Spinal Cord Injury and Compression

See also the separate article on Whiplash and Cervical Spine Injury.

Acute spinal cord compression is a neurosurgical emergency. Rapid diagnosis and management are essential to have the highest chances of preventing permanent loss of function.

The spinal cord extends from the base of the skull and terminates near the lower margin of the L1 vertebral body. Below L1, the spinal canal contains the lumbar, sacral and coccygeal spinal nerves that comprise the cauda equina. Therefore, injuries below L1 involve the segmental spinal nerves and/or cauda equina. Injuries above the termination of the spinal cord at L1 often involve both spinal cord lesions and segmental root or spinal nerve injuries.

The incidence of traumatic spinal cord injury in Western Europe is about 16 per million.\[1\] Spinal cord injury in children is relatively rare.\[2\]

A traumatic spinal cord injury is a lesion of neural elements of the spinal cord that can result in any degree of sensory and motor deficit, and autonomic or bowel dysfunction.\[3\] Spinal cord injuries may be primary or secondary:

- Primary injuries arise from a variety of mechanisms, including mechanical disruption, transection, penetrating injuries due to bullets or weapons, vertebral fracture/subluxation or displaced bony fragments causing penetrating spinal cord and/or segmental spinal nerve injuries.
- The primary traumatic impact initiates vascular and chemical processes leading to oedema and ischaemia which can lead to secondary injuries.
- Further cord insult can occur through subsequent inappropriate manual handling following trauma.
- Secondary injuries are mostly caused by arterial disruption, thrombosis or hypoperfusion due to shock.

Most injuries to the spinal cord don’t completely sever it. An injury is more likely to cause fractures and compression of the vertebrae, which then crush and destroy the spinal nerve tracts. The prognosis is variable between almost complete recovery and complete paralysis. Spinal cord injuries are classified as either complete or incomplete:

- An incomplete injury means that the ability of the spinal cord to convey messages to or from the brain is not completely lost.
- People with incomplete injuries retain some motor or sensory function below the injury.
- A complete injury is indicated by a total lack of sensory and motor function below the level of injury.

Risk factors for spinal injury

- Major trauma - eg, motor vehicle accidents, violent assaults, gunshot wounds, falls, sports and recreation injuries.
- Suggestive mechanism of injury.
- Spinal pain or neurological symptoms/signs.
- Altered consciousness.
- Increased risk in patients with malignancy, inflammation of the spinal cord, osteoporosis, rheumatoid arthritis, osteoarthritis, ankylosing spondylitis, Down's syndrome and in the elderly.
Causes of spinal cord compression

- Trauma (including car accidents, falls and sports injuries):
  - There is usually either vertebral fracture (most common in cervical vertebrae)[4] or facet joint dislocation.
  - Complete transection of the spinal cord can occur.
  - Hemisection of the spinal cord can occur and is known as Brown-Séquard’s syndrome. It is usually caused by a penetrating trauma. [4]

- Tumours, both benign or malignant:
  - These can include bone tumours, primary or metastatic tumours, lymphomas, multiple myeloma and neurofibromata.
  - Acute myelopathy in patients with cancer can also be caused by irradiation, paraneoplastic necrotising myelitis, ruptured intervertebral disc and meningeal carcinomatosis with spinal cord involvement. [4]

- A prolapsed intervertebral disc:
  - L4-L5 and L5-S1 are the most common levels for disc prolapse. [4] Large disc herniations can cause cauda equina syndrome. See the separate article on Cauda Equina Syndrome which discusses it in more detail.
  - Cervical disc herniation can also occur.

- An epidural or subdural haematoma:
  - There may be a history of trauma, a recent spinal procedure and/or the patient may be on anticoagulant therapy. [4]

- Inflammatory disease, especially rheumatoid arthritis:
  - In rheumatoid arthritis there is often considerable weakness of the ligament that holds the odontoid peg. If this ruptures, the atlas can slip forward on the axis and compress the high cervical spine.

- Infection:
  - Spinal infections can be acute or chronic.
  - Acute infections are usually bacterial; chronic infections are usually due to tuberculosis or fungal infection. [4]
  - Vertebral osteomyelitis, discitis or haematogenous spread of infection can lead to an epidural abscess. [4]

- Cervical spondylitic myelopathy:
  - The ageing process can lead to narrowing of the spinal canal due to osteophytes, herniated discs and ligamentum flavum hypertrophy.
  - In advanced stages, it can cause spinal cord compression.

- Spinal manipulation:
  - Damage to the spinal cord may be a very rare complication of chiropractic or osteopathic manipulation of the neck.

Presentation

See also the separate articles on Examination of the Spine, Neurological History and Examination, Neurological Examination of the Upper Limbs and Neurological Examination of the Lower Limbs.

The most common issues raised by people with spinal cord injury in primary care are related to disability and secondary complications such as bowel or bladder dysfunction and pain. [5]
Red flags

See also the separate articles on Neck Pain (Cervicalgia) and Torticollis and Low Back Pain and Sciatica. Red flags that suggest spinal compression include:

- Insidious progression.
- Neurological symptoms: gait disturbance, clumsy or weak hands, or loss of sexual, bladder, or bowel function.
- Neurological signs:
  - Lhermitte’s sign: flexion of the neck causes an electric shock-type sensation that radiates down the spine and into the limbs.
  - Upper motor neurone signs in the lower limbs (Babinski’s sign: up-going plantar reflex, hyperreflexia, clonus, spasticity).
  - Lower motor neurone signs in the upper limbs (atrophy, hyporeflexia).
  - Sensory changes are variable, with loss of vibration and joint position sense more evident in the hands than in the feet.

Motor, sensory and autonomic dysfunction can occur. The latter can lead to neurogenic shock, paralytic ileus, aspiration, urinary retention, priapism and loss of thermoregulation. Clinical features depend upon the extent and rate of development of cord compression. [6]

- Motor symptoms can include ready fatigue and disturbance of gait.
- Cervical spine lesions can produce quadriplegia. Injury above the level of C3, C4, C5 (the segmental level of the phrenic nerve) cause paralysis of the diaphragm and artificial ventilation is required.
- Thoracic spine lesions produce paraplegia.
- Lumbar spine lesions can affect L4, L5 and sacral nerve roots.
- Sensory symptoms can include sensory loss and paraesthesia. Light touch, proprioception and joint position sense are reduced.
- There can be root pain in the legs.
- Tendon reflexes are typically:
  - Increased below the level of injury and/or compression.
  - Absent at the level of injury and/or compression.
  - Normal above the level of injury and/or compression.

- Sphincter disturbances - late features of cervical and thoracic cord and/or compression.
- There may be loss of autonomic activity with lack of sweating below the level, loss of thermoregulation and drop in peripheral resistance causing hypotension.

Patterns of injury

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

- Anterior cord syndrome:
  - This is caused by direct anterior cord compression, flexion injuries of the cervical spine, or thrombosis of anterior spinal artery.
  - Leads to variable paralysis below the lesion level with loss of pain and temperature perception.
  - Dorsal columns (proprioception and vibration sense) are mainly preserved.
  - Has a poor prognosis.

- Brown-Séquard’s syndrome:
  - Caused by hemi-transection or unilateral compression of the cord.
  - Ipsilateral spastic paresis and loss of proprioception and vibration sense.
  - Contralateral loss of pain and temperature perception.
  - Moderately good prognosis.
Central cord syndrome:
- Caused by hyperextension injuries, spinal cord ischaemia and cervical spinal stenosis.
- Usually involves a cervical lesion, with greater motor weakness in the upper extremities than in the lower extremities.
- 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.
- Motor and pain/temperature sensation preserved.

Spinal cord concussion:
- Rare.
- Temporary cessation of spinal cord neurological function, but spontaneous recovery occurs within 48 hours.

Spinal shock:
- Immediate flaccidity, paralysis, areflexia and loss of sensation below the level of the acute spinal cord injury.
- Some reflexes return after a few days and hyperreflexia typical of an upper motor neurone lesion in weeks.

Neurogenic shock:
- Distributive shock from sympathetic fibre disruption causes vasodilatation and hypotension.
- Occurs with high thoracic, cervical spine, and profound brain injuries (spinal cord injury above T6).
- The triad of hypotension, relative bradycardia, and hypothermia is characteristic.
- Areflexia, loss of sensation and flaccid paralysis below the level of the lesion; flaccid bladder and loss of rectal tone.

Spinal cord injury without radiological abnormality (SCIWORA):
- 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.

