SPINAL INJURY MODULE

The majority of spinal injuries are a result of MVA, falls or sports-related injuries. Alcohol intoxication is frequently a contributing factor.

Fortunately serious spinal injury is relatively uncommon. The incidence of C Spine injury is approximately 1.5 - 4% in patients with major trauma. The incidence of thoracolumbar spine injury is approximately 4 - 5% in patients with major trauma. Spinal cord injuries occur in 10-20% of patients with spinal fractures, and nearly 50% of patients with cervical vertebral fractures.

Patients with significant spinal injuries frequently sustain trauma to other parts of the body, commonly the head (approx. 23% of patients with a spinal injury), extremities (26%), chest (20%), abdomen (6%), pelvis (3%) and face (1.3%).

Most spinal column injury in adult patients occurs between C3-C7 with 65% of all fractures, most commonly between C5-6, and 75% of all dislocations, most commonly between C6-7. If a fracture is found at one level it is imperative to go looking for a fracture at another level as multiple fractures occur in 8-10% of patients in whom a vertebral fracture is identified.

Spinal cord injury (SCI) can lead to substantial morbidity and disability.

Primary Injury
- focal cord compression
- laceration
- traction
- transection
- ischaemia

Secondary injury
- hypoxia
- hypotension
- inappropriate manual handling (uncommon as the forces applied when handing the patient are much less than those which caused the injury in the first place)

Distribution of spinal cord injury:
- 60% cervical (most commonly at C5-7)
- 30% thoracic
- 4% lumbar
- 2% sacral

ASSESSMENT OF SPINAL CORD INJURIES

Goals of assessment in patients with a possible spinal injury:
- Identify life threats
- Identify patients with spinal column and spinal cord injuries
- Identify patients who may have their spine cleared clinically without additional imaging, and
- Determine the most appropriate imaging in situations where the spine is not able to be cleared clinically
1. Rapidly identify life threatening complications

**AIRWAY & BREATHING**

- An injury above the innervation of the diaphragm (C3,4,5) has implications for ventilation requirement
  - 50% of patients with a C5 SCI require short term mechanical ventilation
  - Most patients with a C4 SCI and all with a C3 SCI need mechanical ventilation, with 50% of C3 quadriplegics being permanently ventilator dependent

**CIRCULATION**

- Neurogenic shock can occur with SCI above T6
- Severe bradycardia & asystole can occur on tracheal suctioning and turning due to unopposed vagal activity

2. Determine motor and sensory level bilaterally

- Use the ASIA assessment chart to assist
- Assess sensory level using light touch and pin prick
- A motor score of 3 or more is deemed “normal”

- Neurological sensory level is the most caudal level with intact sensation.
  The neurological motor level is the most caudal level with a motor score of 3 or more. The overall Neurological Level of Injury is the most caudal level with intact sensation and a motor score of 3 or more bilaterally.
- Complete v incomplete
  - Complete – absence of sensory and motor function at S4/5
  - Incomplete – partial preservation of sensory and / or motor function at S4/5

**ASIA Impairment Scale (AIS):**

**AIS Score**

<table>
<thead>
<tr>
<th>AIS</th>
<th>Function</th>
<th>Score Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Complete</td>
<td>No Sensory or motor function at S4/5</td>
</tr>
<tr>
<td>B</td>
<td>Sensory Incomplete</td>
<td>Sensation below the neurological level including S4/5 but no motor function more than 3 levels below the motor level and at S4/5</td>
</tr>
<tr>
<td>C</td>
<td>Motor Incomplete</td>
<td>More than half of the key muscles below the neurological level of injury have a grade less than 3</td>
</tr>
<tr>
<td>D</td>
<td>Motor Incomplete</td>
<td>Half or more of the key muscles below the neurological level of injury have a grade greater than or equal to 3</td>
</tr>
<tr>
<td>E</td>
<td>Normal</td>
<td>All components of the exam are normal</td>
</tr>
</tbody>
</table>

- Zone of Partial Preservation – can only be applied when there is a complete injury and refers to those dermatomes / myotomes below the level of injury that have some function (sensory score < 2, motor score < 3)

3. **Determine if there is autonomic involvement**

<table>
<thead>
<tr>
<th>Autonomic effects of spinal cord injury</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Cardiovascular system</strong></td>
</tr>
<tr>
<td><strong>Gastrointestinal system</strong></td>
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<tr>
<td><strong>Genitourinary</strong></td>
</tr>
<tr>
<td><strong>Thermoregulatory</strong></td>
</tr>
</tbody>
</table>
4. **Determine if there is a cord syndrome**

