

## Introduction

The spinal cord extends from foramen magnum to the lower margin of L1 vertebral body. Below L1 is the cauda equina (lumbar, sacral, and coccygeal spinal nerve rootlets).

Spinal cord injuries classified as complete or incomplete depending on any motor or sensory function remaining below the level of the injury.

## Causes

The most common causes of spinal cord injury are:

- Motor vehicle accidents
- Violent assaults, gunshot wounds
- Falls
- Sports and recreation injuries
- Malignancy, infections, arthritis and inflammation of the spinal cord also cause spinal cord injuries.

## Presentation

- The primary traumatic impact → oedema and ischaemia → secondary injuries.
- Motor, sensory and autonomic dysfunction can occur. The latter → neurogenic shock, paralytic ileus, aspiration, urinary retention, priapism, and loss of thermoregulation.

There are two types of injury to the spinal cord:

- Non-haemorrhagic with only high signal on MRI due to oedema.
- Haemorrhagic with areas of low signal intensity within the area of oedema.

There is a strong correlation between the length of the spinal cord oedema and the clinical outcome. The most important factor however is whether there is haemorrhage, since hemorrhagic spinal cord injury has an extremely poor outcome.

### *Spinal cord concussion*

- Rare. Temporary cessation of spinal cord function, but spontaneous recovery within 48h.

### *Spinal shock*

- Immediate flaccidity, paralysis, areflexia, & sensation loss below the level of acute SCI
- Some reflexes return after a few days & hyperreflexia typical of UMN lesions in weeks.

### *Neurogenic shock*

- Distributive shock from sympathetic fibre disruption → vasodilatation & hypotension; occurs with high thoracic, cervical spine, and profound brain injuries (SCI above T6)
  - The **triad of hypotension, relative bradycardia, and hypothermia** is characteristic
- Mx: Fluids, **atropine**, inotropes

### *Autonomic Dysreflexia - not seen acutely and rare if SCI below T6*

- Triggered by afferent stimuli below the level of SCI after spinal shock has worn off.
- Sympathetic storm → ↑BP, headaches, profuse sweating, flushing, & a "feeling of doom".
- Mx: Immediate ID & removal of triggering noxious stimulus (remove tight clothing, sit up & dangle legs over bedside, catheterise or unblock a blocked IDC, clear stool impaction) and antihypertensive Rx e.g. SL GTN or clonidine PO.

### *SCIWORA (Spinal Cord Injury Without Radiological Abnormality)*

- This can be diagnosed only after scans have shown no bony or ligamentous injury.
- More common in children (as their spine is more flexible and less likely to sustain vertebral fracture) and carries a poor prognosis.

## Patterns of Injury

### *Cruciate Paralysis of Bell*

- Odontoid rams into cord → hemiparesis of one arm and the opposite leg

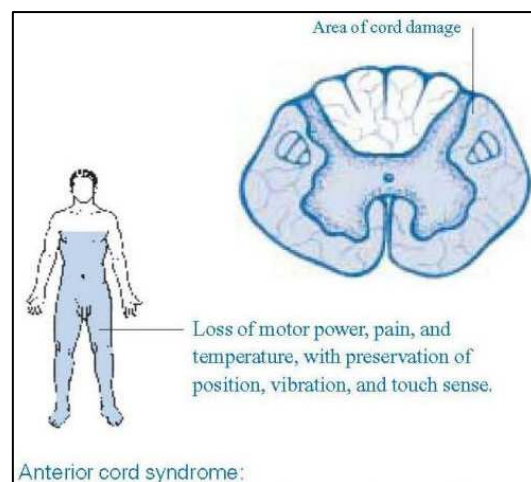
### *Complete cord injury*

- Absence of any motor or sensory function below the level of the injury
- Minimal chance of functional recovery

