Continuing Education Series

Pediatric Spinal Injuries

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Spinal injuries in children present unique challenges. The anatomy of the growing child affects injury patterns and subsequent care. There are many challenges for the child and family, but current research is providing hope for the future.

The incidence of spinal injuries in children is reported to be 2 to 5% of all spine injuries (Reynolds, 2000). Although uncommon, these injuries are more common than anyone would like them to be, and they can be associated with significant morbidity posing challenges to care. Automotive injuries are the most common cause followed by sporting injuries. More than half of pediatric spinal cord injuries occur in the cervical area (Brown, Brunn, & Garcia, 2001; Cirak et al., 2004; Eleraky, Theodore, Adams, Rekate, & Sonntag, 2000).

Signs and Symptoms

Spinal cord injuries can be classified as either complete or incomplete. Complete spinal cord injury results in total loss of sensation and movement below the level of the injury. Incomplete spinal cord injuries often fall into one of the following patterns (Schreiber, 2004):

- Anterior cord syndrome results from injury to the motor and sensory pathways in the anterior cord. These patients can feel some crude sensation, but movement and more detailed sensation is lost.
- Central cord syndrome is injury to nerve cells and pathways in the center of the cervical spinal cord producing weakness or paralysis of arms and some sensory loss in the arms. The legs are less affected.
- Brown-Sequard syndrome results from injury to the right or left half of the cord. Movement and some types of sensation are lost below the level of the injury. Pain and temperature sensation are lost on the opposite side of the body because the pathways cross to the opposite side after they enter the spinal cord.
- Spinal concussion can also occur. This consists of complete or incomplete dysfunction that is transient. It generally resolves within a day or two.
- Cauda equina syndrome results from injury to the lumbosacral nerve roots caused by central lumbar disk herniation. Loss of reflexes to the affected limbs, bowel, and/or bladder result.

Symptoms of spinal cord injury are not easily discerned in young children and are variable depending on the child's age, the injury location, the spinal fracture stability, and other systemic injuries. Generally, signs of spinal cord injury include the following:

- Flaccid extremities.
- Paralysis.
- Numbness or paresthesias (sensations such as tingling or burning).
- Paresis or weakness.
- Priaprism.
- Incontinence of bowel or bladder and loss of rectal tone.

Other necessary assessments include the abdomen (if a lap belt was in place during a motor vehicle crash), rectal tone, and inspection and palpation of the back (Thomas & Bernardo, 2003).

Damage to the vertebrae and ligaments usually causes severe pain and swelling in the area of the injury, and damage to the cord may cause a loss of sensation and/or motor function below the injury. The spinal cord is divided into 31 segments, each with a pair of spinal nerve roots – anterior (motor) and dorsal (sensory). These pairs of anterior and dorsal nerve roots combine to form a spinal nerve as it exits from the vertebral column. The spinal cord is organized into a series of tracts or neuro-pathways that carry motor (descending) and sensory (ascending) information. Spinal shock refers to flaccidity and loss of reflexes that may make the cord appear functionless; the duration is variable, but generally some signs of return to function are seen within the first 72 hours of injury. Neurogenic shock results from impairment of the descending sympathetic pathways resulting in loss of vasomotor tone and sympathetic innervation to the heart. The triad of hypotension, bradycardia, and peripheral vasodilation results (Schreiber, 2004; American College of Surgeons Committee on Trauma, 1997). This is a very important sign in early assessment in the field and the ED.

Differences in Children

The growth and development differences found in children 8 years of age and younger affect injury patterns. These anatomical differences include the following:

- Larger head size relative to body size, which creates greater force on the neck when the head is jerked about. Craniocervical disruption (atlanto axial dislocation) is almost unique to children and difficult to diagnose without a high index of suspicion.
- Greater flexibility of the spine and supporting structures allowing more stretching when force is applied, thus injuring the

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spine without associated bony damage. This accounts for a condition referred to as Spinal Cord Injury Without Radiographic Abnormality (SCIWORA).
- Growth plates are present so that injury and compression of the bone can cause bone damage.
- Development of the spine varies according to the level of the spine. Growth and development is cephalocaudal, or head to tail, so that development in the upper cervical spine differs from the lower cervical spine.
- Ossification centers are present at birth, and fusion occurs as the child grows. Prior to fusion, children are predisposed to subluxation and distraction resulting in spinal injury.

