Injury to the spinal cord without radiological abnormality (SCIWORA) in adults

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Injury to the spinal cord without radiological abnormality often occurs in the skeletally immature cervical and thoracic spine. We describe four adult patients with this diagnosis involving the cervical spine with resultant quadriparesis. The relevant literature is reviewed. The implications for initial management of the injury, the role of MRI and the need for a high index of suspicion are highlighted.

J Bone Joint Surg [Br] 2000;82-B:1034-7.
Received 12 October 1999; Accepted after revision 19 April 2000

Since its first description by Pang and Wilberger,[1] injury to the spinal cord without radiological abnormality (SCIWORA) has been well documented in the paediatric literature.[2,3] The relatively large size of the head and the greater inherent mobility in the immature axial skeleton, combined with ligamentous laxity or disruption, render the spinal cord vulnerable to damage in high-energy trauma. In the absence of osseous injury on plain radiographs or tomography, MRI should demonstrate abnormalities in all cases. SCIWORA in adults is rare, but is of considerable importance because of the potential problems of management inherent in the diagnosis. We report four such cases, highlighting common clinical features, and consider their relevance in general trauma practice.

Case Reports

Case 1. A 24-year-old male motorcyclist came off the road at high speed. He wore no helmet and had a severe head injury. When initially assessed at the receiving hospital the plain radiographs of the neck were normal apart from a narrow spinal canal (Fig. 1a). On regaining consciousness he was noted to be quadriparetic with MRC grade-II power in most muscle groups. Apart from some dysaesthesia in the upper limbs there were no other neurological symptoms or signs. He was transferred to our unit 48 hours later, by which time power in the upper limbs had recovered to MRC grade III and in the lower limbs to grade IV. MR images showed mild, focal swelling of the cord and oedema at C3/4, with prevertebral soft-tissue swelling and disruption of the anterior longitudinal ligament. In addition, there was low signal intensity in the C3/4 disc with a shallow, posterior bulge without focal compression of the cord. There was oedema in the posterior ligamentous complex at the same level and at C4/5. Abnormalities were seen in the horizontal linear signal in the bodies of T2 to T6 indicative of undisplaced compression fractures (Fig. 1b). A diagnosis of central cord syndrome was made. The patient made further neurological recovery, and repeat MRI two months after the injury showed resolution of the oedema in the cord but persistent signal changes which were suggestive of myelomalacia.

Fig. 1a

Fig. 1b

Case 1. Figure 1a – Lateral plain radiograph of the cervical spine showing minimal prevertebral soft-tissue swelling at C3/4 (arrows). No fracture is apparent. The alignment of the vertebral bodies is normal. Figure 1b – Sagittal MRI (T2-weighted) showing a small prevertebral haematoma with elevation of the anterior longitudinal ligament. A shallow posterior bulge of the C3/4 disc is apparent with focal oedema. The alignment of the vertebral bodies is normal. There are undisplaced linear fractures in the upper thoracic spine (arrow). Other images show posterior ligamentous disruption at C3/4 and C4/5 indicating a predominantly hyperflexion injury.

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0301-620X/00/710641 $2.00

Fig. 2a

Fig. 2b

Case 2. Figure 2a – A lateral plain radiograph of the cervical spine showing congenital fusion at C2/3 and C7/T1. Minor spondylotic changes are apparent at C5/6 but no fracture is evident. The central canal is narrow. Figure 2b – Sagittal MRI showing congenital fusion at C2/3 and C7/T1 and constitutional stenosis of the central canal. There are spondylotic changes at the mobile mid-cervical levels and a shallow traumatic protrusion of the disc at C5/6, with associated oedema of the cord from C3 to C7. There is diffuse soft-tissue oedema (arrow) indicative of a hyperflexion injury.

Fig. 3a

Fig. 3b

Case 3. Figure 3a – Lateral plain radiograph of the cervical spine showing a small anterosuperior corner fracture of C6 (arrow). Figure 3b – Sagittal T2-weighted MRI. The images are degraded by movement artefact. The area of low-signal intensity centrally within the cord at C5/6 is indicative of haemorrhage and there is surrounding oedema. There is a shallow posterior bulge of the C5/6 disc although the small anterior fracture of C6 cannot be readily appreciated. Other images show posterior ligamentous injury indicative of a hyperflexion injury.

