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Neurological Evaluation of the Spine

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Abstract

Injuries to the spine account for a sizeable share of musculoskeletal injuries worldwide. The thoracic and lumbar areas account for 75% to 90% of spinal fractures, with thoracolumbar junction injuries being the most frequent (T10-L2).

Based on the patho-morphological criteria, the AO committee has divided thoraco-lumbar spine injuries into three kinds (A: Compression; B: Distraction; C: Axial torque and rotational deformity). Each of these categories is further classified into three groups and three subgroups to indicate the degree of instability and the progression of morphological damage.

Keywords: Morphological, T10-L2, Flexion, Fracture

Introduction

Three types of spinal injuries were identified by Watson-Jones: simple wedge fracture, comminute fracture, and fracture-dislocation. The first of its type, this classification system provided a treatment plan. This methodology suggested various reduction techniques for treating various spinal fractures. Chance described a unique injury brought on by abrupt forward flexion. The anterior flexion injury, often known as a seat-belt injury, was accompanied with distraction injury at the level of the posterior elements. This distraction injury is defined by a transverse fracture line through the posterior part of the vertebral body that extends into the posterior parts of the spine, and a compression fracture of the anterior part of the vertebral body.

The following criteria were used by Nicoll to group 166 thoracolumbar fractures in coal miners:

(1) Anterior wedge fractures;

(2) Lateral wedge fractures;

(3) Fracture dislocations; and

(4) Isolated neural arch fractures.

For the first time, Nicoll distinguished between stable and unstable fractures based on the fact that the interspinous ligament's health is a key factor in determining stability. Subsequent classifications were made using this as a foundation. Two-column theory was described by Holdsworth. The anterior column is made up of the posterior longitudinal ligament (PLL), the surrounding intervertebral disc, the body of the vertebra, and the anterior longitudinal ligament (ALL) (PLL). Pedicles, facet joints, transverse processes, Ligamentum flavum, spinous processes, interspinous and supraspinous ligaments, and pedicles are components of the posterior column. Additionally, he asserted that the main factor influencing spinal stability is the posterior column. Kelly and Whiteside expanded on Holdsworth's two-column theory by describing the neural arches as a hollow posterior column and the anterior vertebral bodies as a solid column. They emphasized the importance of the posterior parts in maintaining spinal stability and mentioned that more instability indicates more severe types of injury.

Later, Denis developed a three-column theory and divided the spine's sagittal profile into three columns. He added the middle column to the previously mentioned front and posterior columns. According to this idea, the middle column, made up of the PLL, the posterior half of the disc, the posterior annulus, and the posterior half of the vertebral body, is in the neutral axis of the spine.

It is thought that the middle column makes the biggest contributions to mechanical stability and can withstand the most axial load during flexion and extension movements. Compression and burst fractures are two separate fracture forms established by the middle column idea. While burst fractures include both the anterior and middle columns, compression fractures only affect the anterior column. Then, a transverse injury affecting all anterior, middle, and posterior columns is reclassified as a chance fracture.

The AO classification, which incorporates the three-column model put forward by Denis, was the next significant advancement in the classification of spinal injuries.

According to the patho-morphological criteria, it divides thoracolumbar spinal injuries into three groups: compression injury (Group A), distraction injury (Group B), and translation or rotation injury (Group C). Within each group, there are up to nine subtypes based on factors like morphology, fracture site, osseous or ligamentous disruption, and direction of displacement. Groups A through C depict a continuum of gradually increasing damage severity and instability, with a concomitant rising likelihood of the need for surgical stabilization, according to one of its main justifications. The AO method places a strong emphasis on the significance of soft-tissue injuries to the spine's intervertebral discs, posterior ligamentous complex, and anterior longitudinal ligament.

The Spine Trauma Study Group created the most recent classification, known as TLICS. This system bases the injury severity score on three factors: the patient's neurologic condition, the integrity of the posterior ligamentous complex, and the injury's morphology. A score is determined for each category, with a lower score given to a less serious injury and a greater score given to a more serious injury needing urgent treatment.

To determine whether to use surgical or nonsurgical care, the overall score is used as a guide. The TLICS places a strong emphasis on the value of MRI in determining PLC damage.

1. Spinal cord anatomy
2. INSCI (ASIA)
3. Motor function

- Examine the strength of key muscle groups in the upper limb
- Examine the strength of key muscle groups in the lower limb

4. Sensory function
5. Reflex examination
6. Sacral sparing tests
7. Clinical Syndromes in SCI

- Brown-Sequard Syndrome
- Central cord syndrome
- Anterior cord syndrome
- Posterior cord syndrome
- Conus Medullaris syndrome

- Cauda Equina Syndrome

8. Cranial nerve examination
9. Spinal cord injury

1. Spinal cord anatomy

The knowledge of the Spinal Cord anatomy is crucial for the interpretation of the results of the physical examination.

- The lateral spinothalamic tracts that are responsible for transmitting pain and temperature sensation.
- The lateral corticospinal tracts that are responsible for the motor function.
- These tracts carry a specific topographical organization.
- The most central portions represent the function of the more proximal areas of the body and the more peripheral portions represent the function of the distal areas of the body.
- The posterior columns transmit position sense, vibratory sensation, and deep pressure sensation.

