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# Lower thoracic SCIWORA in a 3-year-old child: Case report

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Spinal cord injury without radiologic abnormality (SCIWORA) was first described by Pang and Wilberger in 1982. There, several children presented with objective signs of myelopathy as a result of trauma (1), but the spine films, tomographs, and myelographs of these patients showed no evidence of fracture or subluxation. Fortunately, SCIWORA is rare. The overall incidence of SCIWORA is estimated at 1–9% of all spinal cord injuries (2), with larger referral hospitals having a higher incidence and community hospitals having a lower incidence. The injury patterns seen in younger children differ from adults, adolescents, and even older children because of differences in the anatomic and mechanical structure of the spine at various ages.

When compared to older children, the very young (<3 years old) are more likely to have upper cervical cord injury rather than lower cervical cord injury (12). The elasticity of the younger children's spinal column leads to more flexion and extension laxity.

Lower thoracic and lumbar involvement is rarely seen in SCIWORA type injuries. Scher found six cases of lower thoracic and lumbar injuries, but only two patients were 3 years old or less (3). Hubbard had six cases of lumbar spinal cord injury in children, but all except one were more than 3 years old (4). Walsh et al. had one case of an 8-month-old with a T9 injury (5). Additionally, the original SCIWORA article by Pang and Wilberger did not list any lower thoracic or lumbar injuries in children 3 years old or younger.

We present a case of SCIWORA, which involved the lower thoracic spinal cord in a 3-year-old trauma patient and review the mechanisms involved, treatment, and prognosis.

## CASE

A 34-month-old girl presented to our emergency department after being involved in a motor vehicle crash. The patient's vehicle was hit head-on by another car traveling in the opposite direction, which reportedly crossed the median. The patient was an unrestrained back seat passenger seated on her mother's lap. She had no loss of consciousness and was placed in full spinal precautions by emergency medical services (EMS) and arrived in our ED approximately 1 hour and 15 minutes after the accident.

At presentation, she was crying and requesting her mother's presence. The patient had a normal pediatric trauma score of 12 and a normal Glasgow coma score of 15. On physical examination the patient's vital signs were HR 125, RR 28, T 36.8°C (98.2°F), BP 98/56 mmHg. On head/eyes/ears/nose/throat (HEENT) examination, she was noted to have a large right facial ecchymotic area and right subconjunctival hemorrhage. Eye examination showed equal and reactive pupils and normal extraocular movements. Lung examination revealed equal and bilateral breath sounds. The heart had a regular rhythm and was without rubs, gallops, or murmur. Chest examination was non-tender. The abdomen had normal bowel sounds present and was non-tender to palpation. Pelvis was stable and the back was non-tender without ecchymosis. Peripheral pulses were 2+ bilaterally in the radial, femoral, and dorsalis pedis arteries. Neurologically, the patient was crying on examination, looking around the room, and following commands. Cranial nerves II–XII were intact. Motor strength in the upper extremities were 5/5 bilaterally with spontaneous movement. However, movement in the right lower extremity was only with deep pain, and there was no movement in the left lower extremity. Reflexes were 2+ bilateral and equal in the upper extremities, but only trace in the right lower extremity and absent in the left lower extremity. Sensation was intact to light touch in the upper extremities, but intact only to deep pain in both lower extremities below the L1 sensory level. Patient had no rectal tone. According to her father, the patient had moved her feet approximately 15 minutes after the accident, but was then carried out of the car.

Initial x-rays of the cervical, dorsal, and lumbar spine showed no fractures or subluxations (Fig. 1). CT scans of the head, abdomen, and pelvis were also normal. Because of the patient's abnormal neurologic examination, an MRI of the thoracolumbar area was performed, which showed decreased uptake in the T11-T12 area (T1-weighted images) with questionable stretching of the nerve roots in that area (Fig. 2). The patient was started on a steroid protocol 2 hours after presentation with 30 mg/kg bolus of methylprednisolone and a drip of 5.4 mg/kg/h for the following 23 hours.

On re-examination in the PICU approximately 4 hours after the emergency department evaluation, the patient was found to have no elicited movement and no DTR's of both lower extremities. Follow-up x-rays showed questionable soft tissue swelling around the T11 vertebral body. Unfortunately during her admission, the patient's neurologic status did not improve. The patient was diagnosed with a urinary tract infection during her admission and again 15 months later. One year after her initial injury, the patient is still a paraplegic and has had no change in her neurologic status.

## DISCUSSION

Several anatomic and mechanical aspects of children's spines predispose them to spinal cord injury. A tenuous blood supply to the spinal cord, immature vertebral bodies and facets, increased ligamentous laxity, and immature spinal musculature all can decrease the force required to cause cord injury. Traction on the spine, hyperextension, flexion, rotation, crush, or secondary damage can also occur.