**SPINAL CORD SYNDROMES**

- **Dorsal column** (touch, vibration)
- **Corticospinal tract** (upper motor)
- **Anterior horn** (lower motor)
- **Spinothalamic tract** (pain, temperature)

**Complete cord transection**: bilateral paralysis and anaesthesia

**Central cord syndrome**: disproportionate paralysis in arms compared to legs

**Hemi-cord syndrome**: ipsilateral motor and proprioceptive loss with contralateral pain and temperature

**Anterior cord syndrome**: bilateral paralysis, loss of pain and temperature, preservation of proprioception and light touch

5. **Identify co-morbid traumatic injuries**

- Head injuries occur in 25% of patients with spinal injuries
- Multiple vertebral fractures are found in 8-10% of patients with a single vertebral fracture

**CLINICAL CLEARANCE OF THE CERVICAL SPINE**

(See Appendix 1 for the PAH Cervical Spine Pathway)

Unrecognised cervical injury can produce serious morbidity and disability.

Among some clinicians, fear of failing to diagnose such injuries has led to a very liberal use of imaging in blunt trauma. US figures from the past decade estimate that
800,000 people undergo C-spine imaging at a cost of $180 million – with a 2% yield for positive scans.\(^1\)

With this in mind clinical decision rules were formulated in an attempt to reduce the volume of radiological imaging.

Care needs to be taken in the application of decision rules however. They are not a substitute for clinical judgment.

**NEXUS**\(^7\)

NEXUS was a multicentre, prospective, observational study. All comers with blunt trauma who received C-spine plain films were included. In total 34069 patients (including paediatric patients) were studied.

The decision instrument required patients to meet 5 criteria to be classified as having low probability of injury.

- The absence of posterior midline cervical tenderness
- No evidence of intoxication
- No focal neurology
- Normal level of alertness
- No distracting injury

2.4% of the study population had radiographically documented C-spine injury. The sensitivity of the decision rule was 99%, the conclusion being that those people with a low probability of injury can forego imaging. In this study 13% of participants were low probability of serious injury and would have avoided imaging if NEXUS was applied.

**Canadian C-Spine Rule**\(^8\)

This was a prospective cohort Canadian study published in 2001\(^2\). 8924 adult patients were enrolled with blunt trauma to the head or neck. They all had normal vital signs and a GCS of 15.

In this population, clinically important C-spine injury (fracture, dislocation or ligamentous injury) occurred in 1.7% patients. From this data a clinical decision rule was derived with 100% sensitivity for clinically important C-Spine injury.
The potential radiology ordering rate using the Canadian C-spine Rule in this study was 58.2% of patients presenting with blunt trauma to head or neck.

There is an article published in the NEJM comparing the two algorithms which suggests the Canadian approach is superior to its American counterpart\(^1\). The paper
quotes 99.4% v 90.7% sensitivity and lower radiology ordering rates with the Canadian C-spine Rule. This paper however was written by the same people who created the Canadian rule and the conclusions are less convincing if you look at the paper critically. Both decision tools have similar ordering rates – roughly 60%. The Canadian Rule has a significantly lower inter-rater reliability – in keeping with it being a more complex algorithm. And somewhat surprisingly in 10% of cases physicians didn’t apply the Canadian C-spine Rules correctly – omitting the 3rd step and testing neck ROM.

All patients who cannot be clinically cleared must undergo radiographic evaluation. Traditionally, and as supported by Nexus and CCR, radiologic evaluation has commenced with plain films (i.e. AP, Lateral, PEG, Swimmer’s). There has been extensive discussion over the past few years regarding the best approach to initial imaging of the C-spine. There has been a strong push for the use of CT rather than plain films, particularly for patients at high risk of c-spine injury given the high sensitivity and specificity of CT (approaching 100%) for clinically significant injury. In the obtunded patient, a negative CT scan has been shown to exclude clinically significant C-spine injury (< 1%) with MRI not contributing additional information, especially when gross movement of all limbs has been observed. The Eastern Association for the Surgery of Trauma outline a worst case 9% cumulative literature incidence of stable injuries after a negative high-quality CT c-spine with a negative predictive value of finding an unstable c-spine fracture approaching 100%. Thus the risk-benefit ratio does not appear to favour MRI in obtunded patients with a normal CT c-spine.

When to proceed to advanced imaging of the C-spine:

CT:

- Bony injury is best visualised by CT imaging
- The obtunded / intubated multi-trauma patient
- When C-spine plain films are abnormal or inadequate
- When the patient has significant pain or limited ROM even with normal plain imaging
- When the patient with concerns for a C-spine injury is having a CT of another body region, most commonly the head

When do you proceed to MRI in the ED?

