Spinal Injury

- The vertebral column is composed of a series of motion segments.
- A motion segment consists of two adjacent vertebrae, their intervertebral disc and ligamentous restraints.
- Upper cervical spine anatomy is designed to facilitate motion, and stability here is dependent on ligamentous restraints.
- Vertebral anatomy from C3 to C7 is similar.
- The cervicothoracic and thoracolumbar junctions are transitional zones where the spine changes from a mobile section (cervical and lumbar) to a more fixed one (thoracic).
- These two areas are common sites of injury.

- Spinal stability is the ability of the spine to withstand physiological loads with acceptable pain, avoiding progressive deformity or neurological deficit.
- The spinal column can be divided into three columns: anterior, middle and posterior.
- If two or more columns of the spine are injured the spine is considered unstable.
- The AO classifications (Magerl and AO Spine Subaxial Classification System) are based on the mechanism of injury and used to assess spinal stability.

PATIENT ASSESSMENT

- The advanced trauma life support (ATLS) principles apply in all cases.
- The spine should initially be immobilised using full spinal precautions, on the assumption that every trauma patient has a spinal injury until proven otherwise.
- The finding of a spinal injury makes it more (not less) likely that there will be a second injury at another level.
- Spinal boards lead to skin breakdown in insensate patients, and are very uncomfortable for those with normal sensation.
- They should only be used for transferring patients.

- Definitive clearance of the spine may not be possible in the initial stages and spinal immobilisation should then be maintained, until MRI or equivalent can be used to rule out an unstable spinal injury.
- The mechanism and velocity of injury should be determined at an early stage.
- A check for the presence of spinal pain should be made.
- The onset and duration of neurological symptoms should also be recorded.

PHYSICAL EXAMINATION

Initial assessment

- The primary survey always takes precedence, followed by a careful systems examination paying particular attention to the abdomen and chest.
- Spinal cord injury may mask signs of intra-abdominal injury.

Spinal examination

- The overlying skin should be inspected (e.g. for possible penetrating wounds) and the entire spine must be palpated.
- A formal spinal log roll must be performed to achieve this.
- Significant swelling, tenderness, palpable steps or gaps suggest a spinal injury.
- A rectal examination should be undertaken to assess anal tone and perianal sensation.
- Seatbelt marks on the abdomen and chest must be noted, as these suggest a high-energy accident.

Neurological examination

- The American Spinal Injury Association (ASIA) neurological evaluation system is an internationally accepted method of neurological evaluation.
- Motor function is assessed using the Medical Research Council (MRC) grading system (0–5) in key muscle groups.
- A motor score can then be calculated (maximum 100).
- Sensory function (light touch and pin prick) is assessed using the dermatomal map.
- A total sensory score is then calculated.
- Rectal examination is performed to assess anal tone, voluntary anal contraction and perianal sensation.

Level of neurological impairment

- The ASIA Neurological Impairment Scale is based on the Frankel classification of spinal cord injury:
  - **A**: complete spinal cord injury
  - **B**: sensation present, motor absent
  - **C**: sensation present, motor present but not useful (MRC grade <3/5)
  - **D**: sensation present, motor useful (MRC grade ≥3/5)
  - **E**: normal function

DIAGNOSTIC IMAGING

- Clear visualisation of the cervicothoracic junction is mandatory.
- Plain cervical spine radiographs fail to identity 15% of injuries.
- Computed tomography (CT) scanning with two-dimensional (2D) reconstruction remains the gold standard in spinal trauma and is indicated for patients with suspected or visible injuries on plain radiographs.
- Magnetic resonance imaging (MRI) is indicated in all cases with neurological deficit and where assessment of ligamentous structures is important.

CLASSIFICATION AND MANAGEMENT OF SPINAL AND SPINAL CORD INJURIES

- Basic management principles are,
  - Spinal realignment
  - Stabilisation
  - Decompression of the neural elements

Spinal realignment

- In cases of cervical spine subluxation or dislocation, skeletal traction is necessary to achieve anatomical realignment.
- This is done using skull tongs.
- A halo brace can be used to perform a closed realignment and immobilisation of cervical fractures.

Stabilization

- The indication for operative intervention is influenced by the injury pattern, level of pain, degree of instability and the presence of a neurological deficit.
- The only absolute indication for surgery in spinal trauma is deteriorating neurological function.

Decompression of the neural elements

- Realignment of the spine and correction of the spinal deformity may achieve an indirect decompression.
- A direct decompression of the neural elements may also be indicated if there are bone fragments causing residual compression or a significant haematoma.
- The timing of surgery in spinal cord trauma remains controversial.

SPECIFIC SPINAL INJURIES
Upper cervical spine

Occipital condyle fracture

- This is a relatively stable injury often associated with head injuries and is best treated in a hard collar for 6–8 weeks.

Occipitoatlantal dislocation

- This injury is usually caused by high energy trauma and is often fatal.
- The dislocation may be anterior, posterior or vertical.
- Treatment is with a halo brace or occipitocervical fixation.

Atlas fracture (Jefferson fracture)

- Fracture of the C1 ring is associated with axial loading of the cervical spine and may be stable or unstable.
- Most are treated non-operatively in a cervical collar or halo brace.

Atlantoaxial instability

- This is defined as non-physiological movement between C1 and C2.
- It can be translational or rotatory and resolves either spontaneously or with traction followed by a cervical collar.