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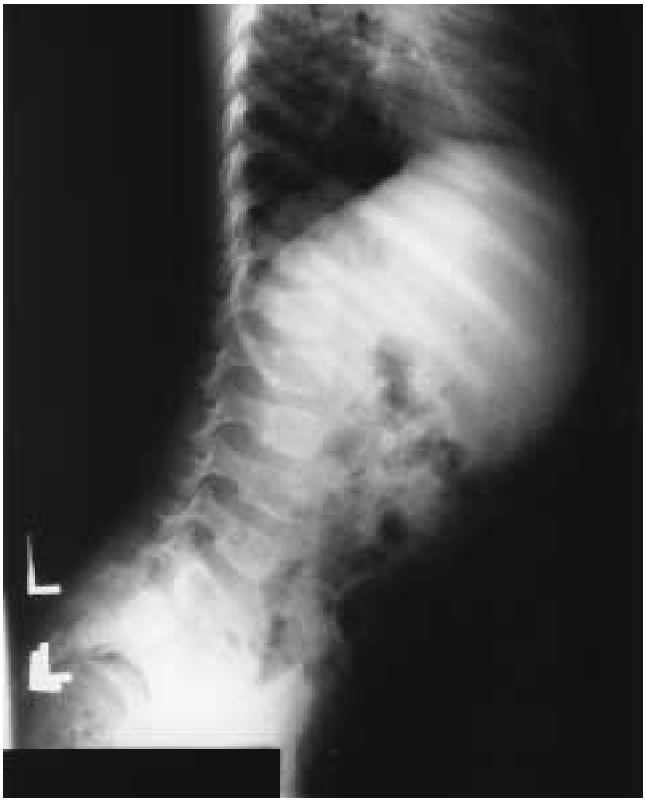

FIG. 1. Normal plain radiography of the lateral lumbar spine.

**Vascular Issues.** The anterior spinal and two posterior spinal arteries supply the spinal cord. The aorta feeds these superiorly via the subclavian and vertebral arteries, and inferiorly via the radicular arteries. Traction, flexion, and rotational injury may tear these conduit arteries from the aorta. The aorta may also rupture or dissect, resulting in hypoperfusion to the spinal cord (3,6).

Injury to the aorta, the conduit arteries, or the anterior or posterior spinal arteries can lead to ischemia in watershed area of the cord (6). This becomes especially important in the lower thoracic and lumbar area where the larger radicular artery of Adamkiewics supplies a large area of the spinal cord. Further vascular cord compromise may result from compression, thrombosis, or shear force tears to the spinal arteries.


FIG. 2. MRI of the spinal cord demonstrating decreased uptake (T1-weighted images) in the T11–T12 region.

**Anatomic Issues.** Structurally, bony vertebrae in children are not completely formed and are largely cartilaginous. In addition, the wedge shape of their vertebral bodies allows for anterior slipping, and their nearly horizontal facet joints allow for easier translation of force to anterior-posterior motion. Cadaver studies have documented that the spinal ligaments of children have more laxity in the anterior-posterior and longitudinal axis when compared to adults. This laxity allows vertebrae to sublux over each other as well as distract in a longitudinal direction. The immature spinal musculature also provides less support than in adults. These anatomic differences equate into more vertebral motion on the spine from the same injury force when compared to adults (7).

**Mechanisms.** During facial and breech birth, Leventhal showed that the infant vertebrae might move up to 5 cm longitudinally but the cord only moves 5–6 mm (8). Traction on the spine may occur from the obvious event of severe pulling on the head or neck of a child, but may also occur during motor vehicle accidents (MVAs) because the larger head size of children may actually pull a restrained child's body forward. Despite the relatively large amount of stretching of the vertebral column, the cord length changes little. The spinal cord is anchored by the cauda equina and lumbar plexus, inferiorly, and the brachial plexus, superiorly (9). Additionally, a small amount of support is offered by the other nerve roots and the pia mater. While traction-related injuries are usually seen in the upper cervical spine, severe propulsion of the head with a flexed lumbar region could result in traction injury to the lower spine (5).

Hyperextension can cause cord injury from bulging of the intralaminar ligaments. This is typically seen with forceful forward motion. While ligament bulging can result in up to 50% narrowing of the cervical spinal canal, the narrowing in the canal area is less significant in the thoracic and lumbar spine. Hyperextension can also cause shortening and bulging of the cord, thereby increasing the cross-sectional area of the cord and increasing the likelihood of injury. Disc protrusion in the thoracic and lumbar area can also occur from hyperextension and cause rupture of the anterior spinal ligament. In the thoracic region the vertebrae, ribs, and sternum are more likely to fracture before herniation occurs (3). When disc protrusion does occur, such a force would likely cause an immediate and irreversible paraplegia (5).

Cord contusion can be caused by vertebral flexion and the resultant horizontal slipping of the vertebral facets. The anterior forward wedging of the vertebral bodies increases the likelihood of injury with flexion, and also allows forward slipping of the vertebrae. The larger head and higher point of maximum flexion in children (C2–C3 in infants opposed to C5–C6 in adults) puts the cervical spine at much higher risk of injury than the lower spine, especially with head trauma. While the thoracic and lumbar facets tend to be more vertical than the cervical facets, facet slipping is possible in children less than 3 years of age (1,7).

Burke has described rotation injury in several cases, usually in flexion-rotation combination injuries (10). This is thought to be secondary to the elasticity of the cartilaginous vertebrae and the ligaments surrounding them. Rotation injury is seen mainly in the atlantoaxial joint and is rare in the lower spine (4). Additionally, the elasticity of the vertebrae and ligaments can lead to thoracic and lumbar spine damage from a crush injury.

**Etiologies.** There are several causes of SCIWORA. Sports-related injuries, falls, pedestrian accidents, violence, and shaken baby syndrome have led to SCIWORA, but MVAs are by far the most common source in children. Increased use of car seats for infants and children will likely reduce spinal cord injury from MVAs (11,12).

The types of cord injuries seen in SCIWORA vary depending on the mechanism. Complete cord injuries have the worst outcomes and tend to occur when more severe forces or younger children are involved. Central cord syndromes are classically seen in SCIWORA of the cervical spine. In the anterior cord syndrome, compression damage to the anterior spinal artery affects the whole cord, except for the posterior columns supplied by the two posterior spinal arteries. Brown-Séquard syndrome is rare in SCIWORA (2,9).

Approximately 20–50% of SCIWORA cases have a delay in onset of neurologic symptoms (12), ranging from 30 minutes to 4 days and averaging 4–5 hours. Delayed SCIWORA are often heralded by early, but transient neurologic symptoms such as burning dysesthesias of the hand (13), shooting back pain, and weakness, or clumsiness. One cause of this is speculated to be progressive cord inflammation. A more elaborate theory is that repeated bouts of minor trauma cause progressive bleeding in the spinal cord and lead to progressive symptoms (2).

**Evaluation.** The evaluation of any trauma patient should follow advanced trauma life support (ATLS) guidelines, at which time a full evaluation of the spine should be undertaken. This includes cervical spine films, with or without flexion and extension views, computed tomography, and magnetic resonance imaging (MRI) when indicated. MRI is the current method of choice for evaluation of spinal cord injury and as a prognostic tool in determining the extent of cord injury (14). For children without neurologic deficit but who may have had transient neurologic symptoms, flexion and extension neck views 5–7 days after the incident are warranted (2,7,15).

**Treatment.** In diagnosed SCIWORA, steroid therapy as set forth by Bracken et al. with methylprednisolone should be used (16). While no specific studies have shown benefit, most literature on SCIWORA includes steroids as treatment. Surgical intervention may be indicated if progressive neurologic deficit occurs, a disc herniation, or an extra dural hematoma is present, or the spine is unable to be externally stabilized. External fixation braces should be used in cases of rapidly progressing deficit, any recurrent injury, or when dynamic films of the neck notes ligamentous injury (17). Sports activity should be prohibited for at least 4–8 weeks for those with transient neurologic symptoms (18).

Spinal cord injuries may lead to morbidity long after the initial insult. Recurrent urinary tract infections (in lower cord injuries) and pneumonia (in upper cord injuries) can lead to sepsis. Additionally, kyphosis is a frequent problem later in the life of children after spinal cord or vertebral trauma. This usually leads to loss of height (2,4), but they generally have a normal life expectancy (10,13,19).

In the case of our 3 year old, the child was seated in her mom's lap unbelted at the time of injury. The neurosurgical consultants felt her SCIWORA was secondary to traction and the resulting elongation of the cord. In holding her child, the mother's hands acted like a lap belt-only restraint, allowing the child's head to be thrust forward and thereby pulling on the spinal cord. The delay and progression of the neurologic deficit in our patient was most likely from progressive bruising or inflammation while the patient was in full spinal immobilization.

The proper use of a child restraint seat would most likely have prevented this injury. We feel that a mother is unable to provide adequate physical restraint.

As noted above methylprednisolone therapy was initiated and completed without improvement in our patient's neurologic status. While Bracken did note improvement in adults in his initial study, there have been no formal studies involving children (16).

## CONCLUSION

SCIWORA is a rare condition in children and more commonly involves the cervical cord. Thoracic and lumbar cord SCIWORA are infrequently seen in children. SCIWORA may be identifiable on initial evaluation, but may not manifest until several hours later. Repeat neurologic examinations are the key to diagnosing it in a timely fashion. MRI is the test of choice for diagnosis. Although not clinically proven, all SCIWORA patients should be started on the steroid protocol as soon as this diagnosis is entertained.

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