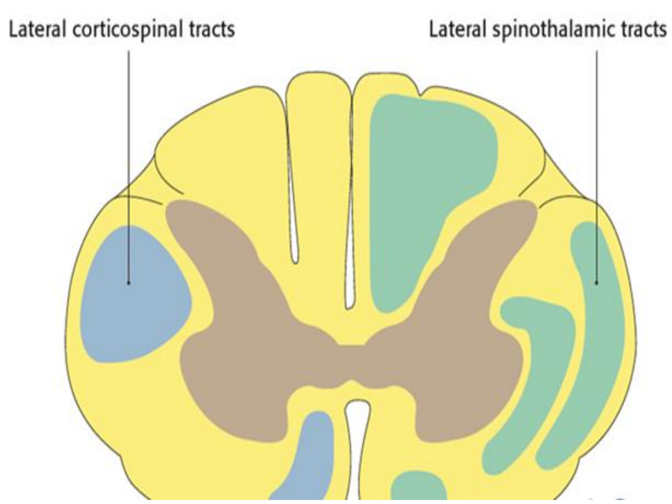


Figure 1: Spinal cord anatomy

INSCI (Formerly referred to as the ASIA standards)

To assess the neurologic status of the patient the International Standards for neurological classification of Spinal Cord Injuries (INSCI; formerly referred to as the ASIA standards) are used systematically.

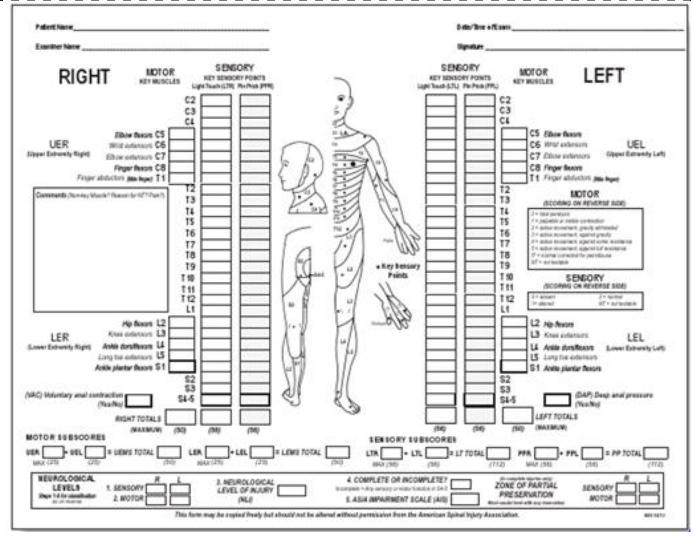
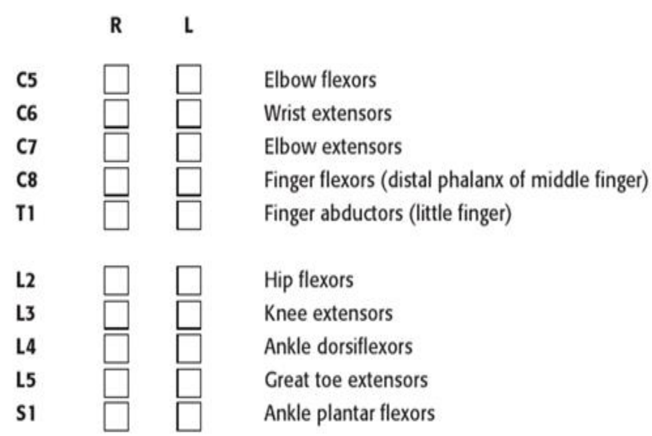


Figure 2: INSCI or ASIA

Motor function

Manual Muscle Testing (MMT) of the following key muscle groups in the upper and lower extremities should be performed.

There are six levels of muscle strength, ranging from 0 – 5, as indicated on the INSCI assessment sheet.



	R	L	
C5	☐	☐	Elbow flexors
C6	☐	☐	Wrist extensors
C7	☐	☐	Elbow extensors
C8	☐	☐	Finger flexors (distal phalanx of middle finger)
T1	☐	☐	Finger abductors (little finger)
L2	☐	☐	Hip flexors
L3	☐	☐	Knee extensors
L4	☐	☐	Ankle dorsiflexors
L5	☐	☐	Great toe extensors
S1	☐	☐	Ankle plantar flexors

Figure 3: Motor function

Examine the strength of key muscle groups in the upper limb

The key muscles are listed below along with the spinal cord level in parentheses.

Elbow flexors (C5)

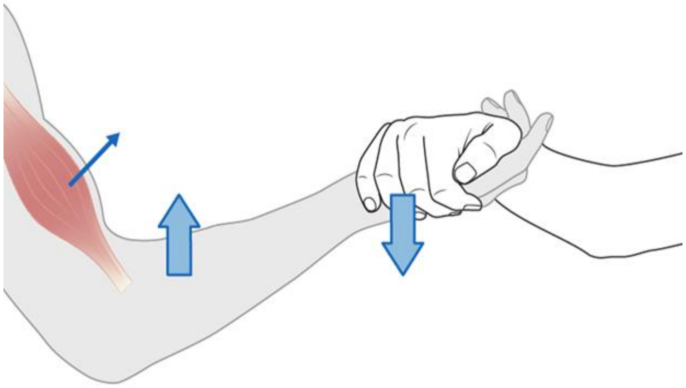


Figure 4: Wrist extensors (C6)

