occur despite presence of focal myelomalacia.

Fenestration, first described by Olsson (Olsson 1975), has been advocated as a treatment and prophylactic procedure for disc disease. Surgical approaches for disc fenestration include dorsolateral, lateral and ventral incisions. Effectiveness of fenestration is related to the amount of nucleus pulposus removed. Multiple disc fenestrations are commonly performed at T11-12 through L3-4.

**Outcome and Recovery**

Differences in recovery rates of nonambulatory dogs vary according to the severity of neurologic dysfunction (neurologic grade), time interval from initial clinical signs to surgery, and speed of onset of signs (Coates 2004). Deep nociception is considered the most important prognostic indicator for a functional recovery (Amsellem 2003). In general the majority of dogs with intact deep pain perception, whether paraplegic or simply paraparetic, have an excellent prognosis, particularly if treated surgically. Dogs with loss of deep nociception for more than 24 to 48 hours prior to surgery have a poorer prognosis for return of function. Without surgery, or with delayed surgery, dogs with absence of deep pain perception have an extremely guarded prognosis although duration of absence of deep pain perception prior to surgery as a prognostic indicator is controversial. Recovery rates for dogs with thoracolumbar IVDD and absent deep pain perception range from 0 to 76%. A study of 87 dogs with loss of deep pain perception reported 58% regained deep pain perception and the ability to walk (Olby 2003). In summary, dogs with absence of deep pain perception that have surgery within 12 to 36 hours have a better chance of more rapid and complete recovery than those with delayed surgery.

Dogs with more severe neurologic dysfunction have a longer period of recovery (Brown 1977). Mean time from post-surgery to ambulatory status varied from 10 days for dogs with clinical signs of pain only or paraparesis to 51.5 days for dogs that presented with paraplegia (Brown 1977). Other long-term studies reported recovery times of 2 to 14 days for dogs that were either ambulatory or nonambulatory with voluntary motor movement and up to 4 weeks for paraplegic dogs (Yovich 1994; Scott 1997). Dogs with disk extrusions caudal to L3-4 are likely to achieve ambulatory status sooner than dogs with disk extrusions between T10 and L3 (Ruddle 2006). Age and weight also have been reported to have an association with time required for ambulation (Olby et al. 2003). Dogs that undergo physical rehabilitation may have shorter times to ambulation (Ruddle 2006).

There are many contradictory studies on the effect of speed of onset of signs and duration of signs prior to surgery on speed of recovery and final outcome. It is agreed that rapid removal of extruded disc material facilitates a more complete and rapid recovery (McKee 1992). Dogs with shorter duration and gradual onset of neurologic dysfunction (less than 48 h) prior to surgery have a quicker recovery (Brown 1977; Gambardella 1980). However, a study of 71 paraplegic dogs with intact deep pain sensation demonstrated that although a shorter duration of signs was indeed associated with a shorter recovery time, the rate of onset of clinical signs did not influence the recovery time, although it did influence the final outcome (Ferreira et al. 2002). Similarly, peracute onset of signs indicated a poorer prognosis for dogs with no deep pain perception (Scott and McKee, 1999). Knecht compared outcome of dogs after hemilaminectomy with duration of clinical signs and concluded that delay before surgery does not influence outcome in dogs with mild neurologic dysfunction but does affect better functional recovery in paraplegic dogs when performed within 12 hours (Knecht 1970).
Prognosis of decompressive laminectomy in treatment of IVDD is dependent on preoperative neurologic status. Overall success rates after decompressive surgery range from 58.8% (Brown 1977) to 95% (Schulman 1987). However, the success of a surgical approach may depend on what criteria are used to define it, how long after the surgery the patient is assessed, as well as the outcome which the owners are willing to accept. Surgical success may be improvement of the patient’s pre-surgery neurological grade but may not mean that the patient is functionally normal and such residual signs as fecal and urinary incontinence can be unacceptable to many owners. Approximately 40% of dogs that recovered from loss of deep nociception continued to have fecal incontinence (Olby 2003).

Recurrence of clinical signs after decompressive surgery attributable to other disk protrusions is a likely and common clinical entity with incidence rates reported from 2% to 27%. A large retrospective study documented that dogs with multiple opacified disks at the time of first surgery should be considered at higher risk (19%) for recurrence of clinical signs associated with TL IVDD (Mayhew 2004). These findings support for possible additional therapeutic interventions like prophylactic fenestrations and disk ablative procedures (Brisson 2004, Bartels 2003).

Selected references available upon request: