MANAGEMENT OF ACUTE SPINAL CORD INJURY: 
FRactures AND LUXATIONS 
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Key Points
- Medical and surgical therapies should address both primary and secondary SCI.
- Nociception is a key prognosticator for outcome in SCI.
- Benefit of high dose corticosteroids is minimal and significant complications are possible.
- Surgery is indicated for paretic animals with intact nociception, animals with worsening neurologic status, or those with unstable fractures or spinal cord compression.

Acute spinal cord injury causes damage through a variety of mechanisms. Broadly speaking, spinal cord injury can be defined as primary or secondary. Primary injury is a mechanical insult that can usually be classified as concussion, compression, shearing, laceration, or elongation. The spinal cord may be subject to multiple primary injuries subsequent to the initial hit, due to ongoing instability or persistent compression. The mechanical insult directly damages nervous tissue and induces a cascade of vascular and molecular events leading to secondary changes such as hemorrhage, ischemia, and edema. A cycle of secondary neuronal injury is induced and mediated via factors including free radicals, excitatory neurotransmitters, cytokines, inflammatory mediators, ionic dysregulation, and catecholamines. This secondary injury may be as damaging as the primary injury itself, and the severity of overall spinal cord damage is a reflection of both the primary and secondary injuries.

The goals of spinal fracture management are to prevent ongoing primary injury to the spinal cord, and to mitigate effects of the initial primary and secondary injuries. Primary injuries are addressed by re-alignment of the spinal canal, stabilization of the spinal column, and decompression of the spinal cord. These interventions, in combination with supportive care and medical management also help attenuate the cycle of secondary injuries to the spinal cord.

Patient Assessment and Stabilization
Most spinal fracture patients are victims of trauma, and 45%-83% of them have concurrent injuries. The initial goal is to stabilize these patients by treating shock and life-threatening injuries. Hemodynamic resuscitation supports the cardiovascular system and ensures adequate oxygenation and perfusion to the spinal cord, helping minimize further neuronal damage and deterioration. Spinal injuries may not become apparent until after initial trauma assessment and stabilization. If spinal cord injury is suspected, the animal should be immobilized on a board during initial assessment and stabilization. Spinal cord injuries are dynamic and neurologic status may worsen if immobilization is delayed. For suspected thoracolumbar injury, the patient can be secured in lateral recumbency to a rigid surface by straps or tape across the pelvis and scapula. When cervical injury is suspected, the head should be immobilized as well. Pharmacologic sedation and pain relief can aid in immobilization, but should only be administered after the initial trauma and neurologic assessment to avoid interfering with patient assessment.
A complete neurologic examination is critical for localizing spinal cord lesion(s), detecting concurrent neurologic disease, and prognosticating outcome. Patients may exhibit a range of neurologic deficits: proprioceptive deficits, voluntary motor deficits, alterations in spinal reflexes, and sensory deficits. Evaluation of voluntary motor function or ambulation may be hampered if the patient is already immobilized on a board. Speaking to the animal or touching them may elucidate voluntary limb or tail movement. In addition, owner history may confirm movement or ambulation after the traumatic event. It is important to remember that in the case of multiple spinal injuries, the signs of one lesion may mask those of a second lesion. The most important prognostic factor for recovery following spinal cord injury is the presence of nociception, the ability to sense noxious stimulus. The absence of nociception in the limbs caudal to the spinal cord lesion indicates a poor prognosis for return of function to the affected limbs. Lack of nociception conveys a much worse prognosis for dogs with spinal fracture or luxation than for dogs intervertebral disc disease (IVDD). Depending on the duration of signs, dogs with IVDD who lack nociception at presentation have as high as a 60-70% chance of a functional recovery, whereas the prognosis for nociception-negative spinal fracture patients is at best 12%, and may be significantly worse.

Evaluation of nociception should be done with the animal in as calm and relaxed state as possible. It is important to recall that the conscious recognition of painful stimulus is a brain-mediated response rather than a reflex. Simple withdrawal reflex does not indicate intact nociception. Signs of conscious recognition of painful stimulus in these patients may be as obvious as vocalization, turning the head toward the stimulated limb, attempting to bite; they may be as subtle as an increase in heart rate or respiratory rate, or pupillary dilation.

Patients with spinal fractures or luxations should be carefully evaluated for concurrent neurologic injury such as intracranial trauma or brachial plexus injury. In a patient who has been immobilized or has other traumatic injuries, these deficits may not be immediately apparent, and may require methodical neurologic evaluation to detect.

**Biomechanical Considerations**

Spinal fractures can be classified according to the “three column spine” principle. The dorsal compartment includes the spinous processes, vertebral laminae, articular processes, vertebral pedicles, and dorsal ligamentous complex (supraspinous ligament, interspinous ligament, joint capsule, ligamentum flavum). The middle compartment includes the dorsal longitudinal ligament, the dorsal annulus fibrosus, and the dorsal vertebral body- essentially the floor of the vertebral canal. The ventral compartment includes the remainder of the vertebral body, the lateral and ventral aspects of the annulus fibrosus, the nucleus pulposus, and the ventral longitudinal ligament. If more than one of these compartments is compromised, the fracture is considered unstable, and surgical intervention is indicated. A simpler classification scheme assesses three principle contributors to spinal stability: the intervertebral disc, the vertebral body, and the articular processes. Injuries with failure of more than one of these three components-intervertebral disc, vertebral body, or articular process- should be considered very unstable, regardless of the degree of displacement seen on imaging.

**Treatment**

Treatment of spinal fractures involves medical and surgical therapy. Decisions are based primarily on the neurologic status of the patient and the biomechanical and compressive characteristics of the fracture or luxation. The goal of surgical treatment is realignment and
stabilization of the spinal column and decompression of the spinal cord. Medical management is directed toward minimizing secondary spinal cord injury via neuroprotective treatments.

