Diseases of the spine: surgical considerations in the management of spinal disease

Rodney S. Bagley

DVM, Dipl ACVIM (Neurology and Internal Medicine), Washington State, USA

Once a spinal cord abnormality has been diagnosed, treatment recommendations can be offered. Some spinal neurologic diseases, such as many of the spinal degenerative disorders, either are not treatable or have no globally accepted treatment.

For those diseases with established treatments, general treatments include either non-surgical (medical) or surgical treatments. Rehabilitation, physical therapy, and pain management are also important aspects of treatment of spinal diseases.

SURGICAL TREATMENTS FOR SPINAL CORD DISEASE

The indications for spinal surgery include decompression of the spinal cord or nerve roots, stabilization or realignment of vertebral structures, diagnosis of spinal disease (biopsy), and preventative treatments such as for intervertebral disk disease. General aspects of spinal surgery are discussed further.

SPINAL CORD DECOMPRESSIVE PROCEDURES

If the spinal cord is compressed by disease, access to the spinal cord and removal of the compressive abnormality is necessary. There are two basic decompressive surgical procedures; the hemilaminectomy and the dorsal laminectomy. In addition, for ventral cervical decompression, a specialized partial spondylectomy referred to commonly as a ventral slot is useful.

As the term laminectomy implies, these procedures involve removal of bone (i.e. the lamina) from various areas around the spinal cord to provide access to the epidural space and dural tube. Depending on the individual surgeon’s preference, either may be used in routine situations, however, the author prefers the hemilaminectomy in most cases due to the increased incidence of ventral and unilateral spinal compression.

The thoracolumbar area can be accessed for decompression via a dorsal approach for either a hemilaminectomy or a dorsal laminectomy. With localized lesions on one side and centered exclusively around the nerve root, a foraminotomy (surgically enlarging the intervertebral foramen) may be the procedure of choice.

ADVANTAGES AND DISADVANTAGES

The major advantage of the hemilaminectomy is that this procedure provides for adequate exposure of the dorsal, lateral, and ventral spinal cord and unilateral nerve root. This degree of exposure is beneficial in most instances of intervertebral disk disease as the herniated disk material is found usually ventrally or laterally. Problems with the hemilaminectomy include the need for accurate localization of the side of the lesion and the potential for hemorrhage from the vertebral sinuses in the vertebral canal.

The dorsal laminectomy is useful for lesions located exclusively in the dorsal aspect of the spinal cord or canal. This technique results in a greater degree of instability of the spine than does the hemi-laminectomy. Surgeons experienced with this technique find it useful even for ventrally situated lesions, however, an increased amount of spinal cord manipulation may result.

Three basic types of dorsal laminectomies exist; Funkquist types A and B, and the modified dorsal laminectomy. Problems with laminectomy membrane formation (postoperative scarring resulting in spinal cord compression) occurred commonly with the Funkquist type A laminectomy and this procedure is almost never performed in the modern era. The Funkquist type B laminectomy was developed to decrease this post-operative scarring complication, but results in limited ventral exposure to the spinal cord. The modified dorsal laminectomy was developed to allow for better exposure to the ventral spinal cord while decreasing the risk of laminectomy membrane formation. This procedure is most adequate for dorsal compressive lesions in the thoracolumbar area, however, may be less ideal for ventral-lateral compression.

The cervical area can be accessed for decompression via a ventral, lateral, or dorsal approach. A ventral slot is the common phrase used to describe a ventral decompressive spinal surgical procedure used primarily in the cervical region. This procedure is most adequate for ventral compressive lesions in the cervical area from C2-3 through C6-7 and possibly C7-T1. This approach allows limited access to the ventral aspect of the spinal cord overlying the disk space. Access is limited due to the normal course of the ventral vertebral sinuses. Additionally, removal of excessive amounts of the vertebral body results in significant spinal instability.

Cervical hemilaminectomy or dorsal laminectomy is most useful for surgical decompression of dorsal and lateral...
(sometimes ventral) compressive lesions in the cervical area from C2-3 through C6-7 and possibly C7-T1. The lateral cervical approach may be used to access the lateral aspect of the caudal cervical area. If necessary, a hemilaminectomy of the caudal cervical and cranial thoracic vertebrae can be performed through this approach. The major disadvantage of the lateral cervical approach is that only C3-4 to C5-6 can be accessed easily. An approach similar to the craniolateral approach to the brachial plexus may allow access to the more caudal cervical area if desired.