Case 2. A 33-year-old woman was admitted with quadriparesis after a fall from a ladder. Physical examination revealed a sensory level at C5, MRC grade-II power in the upper and lower limbs but no tenderness in the neck. Plain radiographs showed congenital fusion at C2/3 and C7/T1 (Fig. 2a). No bony injury was apparent. She was given high-dose intravenous methylprednisolone. MRI showed marked constitutional narrowing of the cervical spinal canal from C3 to C7 with oedema of the cord between C4 and C7. There was focal compression of the cord at C5/6 caused by a spondylotic ridge. Posterior ligamentous oedema was apparent at the C4/5 and C5/6 segments with more diffuse soft-tissue oedema at the upper cervical levels (Fig. 2b).

As there was no early evidence of neurological improvement she underwent laminectomy from C3 to C6; no dural tears were seen at operation. She was transferred to the regional spinal-injuries unit where she recovered MRC grade-IV power in the upper and lower limbs and regained some sphincter control.

Case 3. An 18-year-old man was physically assaulted while drunk. He sustained a severe head injury with a Glasgow Coma Score of 7 on admission. A CT scan of the brain revealed contusion of the left parietal lobe. The patient's level of consciousness returned to normal 48 hours later but he was quadriparetic. Review of the initial cervical radiographs was thought to show a minimal anterior compression fracture of C6 with slight rotation (Fig. 3a).

On transfer to our unit he was noted to have a sensory level at C5 with no active movement in any of his four limbs but no posterior cervical tenderness. Catheter tug sensation was present but the anus was patulous. The bulbocavernosus reflex was present at that stage. MRI showed oedema of the mid-cervical cord and focal haemorrhage at C5/6 (Fig. 3b). There was a shallow, diffuse disc bulge at the same level. Subtle horizontal, linear oedema was seen in the vertebral bodies of C5 and C6 without evidence of discrete fractures. There was associated disruption of the posterior ligament at C4/5, C5/6 and C6/7 with diffuse soft-tissue oedema in the upper cervical region. He was managed conservatively but there was no neurological recovery.

Case 4. A 49-year-old unsecured male passenger in a rear seat was ejected from a car in an accident at high speed. He sustained serious head, maxillofacial and abdominal injuries. Plain radiographs of the neck showed no bony injury. After resuscitation he required a laparotomy at which lacerations of the liver were repaired.

He was transferred to our neurosurgical unit where he was observed to have movement in all four limbs. Repeat CT scans of the brain, and sections through C7/T1 which had not been adequately demonstrated on the initial views, were normal. An intracranial pressure transducer was inserted and his maxillofacial fractures were reduced and stabilised. After four days in intensive care, following extubation and reversal of sedation, he was conscious enough to complain of neck pain. He remained quadriparetic, however, with no useful motor function below C5. MRI of the spine revealed a constitutionally narrow canal. There was a small posterior disc protrusion at C5/6 with associated focal oedema of the cord at this level. There was also injury of the mid-cervical posterior ligament and horizontal, linear signal abnormalities in the vertebral bodies of T3 and T4 (Fig. 4). Subsequent CT of

Fig. 4

Case 4. Sagittal T2-weighted MRI showing a shallow posterior protrusion of the disc at C5/6 with associated oedema of the cord. There are minimally displaced linear fractures at T3 and T4 (other images showed posterior ligamentous injury indicative of hyperflexion injury at C5/6).

the entire cervical spine showed no fracture. There were spondylotic changes at C4/5 and C5/6. Eight days after injury supervised dynamic radiographs with the patient awake, showed no evidence of instability; 15 days after injury, there was neurological improvement to grade IV/V, from the C7 myotome with some active movement of the lower limbs (grade-II ankle dorsiflexion). He was later transferred to the regional spinal rehabilitation unit.

Discussion

SCIWORA in the paediatric spine is a reflection of the inherent elasticity of the soft tissues which ensures immediate spontaneous reduction after considerable intersegmental displacement. The flexibility of the spine is reduced with increasing age and skeletal maturation, and with it, the likelihood of bone injury becomes greater.

SCIWORA in adults is not well documented. Chen et al[4] described five cases with traumatic central cord syndrome and an abnormal cord signal on MRI but without definitive compression of the cord. There is only one case of SCIWORA reported in the surgical literature affecting the adult spine.[5] In this patient, myelography demonstrated gross leakage of contrast and a subsequent CT scan suggested rupture of the cord, confirmed on MRI which also showed an interspinous ligamentous injury.