### *Incomplete cord injury*

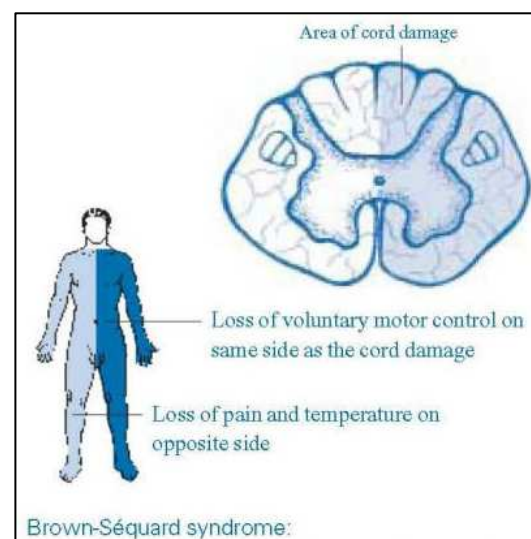
#### Anterior cord syndrome

- Caused by direct anterior cord compression, flexion injuries (e.g. burst fracture, flexion tear drop fracture and herniated disk), or thrombosis of anterior spinal artery.
- Leads to variable paralysis below lesion level (corticospinal tracts) with loss of pain and temperature perception.
- Dorsal columns (proprioception and vibration sense) are mainly preserved.
- Poor prognosis.



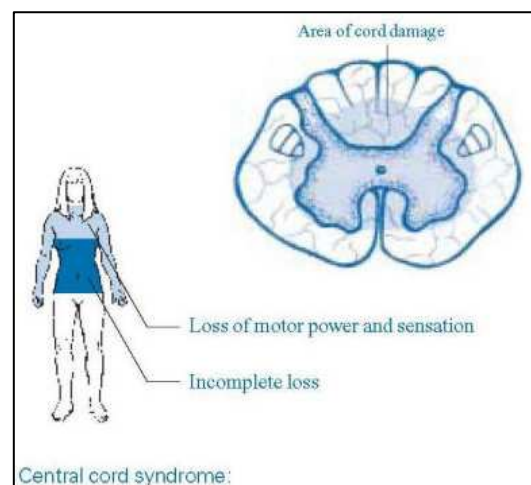
#### Brown-Séquard syndrome

- Caused by hemi-transection or unilateral compression of the cord.
- E.g. rotational injury (fracture-dislocation) or penetrating trauma (stab wound)
- Ipsilateral spastic paresis and loss of proprioception & vibration sense.
- Contralateral loss of pain and temperature perception.
- Moderately good prognosis.



#### Central cord syndrome

- Most common incomplete cord syndrome.
- Caused by hyperextension injuries, spinal cord ischaemia, elderly with underlying spondylosis and cervical spinal stenosis.
- Usually involves a cervical lesion, with greater motor weakness in the upper extremities than in the lower extremities as corticospinal tracts get more lateral caudally.
- The pattern of motor weakness shows greater distal involvement in the affected extremity than proximal muscle weakness.
- Sensory loss is variable, with pain and/or temperature sensation more likely to be affected than proprioception and/or vibration.
- Burning sensation, especially in the upper extremities, is common.
- There is usually sacral sensory sparing.



## Posterior cord syndrome

- Very rarely occurs in isolation.
- Caused by penetrating trauma to the back or hyperextension injury associated with vertebral arch fractures.
- Loss of proprioception and vibration sense due to disruption of dorsal columns.
- Motor and pain/temperature sensation preserved.
- Good prognosis.

## Conus medullaris syndrome

- Sacral spinal cord injury ± involvement of the lumbar nerve roots. Characterized by areflexia in the bladder, bowel, and to a lesser degree, lower limbs. Motor and sensory loss in the lower limbs is variable.

## Cauda equina syndrome

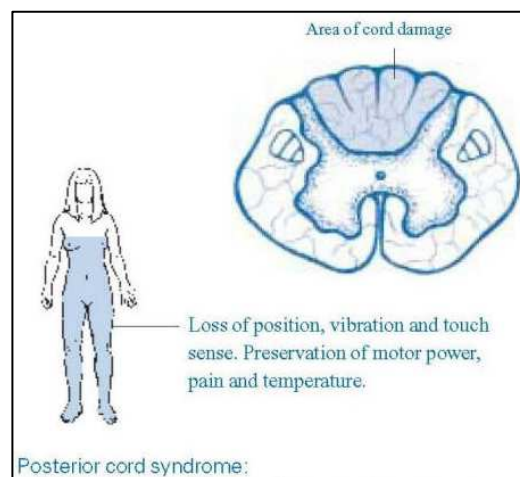
- Injury to lumbosacral nerve roots usually by central disk herniation. Characterized by areflexic bowel ± bladder, with variable motor & sensory loss in lower limbs. Because this syndrome is a nerve root injury rather than a true SCI, the affected limbs are areflexic.

