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Acute Treatment Options for Spinal Cord Injury

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Opinion statement

Most treatment options for acute traumatic spinal cord injury (SCI) are directed at minimizing progression of the initial injury and preventing secondary injury. Failure to adhere to certain guiding principles can be detrimental to the long-term neurologic and functional outcome of these patients. Therapy for the hyperacute phase of traumatic SCI focuses on stabilizing vital signs and follows the Advanced Trauma Life Support (ATLS) algorithm for ensuring stability of airway, breathing and circulation, and disability (neurologic evaluation)—with spinal stabilization—and exposure. Spinal stabilization, with cervical collars and long backboards, is used to prevent movement of a potentially unstable spinal column injury to prevent further injury to the spinal cord and nerve roots, especially during prehospital transport. Surgery to stabilize the spine is undertaken after life-threatening injuries (hemorrhage, evacuation of intracranial hemorrhage, acute vascular compromise) are addressed. Intensive care unit (ICU) admission is to be considered for all patients with high SCI or hemodynamic instability, as well as those with other injuries that independently warrant ICU admission. Avoidance of hypotension and hypoxia may minimize secondary neurologic injury. Elevating the mean arterial pressure above 85 mmHg for 7 days should be considered, to allow for spinal cord perfusion. The use of intravenous steroids (methylprednisolone) is controversial. Early tracheostomy in patients with lesions above C5 may reduce the number of ventilator days and the incidence of ventilator-associated pneumonia. Select patients may benefit from the placement of a diaphragmatic pacer. Aggressive measures, including

CoughAssist and Intermittent Positive Pressure Breaths (IPPB), should be used to maintain lung recruitment and aid in the mobilization of secretions. Some patients with high SCI who are dependent on mechanical ventilation can eventually be liberated from the ventilator with consistent efforts from both the patient and the caregiver, along with some patience. Intermittent catheterization by the patient or a caregiver may be associated with a lower incidence of urinary tract infections, compared with an in-dwelling urinary catheter. Early mobilization of patients and a multidisciplinary approach (including respiratory therapists, nutritional experts, physical therapists, and occupational therapists) can streamline care and may improve long-term outcomes. A number of investigational drugs and therapies offer hope of neurologic recovery for some patients.

Introduction

There are approximately 12,000 new cases of spinal cord injury (SCI) every year in the United States [1, 2]. This is typically a disease of young white males, though the incidence is rising in the middle-aged population [1, 3]. The causes of spinal cord injury are motor vehicle crash (42.1%), falls (26.7%), violent acts (15.1%), sports (7.6%), and other (8.6%), including medical and surgical causes. For those older than 60 years of age, falls are the most common cause of SCI. The cervical cord is most commonly injured (54.1%), compared with 45.2% for the thoracic, lumbar, and sacral levels combined [3]. The clinical signs of spinal cord injury are usually partial or complete muscular weakness, sensory loss, or both at and below the level of the lesion. Those with cervical injuries can have any degree of quadriplegia/paresis; those with thoracic lesions tend to have paraplegia/paresis. Of all patients with SCI, 20.9% have one of these clinical syndromes: anterior cord syndrome, central cord syndrome, Brown-Séquard syndrome, posterior cord syndrome, conus medullaris syndrome, and cauda equina syndrome [4]. The American Spinal Injury Association (ASIA) Impairment Scale (AIS) is used to document the severity of injury and has prognostic value when applied about 7 days after injury. AIS grades range from A (Complete—no motor or sensory function is preserved in sacral segment S4-S5) to E (Normal— motor and sensory function are normal). The numerical ASIA motor score can range from 100 (full/normal strength in all key muscle groups in the upper and lower extremities) to 0 (complete quadriplegia—complete absence of all motor function in key muscle groups in all four extremities). Diagnostic modalities used in spinal cord injury are plain x-rays (limited value), CT of the spine (for diagnosis of bony injury), MRI of the spinal cord (for diagnosis of cord and ligament pathology), and conventional and CT myelography (for diagnosis of spinal canal compromise in patients unable to undergo MRI).

Current acute treatment paradigms for these patients focus on stabilization of the spinal column to prevent further neurologic injury, good supportive management to prevent secondary injury, and measures to enhance cord perfusion. Some patients sustain an injury to the spinal vertebrae, disc, and/or the supporting ligaments without spinal cord injury. It is imperative that the spines of these patients are also stabilized, in order to prevent the development of neurologic injury. Acute care for these patients can be provided in the intensive care unit (ICU), an intermediate care unit, or a medical/surgical unit of a hospital, depending on the stability of the patient's vital signs, the spinal level of the injury, the severity of injury, and other associated injuries.

