Abstract

Acute thoracolumbar intervertebral disc herniation in dogs is a common cause of ‘back’ pain, pelvic limb paresis or paralysis and incontinence. Treatment of this condition has long been a source of controversy, especially since the introduction of surgical interventions in the 1950s. Unfortunately, formal clinical trials to compare effectiveness of conservative and surgical interventions have never been carried out and the current lack of clinical equipoise on this subject now precludes such a trial on ethical grounds. In this article we re-examine and discuss previously published data on recovery associated with the various therapies, focusing on evidence suggesting that decompressive surgery and fenestration may be equally efficacious.

Keywords

Fenestration, thoracolumbar, dogs, disc
**Introduction**

Acute thoracolumbar intervertebral disc herniation in dogs is a common cause of ‘back’ pain, pelvic limb paresis or paralysis and incontinence. Treatment of this condition has long been a source of controversy, especially since the introduction of surgical interventions in the 1950s (Hoerlein 1956). Unfortunately, formal clinical trials to compare effectiveness of conservative and surgical interventions have never been carried out and the current lack of clinical equipoise on this subject now precludes such a trial on ethical grounds. In this article we re-examine and discuss previously published data on recovery associated with the various therapies, focusing on evidence suggesting that decompressive surgery and fenestration may be equally efficacious.

**Intervertebral disc herniation and spinal cord injury**

Acute thoracolumbar intervertebral disc herniation occurs at highest prevalence in chondrodystrophic dogs, mostly during middle-age, but is also well-recognized in older non-chondrodystrophic individuals (Brisson 2010). Clinical and neurological signs range from ‘back’ pain alone to irreversibly-severe spinal cord injury characterised by paraplegia with loss of ‘deep pain perception’ and, sometimes, progressive myelomalacia (Griffiths 1972, Olby et al 2004, Okada et al 2010). These clinical signs are caused by rupture of the dorsal annulus fibrosus, allowing herniation of degenerate, often calcified, nucleus pulposus into the vertebral canal, causing a mixed contusive-compressive spinal cord injury (Hansen 1951, Hansen 1952). Diagnosis is best achieved through cross-sectional imaging such as MRI or CT which, in addition to providing the most sensitive diagnostic information can also provide clues as to the character of the extradural compressive lesion (Bos et al 2012, Newcomb et al 2012). Myelography, although often diagnostic, is fast becoming of historic interest only. Treatment goals are to eliminate pain and restore normal neurological function as quickly as possible.

The volume of degenerate nucleus that herniates is widely variable between cases and the herniating event can occur during a period of seconds to days. The volume and time
period over which herniation occurs constitute two sources of variability, which also likely interact, meaning that each resulting spinal cord injury has a more-or-less unique mix of contusive (impact) and compressive components. The observation that the spinal cord can tolerate severe compression without severe clinical signs implies that the loss of function following acute disc herniation is mostly caused by the contusive component. Contusive spinal cord injury has been extensively studied in the laboratory in order to develop new therapies for spinal cord injury in people (Kwon et al 2011, Tetzlaff et al 2011). Despite this research there is no unequivocally-established drug treatment for spinal cord contusion and, instead, its clinical management centers on nursing care, physical therapy and allowing time for spontaneous recovery.

**Current treatment options**

Treatment options for canine thoracolumbar disc herniation broadly fall into conservative or surgical categories (Brisson 2010).