- All patients with suspected cord injury in the setting of trauma – without adequate delineation on CT - should have MRI imaging of their spine
- Consideration should be given to MRI for suspected ligamentous or disc injury – i.e. ongoing significant midline or radicular pain / neurology with a normal CT

THORACO-LUMBAR SPINE

(See Appendix 2 for the PAH Thoraco-lumbar Spine Pathway)

The incidence rate of TL spine fractures in blunt trauma is approximately 5%. Approximately 50% of all spinal fractures occur in the TL region and 19-50% of these fractures are associated with neurology. A delay in diagnosis of these patients may result in up to an eightfold increase in neurology.

While TL fractures may be asymptomatic, the literature supports the notion that a patient who has a reliable examination (is neurologically intact with a normal GCS, is not intoxicated, has no midline tenderness and no major distracting injury) can be clinically cleared. Judgment needs to be used when considering whether patients should be screened based on mechanism alone and what constitutes a distracting injury.
In light of the above, screening for TL injuries is considered when:

- There is a high risk mechanism
  - MVA > 60 km/hr
  - MBA / cyclist > 30 km/hr
  - Paedestrian impact > 30 km/hr
  - Fall > 3m
  - Vehicle rollover
  - Fatality in the same vehicle
  - Ejection from vehicle
  - Explosion

- Low risk clinical identifiers:
  - Midline tenderness
  - Altered GCS
  - Intoxication
  - Major distracting injuries

- A c-spine fracture has been identified due to the high risk of multi-level fractures

**What imaging is best for thoracolumbar spine fractures?**

Plain films may be used when patients meet the criteria for screening as per above.

CT scanning is more sensitive and specific (approaching 100% for reformatted images with 3mm slices) compared to plain films (sens for diagnosing unstable fractures ranging from 33-77%).

- The obtunded / intubated multi-trauma patient
- Abnormal neurological exam suggestive a TL spine injury
- Haematoma or midline step
- Abnormal plain films
- When the chest, abdomen and pelvis are being imaged allowing reformatting of TL spine views

MRI of the TL spine is indicated when there is a suspected spinal cord injury, ligamentous injury, cord or epidural haematoma, disc injury or facet joint involvement.

**MANAGEMENT OF SPINAL INJURIES**

The priority in managing the patient with spinal injuries is to prevent secondary spinal cord injury while facilitating early intervention of the primary insult.

- Triage to resuscitation area
- **Full spinal immobilisation**
- Comprehensive non-invasive monitoring
- **Urgent orthospinal/neurosurgical referral for intervention if indicated**

**AIRWAY & BREATHING**

- Ensure adequate ventilation – high cervical injuries affecting diaphragmatic innervation will likely require mechanical ventilation in the short term
CIRCULATION

- Correct hypovolaemia
- Volume load to maintain MAP 70 mmHg
- Inotrop support may be necessary in the setting of neurogenic shock after haemorrhage has been excluded – noradrenaline is first line
- Place an arterial line and central venous line if inotropic support required

SPECIFIC

- Full spinal immobilisation
  - Manage cervical spine injuries in soft collar
  - Log roll and pat slide in the department
  - Engrit bed
- Steroids in acute cord injury
  - Controversial practice with inconclusive evidence base\(^\text{17}\)
  - Guided by treating spinal team – however the practice is not supported by the PAH
- ADT prophylaxis and cephalozolin 1g for penetrating wounds

SUPPORTIVE

- Keep warm
- Place NGT
- Place IDC
- Ensure adequate analgesia
- Chart prophylactic antiemetics
- Ensure Pressure ulcer prevention
- Maintenance fluids of normal saline 0.9% 100mL/hr
- Update family where possible and document contact details in chart

DISPOSITION

- All ventilated patients, or those on inotropic therapy are managed in the ICU
- Other suitable spinal injured patients are managed in the trauma HDU or orthospinal ward

RSI likely indicated if:

- GCS < 9 or combativeness preventing imaging
- Ventilatory failure with high cervical cord injury
- Multi-system injuries requiring intubation for overall stabilisation

Ventilator settings
- FiO\(_2\) initially set at 100%
- V\(_T\) of 8mL/kg
- Rate to achieve pCO\(_2\) 35-40mmHg
- PEEP ≥ 5cm H\(_2\)O
PAEDIATRIC SPINAL INJURY AND SCIWORA

INTRODUCTION

Paediatric spinal injuries are uncommon. They are usually secondary to motor vehicle accidents and to a lesser extent falls and sporting injuries. As in adults they are commonly associated with concurrent head injuries. Spinal cord injury is very uncommon with the incidence of spinal cord injury in spine-injured children is 1%.\(^\text{18}\)

ANATOMICAL CONSIDERATIONS OF THE PAEDIATRIC SPINE\(^\text{19}\)

- Relative ligamentous laxity
- Shallow (relatively vertical) angulation of facet joints
- Immature development of neck musculature
- Incomplete ossification of vertebrae
- Disproportionately large head

Subsequently 60-80% of all paediatric spinal injuries are in the cervical region, particularly the upper cervical spine – with 80% occurring at C1-3 in children <8 yo.