**BRACHIAL PLEXUS PROCEDURES**

The brachial plexus is most often accessed for nerve sheath tumor arises from these nerves. Biopsy of affected nerves, as in the case of brachial plexus neuritis, can also be performed. If necessary, a hemilaminectomy of the caudal cervical and cranial thoracic vertebrae can be performed through this approach. Also, the surgical approach can be extending for limb amputation.

**NONDECOMPRESSION PROCEDURES**

Fenestration is a prophylactic procedure wherein the vertebral canal is not entered. The intervertebral disc spaces are incised and the nucleus pulposis is removed. This may prevent further extrusion of nucleus pulposis and may result in fibrosis of the IVD. Success with this procedure varies primarily with the severity of the clinical signs. Fenestration alone, however, is not a spinal decompressive procedure.

**CHOOSING A TREATMENT FOR SPINAL DISEASE**

When a surgical treatment is an option, the choice of either a non-surgical versus a surgical treatment for spinal disease is based on a multitude of factors including financial aspects as surgical treatments tend to be more costly. A major factor, however, in choosing a non-surgical versus a surgical treatment is the degree of impairment or the severity of the clinical signs. The severity of clinical signs can be graded to help in this determination. An assessment of the severity of clinical impairment will also determine that necessary for rapid diagnosis and treatment (i.e. the need for emergency surgery).

While we would all hope scientific data would be available to be used as a guide in making decisions regarding when surgical treatment of spinal disease is necessary, clinical decisions are still commonly based on individual opinion from anecdotal experiences. The following are guidelines for surgical management of animals with spinal cord disease. These are only guidelines and modification may be necessary in individual animals depending upon special circumstances (e.g. systemic health, owner finances).

Decisions regarding when and if surgical versus non-surgical treatment for spinal cord disease is indicated are primarily made based on two main facets: the severity of neurological signs and chronicity of the problem. As important is the presumptive diagnosis based on clinical evaluation. The graded scale can be used to assess severity of spinal injury. The decision as to when to pursue aggressive diagnostics and therapy is also dependent upon the presumptive diagnosis. Animals that are presumed to have diseases that might result in further clinical deterioration should always be evaluated and treated as rapidly as possible. If a disease (such as an acute spinal injury) has occurred to the spinal cord and this injury is assumed to be non-progressive, the choice of therapy is often made based on the degree of clinical impairment. Diseases such as intervertebral disk extrusion or protrusion and exogenous spinal injury usually fall into this category. In some instances, an acute spinal injury will be result in progressive clinical signs over the ensuing hours or days. If a non-surgical treatment option is initially chosen, however, the clinical signs continue to worsen, a surgical treatment should be considered as rapidly as possible prior to significant clinical impairment.

As an example, a dog with a signalment and history that suggests an acute intervertebral disk problem or exogenous spinal injury can be managed generally via these guidelines. Approximately 60-70% of dogs with acute intervertebral disk disease that are grade 6 or higher at initial presentation improve or completely resolve this problem without surgical intervention. If clinical signs worsen during strict confinement, a more thorough evaluation should be pursued.

Generally, animals who are a grade 6 or higher who have had clinical signs for less than two weeks in duration and have a presumptive diagnosis of a spinal injury, either from an intervertebral disk problem or exogenous injury, are candidates for non-surgical management of their spinal problem. Non-surgical management primarily includes strict cage confinement for at least a two-week period of time, acute antiinflammatory medications (for the first day +), and treatment for spinal pain (as necessary) with subsequent reevaluation and reassessments performed as necessary. Clinical assessments are made at least daily if not more frequent until clinical signs are non-progressive for at least a 48-hour period of time. These assessments are often performed with the animal hospitalized for the first 24 to 48 hours following a spinal injury. Confinement may need to be continued for 4 to 8 weeks depending upon the rapidity and completeness of recovery. Corticosteroids can be administered acutely (methylprednisolone 30 mg/kg IV slowly), however, should be continued cautiously after the first 24 hours as the risk of gastrointestinal complications (gastric and colonic ulceration) significantly increases with a longer duration of therapy. Methylprednisolone sodium succinate therefore, is the steroid of choice for these animals (see further).

