Coexistent Sports-Related Concussion and Cervical SCIWORA in an Adolescent: A Case Report

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Background

Sports-related concussion (SRC) results from abnormal traumatic forces applied to the brain, resulting in temporary alteration in neurological functioning. At the time of injury, such forces also are applied often to the cervical spine, placing the athlete at risk of a coexistent cervical spine injury. Spinal cord injury without radiographic abnormality (SCIWORA) is a unique form of spinal cord injury (SCI) occurring predominantly among the pediatric population; it has been reported in both children and adolescents participating in contact sports (3,4,6,8,12–14). Wide variability, subtlety, and delayed onset of the clinical manifestations associated with both SRC and SCIWORA among children and adolescents present significant obstacles to recognizing and managing these conditions, especially when they occur in the same patient.

Case Report

A 13 year-old boy sustained a body-to-head body check during a hockey game. Following a brief loss of consciousness, the patient complained of headache, fogginess, neck pain, and bilateral hand numbness. The patient was evaluated in an emergency room where he underwent x-rays of the cervical spine that were interpreted as normal, and he was referred to a multidisciplinary concussion clinic. During consultation, 3 d after the injury, the patient continued to endorse concussion symptoms such as headache, fogginess, and photosensitivity as well as increasing neck pain and numbness involving his first and third to fifth digits bilaterally. His neurological examination result was normal, apart from a decreased and painful range of motion of his cervical spine and decreased vibration sense and light touch in the left hand compared with those in the right. Following the application of a hard cervical collar, he underwent magnetic resonance imaging (MRI), including T2 fat saturation sequences of his cervical spine, which demonstrated no abnormalities of the cervical spinal cord or ligamentous structures and no evidence of spinal stenosis or congenital spine abnormality (Figs. 1 and 2). Initial flexion-extension x-rays of the cervical spine showed no abnormality but a significantly restricted range of motion. Following consultation with a pediatric neurosurgeon and repeat flexion-extension x-rays 2 wk later, which showed no evidence of instability, the cervical collar was removed and the patient was instructed to avoid all contact sports and physical exercise until resolution of symptoms. Six weeks later, the patient's concussion symptoms and upper extremity numbness had resolved. Delayed flexion-extension x-rays with a full and painless range of motion demonstrated no evidence of spinal instability. Because of the patient's prolonged neurological symptoms related to the patient's SCIWORA, we initiated a slow, graduated return-to-play protocol that was completed without any recurrent neurological symptoms. The patient was cleared to return to contact hockey a total of 2 months following the initial injury and successfully completed the rest of the hockey season without any further symptoms.

Discussion

SCIWORA was defined first by Pang and Wilberger (15) as "objective signs of myelopathy as a result of trauma" without evidence of abnormality on x-ray and computerized tomography (CT) studies. SCIWORA occurs predominantly among the pediatric population, accounting for 13% to 67% of traumatic spinal injuries (4,8,9) and 25% of SCI in children and adolescents (3). Among youths, SCIWORA can result from low- or high-velocity mechanisms, with up to 43% of cases occurring during sport-related activities (3).

Unique anatomical and biomechanical features of the developing immature spine account for age-related differences in spinal level and severity of injury among children and adolescents with SCIWORA (8,13,14). Anatomical

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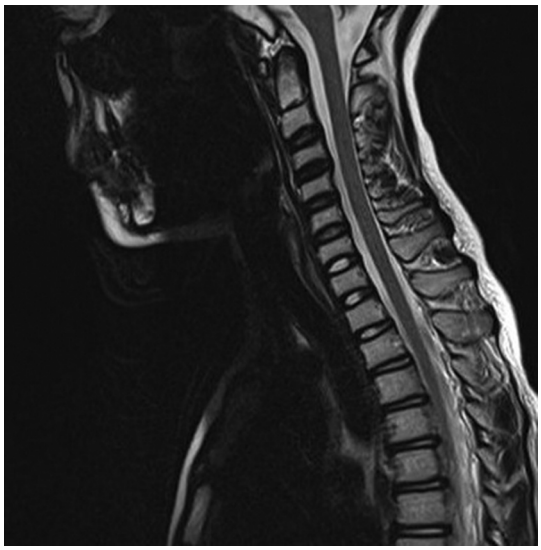