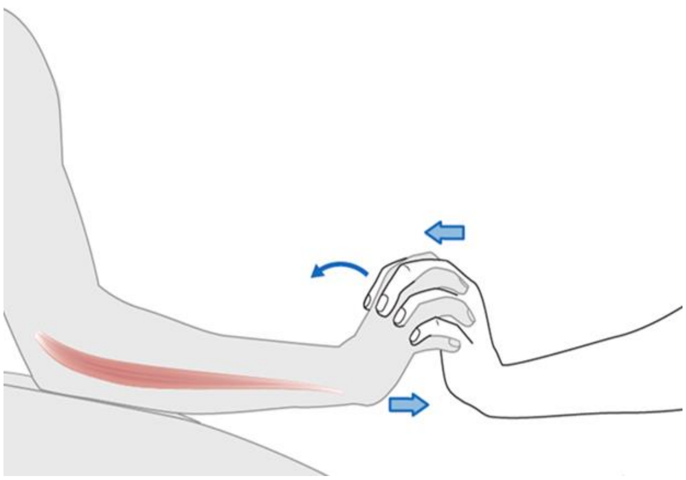


Figure 5: Elbow extensors (C7)

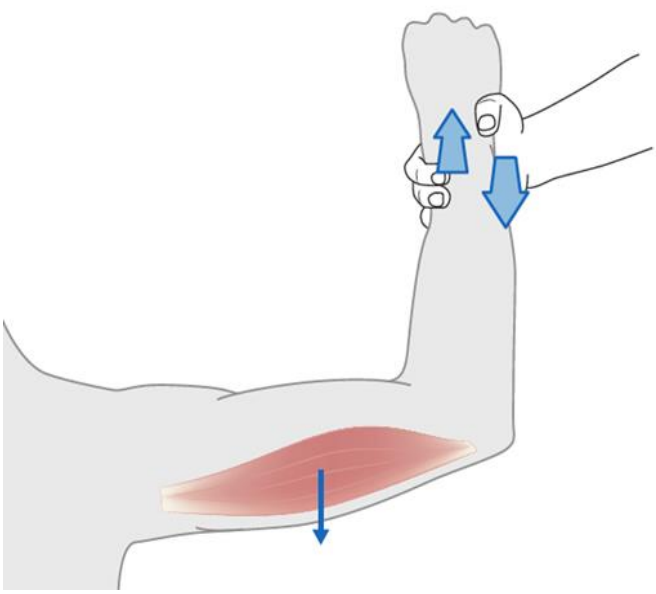


Figure 6: Finger flexors (C8)

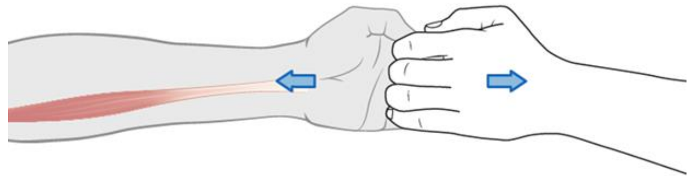


Figure 7: Finger abductors (T1)

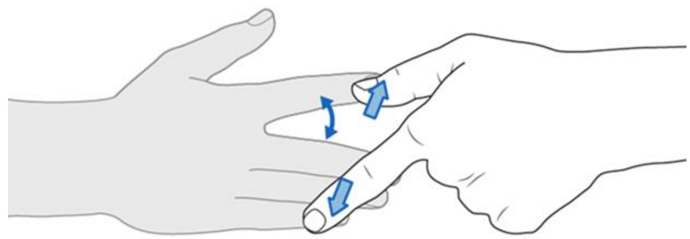


Figure 8:

Examine the strength of key muscle groups in the lower limb

Hip flexors (L2)

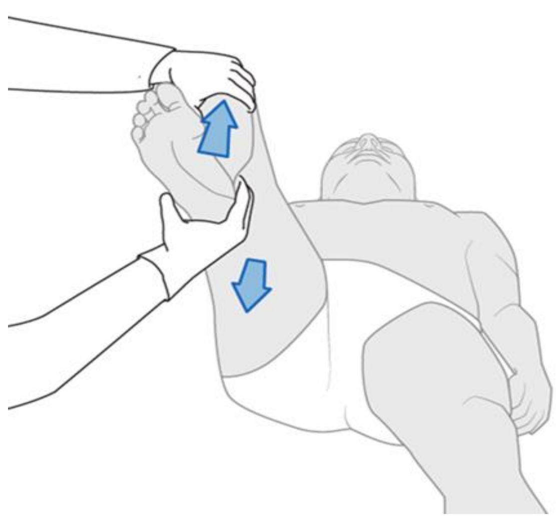


Figure 9: Knee extensors (L3)

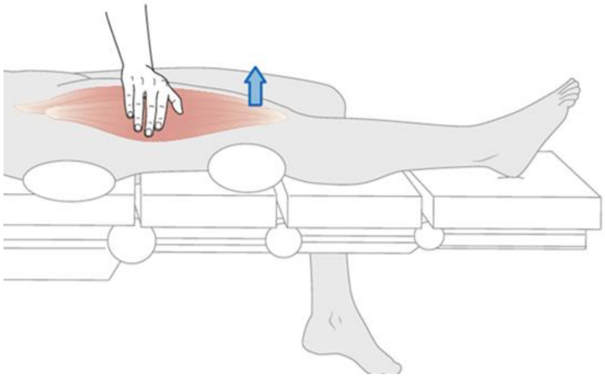


Figure 10: Ankle dorsiflexors (L4)

