Spinal cord injuries

The three-column concept of spinal stability

The spinal column can be divided into three columns: anterior, middle and posterior. When all three columns are injured the spine is unstable. Instability may also exist in some two-column injuries

Spinal neuroanatomy

- The spinal cord extends from the foramen magnum to the T12/L1 junction where it ends as the conus medullaris.Below this level lies the cauda equine.
- A cross-section of the spinal cord consists of **central grey matter** (neuronal cell bodies) surrounded **by white matter** (axons).
- **The lateral spinothalamic tracts** transmit pain and temperature sensation,
- **The lateral corticospinal tracts** are responsible for motor function,
- The **posterior columns** transmit position, vibration and deep pressure sensation.
- A spinal nerve root exits on both sides of the spinal cord at each level.
- There are eight cervical roots. The C1 root exits above the C1 body, the C2 root exits between C1 and C2 and the C8 root exits below C7.
- All thoracic and lumbar nerve roots exit below the pedicle of the same number.

Pathophysiology of spinal cord injuries

The primary injury

This injury occurs when the skeletal structures fail to dissipate the energy of the primary mechanical insult, resulting in direct energy transfer to the neural elements. The injury may occur directly by flexion, extension, axial loading, rotation or traction,

Patient assessment

Basic points

Approach every trauma patient in the same manner using Advanced Trauma Life Support (ATLS) principles. Assume that every trauma patient has a spinal injury until proven otherwise; all assessment, resuscitation and life-saving procedures must be performed with full spinal immobilisation. However, patients must be removed from spinal boards as soon as possible to avoid skin breakdown, particularly in cases of spinal cord injury and unconsciousness.

There should be a high index of suspicion of spinal injury if any of the following are evident:

• Neurological deficit;

• Multiple injuries;

• Head injury;

• Facial injury;

• High-energy injury (e.g. fall from a height);

The unconscious patient

Full assessment of the spine in this situation is difficult. Spinal immobilisation should be maintained until magnetic resonance imaging (MRI) of the entire spine has been used to rule out injury or the cervical spine has been screened while being flexed and extended under image intensifier control.

The pain-free patient

In a conscious patient spinal injury can be excluded if:

• There is no pain;

• Palpation of the spine is non-tender;

• Neurological examination is normal;

• There is a pain-free range of movement;

• There are no other serious injuries that may mask spinal symptoms.

Patient assessment (summery)

■ Use ATLS principles in all cases of spinal injury

■ In polytrauma cases suspect a spinal injury

■ A second spinal injury at a remote level may be present in 10% of cases

■ Spinal boards cause pressure sores

History

The mechanism and velocity of injury should be determined at an early stage.

Physical examinations

Initial assessment

It is important to be aware that spinal cord injury may mask signs of intra-abdominal injury.

Identification of shock

Three categories of shock may occur in spinal trauma:

• ***Hypovolaemic shock*.** This presents with hypotension, tachycardia and cold clammy peripheries. It is most often caused by haemorrhage and is treated with appropriate fluid replacement.

• ***Neurogenic shock*.** Hypotension occurs with a normal heart rate or bradycardia and warm peripheries. It is caused by unopposed vagal tone resulting from cervical spinal cord injury above the level of sympathetic outflow (C7/T1).

• ***Spinal shock*.** This is characterised by paralysis, hypotonia and areflexia. It usually lasts for only 24 hours.

Spinal examination

The entire spine must be palpated and the overlying skin inspected. A formal spinal log roll must be performed to achieve this. Significant swelling, tenderness or palpable steps or gaps suggest a spinal injury. Note the presence of any wounds that might suggest penetrating trauma and document the condition of the skin, particularly over the pressure areas.

Figure 24.12 Spinal log roll.

Neurological examination

Motor function is assessed using the Medical Research Council (MRC) grading system (0–5) and is confined to key muscle groups. Sensory function is assessed using the dermatomal map. Pinprick and light touch sensation are assessed at key dermatomal points and scored from 0 to 2. A rectal examination is performed to assess anal tone, voluntary anal contraction and perianal sensation. Preservation of perianal sensation should at least be some recovery. ***On completion of the neurological assessment the following should be known:***

• The presence or absence of a neurological injury;

• The probable level of injury and impairment;

• Whether the injury is complete or incomplete;

• The type of spinal cord injury;

Level of neurological injury

This is simply the most caudal (lowest) 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

Central cord syndrome

This results from injury to the central portions of the spinal cord. Distal motor function in the legs is typically spared whereas the upper limbs and hands may be profoundly affected. This reflects the topographical arrangement of the cord. Younger patients often recover substantially but may be left with a permanent loss of fine motor hand function.

Brown-Séquard syndrome

This is typically seen in cord hemisection caused by penetrating trauma. This results in ipsilateral loss of power, proprioception and vibration sense with a contralateral loss of

pain and temperature sensation below the level of injury because of the arrangement of the various spinal cord tracts. This type of spinal cord injury carries a good prognosis.

Anterior spinal syndrome

Flexion–compression injuries to the cervical spine may damage the anterior spinal artery, cutting off the blood supply to the anterior two-thirds of the spinal cord.

Posterior column function is preserved but the prognosis is poor.

