Incomplete cord syndromes are spinal injuries that are characterized by partial loss of motor and/or sensory function below the level of spinal injury. They arise from direct traumatic events to the spinal cord or ischemic injury following compression of a vessel. The four classes of incomplete cord syndromes include anterior cord syndrome, posterior cord syndrome, Brown-Séquard syndrome, and central cord syndrome. Diagnosis and classification of the injury are dependent on history and physical examination. Few investigations such as imaging of the spine may be done to ascertain the cause. Management is largely supportive and early surgical intervention for severe/deteriorating cases is recommended.

**Definition**

Incomplete cord syndromes are characterized by partial loss of motor and sensory function below the level of spinal injury. The syndromes are associated with a chance of full recovery.

**Incomplete spinal cord syndromes include:**
Anterior cord syndrome

Anterior cord syndrome causes paralysis and incomplete loss of light touch sensation (lateral spinothalamic spared). It is also known as Becks syndrome or anterior spinal artery syndrome.

Brown-Séquard syndrome

Brown-Séquard syndrome (hemisection cord) is the ipsilateral loss of proprioception and motor function, with contralateral loss of pain and temperature sensation.

Central cord syndrome

Central cord syndrome involves a cervical lesion with larger motor weakness in the upper extremities than in the lower extremities.

Posterior cord syndrome

It is also known as posterior spinal artery syndrome and is characterized by a lesion in the posterior part of the spinal cord.
Etiology of Incomplete Cord Syndromes

Anterior cord syndrome and posterior cord syndrome mostly arise from non-traumatic insults to the cord such as occlusion of the anterior spinal artery resulting in ischemic injury to the cord.

Occlusion of the anterior spinal artery flow can be caused by:

1. Atherosclerosis
2. Lesions in the larger aortic artery which include aortic aneurysms, thrombus, and aortic dissection.
3. External vessel compression by a herniating disc mass near the vessel and osteophytes.

Traumatic injuries to the vessels, such as hypertension injuries, damage the vessels and terminate the blood supply to the cord.

Brown-Séquard syndrome is almost always traumatic, but the compression of the spinal cord is also an important cause. The impingement may result from:

1. Traumatic penetrating injuries with foreign bodies
2. Disc herniation
3. Hematoma/hemorrhage accumulation that compresses the spinal canal
4. Transverse myelitis

Pathophysiology of Incomplete Cord Syndromes

Anatomy of the spinal cord

The spinal cord is the anatomical connection between the brain and the peripheral nervous system. Thus, pathological changes are easily identified as deficits of the peripheral nervous system. The spinal cord is located within the bony vertebrae which protect it. The vertebrae allow for division of the spinal cord into 31 spinal segments which include 8 cervical segments, 12 thoracic segments, 5 lumbar segments, 5 sacral segments, and one coccygeal spinal segment.

Each segment has a pair of anterior (motor) and dorsal (sensory) spinal nerve roots that emerge from each side and combine to form the spinal nerve as it exits from the vertebral column through the neuroforamina.

Microscopically, the spinal cord is organized into a series of neuropathways that carry motor (descending) and sensory (ascending) information. A cross-section of the spinal cord reveals a central gray matter and a peripheral white matter. Fibers that transmit motor and sensory functions include:

1. The corticospinal tracts which are descending motor pathways located anteriorly within the spinal cord. Axons extend from the cerebral cortex in the brain to the corresponding segment, where they form synapses with motor neurons in the anterior (ventral) horn. They decussate (cross over) in the medulla prior to entering the spinal cord.
2. The dorsal columns are ascending sensory tracts that transmit light touch, proprioception, and vibration information to the sensory cortex. They do not decussate until they reach the medulla.
3. The lateral spinothalamic tracts transmit pain and temperature sensation. These
tracts usually decussate within 3 segments of their origin as they ascend.

The fibers of the sympathetic nervous system exit from the spinal cord between C7 & L1, while the parasympathetic system pathways exit between S2 and S4.

