

11. Spinal cord injury

Introduction

Always think spinal (vertebral) and/or spinal cord injury (SCI) in children with trauma. Remember SCIWORA – cord injury may be present without abnormalities on routine X-rays.

All children with possible spinal cord injury in Yorkshire & Humber should be referred to the Major Trauma Centre (MTC). The MTC will organise registration on a national database www.scireferrals.nhs.uk and appropriate multi-disciplinary input as required from intensive care, neurosurgery, orthopaedics, urology, respiratory and rehabilitation.

Think Spinal Cord Injury if

- A child complains of back or neck pain and appears to be guarding their back or neck
- The child complains of sensory changes or loss such as numbness or tingling
- The child is unable to pass urine
- The child has difficulty moving any part of their arms or legs
- There is pre-existing pathology

In general, spinal injuries should be suspected in all children who have been involved in:

- A road traffic accident
- A fall or jump from a height
- An accident resulting in impact or crush injuries
- An accident resulting in multiple trauma
- An accident resulting in the patient losing consciousness

Following an injury, the potential for a spinal cord injury to exist must be considered. Children may present with full movement and sensation of all four limbs; however, they may have a vertebral fracture and, if handled incorrectly, the spinal cord may be damaged and the results could be devastating.

Immediate management of traumatic SCI (actual or suspected)

Approach to initial assessment

Initial assessment is the standard c-ABC approach as per APLS / ATLS guidelines :

- **C**ontrol massive haemorrhage
- **A**irway with cervical spine control
- **B**reathing with ventilation support
- **C**irculation with haemorrhage control
- **D**isability – AVPU, posture and pupils
- **E**xposure with temperature control

c-ABC is the priority, with protection of any potential unstable fracture. The secondary survey is of greater importance in a patient with impaired sensation.

Spinal Shock

At the acute stage there may be total, flaccid paralysis of all skeletal muscle and loss of all spinal reflexes below the level of the lesion. This is referred to as spinal shock. It may last from several hours to several weeks depending on the severity.

Airway and Cervical Spine Control

In any injury the airway can become compromised. The spine should be kept in alignment *at all times*.

- Place the patient in the neutral supine position
- Look for evidence of airway obstruction or compromise
- Use a jaw thrust NOT head tilt / chin lift
- Minimise any movement of the cervical spine
- Consider use of an airway adjunct (NOT nasopharyngeal in head injured patients)
- Seek early help from the most experienced anaesthetist available
- Refer to the section on [emergency anaesthesia](#).

Breathing

The risk of deteriorating respiratory function is extremely high. In cervical and high thoracic injuries the nerves to the intercostal muscles are paralysed, reducing the ability to breathe effectively. In high cervical lesions the diaphragm may also be affected (C3/4/5). In these high lesions the most affected function is coughing. Patients with very high lesions are breathing with the diaphragm only and have no effective cough at all.

- Look at the rate and depth of respirations
- Look for shallow or abdominal breathing, asymmetry, or paradoxical breathing
- Slowing down respirations, grunting and desaturation in oxygen are worrying signs
- There may be evidence of aspiration or consolidation
- Have a low threshold for intubation and ventilation prior to transport to the MTC

Circulation

Neurogenic (spinal) shock is the body's response to the sudden loss of sympathetic control. It occurs in cervical and high thoracic lesions (above T6). Incomplete injuries may not display these signs. Due to lack of vasomotor control significant hypotension results. Bradycardia occurs as a result of unopposed effects of the vagus nerve. A lower mean blood pressure may be compatible with good urinary output and cannot be used as sole indicator of perfusion. However, hypovolaemic shock may also be present and other injuries may escape detection in the cord injured patient with sensory deprivation.

- Keep patient supine and monitor for hypotension and bradycardia
- Abnormal vaso-vagal response can occur through stimulation such as rapid changes in body positioning, i.e. log rolling quickly, tracheal suctioning, or passing a gastric tube.