Figure 1: Lateral T2-weighted imaging of the cervical spine demonstrates straightening of the cervical lordosis but no evidence of intraneural abnormality.

features that assume a more adult orientation at around age 8 or 9 years and confer increased mobility of the pediatric spine include laxity of ligaments and facet joint capsules, increased water content and expandability of intervertebral discs, underdevelopment of neck musculature and uncinate processes, incompletely ossified and wedge-shaped vertebral bodies, and horizontally oriented and shallow facets (2,8,14). Such hypermobility has been postulated to lead to self-reducing "intersegmental displacement" (13), the putative mechanism underlying SCIWORA whereby external forces transmitted to the deformable spine lead the spinal cord to impact the bony surfaces of the spine or stretch the spinal cord beyond its tensile capacity, resulting in injury.

Unlike the symptoms of SRC that are reflective of global alterations in cerebral energy metabolism, the clinical presentation of SCIWORA points to isolated spinal cord dysfunction and can vary from mild signs of myelopathy to complete SCI. Importantly this unique clinicopathological entity must be distinguished from spinal cord concussion, defined as transient functional disturbance of the spinal cord that presents in a similar fashion to SCIWORA but resolves within 48 h (5) and the co-termed "burner" or "stinger," which presents as transient unilateral neuropraxia or radiculopathy resulting from direct impact to the intervertebral foramen or traction injury to the exiting nerve root (17). Four SCI syndromes have been identified in patients with SCIWORA including the following: complete SCI, central cord syndrome, Brown-Séquard syndrome, and partial cord syndrome (13). A significant proportion of adolescents will present with subtle symptoms including neck pain or stiffness, mild weakness or numbness of the extremities, and gait or postural instability that can be misattributed easily to the patient's SRC. Although neck pain and numbness are included in commonly used standardized concussion symptom checklists (*i.e.*, Sport Concussion Assessment Tool (11) and Postconcussion Symptom Scale (10)), the presence of these symptoms always should alert the treating physician to the possibility of an occult cervical spine injury. Delayed symptoms in SCIWORA also can occur hours or even days after the traumatic event and can develop spontaneously or after trivial or sport-related trauma (9,14). Patients who develop delayed symptoms often progress to more severe neurological impairment, resulting in a poorer overall outcome (13,14). Overall the prognosis for children and adolescents with SCIWORA is variable and is largely dependent on the severity of neurological deficits at the time of presentation (6,8,12–14).

The evaluation and management of patients with suspected SCIWORA must focus on the following two key objectives: 1) clinically and radiologically evaluating the patient for evidence of a SCI and/or associated spinal column instability and 2) devising a management plan to reduce the risk of recurrent SCIWORA. Following a complete neurological examination including testing of cranial nerve, motor, sensory, reflex, cerebellar, and gait functioning, any patient with a suspected SCI or SCIWORA should be placed in a hard cervical collar and undergo plain upright x-rays including anteroposterior, lateral, and open-mouthed odontoid views. Because subtle fractures can escape detection by plain films alone, some authors have advocated the use of CT in examining the entire spinal segment or in a focused fashion at the spinal level of the suspected injury (14,18), especially in patients with a high-velocity or worrisome mechanism of injury. Patients that demonstrate a persistent neurological deficit despite no abnormality identified on plain films and CT examinations are diagnosed formally with SCIWORA. All patients with SCIWORA should undergo MRI of the spinal segment including T2 short tau inversion recovery (STIR) or fat saturation sequences, which has demonstrated increased sensitivity to ligamentous injury (1). MRI findings observed in patients with SCIWORA can be defined as extraneural and intraneural, with intraneural findings often correlated with the severity of neurological impairment and ranging from complete spinal cord transection to spinal cord hemorrhage or edema or normal findings