Animals who are grades 5 through grade 1 tend to be more strongly considered as candidates for surgical treatment. Animals with acute intervertebral disk disease and are judged to be within grades 5 -2 who have surgery performed within 48 hours have approximately an 80+% recovery rate of useful function. Animals that lose deep pain sensation and are operated within 48 hours have conservatively a 50% chance of recovery and, in some instances, as high as a 70% recovery rate. Animals who have lost deep pain sensation for
greater than 48-72 hours have a much poorer (5% or less?) chance of recovery of useful function with or without surgery. A dog with obvious signs of myelomalacia will recover no useful spinal cord function. Animals with myelomalacia often appear systemically ill and have fevers. If myelomalacia ascends to involve the nerves responsible for respiration (i.e. the cervical area), the prognosis is grave and it is best to euthanize the animal to relieve further suffering.

An exception to aforementioned rules is the animal who has suffered a traumatic (hit by car, gunshot injury) spinal problem and has no deep pain at presentation. The rate of return of useful function in this group of animal is far less than 50% even if the animal is treated rapidly following the injury.

If the diagnosis is uncertain, or if the clinical signs are periodically recurrent, a diagnosis and possible surgical intervention should be considered as soon as possible. If the clinical signs are not responding to non-surgical treatment in a reasonable amount of time (2 to 4 weeks depending), reassessment, rediagnosis, and surgical assessment is warranted.

While the above discussion provides general guidelines, this clinical classification system has been shown useful in management of most with spinal cord injury. If a question arises, a neurologist or neurosurgeon should be consulted to offer further opinions. Not only should these guidelines be useful for clinical management of animals with spinal compressive disease, they should also allow for communication with the owner of realistic expectations of recovery potential in the animal with spinal injury. All guidelines, however, are modified based on individual patient and disease characteristics. Final treatment judgments need to be made by the primary clinician responsible for the care of the animal.

Spinal instability can result in numerous clinical situations. As the spine is a collection of smaller units (vertebral segments), the complex relationship between such segments can be difficult to fully comprehend. This discussion will focus on general aspects of spinal instability that may be applied in the face of individual disease and clinical scenarios.

Of primary importance is a fundamental understanding of the anatomical configuration of the vertebral and associated supporting elements. Considering the anatomical structure of each vertebral subunit will allow for a prediction of associated malarticulation and/or overt instability. When considering implantation of internal fixation devices, knowledge of the anatomical configuration of vertebral units also is important for bone implant placement.

Traditionally, a dilemma exists between decreasing abnormal instability, while at the same time, maintaining the “normal” ability of the spine to respond to abnormal forces placed upon it. In specific disease situations, unique anatomical or physiologic factors may influence the type and degree of instability present. These unique features should be taken into account when planning internal surgical fixation/fusion/arthrodesis.

As an opening to this discussion, aspects of spinal instability associated with exogenous spinal trauma will be examined.

In general, spinal instability can be difficult to fully appreciate or identify, even with commonly used spinal diagnostic assessments such as radiographs and MR or CT. As instability of a vertebral segment can be difficult to predict from a single radiograph, a model has been devised in humans and adapted in dogs for predicting spinal instability based upon the degree of vertebral damage. In this model, the vertebrae is divided into three compartments. The ventral (anterior) compartment is composed of the ventral vertebral body, ventral ligament, and anulus. The middle compartment includes the dorsal anulus, dorsal vertebral body and dorsal longitudinal ligament. The dorsal compartment includes the articular facets and joint capsules, the ligamentum flavum, and the dorsal vertebral arch and pedicle, and the dorsal spinous processes and interspinous ligaments. Damage of two or more components would indicate the need for surgical stabilization as the chance of clinically significant spinal instability is high. Unfortunately, while this assessment seems straightforward, it is rarely this simple in the clinical setting and in individual animals.

If instability is documented, spinal stabilization should be considered. External fixation with splints and bandages may be helpful if applied correctly. Internal fixation and stabilization, however, is often necessary. A variety of techniques have been used and have been previously reviewed. Each technique has advantages and disadvantages which may be utilized in different situations.

In our hospital, internal fixation using a combination of bone screws, Kirschner wires, Steinmann pins, and polymethylmethacrylate (PMMA) cement is most often chosen for stabilization. These methods of fixation are modifications of previously described techniques. Screws and pins are used to anchor the PMMA to the bone. Similar fixation devices have been shown to provide adequate protection against excessive spinal rotation in canine cadaver spine preparations. Rigid spinal fixation increases the chance of fracture healing in dog spines. While stiffer implants may result in more bypassed bone mineral loss initially (6 - 12 weeks) during healing, ultimate bone mineral density becomes equal at 24 weeks.