- Maintain a normotensive mean pressure and an adequate urinary output for age and size (2 ml/kg/h for infants <1 year old, 1 ml/kg/h for children 1-12 years old, and 0.5ml/kg/h over 12 years old)
- Administer IV bolus fluids as needed plus maintenance. However be careful not to give too much fluid - this may precipitate cardiac failure and pulmonary oedema.
- Inotropes may be necessary to maintain the blood pressure
- CVP monitoring can be helpful
- Problematic bradycardia usually resolves over a few days. Pacemakers can cause management complications in the long term and should be avoided where possible
- There is a high incidence of cardiac contusion in patients with thoracic injuries with a potential for arrhythmias

Neurological Assessment (all cases)

Careful neurological assessment is *absolutely essential* for patient with spinal cord pathology. This is very difficult to perform in young children, and in any child when frightened and distressed.

In the first hours and days following injury the neurological level may change. An extension of the lesion by one or even two levels may be observed and it is critical that any change is monitored, to prevent any avoidable deterioration of neurological deficit. Although the gold standard expects neurological observations should be performed at two hourly intervals this is not feasible in young children. Concentrating on a few key points may give better results in combination with attempting to establish level with MRI scan.

At the site of cord injury there will be a zone of critical ischaemia. This zone may expand with poor oxygen saturation or poor perfusion. Patients with high lesions have poor autonomic vascular control and postural hypotension may be severe and significant. In the acute phase of the injury, postural hypotension may expand the zone of critical ischaemia.

Neurological examination should be undertaken by an experienced member of the medical team using the standardised examination recording chart published by the American Spinal Injuries Association ([ASIA Chart, Appendix 6](#)). Mark the sensory level on the patient as this is very useful in subsequent review. A change from an accurately recorded level may allow diagnosis of potential complications, e.g., epidural haematoma, over distraction when using skull traction. In the period of spinal shock formal classification of the injury is not possible.

Sacral segments have great prognostic significance for recovery as well as bowel and bladder management. Careful examination of perianal sensation, deep anal pressure, tone, and voluntary anal contraction is important but not usually possible in younger children and has to be considered for each child as the information may be extremely unreliable. If not performed the reason for this should be documented for each individual.

Spinal surgery may be contemplated. If spinal surgery is undertaken the ASIA Chart must be carefully completed both prior to surgery and post-operatively. Remember this is, however, less reliable in the presence of spinal shock.

Steroid Therapy Post Injury

There have been no clinical trials in children and no evidence that high dose steroids have any place in the management of acute traumatic spinal injured children.

Transfer to the Regional Spinal Centre

Decisions regarding transfer should be made by senior staff in both the transferring and receiving paediatric units. The Major Trauma Networks have agreed an **immediate transfer** policy regarding patient referrals to the Major Trauma Centre – see [Section 3](#).

The referring team may require clinical advice regarding stabilization and transfer. This may be facilitated by Embrace via the conference call system. When transport is provided by the referring hospital team the principles of safe transfer should be followed – please refer to [Section 19](#).

Special considerations in SCI:

- The transferring team should have the skills and equipment to manage deterioration on route
- A properly immobilised spinal injured patient can be transferred at normal road speeds - sudden acceleration and deceleration should be avoided
- Pay attention to pressure areas and skin care

Handling the Child and Young Person with a traumatic SCI

Patients are usually transferred into Emergency Departments on a scoop stretcher. Transfer onto an appropriate support surface **MUST** be undertaken at the earliest possible opportunity. In the Emergency Department this will be onto a sheet over a vacuum mattress on a standard padded tipping trolley. Ensure sufficient personnel are available for continued maintenance of spinal alignment. Ensure all head huggers and straps are removed before transfer.

No log roll is required to be removed from a scoop stretcher as the two sides can be split and removed laterally.

When moving a child, avoid shearing their skin against the underlying surface.

If a patient presents on a long spinal board extrication device, to ensure that total protection and alignment of the spine is maintained, to allow the patient to be moved, the recommended technique which can be applied is the logroll. It is vital that staff are trained in the technique of log rolling and that the person at the head end takes the lead. The log roll may be used in combination with Patslide and sliding sheets.

RCEM has issued a position statement referencing both APLS and NICE guidance:

- In conscious children, use manual in-line stabilization (MILS) whenever possible
- In unconscious children, or when MILS cannot be maintained, immobilisation should be with a properly fitting collar, blocks and tape
- If no properly fitting collar is available then blocks or rolled blankets should be used to provide

an immobilisation device.

Patients with acute spinal cord injury must be nursed flat initially. Elevation of the whole body up to 15 degrees may assist ventilation. Pressure reducing dynamic air mattresses are contraindicated in unstable injuries and turning regime should be initiated to prevent pressure ulceration.

