Spine Clearance in Polytrauma: Current Practice and Unique Challenges

MTC Teaching
Leeds, 21 October 2016
Nigel Gummerson
Consultant Orthopaedic Spinal Surgeon
Spine Clearance: Care of the Injured and Uninjured Spine

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Clinical assessment remains key

If the neck is clinically broken then it is until proven otherwise
Introduction

- Spinal Trauma
- Neurosurgical vs Orthopaedic
- Goals - Local and Patient based
- National Targets / Standards
Objectives

- Be able to assess, diagnose and manage spinal trauma patients (and those who turn out to have an uninjured spine)
Objectives

- To know of:
  - Mechanism of structural failure
  - Changing patterns of injury in the growing and ageing spine

- To know how:
  - Document spinal cord or nerve root injury
Objectives

- To know how:
- Use adjuncts to restrict spinal motion in paediatric and adult trauma patients
- Modified approach to restrict spinal motion in patients with fixed spinal deformity
- Apply structured assessment tools to clear or image the cervical spine
- To select appropriate method of initial imaging
BOAST 2: SPINAL CLEARANCE IN THE TRAUMA PATIENT

Background and Justification:
All patients involved in significant blunt trauma must be assumed to have an unstable injury to their spine; the incidence is approximately 2% and increases up to 34% in the unconscious patient. 50% of spinal injuries occur in the thoracic or lumbar spine; 20% at two levels. Immobilisation with full spinal precautions for prolonged periods creates difficulties in intensive care units. Spinal immobilisation is associated with pressure sores and pulmonary complications and is not recommended for more than 48 hours. Audits in the UK suggest poor implementation of spinal clearance policies. In the neck ligamentous disruption without a major bony injury may lead to instability. Recent comparative evaluations have shown that a modern helical CT scanning with reformatting can demonstrate the subtle abnormalities offering high sensitivity and specificity in detecting unstable injuries of the cervical spine. Plain radiographs are insensitive in the neck and the upper thoracic spine. MRI scanning has high sensitivity but only moderate specificity and is logistically difficult for ICU patients.

Inclusions:
- All trauma patients who are unconscious, unable to cooperate or who have distracting injuries that exclude reliable clinical assessment.

Exclusions:
- Children under the age of 16

Standards for Practice Audit:
1. A protocol for protection of the entire spine must be in place in all hospitals managing trauma patients at risk of spinal injury. This protection must be maintained from arrival until appropriate examination or investigations are completed and the spine cleared of injury.
2. Documentation of the neurological status must be made in all at-risk patients; any sign of spinal cord injury mandates urgent scanning.
3. A clinical examination of the whole spine should be documented.
4. If it is anticipated a patient will remain unconscious, unassessable or unreliable for clinical examination for more than 48 hours, radiological spinal clearance imaging should be undertaken.
5. For the cervical spine, the appropriate standard is a thin slice (2-3mm) helical CT scan from the base of the skull to at least T1 with both sagittal and coronal reconstructions; extending that scan to T4/5 overcomes the difficulties of imaging the upper thoracic spine.
6. It is recommended that this cervical spine CT scan be undertaken as a routine with the first CT brain scan in all head-injured patients who have an altered level of consciousness.
7. The remaining thoracic and lumbar spine may be adequately imaged either by AP and lateral plain radiographs or by sagittal and coronal reformatting of helical CT scans of the chest, abdomen and pelvis undertaken as part of a modern CT trauma series (<5mm slices).
8. A senior radiologist must report spinal clearance images prior to withdrawal of spinal protection precautions.
9. If a spinal injury is detected, a neurological assessment must be made, even if incomplete, and repeated regularly prior to urgent transfer to an appropriate spinal injury service.
10. MRI is the urgent investigation of choice for spinal cord injury.

Evidence Base:
Predominantly retrospective case series but with good expert reviews and an evolved multinational professional consensus over 15 years.

Limitations:
- There are insufficient series or tested protocols to recommend a policy in children.
- The place of MRI as a clearance tool for instability remains uncertain.
- There are practical issues with scanning ICU patients and high false positive rates for intervertebral disc and ligament abnormality.
BOAST 8: THE MANAGEMENT OF TRAUMATIC SPINAL CORD INJURY

Background and Justification:
Spinal cord injury resulting in neurological deficit is a rare but potentially devastating injury. Compromise to the spinal cord may be due to trauma, vascular injury or other disease process and can result in immediate or insidious onset of neurological symptoms including loss or reduction of voluntary motor function, sensory impairment, bowel or bladder dysfunction and loss of autonomic function. The incidence in the United Kingdom is estimated at 12-16 per million population with about 75% of cases due to trauma. Appropriate management from the time of diagnosis of cord injury has been shown to have significant effect on the long-term outcome for patients and reduce short and long-term complications.