Investigations
- Haemoglobin and haematocrit levels should be measured initially and monitored serially to monitor blood loss.
- Renal function and electrolytes: dehydration.
- Perform urinalysis to detect associated genitourinary injury.
X-rays:

- Diagnostic imaging begins with X-rays of the affected region of the spine. In some centres, CT scanning has supplanted plain X-rays.
- A trauma X-ray series is usually first performed (cervical spine, chest and pelvis). [8]
- CT scan may pick up fractures missed on plain radiographs and is the preferred first radiological investigation in some centres.
- If a patient is unconscious then CT of the brain and the whole of the cervical spine has now become routine. [8]
- X-rays of the cervical spine are indicated in any patient following a head and/or facial injury unless all the following criteria are met:
  - No midline cervical tenderness.
  - No focal neurological deficit.
  - Normal alertness.
  - No intoxication.
  - No painful, distracting injury.

- The standard three views of the cervical spine are recommended: anteroposterior, lateral and odontoid.
- X-rays of the thoracic and lumbar spine are indicated in any patient with pain or tenderness, a significant fall, a high-impact road traffic accident, presence of other spinal fracture and when it is not possible to evaluate the patient clinically. Anteroposterior and lateral views of the thoracic and lumbar spine are recommended. Radiographs must adequately depict all vertebrae.

CT scan:[7]

- Plain X-rays are insensitive to small vertebral fractures. In general, CT should be the first-line approach in high-risk patients and plain X-rays should be reserved for the initial evaluation of patients with a low risk of traumatic lesions. [9]
- CT scanning is reserved for delineating bony abnormalities or fracture. Some studies have suggested that CT scanning with sagittal and coronal reformatting is more sensitive than plain X-rays for the detection of spinal fractures.
- Perform CT scanning in the following situations:
  - Plain radiography is inadequate.
  - Convenience and speed: for example, if a CT scan of the head is required then it may be simpler and faster to obtain a CT of the cervical spine at the same time.
  - X-rays show suspicious and/or indeterminate abnormalities.
  - X-rays show fracture or displacement: CT scanning provides better visualisation of the extent and displacement of the fracture.

- CT/MRI of the thoracic and lumbar spine is essential for any patient who has a neurological deficit following trauma.

MRI:[7]

- If the lateral cervical radiograph and the CT scan are negative, then MRI is the investigation of choice to exclude instability.
- Patients with focal neurological signs, evidence of cord or disc injury, and patients whose surgery requires pre-operative cord assessment should also have an MRI scan. [8]
- Whole spine MRI is indicated for multilevel or ligamentous injuries, and for cauda equina injuries.
- MRI is best for suspected spinal cord lesions, cord compressions, vertebral fractures at multiple levels and ligamentous injuries or other soft tissue injuries or pathology.
- MRI should be used to evaluate soft tissue lesions, such as extradural spinal haematoma, abscess or tumour, or spinal cord haemorrhage, contusion and/or oedema.
- Neurological deterioration is usually caused by secondary injury, resulting in oedema and/or haemorrhage. MRI is the best diagnostic image to depict these changes.

- CT myelography may be considered if MRI is not practicable.
Initial management

- Maintaining stability of the spine and immediate referral to the appropriate local severe trauma service are essential for patients with a possible cervical spine fracture.
- Resuscitation: initial resuscitation following the standard ABCDE protocol, with assessment and management of airway, respiration, and circulation as the first priority.
- Stabilise and immobilise the spine:
  - The patient should be transported immobilised on a spinal board and with a cervical hard collar to maintain spinal alignment.
  - The patient should be secured so that in the event of vomiting, the spinal board may be rapidly rotated while the patient remains fully immobilised in the neutral position.
  - The patient is best treated initially in the supine position.
  - Logrolling the patient to the supine position is safe to facilitate diagnostic evaluation and treatment.
  - Use analgesics (these 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.

- Airway management:
  - In patients with spinal cord injuries, with or without a cervical spine injury, airway management is often difficult.
  - All airway interventions cause spinal movement; immobilisation may have a modest effect in limiting spinal movement during airway manoeuvre.\[10\]
  - The cervical spine must be maintained in a neutral alignment at all times.
  - Clearing of oral secretions and debris is essential to maintain a patent airway and to prevent aspiration.
  - The modified jaw thrust and insertion of an oral airway may be all that is required to maintain an airway in some cases. However, intubation may be required in others.
  - The ideal technique for emergency intubation is fibre-optic intubation with cervical spine control.
  - Indications for intubation in patients with spinal cord injury are acute respiratory failure, decreased level of consciousness (Glasgow score <9), increased respiratory rate with hypoxia, PCO₂ more than 50 mm Hg, and vital capacity less than 10 mL/kg. If a lesion is present at or above C5, intubation and assisted ventilation will often be required.