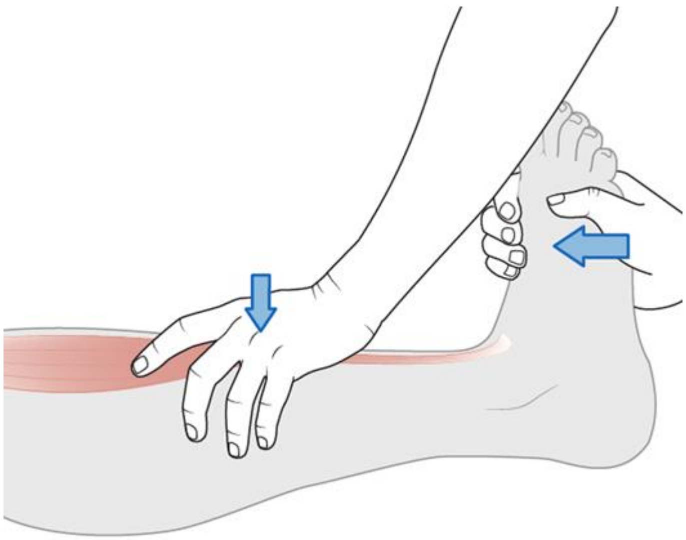


Figure 11: Great toe extensors (L5)

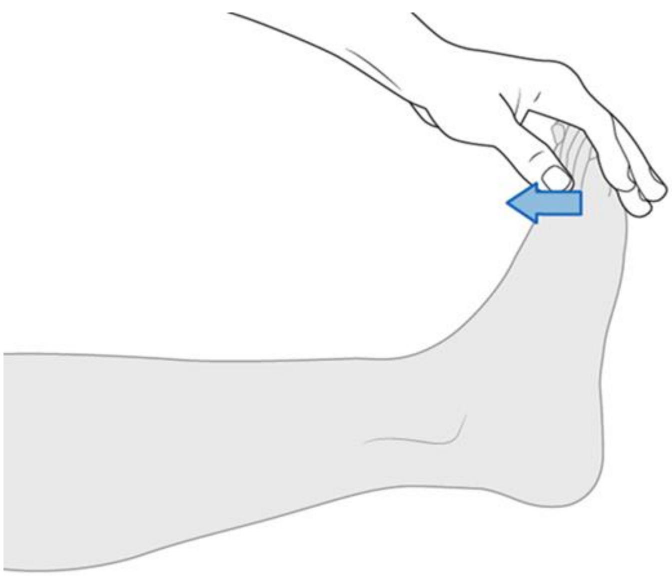


Figure 12: Ankle plantar flexors (S1)

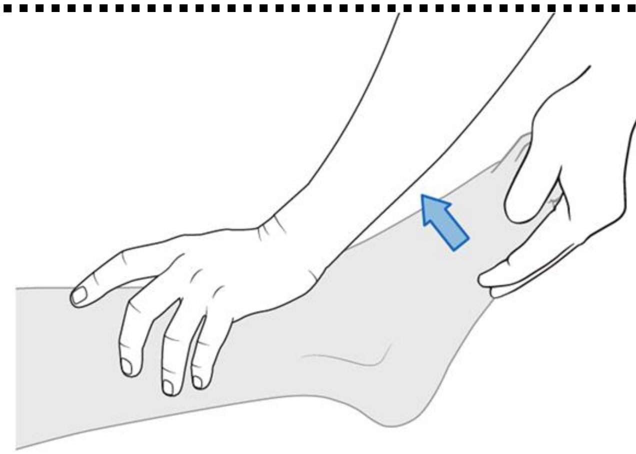


Figure 13

Sensory function

Key sensory points

Pin prick sensation is assessed with a needle.

Light touch sensation is assessed with a piece of tissue paper.

Sensation is scored as absent (0), abnormal (1), or normal (2).

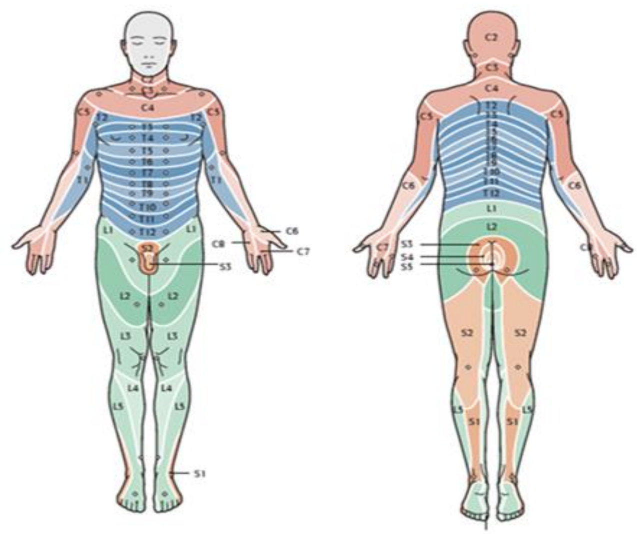


Figure 14: Sensory function

Pearls: C4/5 and T1/2

Because the C4 sensory level extends below the clavicle just above the T2 dermatome, a mid-cervical neurological injury level is often misinterpreted as being a thoracic level. C5 through T1 are in the arms. The T2 dermatome includes the medial forearm the axilla and the upper chest.