Included Patients:
All patients with traumatic spinal cord injury resulting in complete or incomplete para- or tetraplegia. The audit standards apply to those with polytrauma and those with isolated spinal cord injuries but do not apply to patients with spinal column injury without cord involvement. These audit standards apply to adults and children.

Standards for practice audit:
1. All Major Trauma Centres and Trauma Units must have a named, linked Spinal Cord Injury Centre.
2. All hospitals within a major trauma network should have an agreed, common protocol for protecting the neck and spine together with an agreed, common protocol to exclude significant injury (clearance of the neck and spine eg BOAST-2).
3. Centres managing patients with spinal cord injury require 24-hour access to CT and MRI.
4. Clinical evaluation of injured patients must include appropriate and repeated examination of the peripheral nervous system which should be recorded in the medical notes on an ASIA chart in keeping with the International Standards for Neurological Classification in Spinal Cord Injury.
5. Protocols for resuscitation and acute management including skin care, gastric, bowel and bladder care and neuroprotection must be agreed with the linked Spinal Cord Injury Centre and available in all Emergency Departments that may receive patients with spinal cord injury.
6. Centres treating these injuries must have the capability of performing specialist spinal surgery within 4 hours of injury. For those requiring surgery, protocols for anaesthesia and spinal stabilisation must be agreed with the linked Spinal Cord Injury Centre.
7. Protocols for nursing, joint protection and therapy requirements must be agreed with the linked Spinal Cord Injury Centre.
8. Management of the spine must follow written, agreed protocols with the linked Spinal Cord Injury Centre, or alternatively the on call consultant at that centre should be contacted within 4 hours of injury.
9. An early, joint management plan must be formulated and recorded in the medical notes within 12 hours.
10. Once the patient is fit for transfer to a Spinal Cord Injury Centre this should take place within 24 hours, unless it is agreed that it is the patient’s best interest to remain in a Major Trauma Centre or Trauma Unit.
11. Spinal Cord Injury Centres should provide an outreach visit within 5 days of referral for patients unfit for transfer, and then follow-up contact (or visit) at least weekly until the patient is transferred.
12. Appropriately trained psychological support must be available for patients, family and carers.
13. All patients with new spinal cord injuries in England must have referral data submitted to the National Spinal Cord Injuries Database. The referral website is found at www.spinalcordinjury.nhs.uk

References:
References are found at www.spinalcordinjury.nhs.uk/docs.aspx
The Initial Management of Adults with Spinal Cord Injuries (May 2012)
ASIA Protocol
Professional consensus
Head injury

Triage, assessment, investigation and early management of head injury in children, young people and adults

Issued: January 2014

NICE clinical guideline 176

guidance.nice.org.uk/cg176

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How is the spine injured?
How is the spine injured? and what are the consequences?
Spinal Stability

- Maintain patterns of displacement under physiological load
- No initial / additional neurological deficit
- No major deformity
- No incapacitating pain

White and Panjabi
Squashing
(Compression)
Pulling (Tension)
Twisting
(Torsion and shear)
Injuries at junctional zones
What is the result of injury?

- Bone and joint injury
- Ligamentous injury
- Disc injury
- Cord / root injury
Describing Structural Failure
Milwaukee Brewer's Stadium
Describing Structural Failure

Crane smashed Debris everywhere
Describing Structural Failure

Crane unstable
Work stops
Describing Structural Failure

Workers killed and stadium damaged
Describing Structural Failure

Boom crumples
Steel cables snap
Describing Structural Failure

- Location of wreckage and debris
- Stability of structure
- Damage to surroundings
- Mechanism
Thoracolumbar Spine
Thoracolumbar fracture classification

Fracture Morphology

Spinal Stability

Neurological Injury

Biomechanics of Injury
Thoracolumbar fracture classification

- Fracture Morphology
- Spinal Stability
- Neurological Injury
- Biomechanics of Injury
Restriction of spinal motion
Initial Immobilisation

Transport

Ongoing Care
Initial Immobilisation

Transport

Ongoing Care
Initial Immobilisation

Transport

Ongoing Care

Rehabilitation
Immobilisation?
Neck motion in rigid collar

The Effect of Rigid Cervical Collar Height on Full, Active, and Functional Range of Motion During Fifteen Activities of Daily Living

Christopher P. Miller, BA; Jesse E. Bible, MD; Kola A. Jegede, BA; Peter G. Whang, MD; Jonathan N. Grauer, MD

