Spinal cord injury

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Abstract

With an annual incidence of 13 per million, around 40,000 people in the UK live with spinal cord injury (SCI). The extent of morbidity and mortality and thus quality of life, is highly dependent on meticulous management from the first point of contact with medical services. Treatment is focused on reducing the risk of further cord injury and prevention of secondary (penumbral) damage through avoidable complications. As key members of trauma, theatre, intensive care and pain teams, anaesthetists and intensivists play a crucial role in influencing patient outcome in both the acute setting and in managing patients with chronic SCI presenting for emergency or elective surgical intervention.

Keywords Injury; primary; secondary; spine; trauma

Royal College of Anaesthetists CPD Matrix: 2C01, 3A10, 3A08

Learning objectives

After reading this article, you should be able to:

- define primary and secondary spinal cord injury
- outline the initial management of patients with spinal cord injury
- consider appropriate imaging to identify spinal injury
- identify some key anaesthetic considerations when managing a patient with acute or chronic SCI

Epidemiology and aetiology

Trauma is the leading cause of death in Western societies between the ages of 5–44 years. Although traditionally viewed as a disease of the young, major trauma in the elderly is becoming increasingly recognized as a significant challenge to healthcare systems. In 1990 the mean age of patients suffering major trauma was 36.1 years but by 2013 this had risen to 53.8 years. This trend is predicted to continue.[1]

In a recently published analysis of the European Trauma Audit and Research Network (TARN) database,[2] spinal injuries following major trauma were found to be present in 13% of cases, with 1.8% suffering cord injury. It also revealed a male bias (64.9%) and a median age of 44.5 years. In 45% of those with spinal injuries there will be other significant injuries.

Of all spinal cord injuries, 40% resulted from road traffic collisions, 30% falls >2 meters, 16% falls <2 meters. Violence and sporting injuries comprised just over 4% of the total.

Anatomy

Knowledge of the basic anatomy of the spine and spinal cord is essential. It enables the clinician to detect injury, assess level and therefore institute and predict appropriate management.

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In the adult, the spinal cord extends from the medulla oblongata to the conus at L1/2 where it continues on as the cauda equina. It is covered by three layers of meninges (pia, arachnoid and dura) and is protected by 7 cervical, 12 thoracic and 5 lumbar bony vertebrae. The cervical and thoracolumbar segments are most vulnerable to injury due to their greater mobility.

The spinal cord itself is highly complex and acts as a bi-directional information conduit between the brain and body (Figure 1). It consists of many white matter ascending and descending tracts, three of which are regularly used by clinicians to assess cord integrity;

Ascending (sensory)

- Posterior columns (cuneate and gracilis); fine touch, vibration and position sense.
- Anterolateral Spinothalamic tract; pain and temperature

Descending (motor control)

- Lateral corticospinal tract

Axons from spinal sensory neutrons enter and axons from motor neurone leave the spinal cord via segmental nerves or roots. In the cervical spine there are 8 roots (C1–7), these are named according to the vertebrae **above** their point of exit from the spinal cord. In the thoracic (T1–T12) and lumbar (L1–5) regions spinal roots are named after the vertebrae **below** their point of exit. Roots receive sensory information from an area of skin (dermatome) and innervate a group of muscles (myotome). It is by testing these modalities that we can determine at which vertebral level(s) the cord has been injured.

The spinal cord also carries important signals from the autonomic nervous system. SCI can adversely affect the regulation of many bodily functions when this is interrupted.

Blood supply

Blood is supplied to the cord via one anterior and two posterior spinal arteries, which are branches of the vertebral and posterior inferior cerebellar arteries, respectively. There are also important contributions from radicular arteries en route, especially in the thoracic region. The single anterior artery supplies the anterior two thirds of the cord with the posterior arteries supplying the posterior third.

Mechanisms of injury and pathophysiology

Injury can be divided into **primary** and **secondary**.