- Breathing:
  - Give oxygen (hypoxia can compromise the injured cord).
  - Watch for paradoxical (diaphragmatic) breathing indicating a possible cervical injury.

- Hypotension:
  - May be due to haemorrhage or neurogenic shock in acute spinal cord injuries.
  - Haemorrhage may be due to other injuries - eg, chest, intra-abdominal, retroperitoneal, or pelvic or long bone fractures.
  - Initial treatment of spinal shock is careful fluid replacement, usually with an isotonic crystalloid solution.

- Haemodynamically significant bradycardia should be treated with atropine (pharyngeal stimulation - eg, oral suctioning - can also induce significant bradycardia).
- A urinary catheter should be inserted and the urine output monitored. Occasionally, a positive inotrope such as dopamine is required.
- Associated head injury: may require assessment with CT scan and appropriate management.
- Ileus is common. Anasogastric tube is essential. Anti-emetics should be used to prevent aspiration.
- Prevent pressure sores: regular turning of the patient, protective padding to all extensor surfaces and removal of the spinal board as soon as safe and appropriate.
- High-dose methylprednisolone steroid therapy is the only pharmacological treatment shown to be effective when given within eight hours of injury.\[11\] However, the use of methylprednisolone remains controversial and only considered of marginal benefit.\[12\]
- Treatment of pulmonary complications and/or injury in patients includes oxygen for all patients and appropriate treatment for pneumothorax and/or haemothorax.
Further assessment and monitoring:
- ECG monitoring.
- Monitor Glasgow Coma Scale.
- Temperature: there may be loss of thermoregulation, so keep the patient comfortably warm.
- A thorough but rapid assessment of all major injuries is essential. Head to toe examination for other injuries, especially neurological and skeletal.
- Full neurological examination of motor and sensory functions.

Further treatment
- Immediate referral to a neurosurgeon and any other specialties depending on the nature of the injuries, especially an orthopaedic trauma specialist and general surgeon. Once stabilised, patients should be referred to a regional spinal cord injuries centre.
- Emergency decompression of the spinal cord is recommended for patients with extradural lesions, such as epidural haematomas. Impingement of spinal nerves or acute neurological deterioration requires emergency surgical intervention.
- Medium- and long-term management are directed towards rehabilitation, including physiotherapy and occupational therapy.
- Spasticity following spinal cord injury: one review found a significant effect of tizanidine but not gabapentin, clonidine, diazepam or oral baclofen.\(^{13}\)
- Respiratory muscle training is effective for increasing respiratory muscle strength and perhaps also lung volumes for people with cervical spinal cord injury.\(^{14}\)

Spinal cord compression due to metastases
- Metastatic epidural spinal cord compression affects almost 5% of patients with cancer.\(^{15}\) However, less than 0.1% of people with back pain who visit their general practitioner have spinal metastases.\(^{16}\)
- Spinal pain is often present for three months and neurological symptoms for two months before paraplegia, but almost 50% of patients are unable to walk by the time of diagnosis. Of these, almost 70% remain immobile. Of those able to walk at treatment, about 80% remain ambulant.\(^{16}\)[17][18]
- 23% of patients with spinal metastases have no previous cancer diagnosis.\(^{17}\)
- The thoracic spine is most commonly affected in metastatic cancers.\(^4\)

National Institute for Health and Care Excellence (NICE) recommendations for the diagnosis and management of patients at risk of or with metastatic spinal cord compression\(^{16}\)[19]
- The aims of the NICE guidelines are to accelerate the diagnosis of spinal cord compression and to ensure that appropriate specialist management, usually surgery and/or radiotherapy, is available within 24 hours of presentation.\(^{20}\) The goal is to prevent paralysis from metastatic spinal cord compression.
- The following symptoms suggest possible spinal metastases in those with cancer:
  - Pain in the thoracic or cervical spine.
  - Severe unremitting or progressive lumbar spinal pain.
  - Spinal pain aggravated by straining (e.g., coughing, sneezing, passing stool).
  - Nocturnal spinal pain preventing sleep.
  - Localised spinal tenderness.

- The following symptoms suggest metastatic spinal cord compression in patients with cancer and pain suggestive of spinal metastases:
  - Radicular pain.
  - Limb weakness.
  - Difficulty in walking.
  - Sensory loss, or bladder or bowel dysfunction.
  - Neurological signs of spinal cord or cauda equina compression.