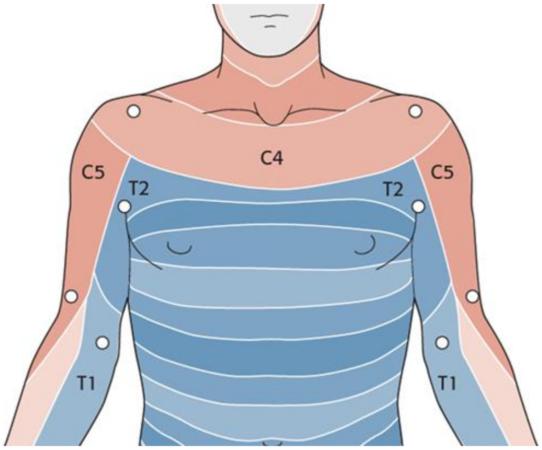


Figure 15: Pearls: C4/5 and T1/2

Pearl: Left and right

The left and the right need to be examined separately and are not always the same.

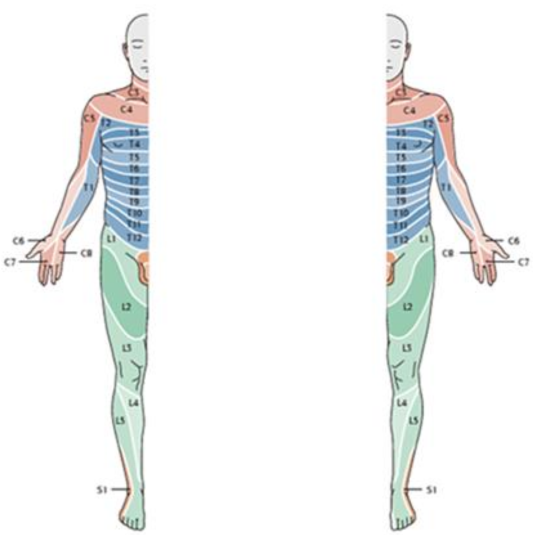


Figure 16: Pearl: Left and right

Reflex examination

Upper and lower extremities should be examined for asymmetry in deep tendon reflexes.

In the setting of an acute spinal cord injury, deep tendon reflexes are absent below the level of injury.

The upper extremity reflexes are listed below with corresponding neurological level in parentheses.

Biceps reflex (C5).

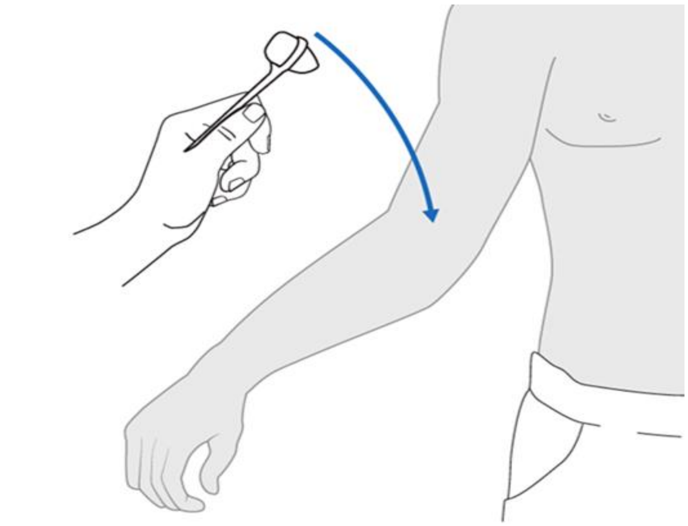


Figure 17: Brachioradialis reflex (C6).

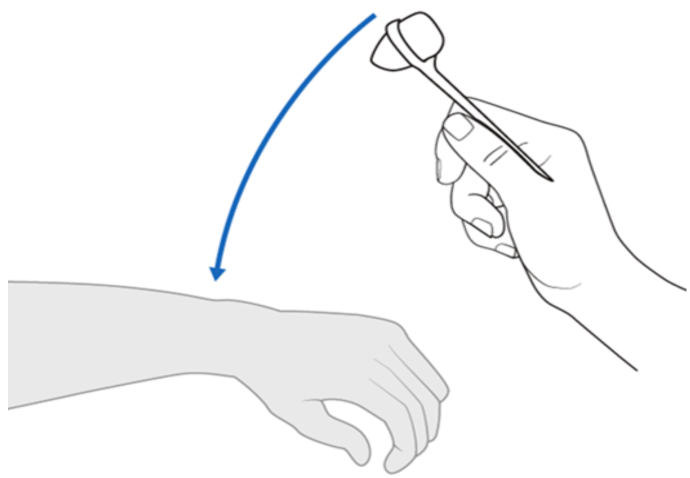


Figure 18: Triceps tendon reflex (C7).

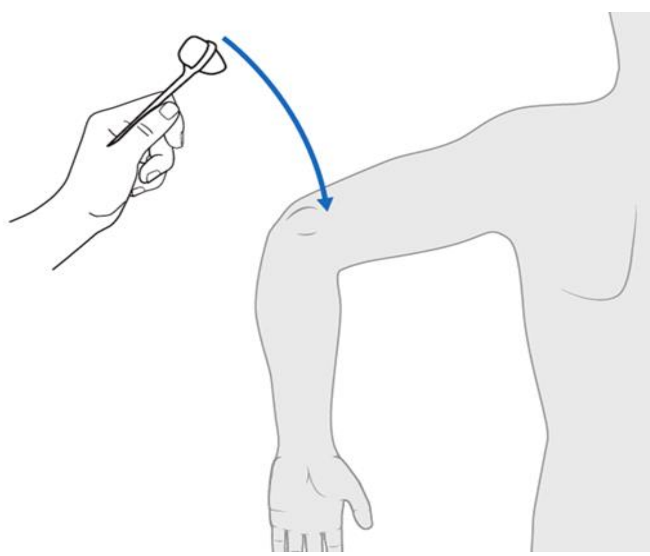


Figure 19: Knee tendon (L4).

