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Spinal clearance and management of spinal cord injury in the trauma patient

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Abstract

The British Orthopaedic Association's Standards for Trauma and Orthopaedics outline the essential clinical standards for spinal clearance and management of spinal cord injury in the acute trauma patient. From initial presentation in the hospital setting to long-term rehabilitation, the recommendations for clinical assessment, imaging, treatment priorities and the role of trauma networks are summarised.

Key words: Computed tomography; Polytrauma; Spinal cord injury; Surgical decompression; Trauma care

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Introduction

Spinal cord injury can be life threatening following acute trauma. As such, all hospitals managing trauma patients should establish written protocols for the immediate management of the spinally injured patient in line with the British Orthopaedic Association's Standards for Trauma and Orthopaedics (BOAST) (British Orthopaedic Association, 2014, 2015). The spinal clearance guideline applies to all unconscious trauma patients, or those with distracting injuries that would preclude a reliable clinical assessment, excluding all patients under the age of 16 years. The BOAST guideline on the management of traumatic spinal injury includes all adult and paediatric patients presenting with quadriplegia or tetraplegia in the context of polytrauma or isolated spinal cord injury. This article summarises the essential principles of the BOAST guidance concerning spinal clearance and onward management of traumatic spinal cord injury.

Background

Biomechanically, the vertebral column is composed of three longitudinal columns: anterior, middle and posterior (Miele et al, 2012). Fractures affecting two adjacent columns may be considered radiologically unstable and risk subsequent neurological injury (Panjabi and White 3rd, 1980; Denis, 1984). Cord lesions can be described as complete or incomplete, depending on whether or not neurological function is preserved below the primary injury site (Bican et al, 2013). Up to 55% of spinal injuries occur in the cervical region, where the C1–C2 and C5–C7 junctions are the most anatomically vulnerable to damage (Sekhon and Fehlings, 2001). Note the spinal cord becomes the cauda equina around the L1/2 level (Ridley et al, 2018). Isolated ligamentous injury without vertebral fracture is extremely rare in blunt trauma and the clinical significance of this isolated injury is disputed (Veale and Lamb, 2002; Ford and Theron, 2012).

The purpose of spinal assessment and clearance is twofold: identifying pertinent injuries and clearing patients without significant injury. Performing this early is vital, since delayed detection of spinal cord injury is associated with significantly worse patient outcomes (Levi et al, 2006). Similarly, Bourassa-Moreau et al (2013) demonstrated that early surgical intervention within 24 hours of injury onset significantly reduces complications and optimises functional neurological recovery. At the other end of the spectrum, unnecessary immobilisation resulting from use of a cervical collar or rigid spinal board increases the risk of developing cutaneous pressure ulcers (Morris et al, 2004). Therefore, early and appropriate assessment helps to reduce morbidity and mortality, both in patients with confirmed and excluded spinal cord injury, by facilitating early intervention or early mobilisation respectively.

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Initial assessment

Spinal injuries are seen in 2% of alert and 34% of unconscious trauma patients, making neurological assessment of this high-risk population challenging (British Orthopaedic Association, 2015). From the moment of injury, spinal instability should be assumed when a dangerous mechanism of injury is present. Protective measures should be undertaken during extrication, transfer to hospital and throughout clinical assessment until the absence of a cord-threatening injury can be demonstrated (British Orthopaedic Association, 2015).

As part of the primary survey, cervical spinal protection is best achieved through three-point immobilisation. This consists of a well-fitted semi-rigid collar, and blocks applied to the side of the head and secured to a rigid board or trolley using non-elastic tape (Veale and Lamb, 2002; Ford and Theron, 2012). This immobilises the cervical spine in three planes. Rigid spinal boards are often used to prevent lateral movements of the thoracic and lumbar spine, although their role in reducing secondary spinal injury is unknown (Morris et al, 2004). Patients should be removed from the spinal board when they arrive in the emergency department to prevent the development of pressure ulcers. Manoeuvres such as log rolling and manual in-line stabilisation are often necessary to facilitate the mobilisation required for examination of the spine or during endotracheal intubation. It is important not to apply axial traction during these manoeuvres as this can exacerbate instability (Conrad et al, 2007).

Spinal injury can be reasonably excluded using clinical tools such as the NEXUS criteria or Canadian C-Spine rules following a low energy mechanism of injury in a fully alert patient. In cases of complex trauma or head injury, definitive radiological clearance of the spine is almost always required.

Clinical decision tools

The National Emergency X-Radiography Utilisation Study (NEXUS) is a decision tool that helps to identify patients with a high risk of cervical spinal fractures (Hoffman et al, 1998). It stipulates five criteria:

1. Absence of tenderness when touching the cervical spine
2. Absence of evidence of intoxication
3. Full consciousness
4. Absence of focal neurological lesions
5. Absence of damage causing distraction.