Pharmacologic agents such as methylprednisolone, administered in the acute phase of therapy, are controversial but have purported benefits in improving neurologic function in some patients [5–7]. Until research efforts targeted at therapies that can reverse injury and restore full neurologic function to these patients reach fruition, the mainstay of treatment will continue to focus on preventive measures (education, safer vehicles, and prevention of violence) and supportive critical care medicine.

Although significant strides in its treatment have improved rates of mortality and morbidity, acute SCI continues to create an enormous societal burden related to the immeasurable detrimental psychological impact on survivors and the resource-intensive nature of their short-term and long-term care. In the United States, it is estimated that SCI has an annual cost exceeding $7 billion [8]. In addition, although the life expectancy for SCI patients is increasing with current multidisciplinary care, these patients still have a much shorter life expectancy than age-matched normals [1, 9]. Historically, renal failure was the leading cause of death for these patients, but current leading causes of early mortality in this population include pneumonias, pulmonary embolism, and septicemia [1, 9].

Treatment

Acute care

- In the hyperacute phase (including the prehospital phase), priority is given to the stabilization of vital signs and follows the ABCDE algorithm of the Advanced Trauma Life Support (ATLS) primary survey [10]. Cervical collars and long backboards are used for spine immobilization.
- Spinal shock—flaccid paralysis of the extremities and failure of the respiratory muscles, including the diaphragm and the intercostals—below the level of the injury can lead to acute respiratory failure and death. Definitive airway control must be achieved, using protective airway maneuvers (jaw thrust) and endotracheal intubation, using either fiberoptic intubation in nonemergent cases or direct laryngoscopy (with manual in-line cervical stabilization) in emergent situations.
- Neurogenic shock, the hemodynamic instability associated with spinal cord injury, is characterized by relative bradycardia and hypotension. It is treated with a combination of volume resuscitation and the use of vasopressors with chronotropic properties (norepinephrine, dopamine). The use of an arterial catheter to monitor blood pressure is preferred.
- Surgical intervention to stabilize an unstable spinal column is performed in the first day or two of hospitalization, after adequate resuscitation of the injured patient and any surgical procedures to control bleeding.

Critical care

- Indications for ICU admission:
  - Respiratory/ventilatory insufficiency secondary to weakness of respiratory muscles
  - Neurogenic shock requiring intensive volume resuscitation and vasopressors/inotropes
  - High spinal cord injuries
  - AIS grade A or B
  - The use of mean arterial pressure elevation (to 85 mmHg)
  - Extensive spinal column surgery (for monitoring and resuscitation in the immediate postoperative period)

- The first few days (to a week) of ICU hospitalization involve stabilizing the medical and surgical issues affecting the patient. A significant proportion of the morbidity and mortality of patients with SCI (especially of the cervical spine) occurs early after injury, as a result of neurologic impairment, associated injuries, the systemic inflammatory response to injury, and prolonged immobilization [11•].

Respiratory function

- Particular attention should be given to the respiratory system function in patients with spinal cord injuries above C5. Most of these patients are endotracheally intubated and mechanically ventilated.
- Early tracheostomy should be considered for these patients. The timing of placement of definitive enteral access varies.
- Devices and maneuvers such as CoughAssist (Philips Respironics, Andover, MA) and Intermittent Positive Pressure Breaths (IPPB) can be used to keep the lung recruited (prevent or reverse atelectasis) and mobilize secretions during mechanical ventilation.
- Positive pressure breaths from the mechanical ventilator in these patients tend to preferentially ventilate the anterior lung regions, leading to basal/dependent atelectasis and compromised oxygen status. Placing abdominal binders provides diaphragmatic support by minimizing abdominal excursion and can help in directing ventilation to the dependent lung segments.
- Weaning from mechanical ventilation to spontaneous breathing may not always be achievable and requires a certain degree of patience and diligence on the part of the care provider and the patient. About 7% of SCI patients are discharged from acute hospitalization with continued dependence on the ventilator [3].
- A select subset of patients with high spinal cord injury who are ventilator-dependent may be candidates for the placement of a diaphragmatic pacemaker to aid in liberation from the mechanical ventilator. These devices work either by stimulating the phrenic nerve or by directly stimulating the diaphragm, enabling inspiration, while expiration remains passive. These devices are still under investigation and are available only at select centers.