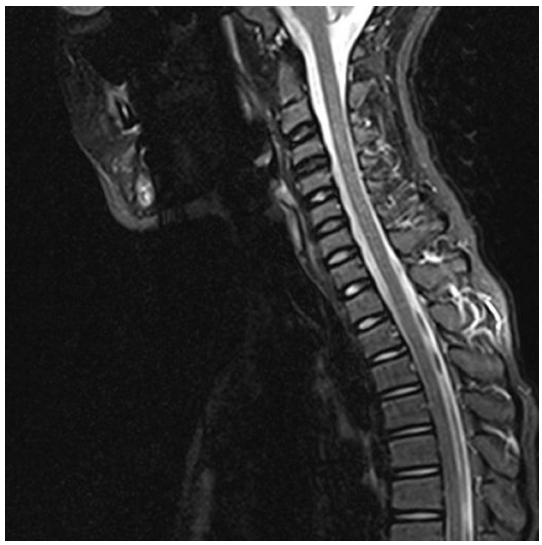

Figure 2: Lateral T2-fat saturation (STIR) imaging of the cervical spine demonstrates straightening of the cervical lordosis but no evidence of ligamentous injury.

(7). Positive MRI findings do not alter the diagnosis of SCIWORA as it was defined classically (15). Accumulating evidence suggests that MRI findings are highly predictive of overall outcome, with nearly all patients with normal MRI findings achieving a complete neurological recovery (13). Any patient with evidence of ligamentous injury or positive intraneural findings on MRI should be referred immediately to a pediatric neurosurgeon for further evaluation and consideration for operative or nonoperative spinal stabilization. Patients with cervical SCIWORA and normal MRI findings subsequently should undergo flexion-extension x-rays to rule out any dynamic spinal instability. In cases where evidence of spinal instability is detected on flexion-extension x-rays, patients should be placed in hard collar immobilization and referred to a pediatric neurosurgeon for further evaluation. These examinations are normal in the vast majority of patients; however paraspinal muscle spasm and pain may limit the range of motion achieved during these examinations and also may mask subtle pathological motion. For this reason, patients with persistent neck pain and restricted range of motion should be treated initially with a period of hard collar immobilization and strict activity restriction until full painless range of motion and satisfactory delayed flexion-extension x-rays can be achieved.

The overall management of patients with SCIWORA is controversial and largely shaped by rare reports of recurrent injury observed among these patients. Recurrent injury has been observed in patients that have been compliant and noncompliant with cervical collar immobilization, have occurred with sports-related activities, and are often associated with more severe neurological deficits (16). Some authors have suggested that patients with SCIWORA indeed may harbor occult spinal instability that cannot be assessed reliably with flexion-extension views and thus recommend a period of up to 3 months of immobilization and abstinence from non- and full-contact sports (14,16,18). Others argue that there is no evidence that occult spinal instability underlies this condition or that spinal immobilization prevents recurrent SCIWORA or improves patient outcomes (3).

In the patient with co-existing SRC and SCIWORA, return-to-play decision making must be made on an individual basis and take into account the unique natural history and evidence-based management guidelines for each condition. Current management guidelines for both SRC and SCIWORA are based on expert opinion only (level III evidence (11,18)) and have not been subjected to prospective study. For this reason, we believe that return-to-play decision making in all cases of coexistent SRC and SCIWORA should be made in collaboration with a pediatric neurosurgeon. Only after the patient's neurological deficits have resolved, spinal instability has been ruled out, and the patient reports no concussion-related symptoms at rest should they be permitted to proceed through a graduated return-to-play concussion rehabilitation program. In the case presented here, we elected to treat our patient with an initial period of hard collar spinal immobilization until spinal instability could be ruled out satisfactorily with MRI and flexion-extension x-rays. The patient subsequently completed a modified return-to-play protocol once his neurological symptoms were fully resolved and he successfully returned to contact sports without any adverse events.

Conclusions

Traumatic forces transmitted to the immature brain and spinal column during sporting activities can result in SRC and coexistent cervical spine injury. SCIWORA is a unique form of SCI that can present with subtle neurological complaints that can be difficult to distinguish from those of SRC. In cases of coexistent SRC and SCIWORA in children and adolescents, sports medicine physicians and pediatric neurosurgeons must partner to rule out occult spinal instability clinically and radiologically and implement an individualized plan to reduce the risk of recurrent brain and cervical spine injury.

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