Locomotion requires as few as 5-10% of intact long tract fibers, so any effort to prevent secondary spinal cord injury may have significant impacts on patient outcome. The importance of maintaining spinal cord perfusion cannot be overemphasized. Hypoxia and ischemia can significantly worsen spinal cord damage, and maintenance of normal arterial oxygenation and blood pressure is essential to minimizing secondary spinal cord injury. Systemic blood pressure can be maintained via combinations of intravenous crystalloid or colloid fluid therapy, blood transfusions, and vasopressors. The goal of these therapies should be maintenance of normotension, as hypertension provides no additional benefit, and may in fact worsen hemorrhage or edema. Spinal fracture patients commonly undergo prolonged anesthesia for diagnosis and treatment. Any steps that can be taken to minimize anesthesia time and potential anesthesia-associated hypotension may minimize secondary spinal cord injury and benefit the patient.

Glucocorticoids have received significant attention as possible modulators of secondary spinal cord injury. Their use remains controversial, and their exact mechanism of action is unclear. It is believed that glucocorticoids mitigate the damaged caused by oxygen-derived free radicals by scavenging lipid peroxides in cell membranes. Methylprednisolone sodium succinate (MPSS) is the only neuroprotective agent that has demonstrated efficacy in controlled multicenter clinical trials in humans. It was initially recommended for the treatment of acute spinal cord injury based on the findings of the National Acute Spinal Cord Injury Studies (NASCIS-2). Compared to placebo, MPSS resulted in small statistically significant improvements in motor scores for treated individuals. In the twenty years since NASCIS-2, it has received major criticism for a variety of reasons, and MPSS has yet to be recommended for use in acute spinal cord injury according to the Food and Drug Administration. No studies have demonstrated a benefit of MPSS in naturally-occurring spinal cord injury in animals. A variety of experimental studies of spinal cord trauma have demonstrated a positive impact of MPSS on outcome, however a larger number have failed to show any effect. Administration of MPSS in dogs has been associated with a high incidence of gastrointestinal side effects, such as diarrhea, melena, and occult gastric hemorrhage. These can lead to bacteremia and gastrointestinal perforation. There exists the potential for side effects such as pneumonia, immunosuppression, and sepsis, which have been documented in human patients. Side effects of MPSS (or any glucocorticoid) may be more likely when administered in conjunction with other glucocorticoids or nonsteroidal anti-inflammatory drugs. Methylprednisolone sodium succinate is contraindicated in these cases. In general, based on the scientific evidence, at best MPSS should be considered a treatment option with no proven benefit, and the possibility of harmful side effects. Clinical studies have not shown a beneficial effect of high dose dexamethasone on outcome, and a recent study showed an increased risk of side effects such as diarrhea and urinary tract infections. Its use cannot be recommended at this time.

Polyethylene glycol (PEG) is a hydrophilic polymer with many applications. Basic research over the past 10 years has proven the ability of PEG to anatomically reattach and physiologically fuse transected axons in white matter of guinea pigs and in isolated spinal cords in spine trauma models. A preliminary study in 35 clinical cases of severe acute spinal cord injury in dogs (nociception-negative IVDD) showed improved outcome measures as compared to historical controls. In this trial, PEG or P 188 (a related co-polymer) was administered intravenously, in conjunction with MPSS and surgical decompression to treat complete
paraplegic dogs with thoracolumbar IVDD. The total neurologic scores and percentage of dogs regaining ambulation after treatment were higher for the PEG and P 188 treatment groups than for 24 historical control cases from two previous studies managed and evaluated in an otherwise similar manner. While these results show promise, this is a preliminary study in a small number of dogs. A larger multicenter randomized study is currently underway to investigate the true potential of PEG in dogs with IVDD.

Many spinal fractures are managed with a combination of surgical and non-surgical methods. Cage rest is recommended for all spinal fracture patients, whether or not surgical stabilization has been performed. Usually 4-6 weeks of rest is prescribed for postoperative patients, to allow for healing of soft tissue structures and minimize early loading of spinal instrumentation. For non-surgically managed cases, treatment typically consists of cage rest with or without external splint placement. Some patients with minimal deficits and stable fractures can be managed successfully with cage rest alone. Lesions in the lumbosacral spine may be most forgiving, as any instability or compression caudal to L6 impacts only the nerve roots and not the spinal cord. Patients with unmanageable pain or worsening neurologic status should be strongly considered for surgical intervention or at least external splinting. The best candidates for splinting are probably smaller animals with minimal neurologic dysfunction or at least normal sensation, an intact ventral buttress, and a lack of concurrent thoracic, abdominal, or pelvic injuries. However, larger dogs with more severe neurologic deficits are reported to achieve functional recovery with conservative management, even if some may not consider this to be the standard of care. This suggests that dogs with intact nociception whose discomfort can be managed and whose owners decline surgical treatment should not be denied the possible benefit of non-surgical treatment with external splinting. Intractable patients or those with non-compliant owners are poor candidates for external splints.

Surgery is the most reliable way to stabilize the spinal column, and is perhaps the only way to accurately align fractured or luxated spinal segments and decompress the spinal cord. Specific indications for surgery vary somewhat between practitioners. In general, surgery is indicated for paretic animals with intact nociception, animals with worsening neurologic status, or those with unstable fractures or spinal cord compression. Many surgical techniques have been described for spinal fracture stabilization in veterinary patients. Currently, choice of technique is based primarily on location of the lesion, fracture configuration, and surgeon preference. Evidence to support decision-making comes primarily from biomechanical studies and retrospective clinical studies. General principles of surgical techniques will be discussed.

References