Heart and circulation

- Hemodynamic considerations include monitoring for relative bradycardia and hypotensive episodes (neurogenic shock) related to loss of sympathetic output from the spinal cord coupled with unbalanced parasympathetic output via the vagus nerve.
- Bradycardia can be treated with external or transvenous pacing, atropine (0.5 mg IV to a maximum dose of 0.04 mg/kg IV),

glycopyrrolate (0.1 mg IV), or albuterol (1 to 2 mg orally three to four times a day).

- The initial use of vasopressors can be followed by the use of an oral alpha agonist such as midodrine (5 to 10 mg oral/enteral three times a day). These drugs can then be slowly weaned over a couple of weeks as hemodynamic stability is achieved.
- The use of fluid therapy and vasopressors to keep the mean arterial pressure (MAP) above 85 mmHg for 7 days after injury (to allow for perfusion of the injured and edematous spinal cord) is an option [2, Class IV].
- Placement of arterial catheters to monitor blood pressure continuously and central venous catheters to administer vasoactive medications is recommended in patients with hemodynamic compromise and in those patients with elevated MAP goals.
- Autonomic dysreflexia is a dramatic and life-threatening paroxysm that can occur in SCI patients. It is characterized by a sudden elevation in blood pressure to very high levels, tachycardia, diaphoresis, and anxiety/agitation associated with a sense of doom. It occurs secondary to inappropriate release of catecholamines from the adrenal gland in response to visceral stimuli (e.g., full bladder, constipation) and can rarely result in death. Treatment is directed at relieving the stimulus (bowel/bladder decompression) and acutely controlling blood pressure with direct arterial vasodilators and IV benzodiazepines.
- The prevention of thromboembolic disease, including deep venous thrombosis (DVT) and pulmonary embolism, is paramount and entails the use of mechanical and pharmacologic means, along with mobilization. Patients with SCI have a higher incidence of DVT than patients hospitalized for other reasons [12••], and pulmonary embolism continues to be a leading cause of mortality in these patients.
- Prophylaxis with low molecular weight heparin (LMWH) is recommended once primary hemostasis is achieved and the risk of bleeding is low [12••, Class I]. In patients with incomplete SCI associated with a spinal hematoma, LMWH is withheld for at least 3 days [12••].
- In many centers, chemical thromboprophylaxis is initiated 72 h after the injury or after spinal surgical intervention because of concern for the development of a compressive hematoma in the spinal canal or hemorrhage into the injured spinal tissue.
- Prophylactic inferior vena cava (IVC) filters were widely used in the past to prevent massive pulmonary embolism, but they should be used only in select cases: patients with documented DVTs of the lower extremities or pelvic veins and with concomitant contraindications to systemic anticoagulation therapy. Routine placement of IVC filters for thromboprophylaxis is not recommended [12••]. Consideration should be given to the placement of temporary caval

filters that can be retrieved once the indication for their presence no longer exists.

- Early mobilization (with spinal column stability ensured by operative fixation, external braces, or both), including frequent turning, out-of-bed to chair, and passive range of motion of limbs, is important for good lung function, maintenance of cardiovascular conditioning, and the prevention of pressure ulcers and venous stasis.

Other care considerations

- An aggressive bowel regimen to ensure passage of stool daily must be implemented to prevent and treat severe constipation/obstipation.
- Prevention and treatment of urinary tract infections is important. Intermittent straight catheterization to decompress the urinary bladder is preferable to an in-dwelling urinary catheter in the long term (if bladder decompression is needed≤3 times per day). In the acute stage, however, placement of an indwelling urinary catheter is recommended to monitor the adequacy of resuscitation and prevent bladder distention. Improvement in urologic care and early identification and treatment of urinary tract infections has played a significant role in reducing the incidence of renal failure in these patients [3].
- An optimal ambient temperature should be maintained, as patients with high spinal cord injury can have difficulty controlling their body temperature, secondary to an inability to sweat below the level of the lesion.
- Adequate pain management is important in these patients. In addition to the use of opioid agents and nonsteroidal antiinflammatory agents, the use of pregabalin or gabapentin to treat neuropathic pain should be considered. Antispasmodics such as benzodiazepines and baclofen also may be helpful.
- A number of investigational therapies are being studied for their role in neuro-protection and recovery of the injured spinal cord [13•].
- Early involvement of a multidisciplinary team consisting of physical therapists, occupational therapists, social workers, and grief counselors is beneficial.