Disclosures

Who should be immobilised

- Spinal immobilisation of all trauma patients with a cervical spine or spinal cord injury or with a mechanism of injury having the potential to cause cervical spinal injury is recommended.
Who should not be immobilised

- Patients with penetrating trauma
Who should not be immobilised

• Patients with penetrating trauma
• Structured assessment tools in pre-hospital care?
Problems in spinal immobilisation
Back to head offset

Case Study: A New Approach to Stabilization of the Cervical Spine in Infants
The Academy Today 2005 Vol 1, Jeffrey A. Nemeth
Day 1 - 09:00h

Male 66 years
Incomplete neurological injury at presentation
Day 1 - 10:30h

Supine in CT in cervical collar
Day 1 - 14:29h and 19:00h
Post Op
3 months
Structured Assessment

NEXUS vs CCR
NEXUS

- Focal Neurologic Deficit Present
- Midline Spinal Tenderness Present
- Altered Level of Consciousness Present
- Intoxication Present
- Distracting Injury Present

If yes to any question - image
Canadian C-Spine

- Exclusion
- Age <16
- GCS <15
- Unstable vital signs
- Paralysis
- Vertebral disease or previous surgery
Canadian C-Spine

• High Risk Factors?
  • Age >65
  • Dangerous Mechanism
  • Paraesthesia in extremities

If yes - image
Canadian C-Spine

- Low Risk Factors?
- Simple rear-end MVC
- Sitting position in ED
- Ambulatory at any time
- Delayed onset of pain
- Absent midline pain

If no - image
Canadian C-Spine

- Active range of motion
- Able to rotate 45 degrees to right and left

If unable - image
Imaging - Adults

- CT for:
  - GCS <13
  - Intubated
  - Inadequate plain films
  - Abnormal plain films
  - CT being done for head or multisystem trauma
Imaging - Children

Plain films vs CT vs MRI
Children presenting to the emergency department who have sustained a head injury.

Are any of the following risk factors present?

- GCS < 13 on initial assessment
- Intubation
- A definitive diagnosis of cervical spine injury is required urgently (e.g. before surgery)
- Other body areas are being scanned for head injury or multi-region trauma
- Focal peripheral neurological signs
- Paraesthesia in the upper or lower limbs

Perform CT cervical spine within 1 hour of risk factor being identified.

Is there neck pain or tenderness?

- Yes
- No

A provisional written radiology report should be made available within 1 hour of the CT taking place.

Was there a dangerous mechanism of injury (fall from >1 metre or 5 stairs; axial load to the head [e.g. Diving]; high-speed motor vehicle collision; rollover motor accident; ejection from a motor vehicle, bicycle collision)?

- Yes
- No

Perform three-view cervical spine X-rays within 1 hour of risk factor being identified.

Are any of the following low risk factors present?

- Involved in a simple rear-end motor vehicle collision
- Is comfortable in a sitting position in the emergency department
- Has been ambulatory at any time since injury
- No midline cervical tenderness
- Presents with delayed onset of neck pain

- No
- Yes

On assessment can the patient actively rotate the neck to 45 degrees to the left and right?

- No
- Yes

No imaging/further imaging required
Imaging - Children

Plain films vs CT vs MRI
Imaging

Radiologists!
Spinal Cord Injury
Cauda Equina & Nerve Root Injury
Increasing Severity of Injury

Severity

<table>
<thead>
<tr>
<th>Type</th>
<th>Group 1</th>
<th>Group 2</th>
<th>Group 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>A1</td>
<td>A2</td>
<td>A3</td>
</tr>
<tr>
<td>B</td>
<td>B1</td>
<td>B2</td>
<td>B3</td>
</tr>
<tr>
<td>C</td>
<td>C1</td>
<td>C2</td>
<td>C3</td>
</tr>
</tbody>
</table>
Neurological Injury

A - 14%, B - 32%, C - 55%

% with neurological injury

Fracture subtypes

A Type - 890 Cases
B Type - 145 Cases
C Type - 177 Cases

1
2
3
## Neurological Injury

<table>
<thead>
<tr>
<th></th>
<th>Frankle</th>
<th>ASIA</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>complete paralysis</td>
<td>&quot;complete&quot; no motor or sensory function in the sacral segments S4-S5</td>
</tr>
<tr>
<td>B</td>
<td>sensory function only below the injury level</td>
<td>sensory but not motor function below neurological level and includes the segments S4-S5</td>
</tr>
<tr>
<td>C</td>
<td>incomplete motor function below injury level</td>
<td>motor function is preserved below level and &gt;50% key muscles below the level have grade of less than 3</td>
</tr>
<tr>
<td>D</td>
<td>fair to good motor function below injury level</td>
<td>motor function is preserved below level and ≥50% key muscles below level have grade of 3 or more</td>
</tr>
<tr>
<td>E</td>
<td>normal function</td>
<td>&quot;normal&quot; motor and sensory scores are normal</td>
</tr>
</tbody>
</table>
INTERNATIONAL STANDARDS FOR NEUROLOGICAL CLASSIFICATION OF SPINAL CORD INJURY