The fulcrum of neck movement is at C2-3 in the infant, C3-4 at 6 yo and C5-6 at 8yo.

After 8 yo the injury pattern is similar to adults.

SCIWORA (Spinal Cord Injury Without Radiographic Abnormality)

SCIWORA refers to objective signs of spinal cord injury following trauma without any evidence of fracture or ligamentous injury on radiological imaging.

The phenomena was first reported in 1982 by Pang & Wilberger\(^\text{20}\) who also noted that delayed presentations with paralysis were occurring up to 4 days following injury. Its incidence has been reported between 1-10% of all spinal cord injuries in children. It is more common in children < 8yo with cervical spine injuries. The hypothesis behind the aetiology of SCIWORA is that of ligamentous laxity and bony immaturity allowing the transfer of forces through to the spinal cord resulting in myopathy without bony injury.

In modern times, SCIWORA has become a misnomer as most of these patients actually have a radiological abnormality on MRI. True SCIWORA is now exceedingly rare.\(^\text{19}\)

SPINAL IMMOBILISATION

Spinal immobilisation can be particularly difficult in smaller children and infants. Traditionally immobilisation has been performed with a rigid cervical collar and fixation to a spinal board with a head immobiliser and strapping. However this can lead to discomfort, distress, pressure areas and in some cases can worsen the initial injury with elevated ICP, the potential for airway obstruction and ventilatory compromise.\(^\text{18}\) Spinal boards need to be modified in children under 8 yo to prevent neck flexion with either an occipital recess or mattress padding.
A balance must be made between diminishing any secondary spinal injury and interfering with assessment and comfort of the child. Parents and carers should be encouraged to help in the process where feasible. Time kept on the spinal board must be limited to the shortest time possible.

Assessment of Possible C-Spine Injury in Children Suffering Blunt Trauma

The Queensland Paediatric Trauma Service has developed an evidence based pathway for assessing the c-spine of children involved in blunt trauma, based on the fact that serious cervical spine injury in blunt trauma is uncommon in the paediatric population (1% of all paediatric blunt trauma cases, incidence ranging from 0.4% in pre-school age to 2.5% in adolescents). The majority of these injuries are stable with only 1-5% requiring operative fixation. Imaging plays an important role in identifying injuries, but has an associated increased life-time risk of malignancy, albeit poorly defined. The PECARN group has identified 8 factors which associated with C-spine injury that form the basis for the clinical algorithm put forward by the Queensland Paediatric Trauma Service:
If a patient is having a CT for other injuries, then serious consideration should be given to concurrent CT of the spine.

FURTHER READING:


REFERENCES

6. The American Spinal Injury Association – website and education module
Appendix 1

Trauma Patients with suspected C-Spine Injury

- Any of the following present?
  - Marked Cervical tenderness on palpation
  - Fixed neurological deficit (e.g., paralysis, absent reflexes, sensory loss)
  - Intubation
  - Frank retropharyngeal abscess
  - Altered mental status (e.g., GCS < 15)

**NO** to ALL

- Tenderness or swelling requiring X-ray?
  - **NO**
    - CT cervical spine with sagittal reconstructions
  - **YES**
    - CT imaging normal
      - CT imaging normal
        - Neurological deficit including transient neuropathy suggestive of possible C-spine injury
      - Neurological deficit including transient weakness suggestive of possible C-spine injury
        - CT C-spine x-rays and/or flexion or extension views
          - If results adequate and normal:
            - CT C-spine with sagittal reconstructions
          - CT imaging normal
            - C-spine cleared
          - C-spine cleared
        - Image thoracic and lumbar spine
          - Consult on-call spine team
            - Depending on the grade of instability and general condition, the on-call spinal team will determine the need for:
              - Soft collar
              - Soft collar and sedation
              - Dual long traction
              - High thoracic brace
              - Surgical management

- **C-spine cleared**

- Neurological deficit including transient weakness suggestive of possible C-spine injury
  - CT imaging normal
    - No radiology necessary
      - C-spine cleared

- C-spine cleared

- Review of CT by treating consultant or radiologist

**PAH Department of Emergency Medicine Spinal Injury Module Revised 2016**