Odontoid fractures

- There are three types of odontoid peg fracture.
- Neurological injury is rare.
- The majority of acute injuries are treated non-operatively in a hard collar or halo jacket for 3 months.
- Internal fixation with an anterior compression screw is indicated for displaced fractures, and a posterior C1/2 fusion is considered in cases of non-union.
- In the elderly, treatment in a soft collar should be considered on the basis that a relatively stable pseudarthrosis will occur.

Traumatic spondylolisthesis of the axis (hangman's fracture)

- This is a traumatic spondylolisthesis of C2 on C3.
- There a four types with varying degrees of instability.
- Those with significant displacement or associated facet dislocation are treated operatively, usually with posterior stabilisation.

SPECIFIC SPINAL INJURIES
Subaxial cervical spine

- The more severe injuries are accompanied by spinal cord injury.
- Operative intervention may be required to decompress the spinal cord, and to stabilise the spine with internal fixation.
- Facet subluxation/dislocation ranges in severity from minor instability to complete dislocation with spinal cord injury.

SPECIFIC SPINAL INJURIES
Thoracic and thoracolumbar fractures

- The system developed by the AO (Arbeitsgemeinschaft für Osteosynthesefragen) can be used to classify these fractures.
- There are three main injury types, A, B and C, with increasing instability and risk of neurological injury.

- Type A fractures are vertebral body compression fractures.
- Type B injuries involve distraction of the anterior or posterior elements and type C injuries are rotational and often coexist with Type A or Type B injuries.
- The majority of type B and type C injuries require surgical stabilisation.

Thoracic spine (T1–T10)

- Osteoporotic wedge compression fractures in the elderly are the commonest injury in this group.
- Most of these fractures heal, but symptomatic fractures can be treated with percutaneous bone cement augmentation, known as vertebroplasty or kyphoplasty.
- In trauma cases, unstable fractures are associated with significant energy transfer to the patient and may be associated with major internal injuries, such as pulmonary contusion and spinal cord injury.
- Multimodality diagnostic imaging is recommended.
- Surgery is appropriate for most thoracic injuries if unstable.

Thoracolumbar spinal fractures (T11–L2)

- The thoracolumbar junction is especially prone to injury.
- This can vary from a from minor wedge fracture to spinal dislocation.
- Anterior surgery for this type of fracture is now very rarely used and the current treatment principles involve posterior fixation.

Lumbar spinal fractures (L3–S1)

- Most fractures of the lower lumbar spine can be treated non-surgically because the incidence of neurological injury is lower.
- Owing to the lumbar lordosis, patients with these injuries are less likely to develop a kyphotic deformity than those with injuries at the thoracolumbar junction.

PATHOPHYSIOLOGY OF SPINAL CORD INJURY

The primary injury

- This is the direct insult to the neural elements and occurs at the time of the initial injury.

The secondary injury

- Haemorrhage, oedema and ischaemia result in a biochemical cascade that causes the secondary injury.
- This may be accentuated by hypotension, hypoxia, spinal instability and/or persistent compression of the neural elements.
- Management of spinal cord injury must focus on minimising secondary injury.

Identification of shock

Three categories of shock may occur in spinal trauma.

1. Hypovolaemic shock

- Hypotension with tachycardia and cold clammy peripheries.
- This is most often due to haemorrhage.
- It should be treated with appropriate resuscitation.

2. Neurogenic shock.

- This presents with hypotension, a normal heart rate or bradycardia and warm peripheries.
- This is due to unopposed vagal tone resulting from cervical spinal cord injury at or above the level of sympathetic outflow (T1/T5).
- It should be treated with inotropic support, and care should be taken to avoid fluid overload.

3. Spinal shock.

- Spinal shock is a temporary physiological disorganisation of spinal cord function that starts within minutes following the injury.
- The length of effect is variable, but it can last 6 weeks or longer.
- It is characterized by paralysis, decreased tone and hyporeflexia.
- Once it has resolved the bulbocavernosus reflex returns.

Level of neurological injury

- The level of neurological injury is simply the most caudal neurological level with normal neurological function.

Complete versus incomplete spinal cord injury

- A spinal cord injury is incomplete when there is preservation of perianal sensation.

Types of incomplete spinal cord injury

- There are several types of incomplete spinal cord injuries.
- These include:
  - central cord syndrome
  - Brown-Séquard syndrome (hemisection)
  - anterior spinal syndrome
  - posterior cord syndrome
  - cauda equina syndrome

REHABILITATION AND PATIENT OUTCOME

- The goal of spinal cord injury rehabilitation is based on a multidisciplinary approach.
- There is a focus on goal-setting, maximizing remaining neurological function and reintegration into employment and society.
- The level of neurological impairment determines the functional outcome.

- Despite continuing improvements in patient care, life expectancy remains below normal following SCI.
- The median life expectancy is 33 years, but varies considerably.
- The prognosis for neurological recovery is strongly influenced by factors such as the level and completeness of the injury, ventilator dependence and the age at presentation.

COMPLICATIONS ASSOCIATED WITH SCI

- Pressure ulcers
- Pain and spasticity
- Autonomic dysreflexia
- Neurological deterioration
- Thromboembolic events
- Osteoporosis, heterotopic ossification and contractures