Skull traction in children must be reviewed on an individual case basis as in young children the majority of injuries are unstable in traction. Children cannot be transferred in traction.

Imaging

Most paediatric major trauma patients do not require spinal imaging of any form. In cases where risk of or clinical suspicion for vertebral fracture exists, regional Trauma Network guidance should be followed on which patients require spinal imaging – see [Section 17](#).

Spinal Surgery

Spinal surgery comprises two components; decompression of the neural tissues and reduction and stabilisation of the spine. Conservative management is also appropriate in some injuries. The role of decompression in the management of patients with spinal cord injury has yet to be fully determined. The only definite indication for decompression and stabilisation is progressive neurological deterioration. Benefits and risks of surgery should be evaluated and discussed at the specialist centre by an experienced spinal surgeon.

Appendix 6

Patient Name _____

Examiner Name _____ Date/Time of Exam _____

ISC

STANDARD NEUROLOGICAL CLASSIFICATION OF SPINAL CORD INJURY

MOTOR

KEY MUSCLES (scoring on nervous side)

<table border="0"> <tr><td>C5</td><td>R</td><td><input type="checkbox"/></td><td>Elbow flexors</td></tr> <tr><td>C6</td><td>L</td><td><input type="checkbox"/></td><td>Wrist extensors</td></tr> <tr><td>C7</td><td></td><td><input type="checkbox"/></td><td>Elbow extensors</td></tr> <tr><td>C8</td><td></td><td><input type="checkbox"/></td><td>Finger flexors (distal phalanx of middle finger)</td></tr> <tr><td>T1</td><td></td><td><input type="checkbox"/></td><td>Finger abductors (proximal finger)</td></tr> </table>	C5	R	<input type="checkbox"/>	Elbow flexors	C6	L	<input type="checkbox"/>	Wrist extensors	C7		<input type="checkbox"/>	Elbow extensors	C8		<input type="checkbox"/>	Finger flexors (distal phalanx of middle finger)	T1		<input type="checkbox"/>	Finger abductors (proximal finger)	<table border="0"> <tr><td>C2</td><td>R</td><td><input type="checkbox"/></td><td>Light Touch</td></tr> <tr><td>C3</td><td>L</td><td><input type="checkbox"/></td><td>Light Touch</td></tr> <tr><td>C4</td><td></td><td><input type="checkbox"/></td><td>Light Touch</td></tr> <tr><td>C5</td><td></td><td><input type="checkbox"/></td><td>Light Touch</td></tr> <tr><td>C6</td><td></td><td><input type="checkbox"/></td><td>Light Touch</td></tr> <tr><td>C7</td><td></td><td><input type="checkbox"/></td><td>Light Touch</td></tr> <tr><td>C8</td><td></td><td><input type="checkbox"/></td><td>Light Touch</td></tr> <tr><td>T1</td><td></td><td><input type="checkbox"/></td><td>Light Touch</td></tr> <tr><td>T2</td><td></td><td><input type="checkbox"/></td><td>Light Touch</td></tr> <tr><td>T3</td><td></td><td><input type="checkbox"/></td><td>Light Touch</td></tr> <tr><td>T4</td><td></td><td><input type="checkbox"/></td><td>Light Touch</td></tr> <tr><td>T5</td><td></td><td><input type="checkbox"/></td><td>Light Touch</td></tr> <tr><td>T6</td><td></td><td><input type="checkbox"/></td><td>Light Touch</td></tr> <tr><td>T7</td><td></td><td><input type="checkbox"/></td><td>Light Touch</td></tr> <tr><td>T8</td><td></td><td><input type="checkbox"/></td><td>Light Touch</td></tr> <tr><td>T9</td><td></td><td><input type="checkbox"/></td><td>Light Touch</td></tr> <tr><td>T10</td><td></td><td><input type="checkbox"/></td><td>Light Touch</td></tr> <tr><td>T11</td><td></td><td><input type="checkbox"/></td><td>Light Touch</td></tr> <tr><td>T12</td><td></td><td><input type="checkbox"/></td><td>Light Touch</td></tr> <tr><td>L1</td><td></td><td><input type="checkbox"/></td><td>Light Touch</td></tr> <tr><td>L2</td><td></td><td><input type="checkbox"/></td><td>Light Touch</td></tr> <tr><td>L3</td><td></td><td><input type="checkbox"/></td><td>Light Touch</td></tr> <tr><td>L4</td><td></td><td><input type="checkbox"/></td><td>Light Touch</td></tr> <tr><td>L5</td><td></td><td><input type="checkbox"/></td><td>Light Touch</td></tr> <tr><td>S1</td><td></td><td><input type="checkbox"/></td><td>Light Touch</td></tr> <tr><td>S2</td><td></td><td><input type="checkbox"/></td><td>Light Touch</td></tr> <tr><td>S3</td><td></td><td><input type="checkbox"/></td><td>Light Touch</td></tr> <tr><td>S4-5</td><td></td><td><input type="checkbox"/></td><td>Light Touch</td></tr> </table>	C2	R	<input type="checkbox"/>	Light Touch	C3	L	<input type="checkbox"/>	Light Touch	C4		<input type="checkbox"/>	Light Touch	C5		<input type="checkbox"/>	Light Touch	C6		<input type="checkbox"/>	Light Touch	C7		<input type="checkbox"/>	Light Touch	C8		<input type="checkbox"/>	Light Touch	T1		<input type="checkbox"/>	Light Touch	T2		<input type="checkbox"/>	Light Touch	T3		<input type="checkbox"/>	Light Touch	T4		<input type="checkbox"/>	Light Touch	T5		<input type="checkbox"/>	Light Touch	T6		<input type="checkbox"/>	Light Touch	T7		<input type="checkbox"/>	Light Touch	T8		<input type="checkbox"/>	Light Touch	T9		<input type="checkbox"/>	Light Touch	T10		<input type="checkbox"/>	Light Touch	T11		<input type="checkbox"/>	Light Touch	T12		<input type="checkbox"/>	Light Touch	L1		<input type="checkbox"/>	Light Touch	L2		<input type="checkbox"/>	Light Touch	L3		<input type="checkbox"/>	Light Touch	L4		<input type="checkbox"/>	Light Touch	L5		<input type="checkbox"/>	Light Touch	S1		<input type="checkbox"/>	Light Touch	S2		<input type="checkbox"/>	Light Touch	S3		<input type="checkbox"/>	Light Touch	S4-5		<input type="checkbox"/>	Light Touch
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UPPER LIMB TOTAL (MAXIMUM) (25) (25) = (50)