*Conservative treatment* consists of analgesic drugs, a period of strict (cage) rest to reduce the risk of further nuclear herniation and allow healing of the ruptured annulus (which is a prolonged process – see Bron et al 2009), attentive nursing care - particularly for paraplegic dogs that have lost bladder control, and physical therapy to aid recovery of ambulation (Levine et al 2007, Mann et al 2007). Recovery following conservative management relies on resolution of the acute inflammation in the spinal cord, regeneration of myelin sheaths and the innate plasticity of the CNS to overcome the effects of tissue loss by adjusting pathways used to perform specific functions (Jeffery & Blakemore 1999, Bareyre et al 2004). It is also possible, and documented in some cases (Steffen et al 2014), that herniated nucleus pulposus can be eliminated from the vertebral canal (e.g. by phagocytosis induced during the secondary inflammatory response), thus abrogating the compression (Prata 1981, Steffen et al 2014, Hong and Ball, 2016).
It is well-established that the majority of dogs that suffer paralysis as a result of acute thoracolumbar disc herniation will recover unassisted ambulation with conservative therapy; reported recovery with conservative management varies between 50-100% (overall 86%) except in dogs with negative ‘deep pain’ perception, for which reported success is poor (6 %, see below), although this estimate is based on very small numbers of animals (Table 1). The overall recovery associated with conservative management shown here may be biased by the inclusion of more mildly affected dogs (a lower proportion of non-ambulatory and ‘deep pain’ negative). However, in a large retrospective study of medically-managed dogs the severity of neurological dysfunction at initial presentation was not correlated with treatment success, although the duration of clinical signs was a significant predictor of recovery (Levine et al 2007). In that study, dogs failing to show ‘sufficient’ improvement with conservative management within a certain time frame were then treated surgically, meaning that the true proportion of successfully managed cases may be mis-estimated, since it is possible that many dogs might have recovered to walk again without surgical intervention (Levine et al 2007).

The aim of **decompressive surgery** is to remove the herniated material from the vertebral canal and thereby alleviate compression of the spinal cord. Decompressive surgery is advocated on the basis of *in vitro* evidence that the contused spinal cord is less tolerant of compression (Shields et al 2005), and experimental evidence that early decompression results in more rapid and, possibly, more complete recovery of function (Delamarter et al 1995, Dimar et al 1999), as well as the intuitive sense that a compressed spinal cord should be decompressed. Surgical treatment by hemilaminectomy (Gage & Hoerlein 1968) has become a well-accepted treatment modality for patients with severe or progressive neurological deficits (Brisson 2010).

Reported success associated with treatment by hemilaminectomy of thoracolumbar spinal cord injury caused by intervertebral disc herniation in dogs range from 63-100% (overall 82%) with a level of 56% for dogs with loss of ‘deep pain’ perception (Table 2).
The overall percentage may be influenced by the relatively high proportion of dogs with negative deep pain perception included in many studies, which are less common in conservative treatment series. However, after decompressive surgery 90% of dogs with intact ‘deep pain’ sensation recovered, which is similar to the 86% recovery with conservative management. It would be interesting to examine the proportion of non-ambulatory dogs retaining ‘deep pain’ sensation that recover in each treatment group, but, unfortunately, many of the studies do not clearly segregate the cases for this type of post hoc analysis.

**Current ‘unknowns’ regarding the value of surgical decompression**

Although decompressive surgery is currently the standard-of-care for dogs that have lost the ability to walk after an acute thoracolumbar intervertebral disc herniation (Moore et al 2016) there are several inconsistencies that bring its true value into question.

Work in experimental animals provides some foundation for the belief that spinal cord compression should be eliminated in clinical cases. For instance, there is *in vitro* evidence that relatively mild spinal cord compression can cause a reversible conduction block (Shi 1996) associated with disruption of myelin and potassium channels (Ouyang et al 2010), and various workers have shown both grey and white matter damage associated with long-term compression (albeit ‘dynamic’ compression) (Wright & Palmer 1969, Al-Mefty et al 1993). It is also possible that the severely contused spinal cord is less able to tolerate even mild compression (Dimar et al 1999). This evidence can therefore provide a possible explanation for any difference in recovery rates between ‘deep pain negative’ dogs treated conservatively and those undergoing surgical decompression. Indeed, there is evidence that residual compression after surgery can delay recovery (Forterre et al 2010, Hettlich et al 2012), and that better outcomes are achieved with complete decompression rather than partial (McKee 1992).
On the other hand, it is well-known that dogs can incur major spinal cord compression in the thoracolumbar region whilst showing no neurological deficits (Sukhiani et al 1996). Also, there does not appear to be an association between MRI-documented spinal cord compression and severity of signs or prognosis following acute thoracolumbar disc herniation (Besalti et al 2005, Penning et al 2006), although an association between the length of compression and severity of initial signs has been proposed (Levine et al 2009). The clear implication of these lines of evidence would be that decompression is not always required in order to allow clinical recovery. In support of this notion, residual disc material is commonly found in the spinal canal following decompressive surgery but does not appear to adversely affect recovery (Roach et al 2012, Huska et al 2014).