MOTOR
KEY MUSCLES (scoring on reverse side)

R L
C5 Elbow flexors
C6 Wrist extensors
C7 Elbow extensors
C8 Finger flexors (distal phalanges of middle finger)
T1 Finger abductors (little finger)

UPPER LIMB TOTAL
(MAXIMUM) (25) (25) (50)

S1 Ankle plantar flexors

L4 Ankle dorsiflexors
L5 Long toe extensors
S1 Voluntary anal contraction

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

COMPLETENESS OF INJURY: Complete = Motor and Sensory loss at all levels below lesion.
Incomplete = Motor or sensory loss at any level below lesion.

SENSORY
KEY SENSORY POINTS

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

(DAP) Deep anal pressure (yes/No)
PIN Deep pin prick (max: 12)
LIGHT TOUCH SCORE (max: 12)

This form may be copied freely but should not be altered without permission from the American Spinal Injury Association.
Guidelines for initial spinal management of sedated and ventilated trauma patients

University Hospital Southampton NHS Foundation Trust

Full spinal precautions

Unknown mechanism of injury or fall greater than patient's own height or high energy impact or age >50

Hospital No: DOB: Surname: First name:

1. Full Trauma CT or CT Head & Cervical spine & thoracolumbar imaging

   - Yes
   - No

   - Full Trauma CT or CT Head & Cervical spine & thoracolumbar imaging
   - Bony injury of C-Spine

   Consultant radiologist report

   Report of spinal imaging to include:
   - any inadequacy of imaging
   - fracture ?alignment (dislocation)
   - soft tissue swelling indicative of spinal injury

   Signed: Print: Date: Time:

   - Cervical (C-spine) imaging report
   - Thoracolumbar (T&L spine) imaging report

   Consultant name:

2. Injury reported on imaging of spine

   - No
   - Yes

   - A normal CT does not exclude ligamentous injury.
   - No hard collar
   - Patient sat up
   - Normal turns

   Consultant spinal Surgeon

   Management plan / nursing care to ensure alignment maintained

   - Stable C-spine
   - Stable T&L spine
   - Unstable C-spine
   - Unstable T&L spine
   - Stable C-spine
   - Stable T&L spine
   - C-spine stable in hard collar
   - Unstable T&L spine
   - Unstable C-spine +/- Unstable T&L spine

3. ICU Consultant signature:

   - Print:
   - Date:
   - Time:

   Mark identical box A-D over the page

Sept 2012, Version 4.2
Management plan for when sedation is reduced

**A**
- No hard collar
- Patient sat up
- Normal turns

Sedation reduced, allowing patient to move

Evidence of vertebral fusion due to degenerative disease or operation, or extremely high velocity injury?

- No
  - No Hard Collar
  - See Note
- Yes
  - Hard Collar
  - Patient requires hard collar until MRI or patient is GCS 15 with no distracting injuries, allowing clinical assessment, followed by flexion extension views.

**B**
- No hard collar
- Patient sat up
- Bed tilted head up
- Full spinal turns

Change to T&L logroll turns i.e. no head hold

See Note

**C**
- Hard collar
- Patient sat up
- Normal turns
- With head hold

Bed flat once patient spontaneously ventilating, including after extubation

Yes
- Extubate

No
- Change to Normal turns

- Place in hard collar if patient complains of neck pain or develops neurological signs or symptoms e.g. paraesthesia

**D**
- Hard collar
- Patient sat up
- Bed tilted head up
- Full spinal turns

Extubate

Spinal consultant management plan

Name of spinal consultant:

Comments

- Hard collar for ....... weeks
- Halo jacket
- Extension brace

ALL PATIENTS

Side lie ALL patients to prevent pressure sores, unless specifically contra-indicated. Eg unstable pelvis

Contra-indicated

Reason

ICU Consultant signature:

Date:

Print:

Time:
The Future...
Guidelines for initial spinal management of sedated and ventilated trauma patients