The spine has attained near adult size by the age of 8 to 10 years, so assessment and care of the child under the age of 8 years with a spinal injury has to be individualized (Cirak et al., 2004; Martin, Dykes, & Lecky, 2004; Reynolds, 2000; Zuckerbraun, Morrison, Gaines, Ford, & Hackam, 2004).

Mechanisms and Type of Injury

Spine and vertebral injuries are usually caused by one of three types of severe force; longitudinal compression, hinging, or shearing.
- **Longitudinal compression** crushes one vertebra lengthwise against another; the majority of compression injuries in children are a result of falls from a height.
- **Hinging** subjects the spinal column to sudden, extreme bending such as would be experienced in whiplash. Chance fractures are commonly reported in children; these are posterior or transverse fractures through the lumbar vertebral body. The mechanics are associated with lap belts and therefore often have associated abdominal injuries.
- **Shearing** combines hinging and twisting or rotation, and often happens when a pedestrian is hit by a motor vehicle and the individual is spun around.

Forces from the mechanism of injury may dislocate the vertebrae, fracture vertebrae, or rupture ligaments that bind them together. In severe dislocations or fractures, the vertebrae, accumulated fluid, or a blood clot may press on the spinal cord or the cord may be torn or even severed. Therefore, function is impaired or destroyed. These injuries may be unstable, meaning that the vertebrae may shift and cause injury to the spinal cord.

Spinal cord injuries (SCI) may be primary or secondary. Primary SCIs result from mechanical disruption, transection, extra-dural pathology, or distraction of neural elements, and occur with fracture and/or dislocation or penetrating injury. Vascular injury to the spinal cord, caused by bleeding, clots, or hypoperfusion (shock), are the major causes of secondary injury (Schreiber, 2003).

Management of Pediatric Spinal Injuries

Fortunately, most injuries to the spine are not severe and not associated with injury to the cord. Some fractures may require only immobilization such as that provided by a rigid collar or some type of orthotic or thoracic, lumbar or sacral brace depending upon the location of the injury. In these instances, it is imperative that the child and family understand the necessity for any activity restrictions and are prepared for care at home when the child is discharged. The following case provides an example of the importance of adherence to recommended activity restrictions after discharge.

Case Study

Linda Daniels is a 5-year-old girl who was injured in a motor vehicle crash. She was riding in a restraint system in the back seat and sustained a Chance Fracture due to the seat belt; the fracture was at the level of L2. She was placed in a Risser cast in hyperextension and discharged home to her single mother who had little assistance with child care. The child ambulated sufficiently that the cast loosened and reduction was lost. Three weeks later, she was readmitted for open reduction, a spinal fusion L1-5, and internal fixation. She was then sent home in a hyperextension brace and referred to physical therapy for gait training. Her injury healed with 30° of kyphosis.

Concomitant injuries may mask the spinal injury, for example, head injury may prevent or delay diagnosis and treatment. *Therefore, a high index of suspicion should be maintained until an injury is identified or ruled out.* The full extent of the injury may not be apparent initially, and incomplete cord lesions may evolve into more complete lesions. Commonly, the injury extends upward 1 or 2 spinal levels during the immediate post injury hours and days. Damage to the cord does not stop at the time of the injury but continues for a period of time following. This delay has implications for treatments to reduce the extent of disability (National Institute of Neurological Disorders and Stroke, 2001).

Approaches that may be used to prevent further damage include immobilization and administration of high doses of steroids. Spinal immobilization and placement of a rigid cervical collar should begin in the field, continue to the Emergency Department, and then on to the Intensive Care Unit until it has been determined by physical examination and radiographic studies that there is no injury. Various algorithms and decision models have been developed that are evidence-based; these can be used in assessing the appropriateness of removing immobilization devices such as backboards and cervical collars (Cook, Fanta, & Schweer, 2003; Lee, Sena, Greenholz, & Fledderman, 2003). An example is the Pediatric Cervical Spine Clearance algorithm developed at the Cincinnati Children's Hospital based upon the National Emergency X-Radiography Utilization Study (Cook et al., 2003). The goal is safe removal of the collar as soon as possible because prolonged immobilization may result in significant problems related to hygiene, skin breakdown, and decubitus ulcer.

The use of steroids to prevent further spinal cord injury is somewhat controversial. Methylprednisolone has been shown in some studies to improve the overall outcome, but other studies find increased risks associated with high doses of steroids and recommend against the use. If the medication is to be used, there should be a written protocol and it should be followed carefully (American Spinal Injury Association [ASIA], 2002; Benzel, 2002; Bracken & Holford, 2002).