Rapid decompression has been suggested to be important in promoting recovery of function in some veterinary studies (Brown et al 1977), but others have not shown an association of duration or severity of clinical signs with outcome (Davis & Brown 2002, Ferreira et al 2002, Olby 2003, Jeffery et al 2016). Whilst this does not imply that decompression in itself may not be an effective treatment option, it lends credence to the notion that decompression may not be essential for recovery in many cases. Furthermore, ‘deep pain negative’ dogs treated by fenestration alone have a recovery rate more similar to those treated by decompression than those treated conservatively (see Table 3), suggesting that persistent compression may not alter the prognosis for a large proportion of these cases.

In summary, the available evidence suggests contrasting interpretations, possibly because many of the studies are based on non-pre-specified analyses of retrospective data often combined with small sample sizes, all factors known to increase the risk of false conclusions (Simmons et al 2011, Button et al 2013). Clearly more work is required to establish the precise role of compression in acute thoracolumbar disc herniation but perhaps the conflicting evidence can be reconciled by suggesting that compression, when combined with contusion, is involved in determining the severity of initial neurological dysfunction but does not determine long-term prognosis. This line of explanation would
suggest a profound difference in the cause of neurologic deficits between acute and chronic disc herniation: acute nuclear herniation can cause a static compressive lesion that may sometimes be removed by phagocytosis or remodel within the vertebral canal, such that spontaneous complete recovery may occur; in contrast, chronic annular protrusion causes dynamic compression that cannot be resolved without surgical intervention.

Another window on the dilemma

Fenestration of thoracolumbar discs has, in the past, been widely advocated as a stand-alone surgical treatment for acute symptomatic thoracolumbar disc herniation (Flo & Brinker 1975, Denny 1978, Butterworth & Denny 1991). The rationale for fenestration as a treatment is based on removal of the remaining nucleus from within annulus fibrosus of the herniated disc (thereby preventing further herniation), reduction of the dynamic factors involved in herniation (Olssen 1951) and elimination of disc-associated pain (Butterworth & Denny 1991). Fenestration has also been commonly used for prophylaxis against future episodes of nuclear herniation at other sites and, although controversial (Brisson et al 2004, Forterre et al 2008), appears now to be well-established (Brisson et al 2011, Aikawa et al 2012). The potential advantages of fenestration alone in the treatment of acute thoracolumbar disc herniation include avoidance of the requirement for cross-sectional imaging for surgical planning, which also reduces total procedure time, and reduced requirement for specialised instrumentation.

During the 1990s a large number of veterinary surgeons did not carry out decompressive surgery for treatment of acute thoracolumbar intervertebral disc herniations in dogs and, instead, used fenestration alone (Denny 1978, Davies & Sharp 1983, Butterworth & Denny 1991). Reported recovery following multiple disc fenestration alone ranges from 88-100% (overall 92%), with recovery of ‘deep pain negative’ dogs being 45%, and recovery of all dogs retaining deep pain perception being 94% (Table 3). This compares well with the reported success for decompressive surgery. The proportion of successful
outcomes appears higher than for conservative treatment, especially in ‘deep pain
negative’ dogs (Table 4) which is an interesting observation: perhaps dogs with absent
‘deep pain’ treated by fenestration alone had minimal compression of the spinal cord,
although this cannot be confirmed by analysis of the available published data.