LOWER LIMB TOTAL (MAXIMUM) (25) (25) = (50)

Voluntary anal contraction (Yes/No)

SENSORY

KEY SENSORY POINTS

0 = absent
1 = impaired
2 = normal
NT = not testable

Any anal sensation (Yes/No)

PIN PRICK SCORE (max: 112)

LIGHT TOUCH SCORE (max: 112)

TOTALS (MAXIMUM) (58) (58) = (58)

Comments:

NEUROLOGICAL LEVEL (The most caudal segment with normal function)

R	L	<input type="checkbox"/>	Sensory
R	L	<input type="checkbox"/>	Motor

COMPLETE OR INCOMPLETE? (Incomplete - Any sensory or motor function in S4-S5)

ASIA IMPAIRMENT SCALE

R	L	<input type="checkbox"/>	Sensory
R	L	<input type="checkbox"/>	Motor

ZONE OF PARTIAL PRESERVATION (Caudal extent of partially preserved segments)

R	L	<input type="checkbox"/>	Sensory
R	L	<input type="checkbox"/>	Motor

Muscle Function Grading

- 0 = total paralysis
- 1 = palpable or visible contraction
- 2 = active movement, full range of motion (ROM) with gravity eliminated
- 3 = active movement, full ROM against gravity
- 4 = active movement, full ROM against gravity and moderate resistance in a muscle specific position
- 5 = (normal) active movement, full ROM against gravity and full resistance in a functional muscle position expected from an otherwise unimpaired person
- 5* = (normal) active movement, full ROM against gravity and sufficient resistance to be considered normal if identified inhibiting factors (i.e. pain, disuse) were not present
- NT = not testable (i.e. due to immobilization, severe pain such that the patient cannot be graded, amputation of limb, or contracture of > 50% of the normal ROM)

Sensory Grading

- 0 = Absent
- 1 = Altered, either decreased/impaired sensation or hypersensitivity
- 2 = Normal
- NT = Not testable

When to Test Non-Key Muscles:

In a patient with an apparent AIS B classification, non-key muscle functions more than 3 levels below the motor level on each side should be tested to most accurately classify the injury (differentiate between AIS B and C).