1. Full spinal precautions
   - Unknown mechanism of injury or fall greater than patient's own height or high energy impact or age >50
     - Yes
     - No
       - Full Trauma CT or CT Head & Cervical spine & thoracolumbar imaging
       - CT Head & Cervical spine
       - Bony injury of C-Spine
       - Signed: Print: Date: Time:
         - Consultant radiologist report
           - Report of spinal imaging to include:
             - Any inadequacy of imaging
             - Fracture ?alignment (dislocation)
             - Soft tissue swelling indicative of spinal injury
         - Thoracic (C-spine) imaging report
         - Thoraocolumbar (T&L spine) imaging report
       - Signed: Print: Date: Time:
         - Consultant name:

2. Injury reported on imaging of spine
   - No
   - Yes
     - A normal CT does not exclude ligamentous injury.
     - Stable C-spine Stable T&L spine
     - Stable C-spine Unstable T&L spine
     - C-spine stable in hard collar Stable T&L spine
     - Unstable C-spine +/- Unstable T&L spine
       - Consultant spinal Surgeon
         - Name:
         - Management plan / nursing care to ensure alignment maintained

3. ICU Consultant signature:
   - Print:
   - Date: Time:
     - Mark identical box A-D over the page

Sept 2012, Version 4.2
Guidelines for initial spinal management of sedated and ventilated trauma patients

1. Full spinal precautions

   Unknown mechanism of injury or fall greater than patient's own height or high energy impact or age >50

   Yes
   Full Trauma CT or CT Head & Cervical spine & thoracolumbar imaging
   No
   Bony injury of C-Spine

   Signed: Print: Date: Time:

   Consultant radiologist report
   Report of spinal imaging to include:
   - Any inadequacy of imaging
   - Fracture? Alignment (dislocation)
   - Soft tissue swelling indicative of spinal injury

2. Injury reported on imaging of spine

   No
   A normal CT does not exclude ligamentous injury.
   Yes
   Consultant spinal Surgeon
   Management plan / nursing care to ensure alignment maintained

   Stable C-spine
   Stable T&L spine
   C-spine stable in hard collar
   Unstable T&L spine
   Unstable C-spine +/- Unstable T&L spine

3. ICU Consultant signature: Print: Date: Time:

   A
   No hard collar
   Patient sat up
   Normal turns

   B
   No hard collar
   Bed tilted head up
   Full spinal turns

   C
   Hard collar
   Patient sat up
   Normal turns with head hold

   D
   Hard collar
   Bed tilted head up
   Full spinal turns

Mark identical box A-D over the page
Management plan for when sedation is reduced

A  No hard collar
   Patient sat up
   Normal turns

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Yes
   Hard Collar
   Patient requires hard collar until MRI or patient is GCS 15 with no distracting injuries, allowing clinical assessment, followed by flexion extension views.

B  No hard collar
   Bed tilted head up
   Full spinal turns

Extubate

Change to T&L logroll turns i.e. no head hold
   See Note 1

C  Hard collar
   Patient sat up
   Normal turns with head hold

Extubate

High spinal cord injury?

Yes
   Bed flat once patient spontaneously ventilating, including after extubation

No
   Extubate

Extubate

D  Hard collar
   Bed tilted head up
   Full spinal turns

Extubate

Spinal consultant management plan

Name of spinal consultant: ____________________________

Comments:

   □ Hard collar for ______ weeks
   □ Halo jacket
   □ Extension brace

ALL PATIENTS

Side lie ALL patients to prevent pressure sores, unless specifically contra-indicated. Eg unstable pelvis

Contra-indicated Reason: ____________________________
Questions?
Suggested Reading

Guidelines for the Management of Acute Cervical Spine and Spinal Cord Injuries


Thoracolumbar spinal fractures: review of anatomy, biomechanics, classification and treatment

*Orthopaedics and Trauma*, April 2014; 28(2):70–78

Rudol, G and Gummerson, N
END
Motor and descending (efferent) pathways (red)

Pyramidal tracts
- Lateral corticospinal tract
- Anterior corticospinal tract

Extrapyramidal Tracts
- Rubrospinal tract
- Reticulospinal tracts
- Olivospinal tract
- Vestibulospinal tract

Sensory and ascending (afferent) pathways (blue)

Dorsal Column Medial Lemniscus System
- Gracile fasciculus
- Cuneate fasciculus

Spinocerebellar Tracts
- Posterior spinocerebellar tract
- Anterior spinocerebellar tract

Anterolateral System
- Lateral spinothalamic tract
- Anterior spinothalamic tract
- Spino-olivary fibers
Incomplete lesions of the spinal cord

Central Cord Syndrome

Anterior Cord Syndrome

Brown-Séquard Syndrome

Corticospinal tract

Spinothalamic tract