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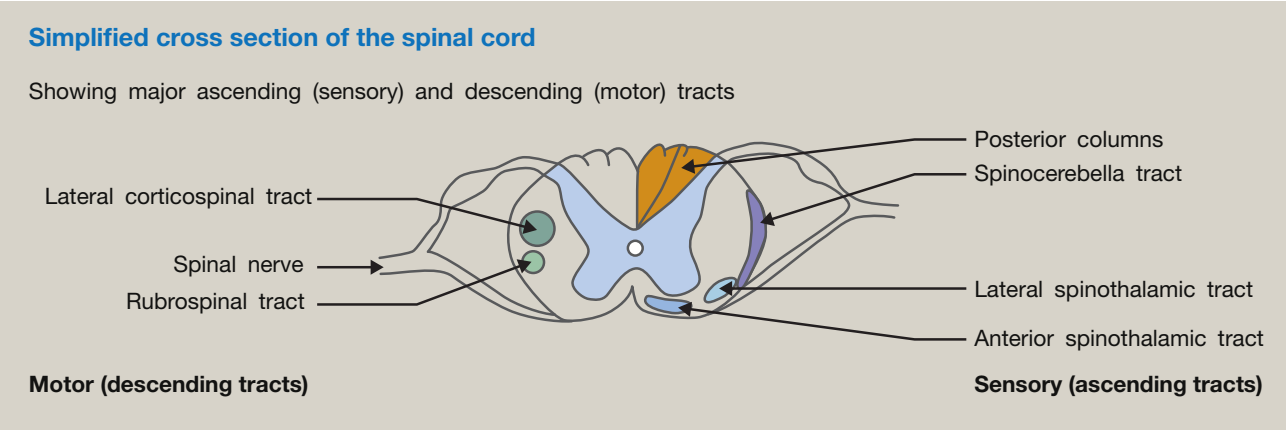

Figure 1

Primary injury is concerned with direct damage to the cord or supporting vasculature caused by the initial trauma. This can be caused by a number of mechanical forces:

- *Distraction* – Occurring when the bony spine is hyperextended, as in rapid acceleration and deceleration injuries.
- *Compression* – Resulting from axial loading, compromising the spinal cord because of encroachment of vertebral body fragments or intravertebral discs.
- *Penetrating Trauma* – Can directly damage the spinal cord or vessels.

There is very little that can be done to reverse primary cord injury. Immediate management is focused on preventing secondary injury.

Secondary injury occurs within minutes of the primary insult. Damage to neural cells and blood vessels cause a spiraling cascade of injury which includes haemorrhage, disruption of cell metabolism and apoptosis, electrolyte shifts, and release of free radicals and inflammatory messengers. These lead to increased cord oedema, ischaemia and loss of autoregulation. Oedema will not be localized to the site of primary injury, but continue to spread bidirectionally along the cord for up to 72 hours, increasing the neurological compromise.

Systemic insults such as hypoperfusion, hypoxia, hyperthermia and catecholamine release can significantly increase the extent of penumbral damage. Initial management of SCI is focused on the prevention of these secondary insults.

Classification of injury

Classification of injury is important as it enables the clinician to not only prognosticate but also plan appropriate short and longer term management for the patient.

The most consistent predictor of long-term morbidity and mortality is severity of neurology as measured by completeness and level of injury.

An injury can be defined as **complete** or **incomplete.**

- *Complete (cord transection)* – Complete absence of motor and sensory function below the level of the injury (i.e no sacral sparing).
- *Incomplete* – Partial preservation of neurological function more than one level below the injury. This can be sensory, motor or both. This has a better prognosis for recovery than complete injury. Up to 80% with incomplete paraplegia will stand by 12 months, 50% will walk out of hospital within 12 months and neurological recovery can be seen up to 2 years post injury. Incomplete lesions can result in syndromes or patterns of injury.
  - *Anterior cord syndrome* – Infarction of the anterior two thirds of the cord due to an interruption in blood flow through the anterior spinal artery. This results in loss of motor function and pain/temperature sensation below the level of the injury. Proprioception and fine touch sensation are preserved.
  - *Brown-Sequard syndrome* – Caused by lateral hemisection of the cord and characterized by loss of motor function, fine touch, proprioception on the ipsilateral side and loss of pain and temperature sensation on the contralateral side.
  - *Cauda-equina syndrome* – Damage to the cauda equina causes loss of sensation in the saddle area and disturbance of bowel and bladder function.
  - *Central cord Syndrome* – This is the most common pattern of incomplete SCI. It is characterized by disproportionate upper limb weakness compared to lower limb, variable sensory loss below the level of injury, and bowel and bladder dysfunction.
  - *Posterior cord syndrome* – Caused by an interruption to blood supply to the posterior cord. It is characterized by the loss of proprioception and vibration sense only. It is very rare.

The American Spinal Injury Association (ASIA) have developed a standardized neurological impairment scale for SCI that combines severity of deficits with completeness of injury to produce 5 classes (A–E) that correlate with outcome[3,4] (Box 1).

Level of injury

The strength of each muscle function is graded on a six point scale where: 0 = total paralysis; 1 = palpable or visible contraction; 2 = active movement, full range of motion (ROM) with gravity eliminated; 3 = active movement, full ROM against gravity; 4 = active movement, full ROM against gravity and moderate resistance in a muscle specific position; 5 = active movement, full ROM against gravity and full resistance in a

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