The spinal cord in trauma – early, subacute and late considerations

Dr Tom Meagher
Stoke Mandeville Hospital
Buckinghamshire Healthcare Trust
Objectives

• Background

• Image strategies/acquisition

• Acute cord injury (1 month)
  *Diagnosis/signs*

• Subacute (1 – 6 months)
  *Neurological deterioration*

• Chronic (beyond 6 months)
  *Signs/neurological deterioration/spasticity*
Trauma centres

• “A network of 22 new centres specialising in treating patients who suffer from major trauma will open across England”,

*Health Secretary Andrew Lansley, April 2nd, 2012*
Spinal cord injury

- Incidence 12.2/million
- Average age 48 y
  (Bimodal 15-29 & > 65y)
- Traumatic cord injury (70%)
- Non-traumatic injury (30%)
Causes of spinal cord injury

Traumatic

- Falls 42% (26%)
- RTA 37% (42%)
- Sport 12%
- Assault 3% (15%)
- Other 6%
Clinical evaluation: AIS Score

- AIS A: motor & sensory incomplete
- AIS B: sensory incomplete but no motor below injury
- AIS C: motor preservation but > half muscles < Grade 3 power
- AIS D: motor preservation but > half muscles grade > Grade 3
- AIS E: normal.
Cord injury outcomes at 1 year

<table>
<thead>
<tr>
<th>AIS A</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
</tr>
</thead>
<tbody>
<tr>
<td>89</td>
<td>6</td>
<td>3.8</td>
<td>2.2</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>AIS B</td>
<td>5</td>
<td>47</td>
<td>26</td>
<td>21</td>
<td>0</td>
</tr>
<tr>
<td>AIS C</td>
<td>1.4</td>
<td>1.4</td>
<td>37</td>
<td>60</td>
<td>0.3</td>
</tr>
<tr>
<td>AIS D</td>
<td>0.8</td>
<td>1</td>
<td>0.8</td>
<td>96</td>
<td>1.2</td>
</tr>
</tbody>
</table>

Acute cord injury: low velocity injury

- 57 patients with acute dislocation
- 8 of 32 with AISA reduced within 4 hours made full recovery
- Of 24 reduced after 4 hours only 1 made partial recovery
- *(refuse urgent MRI?)*

Newton, England, Doll, Gardner
The case for early treatment of dislocations of the cervical spine with cord involvement sustained playing rugby.

Acute traumatic cord injury: diagnosis

- Falls: 42%
- RTA: 37%
- Sport: 12%
- Assault: 3%
- Other: 6%
Acute traumatic cord injury: diagnosis
Acute traumatic cord injury: diagnosis
Acute traumatic cord injury: diagnosis
Urgency in assessing cord compression

• Cauda equina

• Cord compression cancer – image in 24 hours

• Trauma imaging? (decompression within 24 hours?)

Out of hours MR availability

- Survey of 234 units. 107 responded.
- 14% provide 24/7 MRI
- 74/207 referrals from DGH to NSIC
- 39% of these had MRI within 24 hours.

Out-of-hours MRI provision in the UK and models of service delivery. Hauptfleisch, Meagher, King, Lopez de Heredria, Hughes
Clin Rad Jan 2013 Vol 68
Acute major trauma: initial imaging evaluation

- Whole body CT
- MRI when stable
Acute injury - stable: MR first

Sagittal STIR of whole spine

Large FoV injured segment
Acute injury: MR image acquisition

FSE

Gradient echo
Diffusion tensor imaging
Signs in acute cord injury

Maximum cord compression

Fehlings et al.  
Interobserver and intraobserver reliability of maximum canal compromise and spinal cord compression for evaluation of acute traumatic cervical spinal cord injury.  
Signs in acute cord injury: increased cord signal
Signs in acute cord injury: cord oedema
Signs in acute cord injury: cord haematoma
Signs in acute cord injury: cord contusion
Signs in acute cord injury: epidural haemorrhage
Signs in acute cord injury: dural haemorrhage
Signs in acute cord injury: transection
Vertebral artery injury & posterior circulation infarction

<table>
<thead>
<tr>
<th>Study</th>
<th>N</th>
<th>Mean Age</th>
<th>Age Range</th>
<th>Number (Percentage)</th>
</tr>
</thead>
<tbody>
<tr>
<td>JAMA Katzman et al.</td>
<td>1000</td>
<td>30.6</td>
<td>3-83</td>
<td>3 (0.3%)</td>
</tr>
<tr>
<td>Stroke study</td>
<td>98</td>
<td>46</td>
<td>18-82</td>
<td>8 (8%)</td>
</tr>
</tbody>
</table>

*Mean age 30.6, age range 3-83*

*Mean age 46, age range 18-82*
Radiology signs & neurological outcomes

Poor neurological outcome

- Maximum cord compression
- Lesion length
- Medullary haemorrhage

AIS A

- Medullary haemorrhage
- Cord swelling
- Cord oedema

M der Haar; SM Naidoo; S Govender; P Parag; TM Esterhuizen
Acute traumatic cervical spinal cord injuries: correlating MRI findings with neurological outcome.
SA orthop. j. vol.10 no.1 Pretoria 2011
Subacute cord injury: neurological deterioration