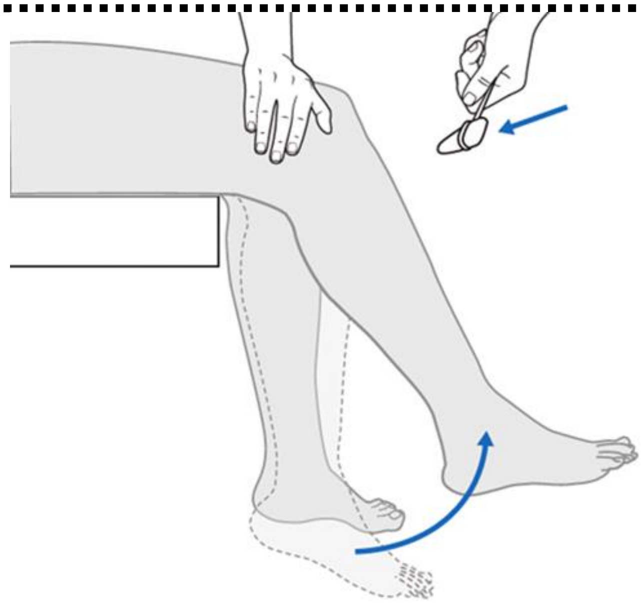


Figure 20: Achilles tendon (S1).

Figure 21

Pathological reflexes

Clonus and Babinski reflexes should be assessed. If positive, this may be an indication of spinal cord dysfunction.

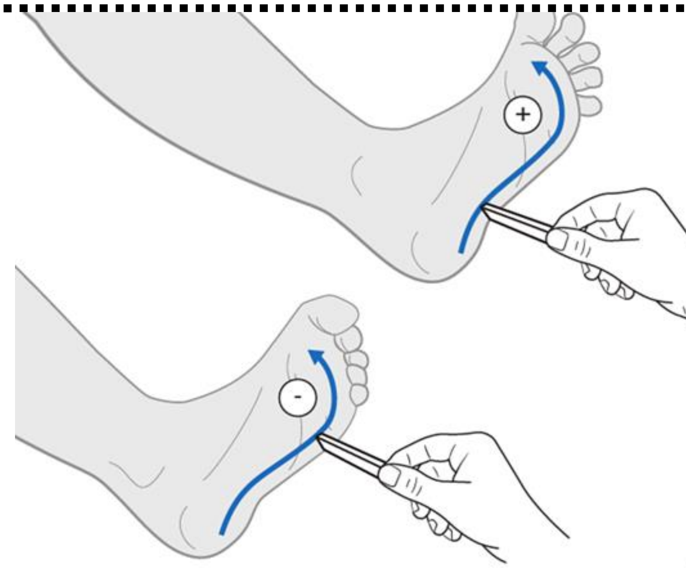


Figure 22: Babinski reflex

Sacral sparing tests

Because the sacral roots are most caudal, the presence of any sacral root function indicates the absence of complete spinal cord injury which impacts both treatment and prognosis.

Rectal examination

A rectal examination should be performed to assess for anal sphincter tone as well as proprioception and perianal sensation. Anal sphincter tone should be scored as absent or flaccid, reduced or normal.

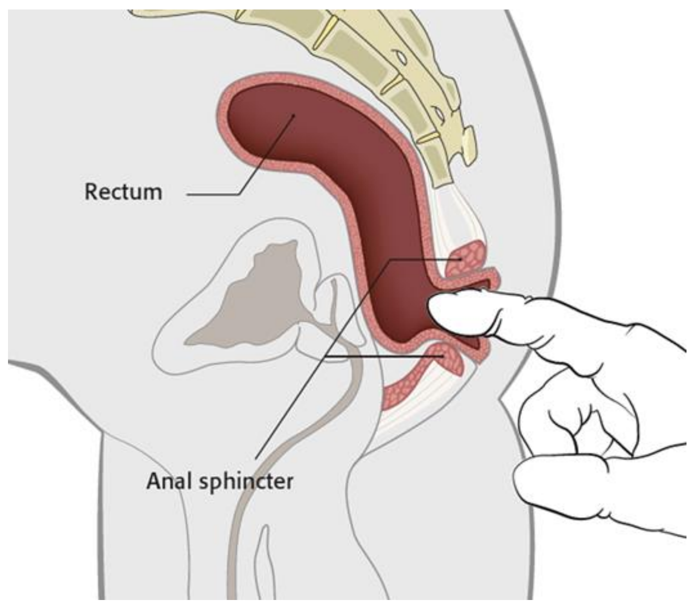


Figure 23: Rectal examination

The anal sphincter allows for the most caudal assessment of motor innervation.