Diet and lifestyle

- Nutritional needs following SCI vary in the acute phase, depending on the level of injury, associated neurologic deficits, and the presence of concomitant injuries, especially traumatic brain injury [2, Class IV].
- Indirect calorimetry performed in consultation with a nutrition specialist is often the best way to determine the caloric and nutritional needs of the patient [2, Class IV].
- The severity of neurologic deficits determines what lifestyle alterations will have to be made. Quadriplegia with chronic respiratory failure will relegate many to life in a ventilator facility dependent on total care. Patients with paraplegia may need to use a wheelchair and

will have to make accommodations for care of bowel and bladder function. Some patients may be able to ambulate with assistive devices such as canes or walkers.

- Some SCI patients are able to drive with special accommodations.

Pharmacologic treatment

- There are few pharmacologic treatment options for SCI patients in the acute (and subsequent) phases of injury. The use of steroids (IV methylprednisolone) was popular following the publication of the National Acute Spinal Cord Injury Study (NASCIS) II and III [5, 6] and a Cochrane meta-analysis [7], but the use of steroids has increasingly fallen out of favor because of its unfavorable risk-benefit ratio.
- Intravenous fluid therapy and vasopressors with inotropic and chronotropic properties, such as norepinephrine and dopamine, are used for resuscitation and for the treatment of hemodynamic collapse due to neurogenic shock.
- Intravenous fluid therapy with the use of vasopressors such as phenylephrine and norepinephrine is used to elevate the patient's MAP to>85 mmHg to allow for increased perfusion of the injured (edematous) spinal cord.
- Atropine (0.5 mg IV to a maximum dose of 0.04 mg/kg IV), glycopyrrolate (0.1 mg IV), and/or albuterol (1 to 2 mg PO three or four times per day) are sometimes used to treat bradycardia, and midodrine (5–10 mg PO three times daily) is used to treat hypotension.
- The use of LMWH (enoxaparin) or unfractionated heparin in combination with mechanical measures for thromboprophylaxis is recommended. Enoxaparin has been shown to be superior to subcutaneous heparin with mechanical measures in decreasing the incidence of pulmonary embolism but not DVTs [14, Class I].
- Pharmacologic measures directed at enhancing neurologic recovery consist of using high-dose steroids intravenously. We do not recommend the routine use of IV steroids in SCI patients because of their unfavorable risk-benefit ratio. Even though data have suggested that they may minimally improve motor function [5], these benefits may be outweighed by the risk of complications such as significant gastrointestinal bleeding and more frequent and more severe infections [2]. Exceptions may be considered for patients with high spinal cord injury (such as a patient with a C3 level, in whom improvement by one level would give a better chance of being liberated from the mechanical ventilator).
- Drugs such as riluzole, minocycline, and hypertonic saline, among others, are being investigated for a potential therapeutic role in these patients [13•].

Methylprednisolone

Standard dosage	30 mg/k bolus, then 5.4 mg/kg per hour for 24 h if administered within 3 h of injury or for 48 h if started 3 to 8 h after injury [5–7, Class III].

Contraindications	Absolute contraindications for this drug are limited to hypersensitivity reactions to the drug, evidence of a systemic fungal infection, and recently receiving a live or live-attenuated vaccine. It is also contraindicated in penetrating traumatic spinal cord injury.
Main drug interactions	Multiple drug interactions (e.g., antidiabetic agents) necessitate monitoring of therapy; consider dose adjustments in patients receiving CYP3A4 inhibitors.
Main side effects	Immunosuppression (leading to increased incidence and severity of infections), gastrointestinal (GI) hemorrhage, hyperglycemia and psychosis are the notable adverse effects.
Special points	The use of IV steroids is a matter of much debate. Increasingly it has been noted that it has an unfavorable risk-benefit ratio: Its use is associated with a modest improvement in motor function (improvement of motor level by one), but its adverse effects (increased infections and GI bleeds) may outweigh that benefit.
Cost/cost-effectiveness:	1 (40 mg) vial, USD $12.99. Although the actual drug itself is not expensive, it may not be cost-effective if its adverse effects are considered.