## Differential diagnosis

- Spinal epidural haematomas and abscesses may cause acute cord compression.
- Spinal cord compression from metastatic disease
- Aortic artery dissection
- Epidural and subdural infections
- Syphilis
- Transverse myelitis
- Acute intervertebral disk herniation

## Initial management

- Resuscitation: initial resuscitation following the standard ABCDE protocol, with assessment and management of airway, respiration, and circulation is the first priority.
- Stabilize and immobilize the spine. Transport immobilised on spinal board with cervical hard collar to maintain spinal alignment. Log-rolling the patient to the supine position is safe if vomiting or to facilitate diagnostic evaluation and treatment.
- Use analgesics (should initially be given intravenously) to maintain the patient's comfort, especially if they have been lying on a hard backboard for an extended period.
- Hypotension: may be due to haemorrhage (likely ↑HR) or neurological shock (↓BP & ↓HR) in acute spinal cord injuries. Initial treatment of shock is careful fluid replacement, usually with an isotonic crystalloid solution.
- A urinary catheter should be inserted and the urine output monitored.
- Ileus is common. A nasogastric tube is essential. Antiemetics to prevent aspiration.
- Prevent pressure sores: regular turning of the patient, protective padding to all extensor surfaces and remove the spine board as soon as safe and appropriate.
- High-dose steroid use is controversial and should be used only in conjunction with spinal or neurosurgical specialist. **Methylprednisolone** 30mg/kg IV over 15mins & then 45mins later give 5.4mg/kg IV over 23hrs or 47hrs depending if <3 or 3-8hrs since injury.
- Monitor temperature as there may be loss of thermoregulation



## Other Treatment

- Immediate referral to a neurosurgeon and any other specialties depending on the nature of the injuries, especially orthopaedic trauma specialist and general surgeon. Once stabilized, patients should be referred to a regional spinal cord injuries centre.
- Emergency decompression is recommended if extradural lesions, such as epidural haematomas, impingement of spinal nerves or acute neurological deterioration, facet dislocation, bilateral locked facets, or cauda equina syndrome.
- Medium and long term management is directed towards rehabilitation, including physiotherapy and occupational therapy.

## Complications

- Neurological deficit often increases during the first few days following acute injury. One of the first signs of deterioration is the cephalic extension of the sensory deficit.
- Pressure sores: careful and frequent turning of the patient is essential.
- Potential lung complications include aspiration, pneumonia, ARDS, atelectasis, ventilation-perfusion mismatch, and decreased coughing with retention of secretions.
- Hypothermia.

## Prognosis

- Patients with a complete cord injury are unlikely to recover, especially if >72 hours.
- The prognosis is much better for the incomplete cord syndromes.
- Preservation of S4-5 sensation at 3-7d is best predictor of improved outcome.
- As well as neurological dysfunction, the prognosis is also determined by Cx.
- People who survive a spinal cord injury often have medical complications, e.g. chronic pain, bladder and bowel dysfunction, increased susceptibility to lower respiratory tract infections.

## Prevention

- Avoidance of excess alcohol intake
- Encourage adherence to rules and safety regulations with high-risk activities (e.g. rugby, equestrian, hang gliding).

## Motor Level Test Sequence

- C1-4 Spontaneous breathing
- C5 Shoulder abduction, flex elbow
- C6 Wrist extension
- C7 Elbow extension
- C8 Finger flexion
- T1 Finger adduction/abduction
- T2-12 Intercostal/abdominal muscles
- L2-4 Hip flexion, knee extension
- L4 Ankle dorsiflexion
- L5 Hallux extension (heel walking)
- S1 Ankle plantarflexion/eversion (toe walking)
- S2-4 Rectal sphincter tone

## Sensory Dermatomes:

Shown in diagram to right.