The skin is incised over the affected area with a routine removal of the paraspinous muscles from the affected vertebrae. Caution is advised during muscle removal as the normal anatomy may be disrupted by the trauma and removal of muscle, tendinous, and ligamentous support may result in increasing vertebral instability intraoperatively. Once the muscles have been elevated, an attempt should be made to realign the vertebral segments either before, or sometimes after placement of screws or pins. More normal anatomical alignment decreases compression of associated dura and nerve roots. Excessive spinal manipulation, however, should be avoided as additional spinal cord damage can result.

Manual reduction of vertebral fractures is difficult. The use of surgical tools to provide counterbalancing forces or torque aids in realignment. As most vertebral fractures are associated with collapse of the associated vertebral segment, lamina spreaders are useful to distract collapsed vertebral segments. Slowly increasing the degree of distraction of the vertebral segments may overcome some of the paraspinous muscle spasm and contracture that produces some of the vertebral segment collapse. This may take 5 to 15 minutes.
Manipulations may also be aided by neuromuscular blockage during anesthesia. If it is difficult to achieve a solid purchase point on the vertebral body on either side of the fracture, the lamina spreader can be placed in previously placed screws or pins to achieve this purchase. The jaws of the lamina spreader should be placed as close to the screw/bone interface to decrease the potential for causing loosening of the screws when a distraction force is placed with the lamina spreader. When the vertebral segments are distracted they become easier to realign either manually or with additional surgical instrumentation.

Principles of vertebral screw placement have been reviewed. Preventing disruption to as much normal bone and joint space as possible and increasing the amount of bone contacted with the screw are important considerations. In dogs and cats, screws are usually placed in the vertebral bodies due to the relatively larger amount of bone present. Screws holes are directed from dorsolateral to ventromedial due to the relatively larger amount of bone present. Screws holes are directed from dorsolateral to ventromedial at approximately a 45 to 60° angle from the dorsal sagittal plane into the vertebral body to increase the amount of bone contacted. To avoid entering the spinal canal, the screws should be placed no more dorsal than the accessory processes. In the lumbar area, a screw can safely be placed at the level where the transverse process connects with the vertebral body and directed ventrally. In the thoracic area, ventral exposure is more difficult to achieve without entering the thoracic cavity as the vertebral bodies are relatively smaller as compared to the lumbar and cervical areas. In this area, screw holes are drilled more often into the transverse processes and, therefore, in a more dorsal to ventral direction as compared to lateral to medial. The increased amounts of bone at the articular and dorsal spinous processes of the vertebrae can be used for screw placement.

To allow room for drilling, muscles over the unstable vertebral segments are retracted bilaterally. This should be performed cautiously, however, as excessive removal of paraspinal ligament and bone may result in increased spinal segment instability. Because the necessary orientation of the screw holes often results in drilling on a slanted part of the vertebrae, it may be helpful to make a small divot in the outer cortical bone with a bone curette (House curette) to allow for initial drill purchase. Due to the angulation of the drill, the bit may be placed close to and possibly entwine the overlying musculature. To avoid damage to this tissue by the drill bit and in addition to the drill guide, an aluminum suture packet can be used to cover the underlying musculature during drilling. Drilling screw holes with a drill bit does not decrease pullout strength or cause weaker fixation. Tapping of the holes prior to screw insertion, however, may weaken fixation strength due to the significant amount of associated cancellous bone in vertebrae.

The screw hole is drilled through the vertebral body to the ventral cortical level. Often, the drill hole extends ventrally through the ventral cortical surface of the vertebral body. This cortical surface should be penetrated cautiously to avoid damage to underlying structures such as the aorta. Screws should be directed away from the intervertebral disk area to avoid damage to exiting nerves. Screw size chosen depends upon the amount of bone available for screw placement.

In the cervical area, screws can similarly be placed in the vertebral bodies, however, this is usually performed after a ventral approach rather than a dorsal or lateral approach. The ventral, convex surface of the cervical vertebrae provide some indication of the position of the underlying spinal cord. Screw holes are initially begun slightly lateral to midline and angled more laterally to avoid iatrogenic spinal cord penetration. This angulation, however, may damage paraspinal vascular structures such as the vertebral artery and brisk bleeding will be encountered when the drill bit is removed. This can usually be controlled by quickly tapping and placing the screw into the drill hole. Bone wax placed at the interface of the bone and screw may also help in decrease bleeding. For fractures involving C1/C2, the larger wings of C1 can be used for screw purchase.