- MRI of the whole spine (not plain X-rays) should be carried out so that definitive treatment can be planned. This should be:
  - Within one week if clinical features suggest spinal metastases.
  - Within 24 hours if clinical features suggest spinal cord compression.
  - Sooner (including out of hours) if emergency treatment is needed.
Management

- Nurse the patient flat with the spine in neutral alignment (eg, using logrolling or turning beds) until spinal and neurological stability are ensured.
- Give a course of dexamethasone unless contra-indicated until a definitive treatment plan is made.
- Manage postural hypotension with positioning and devices to improve venous return; avoid overhydration.
- Insert a catheter to manage bladder dysfunction.
- Use breathing exercises, assisted coughing, and suctioning to clear airway secretions.
- Follow the NICE guidance for the prophylaxis of venous thromboembolism, the prevention and treatment of pressure ulcers, and the management of bowel dysfunction.
- Offer and provide psychological and spiritual support as needed (including after discharge).
- Analgesia, palliative radiotherapy, spinal orthoses, vertebroplasty or kyphoplasty, or spine stabilisation surgery may be required for pain control.
- Bisphosphonates should be offered to all patients with vertebral involvement from myeloma and breast cancer and to patients with prostate cancer in whom conventional analgesia is inadequate.
- Specialist pain control procedures may be needed for intractable pain (eg, epidural analgesia).
- If definitive treatment of the cord compression is appropriate, it should be started before patients lose the ability to walk or other neurological deterioration occurs, and ideally within 24 hours.
- Definitive treatment may be using surgery (eg, laminectomy, posterior decompression ± internal fixation) or using radiotherapy.
- Discharge should be fully planned and community-based rehabilitation and support should be available when the patient returns home. This includes support and any necessary training of carers and families.

Complications

- The neurological deficit often increases during the first few days following acute spinal cord injury. One of the first signs of deterioration is the cephalic extension of the sensory deficit.
- Autonomic dysreflexia: associated with spinal cord injury at or above T6. If not treated promptly and correctly, it may lead to seizures, stroke, and even death. Features include:
  - Acute, uncontrolled hypertension
  - Severe headache
  - Intense sweating and skin blotches above the level of the injury
  - Cold and clammy skin below the level of the injury
  - Restlessness
  - Chest tightness
  - Bradycardia
  - Dilated pupils

- Pressure sores: careful and frequent turning of the patient is essential.
- Hypothermia.
- Potential lung complications include aspiration, pneumonia, acute respiratory distress syndrome, atelectasis, ventilation-perfusion mismatch and decreased coughing with retention of secretions.
- Chronic musculoskeletal pain is common in people with spinal cord injury.\[21]\n- Depression can occur and those with spinal cord injury have an increased risk of suicide.\[22]\n- Leading causes of death after spinal cord injury include pneumonia, pulmonary emboli, septicaemia and renal failure.\[22]\n
Prognosis

- The spinal cord has very limited powers of regeneration.
- Patients with a complete cord injury have a very low chance of recovery, especially if paralysis persists for longer than 72 hours.
- The prognosis is much better for the incomplete cord syndromes.
- The prognosis for cervical spine fractures and dislocations is very variable, depending on the degree of neurological disability.
- Prognosis for neurological deficit depends on the magnitude of the spinal cord damage present at the onset.
- As well as neurological dysfunction, the prognosis is also determined by the prevention and effective treatment of infections - eg, pneumonia, and urinary tract infections.
- In general, most individuals regain some motor function, mostly within the first six months, although there may be further improvement observed years later.\[22\]
People who survive a spinal cord injury often have medical complications - eg, chronic pain, bladder and bowel dysfunction, and increased susceptibility to lower respiratory tract infections.

Prevention

- Avoidance of excess alcohol intake.
- Road safety.
- Encourage adherence to rules and safety regulations with high-risk activities - eg, rugby, equestrian pursuits, hang-gilding.

Further reading & references

- Spinal injury: assessment and initial management; NICE Guidance (February 2016)
- Multidisciplinary Association of Spinal Cord Injury Professionals
- British Association of Spinal Cord Injury Specialists
- Spinal Injuries Association

6. Spinal Cord Compression; Surgical Tutor
7. Radiology guidelines and best practice statements (various); Royal College of Radiologists (various dates)

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