If any of the above criteria are not met, radiographic imaging of the cervical spine is required, since the NEXUS criteria have a 99.6% sensitivity for detecting cervical spine fractures (Hoffman et al, 2000).

The Canadian C Spine rules are broadly similar to the NEXUS criteria, but also include the mechanism of injury and other pertinent risk factors which, if present, indicate that the patient will require imaging (Stiell et al, 2003). Cervical spine imaging is indicated if high risk factors are met:

- Aged ≥65 years or
- Dangerous mechanism of injury (fall from >1 m, axial load to head, for example diving, high speed (>100 km/h) motor vehicle crash, bicycle collision, recreational motor vehicle use) or
- New paraesthesias in extremities.

If none of the above are met, the patient should be assessed for low risk factors:

- Simple rear-ended motor vehicle collision or
- Sitting position in emergency department or
- Ambulating after incident or
- Delayed onset neck pain or
- No midline cervical tenderness.

If the patient fails to meet the low risk criteria, then imaging is indicated. In case of low risk injury, the patient should be asked to laterally rotate their head 45° – failure to achieve the desired range of motion necessitates cervical spine imaging.

While both the NEXUS and Canadian C Spine rules are widely used, the Canadian C Spine rules are more sensitive (99.1% vs 90.7%) and more specific (45.1% vs 36.8%) than the NEXUS tool (Stiell et al, 2003).

As part of the secondary survey, clinical examination of the whole spine and assessment of neurological status must be performed and clearly documented at the earliest opportunity. Any sensory and/or motor deficiency must be clearly assessed, with care taken to determine whether it is a complete or incomplete spinal cord injury. This also includes the assessment of anorectal tone and sensation. All signs of neurological deficit detected on examination should be treated with a high index of suspicion and require urgent magnetic resonance imaging of the spine, as this is highly suggestive of spinal cord injury. If it is expected that a patient will remain unconscious for >48 hours, unassessable or unavailable for reliable repeated clinical assessment, spinal clearance should be sought out radiologically rather than clinically (British Orthopaedic Association, 2015).

The deleterious effects of prolonged spinal immobilisation increase rapidly after 48 hours. They include cutaneous pressure necrosis, venous thromboembolism, aspiration pneumonia, raised intracranial pressure and poor enteral nutrition among many others (Morris et al, 2004). Once cleared, spinal precautions should be removed as soon as possible to lessen these risks.

Imaging

Computed tomography and magnetic resonance imaging must be available 24 hours a day in centres managing spinal injuries. To adequately visualise the cervical spine for radiological clearance, helical computed tomography scanning with 2–3 mm slices with sagittal and coronal reconstructions should be performed to visualise the base of the skull to at least T1 (**Figure 1**). This method can exclude cervical spine injury with over 99% sensitivity (Morris et al, 2004). For practical reasons, it is recommended that a computed tomography scan of the cervical spine is performed with the initial cranial computed tomography scan in head-injured patients, or those with an altered level of consciousness (British Orthopaedic Association, 2015).

Figure 1. Computed tomography cervical spine sagittal section showing a C6/7 bifacet dislocation following high energy trauma.

Figure 2. T2 magnetic resonance imaging of an elderly man with central cord syndrome (upper limb > lower limb weakness) following a fall. Magnetic resonance imaging shows cord oedema (high signal intensity) at C4/5.

The thoracolumbar spine may be sufficiently visualised with plain anteroposterior and lateral radiographs, or with coronal and sagittal reconstructions of computed tomography chest, abdomen and pelvis if conducted as part of the computed tomography trauma series with slices <5 mm. Spinal precautions must only be withdrawn once an unstable injury has been excluded by a senior radiologist (British Orthopaedic Association, 2015).

Magnetic resonance imaging remains the gold standard for accurate radiological evaluation of spinal cord injury (**Figure 2**). T2 sagittal magnetic resonance imaging evaluation in particular is useful for the prognostication of severity of spinal cord injury (Bozzo et al, 2011). However, computed tomography is more sensitive than magnetic resonance imaging for the detection of bony vertebral column injury. Computed tomography and plain radiographs as first-line investigations are equal to or better than magnetic resonance imaging for the detection of potential unstable vertebral column injuries in the acute setting (Morris et al, 2004). The superior sensitivity of magnetic resonance imaging in detecting soft tissue injuries is of uncertain significance relating to spinal stability, and may increase the risk of prolonged spinal immobilisation (Morris and McCoy, 2004; Chew et al, 2013). Additional impracticalities relating to availability, speed and ferro-compatibility mean that routine use of magnetic resonance imaging to screen for unstable injuries is not recommended.