Spinal cord injury should be suspected in anyone with significant trauma to the head and/or neck. Almost unique to the pediatric age group is the phenomenon of spinal cord injury without radiographic abnormality (SCIWORA), which is more common in children under the age of 8 years. In this phenomenon, the spinal cord stretches beyond its normal range leading to tears, contusion, or transection. The spinal cord and vertebrae return to normal length

Table 1. The American Spinal Injury Association Scale for Motor Strength Assessment

0 = No contraction or movement
1 = Minimal movement
2 = Active movement, but not against gravity
3 = Active movement against gravity
4 = Active movement against resistance
5 = Active movement against full resistance

Source: ASIA, 2002.

and alignment, so radiographs and computerized tomography films show no bony abnormalities. If this injury is suspected, an MRI should be done. The treatment is external immobilization (bracing) for a period of at least one to two months.

The Need for Assessment

Continued assessment is extremely important for these children. Initial assessments focus on identification of the injury and its level. History of the injury, clinical examination, and proper radiographic studies are the basis. Once **A**irway, **B**reathing, and **C**irculation are assessed, the neurologic status, or **D**isability, should be assessed beginning with level of consciousness using either the Glasgow coma scale or AVPU (Alert, responds to Verbal stimuli, responds to Painful stimuli, Unresponsive) methods (Thomas & Bernardo, 2003). Movement and strength in the extremities and tendon reflexes are assessed in the secondary survey. The American Spinal Injury Association provides a scale for assessment of motor strength (ASIA, 2002) (see Table 1).

Care of the Child with a Spinal Injury

Patients with SCI are usually admitted to an ICU. Standard ICU care includes monitoring and maintaining blood pressure, monitoring CV function, maintaining continuous neurovascular and motor/sensory checks, ensuring adequate ventilation, and preventing and treating infection and any other complication. Sometimes a surgeon may take the patient to the operating room immediately if it appears that there is compression from a clot, herniated disc, or other lesion, and the cord impairment may reverse as a result of the decompression. However, immediate decompression as apposed to waiting is controversial. If surgery cannot be done to reverse the damage, stabilization may still be needed to prevent pain and deformity.

The care of children with spinal cord injuries requires long-term planning. Psychological issues may arise during the acute phase of care and persist or worsen during the rehabilitation phase. Depression and social isolation are frequently experienced. The alert child may be very frightened by the transportation to the hospital and the environment of the Emergency Department. Parents may experience similar anxiety exacerbated by the uncertainty of the extent of the child's injury. Close communication and support of the child and family are essential throughout the pre-hospital and hospital phases. Discharge planning must include the entire family so that they are prepared and able to provide both the physical and psychological care that is needed.

Research and Future Innovations

Discussions at neuroscience meetings worldwide are increasingly turning to translational research or the process of moving from an experimental laboratory model to a human clinical model. Much of the new research is targeting neural repair and neuroprotection. The scientific community is proceeding with caution so that they "get it right the first time" and do not rush into clinical trials. Sufficient safety and effectiveness should be in evidence when plans are made. Improving functional status is also a focus. Neuropathic pain, spasticity, and motor and sensory function currently are a thrust of translational research.

Chronic neuropathic pain is one of the frequently reported reasons for the reduced quality of life, and it is one of the most difficult types of pain to manage. Better pain assessment tools that are specific to this type of pain are being developed and tested, and they will be essential in future evaluation of pain management. Various drug treatment protocols and cell transplant strategies are being tested.

Spasticity severe enough to need treatment is experienced by about 35% of those with spinal cord injuries. A chemical called GABA is deficient in the spinal cord following injury and is associated with spasticity. Transplanting GABA secreting cells near the cord is being investigated. The use of pharmaceuticals such as baclofen (Lioresal®) or botulinum toxin type A (Botox®) may temporarily relieve spasticity (Rehabilitation Institute of Chicago, 2004a & b).

Aside from walking, moving, and feeling, other motor and sensory functions are concerns. Muscle atrophy, increased risk of cardiovascular disease and diabetes, weight gain, respiratory problems, and osteoporosis and other skeletal problems also are cause for worry. A goal of rehabilitation is to optimize independence in daily activities and mobility, and strength, power, and endurance are critical factors. Functional electrical stimulation is being tried for walking, bladder control, and lower extremity exercise (The Miami Project to Cure Paralysis, 2004).

Prevention is perhaps the most important thrust for the future. One of the most successful programs has been THINK FIRST, begun by North American neurosurgeons to educate the public, especially children and adolescents, about the implications of head and spinal injury. The program also emphasizes ways to minimize individuals' chances of sustaining such injuries (American Association of Neurological Surgeons and the Congress of Neurological Surgeons, 2004).