It is possible that dogs treated with fenestration alone may take longer to recover than
those treated by decompression, and it has also been suggested that it may not be
suitable for dogs with absent ‘deep pain’ perception (Brisson 2010). However it is
difficult to compare outcomes between different reports and between different treatment
approaches, because of the lack of strict definitions of what ‘recovery’ means. Also,
many articles provide little follow-up information, meaning that time to achieve recovery
is largely unreported. It is possible – and frequently claimed based on anecdotal
experience - that dogs treated by decompressive surgery may attain more complete
recovery than those treated either conservatively, or by fenestration alone. However,
this type of data has not been systematically reported in the available literature meaning
that this aspect of treatment efficacy cannot be compared. In our analysis we have tried
to take the authors’ definitions of success, or the recovery of unassisted four-legged
ambulation, to denote a successful outcome.

In general, reported proportions of successful treatment for decompressive surgery and
fenestration alone are very similar for dogs both with and without ‘deep pain’ perception.
It is only conservatively-managed ‘deep pain negative’ dogs which show lower rates of
recovery, and even this conclusion may be unreliable because there is a paucity of data
from which to define the true recovery level for dogs in this specific severity and
treatment category (Table 4). We found only four articles containing information on
recovery of dogs without ‘deep pain’ perception following conservative management,
including two which reported on electroacupuncture as a treatment modality.
Unfortunately these two articles (Hayashi et al 2007, Joaquim et al 2010) defined
recovery as return of ‘deep pain’ perception and, or, ambulation, whereas the other two
articles (Davies & Sharp 1983, Levine et al 2007) clearly stated return of ambulation as their definition of success. Taking the latter only, successfully treated cases were just 1/17 (6%) but if the other two articles are included, ‘success’ was achieved in 11/41 (27%).

A proposal

There are legitimate questions regarding the value of decompressive surgery in the treatment of acute thoracolumbar intervertebral disc herniation, especially since robust clinical studies to compare outcomes with conservative therapy have never been carried out. The ideal approach to answer these questions would be a randomised trial to determine the difference in outcome between surgical and non-surgical approaches. Unfortunately, there is currently a lack of equipoise (i.e. equal balance of expert opinion) regarding the value of surgical decompression for this condition in non-ambulatory dogs and so such a study could not now ethically be undertaken. However, perhaps fenestration might play a role in bridging this gap. Although fenestration does not purport to reduce the compression on the spinal cord that results from the extruded disc, it is thought to reduce the risk of further extrusions from an already damaged annulus (Forterre et al 2008, Brisson et al 2011, Aikawa et al 2012) thus preventing worsening of the clinical signs.

Whilst we are not proposing to abandon the current treatment protocols for canine intervertebral disc disease, might it not be appropriate to consider comparing the rapidity and completeness of recovery following standard decompressive surgery versus that after multi-level fenestration in a large randomised clinical trial in chondrodystrophic dogs? The results of such a study would not only determine whether decompressive surgery improves the proportion of dogs that recover but also will provide evidence of possible effects on rapidity or completeness of recovery.
References


Joaquim JGF, Luna SPL, Brondani JT (2010). Comparison of decompressive surgery, electroacupuncture, and decompressive surgery followed by electroacupuncture for the
treatment of dogs with intervertebral disk disease with long-standing severe neurological

signs as prognostic indicators in 30 dogs with thoracolumbar disk disease after surgical

of thoracolumbar disc protrusion: a retrospective study of 331 dogs. J Small Anim Pract
46: 479-84.


Knecht CD (1972). Results of surgical treatment for thoracolumbar disc protrusion. J

pharmacologic neuroprotective treatments for acute spinal cord injury. J Neurotrauma

Laitenen OM, Puerto DA (2005). Surgical decompression in dogs with thoracolumbar
intervertebral disc disease and loss of deep pain perception: a retrospective study of 46

Levine SH, Caywood DD (1984). Recurrence of neurological deficits in dogs treated for

Levine JM, Fosgate GT, Chen AV et al (2009). Magnetic resonance imaging in dogs with
neurologic impairment due to acute thoracic and lumbar intervertebral disk herniation. J

management for presumptive thoracolumbar intervertebral disk herniation in dogs. Vet