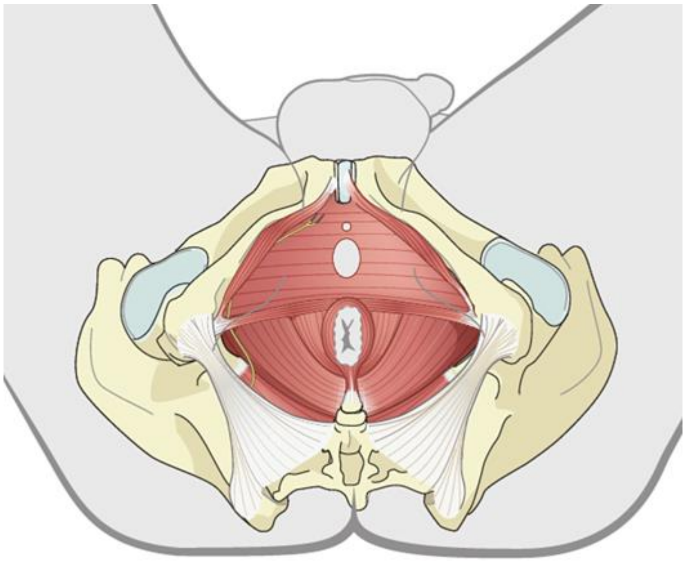


Figure 24: Anal sphincter

The S2-5 dermatomes should be assessed for pin prick and light touch sensation (diagram, dermatome).

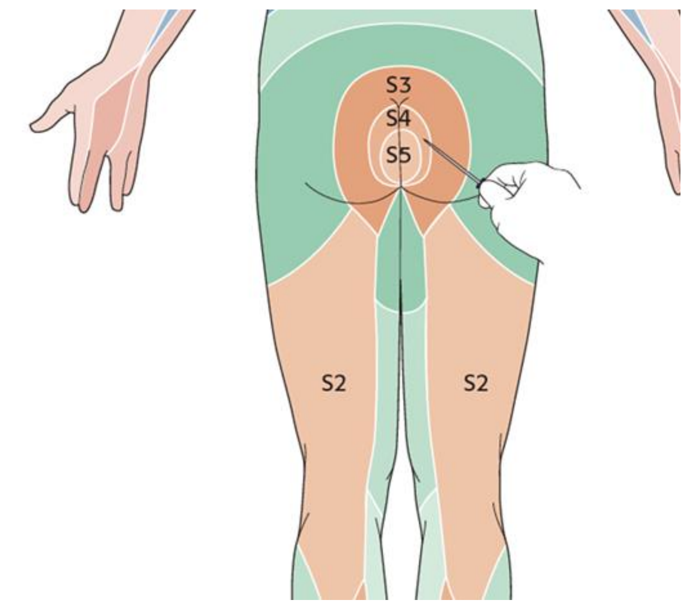


Figure 25: S2-S5 dermatome assessed for pin prick and light touch sensation (diagram, dermatome).

Clinical Syndromes in SCI

Neurological examination in spinal cord injury

1. To describe a normal neurological examination, as well as the possible abnormalities.

2. To identify the dermatome and myotome distribution patterns.

3. To highlight the difficulties of the neurological evaluation in unconscious patients.

4. To recognize the international scales applied for neurological evaluations.

Brown-Sequard Syndrome

Is caused by a hemi section of the spinal cord.

Clinical presentation

- Unilateral lateral column damage results in ipsilateral muscle paralysis
- Injury to the dorsal column results in an ipsilateral loss of joint position sense, vibratory sense, and tactile discrimination
- Damage to the lateral spinothalamic tracts results in loss of pain and temperature sensation on the contralateral side of the body

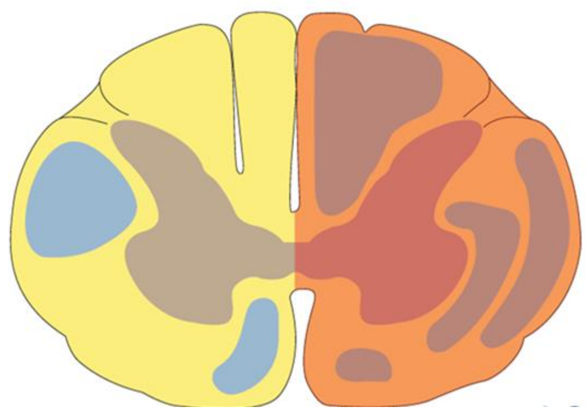


Figure 26: Brown-Sequard Syndrome

Central cord syndrome

Is caused by hyperextension injuries and the most common SCI.

This syndrome is most common in elderly patients and patients with cervical stenosis.

Clinical presentation

- There is typically more motor impairment of the upper than the lower extremities
- Bladder dysfunction

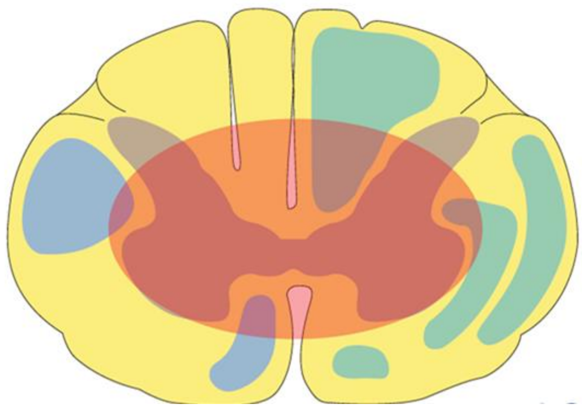


Figure 27: Central cord syndrome

Anterior cord syndrome

Results from damage to the anterior 2/3 of the spinal cord. This may be caused by compromised blood supply from the anterior spinal artery or flexion compression forces on the cervical spine.