- Failure of fixation
- Haemorrhage
- SPAM
Subacute cord injury: neurological deterioration
Subacute cord injury: progressive ascending myelopathy (SPAM)
Subacute Progressive Ascending Myelopathy

- Rising neurological deterioration that occurs typically in the first two weeks following cord injury
- At least 4 segments
- Does not return to initial injury level
- Mortality c. 10%
- (Accompanied by fever)

SPAM: MR signs

Central intramedullary cord signal change

High signal T2 WI

Minimal T1 WI signal change

Cord expansion

Ascends 4 – 11 segments

Preserved rim of normal cord
SPAM: treatments

Decompression
Anticoagulation
Antiviral
Methylprednisolone
Mannitol
Supportive
Cordectomy

Chronic cord injury

- Good life expectancy
- High morbidity
- Pain
- Altered neurology
- Worsening spasticity
Chronic cord injury: image acquisition

FSE, high bandwidth

Gradient echo
Chronic cord injury: MR signs

- Atrophy
- Myelomalacia
- Cyst
- Cord disruption
- Syrinx
- Dural adhesion
- (Tethering)
MR signs of chronic post traumatic cord injury

- Extended atrophy 62.1%
- Myelomalacia 66.6%
- Syrinx 20.9%
- Disruption 3.9%
- Tethering 3.9 (?)
- Atrophy/myelomalacia 45%
- Atrophy/syrinx 14%

Wang et al. A clinical MRI study of traumatised cord more than 20 years following injury
Paraplegia 1996 34, 65 - 81
MR signs of chronic post traumatic cord injury: (Extended) atrophy

- 7 mm upper limit of normal cervical cord
- 6 mm for thoracic cord
- Extends at least 2 segments above injured level

Norqvist L Post mortem studies Acta Radiologica 1964

Wang et al A clinical MRI study of traumatised cord more than 20 years following injury Paraplegia 1996 34, 65 - 81
MR signs of chronic post traumatic cord injury: Myelomalacia

- Intermediate signal between CSF & cord
- Best appreciated T1 images
- No histological equivalent. (Gliosis?)

Wang et al A clinical MRI study of traumatised cord more than 20 years following injury
Paraplegia 1996 34, 65 - 81
Chronic cord injury: cyst

- Round/oval in shape
- Isointense to CSF
- Confined to area of vertebral injury
- Related to cord haemorrhage?
- Unlikely to progress to syrinx
MR signs of chronic post traumatic cord injury: Dural adhesion (tethering)

- Best appreciated on axials

- Most frequently posterior

- Injured cord often confluent with dura
Chronic cord injury: Syrinx

- Usually tapered
- Well defined
- Extends beyond the level of vertebral injury
- Usually eccentric on axials
- Syrinx cavity isointense to CSF on T1 & T2

Prevalence: 20.9% / symptomatic syrinx: 4.45%
Chronic cord injury: Syrinx - inferior extension

- May result in worsening spasticity

<table>
<thead>
<tr>
<th>Direction</th>
<th>Patients</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rostral</td>
<td>11</td>
</tr>
<tr>
<td>Caudal</td>
<td>11</td>
</tr>
<tr>
<td>Both</td>
<td>7</td>
</tr>
</tbody>
</table>
Chronic cord injury: neurological deterioration & syrinx

- **Strong recommendation** for intervention for motor deterioration
- **Weak recommendation** against intervention for sensory loss/pain for expanding syrinx

*Surgical management of post traumatic syrinx*

Bonfield CM, Levi AD, Arnold PM, Okonwo DO
Spine 2010 Oct 35 S245 - 58
Chronic cord injury: dural adhesion

- Common at site of cord injury
- May lead to neurological deterioration
- May be secondary to implants e.g syrinx shunt
- Can be treated by duroplasty/adhesionlysis/cordectomy

Chronic injury: dural adhesions
Symptomatic chronic cord injury: spinal neuropathic arthropathy

Prevalence of 6%

- Low signal T1 end plate changes
- Increased T2 signal change
- Facet slip

Wagner et Al
Radiology 2000 214, 693 - 699
Symptomatic chronic cord injury: spinal neuropathic arthropathy

- Early changes may be challenging
- MRI first line imaging
- May require CT to clarify diagnosis
- Rarely need biopsy to exclude infection
Symptomatic chronic cord injury: spinal neuropathic arthropathy

- Treatment difficult
- May require complex imaging for persisting symptoms post intervention
Key points

- High speed complete cord injury has poor prognosis. **NB low velocity dislocation**
- Trauma centres are unlikely to protect radiologists from cord injury!
- MR first in stable cord injury
- Think about MR protocols/ set up DWI of cord
- Low threshold for MR for subtle deterioration and spasticity in chronic cord injury