One study has suggested that cortical bone screw/PMMA fixation may have a greater failure rate than a similar fixation with Steinmann pins/PMMA. Cortical screws were shown to bend at the screw/bone interface during experimental manipulations of isolated canine spinal cadaver preparations. This complication is rarely encountered clinically when cortical bone screws/PMMA are used to fix in vivo spinal fractures. This is most likely due to the associated paraspinal ligament/muscular support in the intact animal, additional apparatus incorporated in the fixation, and the decreased likelihood of the intact spinal segments to undergo the excessive forces used experimentally. Regardless, pins may be used as alternatives to screws for obtaining purchase into the vertebrae.

Advantages to the use of bone screws over Steinmann pins for spinal fixation include ease of placement and possibly more secure anchoring of the vertebral bone and the PMMA. Increased resistance to Steinmann pin placement is encountered at the vertebral end-plate. This may increase pin wobble during placement, possibly contributing the pin loosening. Pre-drilling of the pin path with a smaller pin may decrease this problem.

These screws are incorporated with PMMA either in a “donut-shaped” or bilateral “cigar-shaped” configuration. Bone wax should be placed within the screw heads to prevent plugging with PMMA. This becomes important if the screws need to be removed at a future date.

The area should be lavaged with saline during the time that the PMMA is curing as this process creates heat which could damage adjacent tissues. This is most critical when a laminectomy has been concurrently performed, as heat-damage to the spinal cord is possible. Placement of Gelfoam sponges (Gel Foam, The Upjohn Co., Kalamazoo, MI) over the laminectomy defect will not prevent this damage. The PMMA is formed to encompass the metal apparatus without damaging exiting peripheral nerves. If it is necessary to form the PMMA close to the laminectomy defect, the spinal cord can be covered using an aluminum suture packet. After curing of the cement, the packet can be removed as the cement will not bond to this substance.

If additional implant rigidity is required, Steinmann pins can be placed dorsally in a longitudinal fashion along the dorsal spinous processes. These pins can be bent to approximate the angulation of the vertebral column and wired to the implanted screws to secure them in place. Polymethyl-
methacrylate is placed over these pins and screws as described previously. Any wires used should be totally encased with PMMA to increase wire strength. Small Kirschner wires can also be placed perpendicularly through the dorsal spinous processes and incorporated into the fixation.

Decompression is indicated if myelography indicates spinal cord compression from to intervertebral disk rupture or hematoma. Often with fractures and luxations, spinal compression is the result of the bony instability and realignment of the vertebrae is all that is needed. Additional bone removed from the damaged area during laminectomy may increase the amount of instability and make internal fixation more difficult. Removal of the articular facets and discectomy have significantly increased spinal rotation instability in canine cadaver spinal preparations.

A hemilaminectomy is preferable if decompression is needed, as this results in the least amount of instability of all decompressive procedures. If no compression is seen other than that occurring due to displaced vertebrae, it is preferable to realign the vertebrae and not perform a laminectomy in order to preserve as much bone integrity as possible.

Durotomy and myelotomy may also be indicated in severely affected animals to afford further decompression and to assess the severity of spinal cord damage. Myelomalacia can be accurately assessed only after durotomy.

This need for realignment is exemptified with fractures in the lumboscaral area. The body of L7 generally is displaced dorsocaudally and the lumbosacral articular facets are luxated. Therefore, elevation of the sacrum or depression of L7 are necessary to anatomically reduce the fracture. This can be accomplished with the L-shaped end of the Senn retractor. The blade end of the retractor is placed within the vertebral canal and is directed caudally. The retractor shaft is then pushed cranially and dorsally to elevate the sacrum and to depress L7. The use of the lamina spreader to distract the vertebrae after realignment with the Senn retractor results in more appropriate anatomical reduction.

Once reasonable alignment of most vertebral segments is achieved, and if at least one pair of articular facets remain intact, a small K-wire can be driven across the facets to maintain alignment during subsequent screw placement. It is important to make sure the articular facets are in as normal a configuration as possible to avoid fixation of the vertebral segments in a collapsed to excessively distracted position. Screws or pins are then placed on either side of the vertebrae and cranial and caudal to the fracture site in the vertebral bodies.

Author’s Address for Correspondence:
Professor Rodney S. Bagley, Washington State University,
College of Veterinary Medicine, Pullman WA 99164-6610