References

American Association of Neurological Surgeons and the Congress of Neurological Surgeons. (2004). *Think first programs*. Rolling Meadows, IL: Think First National Injury Prevention Foundation. Retrieved September 14, 2005, from http://www.thinkfirst.org

American College of Surgeons Committee on Trauma. (1997). *Advanced trauma life support for doctors* (6th ed.) Chicago: American College of Surgeons.

American Spinal Injury Association. (2002). Guidelines for the management of acute cervical spine and spinal cord injuries. *Neurosurgery, 50*(Suppl. 3), S1-S199.

Benzel, E.C. (2002). Commentary on National Acute Spinal Cord Injury Study III (editorial). *Journal of Neurosurgery (Spine 3), 96*, 257-258.

Bracken, M.B., & Holford, T.R. (2002). Neurological and functional status 1 year after acute spinal cord injury: Estimates of functional recovery in National Acute Spinal Cord Injury Study II from results modeled in National Acute Spinal Cord Injury Study III. *Journal of Neurosurgery (Spine 3), 96*, 259-266.

Brown, R.L., Brunn, M.A., & Garcia, V.F. (2001). Cervical spine injuries in children: A review of 103 patients treated consecutively at a Level I pediatric trauma center. *Journal of Pediatric Surgery, 36*(8), 1107-1114.

Cook, B.S., Fanta, K., & Schweer, L. (2003). Pediatric cervical spine clearance: Implications for nursing practice. *Journal of Emergency Nursing, 29*(4), 383-386.

Cirak, B., Ziegfeld, S., Knight, V.M., Change, D., Avelino, A.M., & Paidas, C.N. (2004). Spinal injuries in children. *Journal of Pediatric Surgery, 39*(4), 607-612.

Eleraky, M.A., Theodore, N., Adams, M., Rekate, H.L., & Sonntag, V.K. (2000). Pediatric cervical spine injuries: report of 102 cases and review of the literature. *Journal of Neurosurgery, 92*(1, Suppl.), 12-17.

Lee, S.L., Sena, M., Greenholz, S.K., & Fledderman, M. (2003). A multidisciplinary approach to the development of a cervical spine clearance protocol: Process, rationale, and initial results. *Journal of Pediatric Surgery, 38*(3), 358-362.

Martin, B.W., Dykes, E., & Lecky, F.E. (2004). Patterns and risks in spinal trauma. *Archives of Diseases in Children, 89*(9), 860-865.

National Institute of Neurological Disorders and Stroke. (2001). *Spinal cord injury: Emerging concepts*. Retrieved March 1, 2004, from http://www.ninds.nih.gov/health_and_medical/pubs/sci_report.htm

Rehabilitation Institute of Chicago. (2004a). *Spasticity: Chemodenervation (Botox and Myobloc): What is it? And when is it used to treat spasticity?* Retrieved March 1, 2004 from http://lifecenter.ric.org

Rehabilitation Institute of Chicago. (2004b). *Spasticity: Treatment with a Baclofen Pump.* Retrieved December 17, 2004, from http://lifecenter.ric.org/content/2290/

Reynolds, R. (2000). Pediatric spinal injuries. *Current Opinion in Pediatrics, 12*, 67-71.

Schreiber, D.S. (2004). Spinal cord injuries. *E medicine.* Retrieved August 12, 2004, from www.emedicine.com/emerg/topic553.htm

The Miami Project to Cure Paralysis. (2004). *Newsletters*. Retrieved July 7, 2004, from www.miamiproject.med.miami.edu/newsletters

Thomas, D.O., & Bernardo, L.M. (2003). *Core curriculum for pediatric emergency nursing.* Boston: Jones and Bartlett.

Zuckerbraun, B.S., Morrison, K., Gaines, B., Ford, H.R., & Hackam, D.J. (2004). Effect of age on cervical spine injuries in children after motor vehicle collisions: Effectiveness of restraint devices. *Journal of Pediatric Surgery, 39*(3), 483-486.

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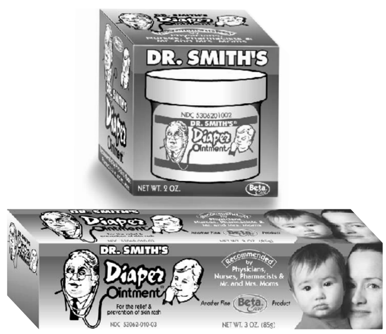

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