- **Injury to the corticospinal tract or dorsal columns, respectively**, results in ipsilateral paralysis or loss of sensation of light touch, proprioception, and vibration.

- **Injury to the lateral spinothalamic tract** causes contralateral loss of pain and temperature sensation.

The blood supply of the spinal cord comes from one anterior and two posterior spinal arteries. The anterior spinal artery supplies the anterior two-thirds of the cord and injury to the vessel results in dysfunction of the corticospinal and lateral spinothalamic tract. The posterior spinal arteries primarily supply the dorsal columns. Both anterior and posterior spinal arteries are branches of the vertebral artery.

At any given level of the spinal cord, the central part is a watershed area and hyperextension injuries may cause ischemic injury to the central part of the cord, causing a central cord syndrome.

**Pathogenesis**

**In anterior and posterior spinal cord syndromes:**

Injury to the vessels after a traumatic event or occlusion by a nearby mass or osteophyte compromises the blood supply to the cord segment causing tissue hypoperfusion and ischemic injury to the spinal cord. The anterior spinal artery supplies the anterior two-thirds of the spinal cord housing the motor tracts and lateral spinothalamic tracts while the posterior spinal artery supplies the region carrying the dorsal column fibers. Thus, patients have compromised motor function. The loss of pain and temperature sensation on the contralateral side is due to injury to the ascending lateral spinothalamic tract that decussate in the spinal cord.

**In anterior spinal cord syndrome:**

There is an intact dorsal column of fibers. Hence a preserved sense of light touch, vibration, and proprioception which is the altered function in posterior cord syndrome.

**Brown-Séquard syndrome:**

Upon sustaining trauma, such as penetrating injury to the spinal cord, there is damage to the hemisection of the spinal cord and injury to both the ascending and descending spinal pathways of the ipsilateral side. Hence there is ipsilateral paralysis below the lesion since the descending motor tracts decussate high up in the medulla. Similarly, there is an ipsilateral loss of proprioception and vibration following an injury to the fibers of the dorsal column that cross high up in the medulla.

Conversely, there is a contralateral loss of pain and temperature sensation below the lesion due to the injury of the lateral spinothalamic tract that decussates two to three levels above the spinal column of injury.

**Central cord syndrome:**

It manifests so due to the arrangement of spinal columns at different levels of the vertebrae. The lower regions take up the peripheral parts of the spinal cord while the
uppermost segments, i.e., the cervical spinal cord segments, take up the most central part of the spinal cord. In individuals whose spinal column has been compromised, such as in patients suffering from spondylosis, an event like a hyperextension injury causes pinching of the cord between a hypertrophied ligament flavum and the spinal cord wall. This, in turn, leads to an injury to the central parts of the spinal cord and a central cord syndrome arises.

Since the cervical spinal fibers are central in location, there is a more neurological impact in the upper limbs compared to the lower limbs.

Clinical Presentation of Incomplete Cord Syndromes

**Patients with anterior spinal cord syndrome present with:**

1. A history of trauma or vascular disease that predicts the cause of vessels’ compromise.
2. Ipsilateral paralysis below the level of the lesion.
3. Contralateral loss of pain and temperature sensation.
4. Preserved function of vibration, soft touch and proprioception.
5. Sometimes bladder and bowel dysfunction is seen depending on the level.

**The posterior spinal cord syndrome is characterized by:**

1. Loss of vibration, soft touch and proprioception sensory function.
2. Preserved motor function and pain and temperature sensation due to injury to the dorsal column of fibers.

**Hemisection of the cord results into:**

1. Ipsilateral paralysis below the lesion.
2. Ipsilateral loss of proprioception and vibration sensation.
3. Contralateral loss of pain and temperature sensation below the lesion.

**The central cord syndrome** has a hallmark of *severe paralysis of the upper limbs and minimal involvement of the lower limbs*. Additional features of the syndrome include:

1. Loss of all sensations below the site of injury, i.e., light touch, vibration, proprioception, and positional sense.
2. Muscle stretch reflexes may be absent only to return later as the disease progresses.