Movement	Root level
Shoulder: Flexion, extension, abduction, adduction, internal and external rotation	C5
Elbow: Supination	
Elbow: Pronation	C6
Wrist: Flexion	
Finger: Flexion at proximal joint, extension.	C7
Thumb: Flexion, extension and abduction in plane of thumb	
Finger: Flexion at MCP joint	C8
Thumb: Opposition, adduction and abduction perpendicular to palm	
Finger: Abduction of the index finger	T1
Hip: Adduction	L2
Hip: External rotation	L3
Hip: Extension, abduction, internal rotation	L4
Knee: Flexion	
Ankle: Inversion and eversion	
Toe: MP and IP extension	
Hallux and Toe: DIP and PIP flexion and abduction	L5
Hallux: Adduction	S1

ASIA Impairment Scale (AIS)

A = Complete. No sensory or motor function is preserved in the sacral segments S4-5.

B = Sensory Incomplete. Sensory but not motor function is preserved below the neurological level and includes the sacral segments S4-5 (light touch or pin prick at S4-5 or deep anal pressure) AND no motor function is preserved more than three levels below the motor level on either side of the body.

C = Motor Incomplete. Motor function is preserved at the most caudal sacral segments for voluntary anal contraction (VAC) OR the patient meets the criteria for sensory incomplete status (sensory function preserved at the most caudal sacral segments (S4-S5) by LT, PP or DAP), and has some sparing of motor function more than three levels below the ipsilateral motor level on either side of the body.
(This includes key or non-key muscle functions to determine motor incomplete status.) For AIS C – less than half of key muscle functions below the single NLI have a muscle grade \geq 3.

D = Motor Incomplete. Motor incomplete status as defined above, with at least half (half or more) of key muscle functions below the single NLI having a muscle grade \geq 3.

E = Normal. If sensation and motor function as tested with the ISNCSCI are graded as normal in all segments, and the patient had prior deficits, then the AIS grade is E. Someone without an initial SCI does not receive an AIS grade.

Using ND: To document the sensory, motor and NLI levels, the ASIA Impairment Scale grade, and/or the zone of partial preservation (ZPP) when they are unable to be determined based on the examination results.

Steps in Classification

The following order is recommended for determining the classification of individuals with SCI.

1. Determine sensory levels for right and left sides.

The sensory level is the most caudal, intact dermatome for both pin prick and light touch sensation.

2. Determine motor levels for right and left sides.

Defined by the lowest key muscle function that has a grade of at least 3 (on supine testing), providing the key muscle functions represented by segments above that level are judged to be intact (graded as a 5).

Note: In regions where there is no myotome to test, the motor level is presumed to be the same as the sensory level, if testable motor function above that level is also normal.

3. Determine the neurological level of injury (NLI)

This refers to the most caudal segment of the cord with intact sensation and antigravity (3 or more) muscle function strength, provided that there is normal (intact) sensory and motor function rostrally respectively.
The NLI is the most cephalad of the sensory and motor levels determined in steps 1 and 2.

4. Determine whether the injury is Complete or Incomplete.

(i.e. absence or presence of sacral sparing)
If voluntary anal contraction = **No** AND all S4-5 sensory scores = 0 AND deep anal pressure = **No**, then injury is **Complete**.
Otherwise, injury is **Incomplete**.

5. Determine ASIA Impairment Scale (AIS) Grade:

Is injury Complete? **NO** \downarrow **YES**, AIS=A and can record ZPP (lowest dermatome or myotome on each side with some preservation)

Is injury Motor Complete? **NO** \downarrow **YES**, AIS=B

(No=voluntary anal contraction OR motor function more than three levels below the motor level on a given side, if the patient has sensory incomplete classification)

Are at least half (half or more) of the key muscles below the neurological level of injury graded 3 or better?

NO \downarrow **AIS=C** **YES** \downarrow **AIS=D**

If sensation and motor function is normal in all segments, AIS=E

Note: AIS E is used in follow-up testing when an individual with a documented SCI has recovered normal function. If at initial testing no deficits are found, the individual is neurologically intact; the ASIA Impairment Scale does not apply.