Posterior cord syndrome

This rare injury results from isolated posterior column injury. Motor function is preserved but joint position sense is lost.

Cauda equina syndrome This is most frequently associated with large central disc herniations at L4/5 and L5/S1. Patients typically describe numbness around the perineum and down the inside of the thighs (saddle paraesthesia) They may also be unable to pass urine and have loss of anal tone. If possible, imaging and surgery should be undertaken within hours of the onset of symptoms as the prognosis deteriorates rapidly over time.

Level of neurological impairment

The neurological impairment scale is based on the Frankel classification of spinal cord injury:

A: absent motor and sensory function;

B: sensory function present, motor function absent;

C: sensory function present, motor function present but not useful (MRC grade < 3/5);

D: sensory function present, motor function useful (MRC grade ≥ 3/5);

E: normal function (Summary box 24.5).

DIAGNOSTIC IMAGING

Plain radiographs

In total, 85% of significant spinal injuries will be seen on the standard lateral cervical spine radiograph recommended at the resuscitation of polytraumatised patients. If the thoracocervical junction cannot be visualised, even with a swimmer’s view, a computerised tomography (CT) scan should be obtained.

Significant loss of vertebral body height, sagittal deformity and widening of the interpedicular distance (on the anteroposterior view) may signify an unstable injury of a vertebra.

Computerised tomography

CT scanning remains the most sensitive imaging modality in spinal trauma. Complex fracture patterns can be understood and an accurate assessment of spinal canal compromise by bony fragments can be made.

Magnetic resonance imaging

MRI is best at visualising the soft-tissue elements of the spine. It is possible to see spinal cord haemorrhage and epidural and prevertebral haematomas. Spinal cord haemorrhage carries a poor prognosis. MRI is not good at assessing bony structures and has a relatively low sensitivity in identifying fractures (particularly those in the posterior element). In cases of spinal trauma without neurological injury, plain radiographs and CT usually give sufficient information, unless it is particularly important

Classification and management of the spine and spinal cord injuries

General points

In cases of neurological injury, initial intervention is aimed at reducing the secondary injury, preventing further deterioration and allowing return of neurological function in some cases. Most spinal trauma centres no longer use steroids in cases of spinal cord injury as there is no evidence that they work.

Basic management principles

- ***Spinal realignment***

In cases of cervical spine subluxation or dislocation, skull tongs (See below) are used to apply traction. The alternative is open reduction and operative realignment using internal fixation (see below).

Skeletal traction using skull tongs

Thoracolumbar fracture–dislocation treated with open reduction and posterior fixation.

- ***Stabilisation***

If a spinal fracture or dislocation is unstable (moves abnormally when stressed) there is a risk of new or further neurological injury as well as painful post-traumatic deformity. Many spinal injuries can be managed non-operatively with external support but, when possible, internal fixation should be used. Most spinal surgeons agree that, in cases of incomplete cord injury and progressive neurology, expeditious surgery is appropriate.

In cases of complete cord injury timing of surgery is less important as the prognosis neurologically is unlikely to be affected; however, relatively early surgery with realignment and stabilization may facilitate early mobilisation and reduce in-patient

complications. Indication for surgery in spinal trauma is deteriorating neurological function. All other indications are relative.

Early stabilisation has the advantage that it allows early mobilization of the patient.

- ***Decompression of the neural elements***

Spinal realignment is important in this regard. Compression of the cord by bone and/or disc material requires surgical removal

Management of spinal trauma (summery)

■ The management of spinal trauma depends on the presence or absence of neurological deficit

■ Deteriorating neurological status is an absolute indication for surgical intervention

■ Many spinal cord injury units no longer advocate the use of high-dose corticosteroids

Complications associated with spinal cord injury

Pain and spasticity

Neurogenic pain is extremely common following spinal cord injury and in some cases may be difficult to control. Once reflex activity returns spasticity can be problematic. Intrathecal infusion of baclofen may be required in resistant cases.

Autonomic dysreflexia

This is a paroxysmal syndrome of hypertension, hypohydrosis (above level of injury), bradycardia, flushing and headache in commonly triggered by bladder distension or rectal loading from faecal impaction.

Neurological deterioration

Post-traumatic syringomyelia may cause late (> 3 months postinjury) neurological deterioration and occurs in 3–5% of spinal cord injury cases. Increase in pain and/or spasticity, ascending loss of pain and temperature sensation, and ascending loss of deep tendon reflexes are some of the features associated with this syndrome.

Thromboembolic events

Approximately 30% of spinal cord-injured patients develop a clinically significant deep vein thrombosis. Fatal pulmonary embolus is reported in 1–2% of all spinal cord injury

deaths within the first 3 months of injury, with the highest risks within the first 3 weeks. Prophylactic intervention is therefore important in this patient group.

Heterotopic ossification and contractures

The most frequent areas affected by heterotopic ossification are hips, knees, shoulders and elbows. It occurs in 25% of spinal cord injured patients. Patients should receive prophylactic sodium etidronate or indomethacin. Surgery for joint ankylosis should only be considered when the process becomes dormant (normal alkaline phosphatase level, negative isotope bone scan).

Soft tissue contractures around joints may occur where opposing muscle groups have unequal power. These are avoided by appropriate physical therapy, positioning and splinting. Surgical release may be required in certain cases.

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