Investigations of Incomplete Cord Syndromes

The workup for incomplete spinal cord injury patients is focused on the assessment of the severity of the injury and identification of the cause of injury to institute the appropriate management approach.

Tests:

- **History taking** and thorough **neurological examination** remain vital in the diagnosis of the injuries and their classification.

- **CT scan of the spine** is an excellent method of imaging the bone in the
cases of suspected tumors or in traumatic causes. CT scan delineates the structural pathology and its position. It is the preferred imaging in older children and adults.

- **MRI scan of the spine** has superior soft-tissue images that are desired in the assessment of the spinal cord. Thus, it is best for analyzing congenital malformations, spondylosis, subluxation and other forms of spinal root compression.

- **Blood studies (CBC, UECs)** are used as an additional workup for patients with suspected infective causes. The tests are also done as a baseline before management.

- **A myelogram** is a contrast-enhanced spine x-ray that delineates the position of compression of the spine.

- **Assessment of bladder function involves** collection or identification of the significant amount of urine; little or no urge to urinate indicates dysfunction.

- **Needle electromyography (EMG)** is an objective test to grade the denervation for more accurate classification of the injury.

### Differential Diagnosis of Incomplete Cord Syndromes

<table>
<thead>
<tr>
<th>Differential Diagnosis</th>
<th>Description</th>
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<tr>
<td><strong>Ankylosing spondylitis</strong></td>
<td>A special form of arthritis that affects the spine but may also involve other joints of the body.</td>
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<tr>
<td><strong>Gillian Barre syndrome</strong></td>
<td>Presents with peripheral motor and sensory deficits that mimic a spinal injury. However, there is no history of trauma preceding the symptoms, and the disease progresses rapidly over hours compared to spinal cord injury that rarely worsens after the presentation.</td>
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<tr>
<td><strong>Spinal cord infections</strong></td>
<td>A cause of spinal cord injury that should be differentiated from other causes. Treatment is mainly medical and not surgical.</td>
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<tr>
<td><strong>Brachial plexus injury</strong></td>
<td>Mimics a central cord syndrome but lacks lower limb involvement. Bladder and bowel functions are intact.</td>
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### Treatment of Incomplete Cord Syndromes

The treatment could be:

**Supportive treatment**

1. **Physical therapy** is done with the goal of attaining the functional recovery of the patient. Both chest and limb physiotherapy.
2. **Occupational therapy** to achieve a residual function for activities of daily living.
3. High-dose **corticosteroids** reduce the swelling around the injured part and relieve any compressions.
4. **Bisphosphonates** are administered in patients with bony lesions.
5. **Skeletal muscle relaxants** help in relieving the spasticity associated with weak muscles and allow for physical exercise.
6. **Bladder and bowel care** by manual evacuation of bowels or administration of enemas. Fixation of catheters to avoid soiling and irritation of the skin due to incontinence.
7. **Analgesics** such as opioids to maintain the patients’ comfort.
8. **Skincare** of the neurologically compromised patient to avoid the development of pressure ulcers. This is achieved by the use of alternating pressure mattresses, the 2-hourly turning of the patient and padding of bony surfaces.

**Definitive treatment**

It involves administration of **antibiotics** in infective causes. **Surgical decompression** is done with a goal of reducing pressure on the spinal cord or the nerve roots. After surgery, the patients are monitored for recovery of motor and sensory function. Early intervention, within 48 hours, is advocated; studies indicate good results with intervention within 6 hours of injury.

Spinal cord injuries involving the cervical region should include placement of a cervical collar at first contact with the patient to immobilize the spine and limit further injury to the spinal cord.

**Complications and Prognosis of Incomplete Cord Syndromes**

Of all incomplete spinal cord injuries, anterior cord syndromes carry the worst prognosis as they mimic complete cord syndrome. They have a 10-20% chance of full recovery.

**Complications of disease progression**

1. Incontinence: Bladder and bowel dysfunction if the injury is not reversed and left to progress.
2. Back pain.
3. Pressure ulcers due to loss of sensation and immobilization.
4. Gait changes and residual weakness.

**References**


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