Low molecular weight heparin (enoxaparin)

Standard dosage	30 mg subcutaneous every 12 h, or 40 mg subcutaneous daily.
Contraindications	In the immediate posttraumatic period when there is high risk for bleeding (concomitant traumatic brain injury), inadequate hemostasis, or coagulopathy, and in incomplete spinal cord injury associated with a spinal hematoma [12••, Class I].
Main drug interactions	Use caution when combined with certain antidepressants or other anticoagulants or antiplatelet agents.
Main side effects	Bleeding.
Special points	In patients who have undergone spinal operative manipulation, it is routine practice in our institution to wait for 72 h prior to using enoxaparin for thromboprophylaxis.
Cost/cost-effectiveness	1 syringe (30 mL/0.3 mL), USD $23.99. Very cost-effective if its primary endpoint (prevention of thromboembolism) is achieved.

Interventional procedures

- Not many interventional procedures are required for an acutely injured spinal cord patient. However, if a patient with absolute contraindications to systemic anticoagulation develops a DVT in the lower extremities, a pulmonary embolism, or both, then the placement of an **inferior vena caval filter** to prevent large pulmonary embolisms (thought to arise from the lower extremity or pelvic veins) may be of some short-term benefit. The placement of these filters as a primary means of thromboprophylaxis is not recommended [12••], as it can increase the risk of development of DVT in trauma patients [15, Class II]. Some practitioners prefer to place temporary caval filters, intending to retrieve them within 3 months if the indication for placement no longer exists. After 3 months, these filters are considered permanent, as the endothelialization of the filter prevents safe retrieval. Contraindications are inability to access the femoral veins because of local trauma or infection, although in some cases the filters can be deployed from above, via the upper torso central veins (internal jugular and subclavian). Also, these filters may not be beneficial in preventing massive pulmonary embolisms if the source of the emboli was above the renal veins, in the cardiac chambers or the upper extremity veins. These filters can be the nidus for thrombus formation themselves and in some cases allow propagation of clot through the inferior vena cava, resulting in a pulmonary embolism. Some patients with a concomitant hypercoagulable state can develop phlegmasia cerulea dolens (massive proximal ileofemoral thrombosis), which can lead to severe morbidity and even mortality. The cost for these procedures and devices is considerable, requiring trained personnel, special equipment, and usually a special suite.

- **CT myelogram** and **conventional myelogram** are sometimes employed for diagnostic reasons in the acutely injured spinal cord patient if MRI is contraindicated. These studies can detect encroachment of the spinal canal and spinal cord impingement by penetrating objects, bony fragments, or intervertebral discs and can help with diagnosis of the level of spinal cord injury and preoperative planning. The procedure involves placement of radio-opaque dye in the spinal canal via lumbar puncture, followed by a CT scan or plain radiographs.
- Diagnostic **angiogram** or **CT angiogram** may be used to evaluate for blunt cerebrovascular injury and for penetrating vessel injury. All patients with significant cervical spine fractures or subluxations should undergo a diagnostic angiogram or CT angiogram to assess for vertebral artery injury [16].

Surgery

- A number of nonsurgical and surgical options can be used to restore anatomic alignment in patients with fracture or dislocation injury of the spinal column. Proper anatomic alignment is important, as it restores the diameter of the spinal canal, prevents compression of the spinal cord, and is potentially associated with improved neurologic outcomes [2, Class IV]. The ongoing Surgical Treatment for Acute Spinal Cord Injury Study (STASCIS) might help to clarify the role and timing of surgical decompression for acute SCI [13•].
- For patients with central cord syndrome, there may be a role for surgical decompression. The timing of this surgery, whether early (within 5 days) or late (6 weeks after injury), is still being studied [13•].
- Tracheostomies are commonly performed on patients with high spinal cord injuries who have respiratory compromise, as means

of providing airway protection, faster liberation from the mechanical ventilator, and pulmonary toileting.

- Enteral feeding access via a percutaneous or open gastrostomy is performed in some of these patients, who are unable to swallow safely.