Management of spinal injury

Initial priorities are airway, breathing and circulation management as per the primary survey to prevent cord hypoxia and hypotension (ATLS subcommittee et al, 2013). This lessens the risk of secondary spinal cord injury in the surrounding ischaemic penumbra (Tator and Fehlings, 1991). Any unstable injuries should be externally stabilised and log rolling performed until stability is confirmed. If a spinal injury is detected, regular clinical assessment of the peripheral nervous system and neurological observations should be undertaken on an American Spinal Injury Association (ASIA) chart in concordance with the International Standards for

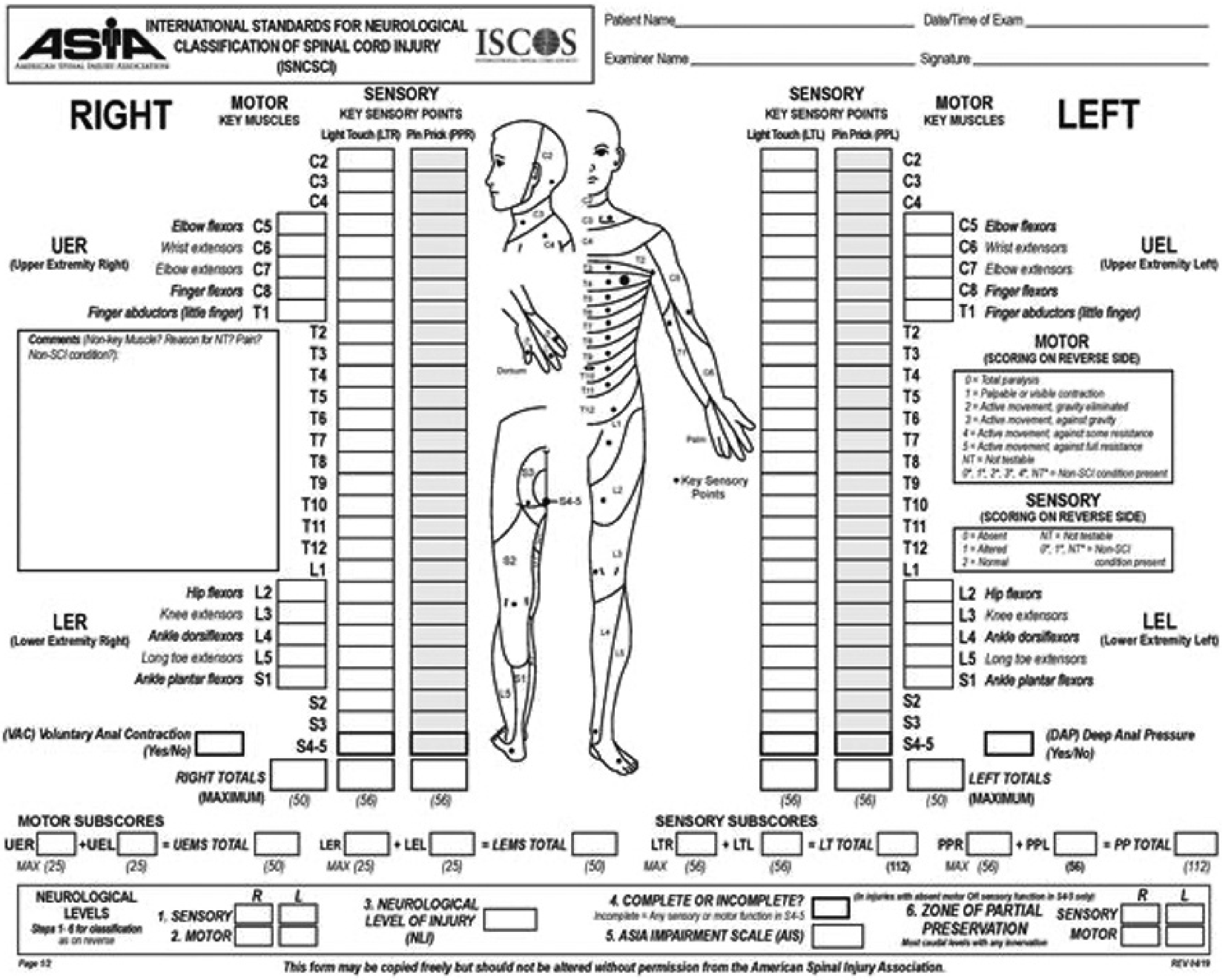

Figure 3. American Spinal Injury Association International Standards for Neurological Classification of Spinal Cord Injury Worksheet.