In the conscious patient, pain or neurological symptoms will suggest the possibility of injury to the cervical spine. Cervical injuries are likely to be missed in multiple trauma, craniofacial injuries and drug- or alcohol-related accidents; three of our cases illustrate the difficulties of clinical assessment in such situations. Adequate spinal radiographs are essential.[6] The cross-table lateral radiograph will demonstrate 75% of fractures, with a sensitivity of 82% to 85%. The diagnostic accuracy approaches 92% to 99% when all cervical views (lateral, anteroposterior, open mouth and oblique) are obtained.[7] CT will demonstrate subtle injuries to the posterior arch or lateral masses and injuries in the atlantoaxial region.

Despite the above data, a recent survey of UK practice by Lockey, Handley and Willett[8] showed wide variation in the protocols for reviewing the cervical spine in the unconscious patient. Some units relied only on a cross-table lateral radiograph. Where the C1/2 or C7/T1 areas were not demonstrated on plain radiographs, there was often no protocol for CT of the neck at the same time as examination of the brain. Lockey's own departmental policy was to take dynamic fluoroscopic views in the intubated or unconscious patient to exclude instability. Bedside fluoroscopic examination has been reported in other centres where the incidence of cervical instability was 5% in patients with otherwise normal radiological appearances.[9]

Between 8% and 15% of cervical fractures are associated with herniation of a disc which may compress the cord. Benzel et al,[10] using MRI, found an incidence of 16% of abnormality of a disc following trauma. In two of our cases SCIWORA occurred in association with a constitutionally narrow canal. We question the wisdom of performing dynamic radiographs in this situation when demonstrable instability may cause injury to the cord. Furthermore, as our cases illustrate, there may not be documented movement of the limbs before admission to hospital. If the patient recovers consciousness with obvious quadriparesis, the question arises as to whether the deficit was the result of the initial accident or of the examination. There are obvious medicolegal implications.

Prolonged cervical immobilisation with hard collars may cause complications.[11] Increased intracranial pressure, care of the skin and difficulties with nursing may demand early removal of a hard collar, in a patient who is ventilated after a head injury. Our experience leads us not to rely on plain radiographs or CT to exclude cervical injury. In such circumstances, it is safer to presume the presence of an unstable spinal injury. MRI is useful in demonstrating ligamentous injury and is being advocated for routine review of the cervical spine.[12] The logistics of MRI in the ventilated patient and the limited availability of this investigation throughout the UK prevents its use from being obligatory. It is our policy that when MRI is not practical, the collar is removed when the patient is sedated and intubated. The neck is assumed to be unstable and supported with sand bags in neutral alignment. The collar is reapplied when the patient is being weaned from the ventilator, until formal neurological examination is performed. Depending on the circumstances, dynamic radiography or MRI is then performed.

MRI has been useful in this series as there were focal

changes in the cord, and ligamentous and disc injury. In addition, relative narrowing of the spinal canal is well demonstrated. Plain radiography and the use of the Pavlov ratio have not been helpful in estimating relative dimensions of the canal or the space available for the cord.[13] The importance of narrowing of the canal in the context of SCIWORA is that the mechanism of inducing the central cord syndrome probably differs from that seen in the older patient. In the latter case, the cord is compressed between the enfolded ligamentum flavum and anterior vertebral osteophyte in a hyperextension injury.[14] Our cases have shown significant signal changes on T2-weighted images, particularly in the posterior ligament complex. This implies a hyperflexion-compression force, as described by Allen et al.[15] In support of this is the linear high-signal changes in the upper thoracic vertebrae indicative of axial loads transmitted caudally at the moment of impact. The damage to the cord may then occur as a consequence of traction, forward translation and compression between a modest disc bulge and the laminae. This concept has been supported by the observations of Chen et al[4] and may be similar to that described by Braakman and Penning,[16] who refer to it as a 'hyperflexion sprain'.

The demonstration of changes in the cord has also been useful in predicting recovery. The neurological outcome in patients with focal oedema of the cord has been better than in the patient with overt haematoma of the cord as seen on MRI. These observations appear to confirm the findings of Schaefer et al[17] in which focal oedema was associated with motor recovery of 70%.

In conclusion, SCIWORA must be suspected in all patients with a neurological deficit and apparently normal radiographs. A high index of suspicion is necessary in injured patients in whom movement of all limbs is not seen. The presence of constitutional narrowing of the canal would seem to predispose to lesions of the cord especially in young adults with a compression-flexion type of injury. MRI is a sensitive method of demonstrating ligamentous damage and protrusion of the discs, which are important features in the mechanics of injury to the cord. The use of dynamic fluoroscopy in these patients may be dangerous.

No benefits in any form have been received or will be received from a commercial party related directly or indirectly to the subject of this article.

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