Assistive devices

- A variety of assistive devices are used in the management of the SCI patient.
- In the prehospital setting, a cervical collar (or cervical immobilization method) and rigid backboard are used to prevent further neurologic deterioration.
- In the acute hospital setting, the use of a cervical collar is continued until stability of the spine is assured. In most instances of cervical SCI, the use of a cervical collar is continued for 6 to 8 weeks (depending on the injury and type of operative intervention).
- External immobilizers are used for some patients. These include halo vests and thoracic lumbar sacral orthosis (TLSO) braces.
- For patients on mechanical ventilation, devices such as abdominal binders, a mechanical insufflator-exsufflator (CoughAssist), and Intermittent Positive Pressure Breaths (IPPB) are invaluable to prevent and treat atelectasis and mobilize secretions, keep the lungs recruited, and promote liberation from the ventilator.
- Numerous assistive devices used in the rehabilitation of these patients (motorized scooters, modified car controls, special walkers) are the topic of ongoing research and innovation.

Physical therapy, occupational therapy, speech therapy and exercise

- Physical and occupational therapists and speech-language pathologists (SLPs) provide invaluable services in the care of the patients with SCI. In many instances, they are involved early in the hospitalization of these patients.
- SLPs provide assessment of swallowing function in these patients. In addition, they provide speaking valves for patients with tracheostomies and educate patients in their use, allowing them to communicate verbally.
- Physical therapists play a crucial role in the early mobilization of the patient and educate patients and their caregivers in range of motion exercises of the limbs to maintain joint mobility and muscle mass. SCI is associated with a significant loss of lean body mass, which is associated with morbidity and mortality.
- Exercise regimens can be tailored to the individual patient, depending on the degree of neurologic deficits. Most exercise regimens play a larger role in subacute and rehabilitation settings than in the acute setting.
- Occupational therapy referrals are used to obtain special splints and devices. Splints are used to maintain anatomic congruity of joints.

Emerging therapies

- Given the lack of a true "cure" for the neurologic disability arising from SCI, a number of therapies are being investigated for their role in improving neurologic and functional outcomes, ranging from pharmacologic agents, use of biologic agents and stem cells, and temperature manipulation to innovations in robotics.
- Drugs currently being studied include riluzole, minocycline, polyethylene glycol, erythropoietin, hypertonic saline, and Rho pathway antagonists [13•].
- Biologic agents being studied include anti-Nogo-A monoclonal antibodies, stem cells, bone marrow stromal cells, and olfactory ensheathing cells to promote cell-mediated repair [13•].
- Drainage of cerebrospinal fluid (CSF) for 72 h as a means to reduce intrathecal pressure and promote medullary perfusion is also being investigated [13•].
- Induction and maintenance of therapeutic hypothermia is also investigational [17].
- Devices being studied include the diaphragmatic pacer [18, 19] and electrical spinal cord stimulators [20, 21].

Pediatric considerations

- Specific pediatric considerations should to be taken into account when evaluating and treating pediatric patients (especially those less than 8 years of age). Injury patterns in SCI differ from those of adults.
- It is important to provide thoracic elevation or an occipital recess for children less than 8 years of age who are placed on a backboard for spinal stabilization after traumatic injury [2], because these children tend to have larger heads compared with their bodies, and this difference may cause unwanted flexion of the cervical spine when they are laid flat, with deleterious effects on the airway and neurologic function.
- When interpreting diagnostic studies of the spine in children, consideration should be given to age-related development of osseous and ligamentous anatomy. This consideration also applies to treatment, as the degree of physical maturation must be kept in mind along with the specific injury in choosing methods of reduction, stabilization, and subsequent surgical or nonsurgical treatment [2].
- *SCIWORA* (Spinal Cord Injury WithOut Radiographic Abnormality) is a condition sometimes seen in children who suffer from trauma. In this condition, there is objective evidence of traumatic myelopathy but an absence of radiologic abnormalities on plain x-rays, fluoroscopy (no abnormal flexion or extension), and CT scan [2]. (This diagnostic syndrome gained traction in the pre-MRI era.) The neurologic deficits associated with SCIWORA can be transient with full recovery, permanent with partial recovery, or permanent with no recovery. As a result, the prognosis varies widely, but SCIWORA has

been associated with a high incidence of complete neurologic injuries, especially in children less than 9 years of age. MRI performed in children with SCIWORA can help in identifying potential surgical candidates (those with cord or nerve root compression or certain types of ligamentous injury), providing prognostic information, and potentially determining the duration of therapy (external mobilization) for the injury type. Treatment for SCIWORA consists mainly of immobilization of the spine and avoidance of activities that could potentially cause instability of the spine or further injure the spinal cord, though this is a subject of increasing controversy [2].

Disclosure

No potential conflicts of interest relevant to this article were reported.

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