Neurological Classification of Spinal Cord Injury (Figure 3; National Spinal Cord Injury Strategy Board, 2012). The ASIA assessment framework consists of a comprehensive sensorimotor examination and scoring system to grade severity of neurological impairment and degree of cord dysfunction (Table 1).

Tertiary care

All major trauma centres and trauma units must be linked to a spinal cord injury centre within a regional trauma network. All centres managing patients with spinal injuries must be able to provide specialist spinal surgery within 4 hours of injury (British Orthopaedic Association, 2015). In order to safeguard continuity across multicentre networks, written standardised care protocols should be uniformly agreed between units to include guidance on spinal stabilisation, anaesthesia, neuroprotection, skin care, gastric, bowel and bladder care, nursing, joint protection and rehabilitation therapies (British Orthopaedic Association, 2015).

When a spinally injured patient arrives at a major trauma centre or trauma unit, appropriate computed tomography and/or magnetic resonance imaging should be obtained early following resuscitation and stabilisation. The management of these patients must follow the agreed protocol of the attached spinal cord injury centre, or the centre's consultant on call must be contacted within 4 hours of injury to determine an appropriate management plan (British Orthopaedic Association, 2015). This initial joint management plan should be recorded in the notes and implemented within 12 hours of injury (National Spinal Cord Injury Strategy Board, 2012). Once resuscitated, it is advisable for clinically stable patients

Table 1. American Spinal Injury Association impairment scale	
Grade	**Definition**
A	Complete. No sensory or motor function is preserved in sacral segments S4–S5
B	Incomplete. Sensory but not motor function is preserved below the neurological level, including segments S4–S5
C	Incomplete. Motor function is preserved; more than half of key muscles below the neurological level have a muscle grade less than 3
D	Incomplete. Motor function is preserved; more than half of key muscles below the neurological level have a muscle grade greater than or equal to 3
E	Normal. Sensory and motor functions normal

From National Spinal Cord Injury Strategy Board (2012)

to be transferred within 24 hours to a spinal cord injury centre as this reduces acute and late complications in addition to hospital length of stay, unless it is agreed that ongoing treatment at the primary trauma centre is in the patient's best interests (Consortium for Spinal Cord Medicine, 2008; Hachem et al, 2017). In some studies, early access to decompressive spinal surgery has improved long-term outcomes such as motor ASIA scores at 6 and 12 months post-injury (Fehlings et al, 2017), but many other studies have not shown this benefit.

Patients who remain in their receiving major trauma centre or trauma unit because of concerns over fitness for transfer should be provided with an outreach service from the named spinal cord injury centre within 5 days of referral (National Spinal Cord Injury Strategy Board, 2012). Outreach contact or visits should be repeated weekly until the patient is deemed fit enough to be transferred to the appropriate spinal cord injuries unit (British Orthopaedic Association, 2015). Such services tend to include nurse specialists, physiotherapists and occupational therapists who provide individualised assessments and recommendations for care and rehabilitation. Appropriate psychological services should also be readily available to patients, families and caregivers to support them through rehabilitation from potentially life-changing injuries and disabilities (British Orthopaedic Association, 2015).

All patients who sustain spinal cord injuries should have referral information submitted to the National Spinal Cord Injuries Database (www.spinalcordinjury.nhs.uk), which reports data outcome measures for use in service commissioning and quality improvement (British Orthopaedic Association, 2015).

Conclusions

The devastating consequences of spinal cord injury require strict precautions to protect and clear the spine in all patients suffering high impact trauma. Optimum management in these complex patients requires urgent cross-sectional imaging, and early discussion and transfer between trauma and neurosurgical centres to optimise functional outcomes. The initial principles of management are early external stabilisation, prevention of hypoxia and hypotension, imaging, then spinal realignment, decompression and definitive stabilisation. Subsequent management in specialist spinal cord injury centres seeks to optimise function for patients with this lifelong condition.

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Key points

- Spinal injuries should be assumed and precautions taken until radiological clearance has been achieved.
- Helical computed tomography scanning is the imaging modality of choice to exclude vertebral instability.
- Magnetic resonance imaging is the imaging modality of choice to diagnose cord injury.
- Repeated clinical examination should be routinely undertaken in line with the International Standards for Neurological Classification of Spinal Cord Injury assessment framework.
- Patients with spinal cord injuries should be managed in specialised tertiary centres as part of regional trauma networks.
- All hospitals managing patients with spinal cord injury should use protocols for the multidisciplinary care of these complex patients.

Curriculum checklist

This article addresses the following requirements from the general internal medicine training curriculum:

- Managing medical problems in patients in other specialties and special cases
- Managing a multidisciplinary team including effective discharge planning
- Delivering effective resuscitation and managing the acutely deteriorating patient.

Conflicts of interest
The authors declare no conflicts of interest.

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