Clinical presentation

- Patients will have minimal distal motor function because of damage to the lateral corticospinal tracts

This syndrome has the poorest prognosis for functional recovery.

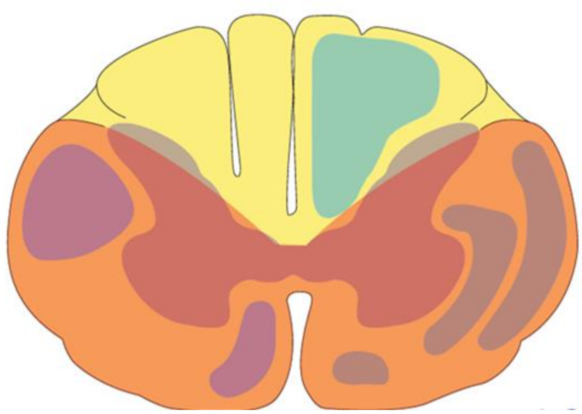


Figure 28: Anterior cord syndrome

Posterior cord syndrome

Is a very rare injury, sparing the anterior 2/3 of the spinal cord.

Clinical presentation

- Patients lose their ability to discern deep pressure and vibration and joint position
- Ambulation is only possible with visual feedback

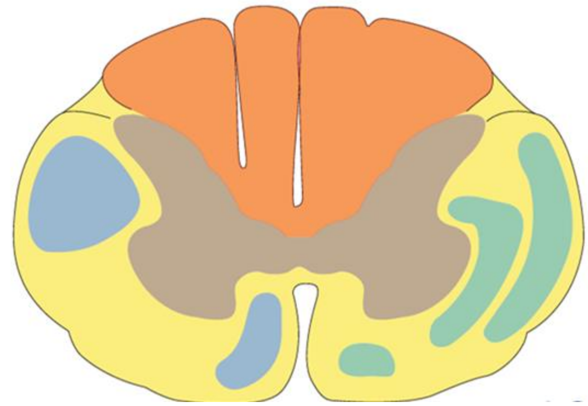


Figure 29: Posterior cord syndrome

Conus Medullaris syndrome

There is an injury to conus medullaris or the lumbar nerve roots. This typically occurs after fractures at the T12-L1 level.

Clinical presentation

- Isolated bowel and bladder dysfunction
- Deficits reflecting both cord and root components

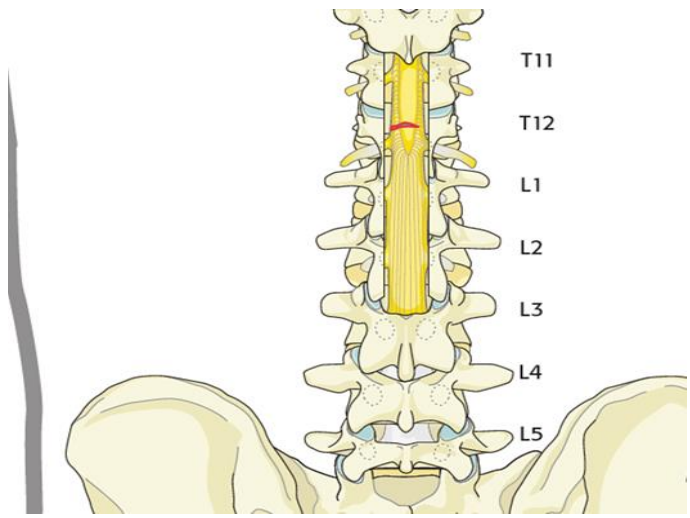


Figure 30: Conus Medullaris syndrome

Cauda Equina Syndrome

There is an injury to the spinal rootlets below the level of the spinal cord (typically below the L1–L2 level.

Clinical presentation:

- Bowel and bladder dysfunction
- motor deficits
- radicular symptoms from lower motor neuron damage

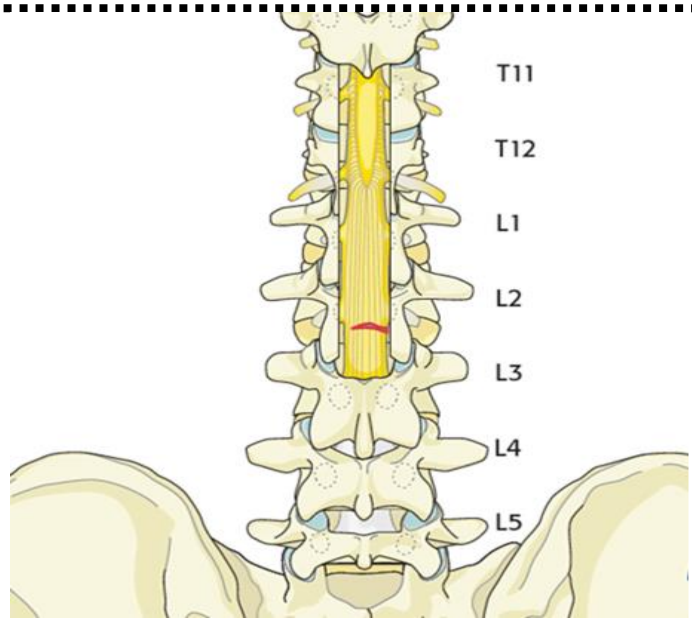


Figure 31: Cauda Equina Syndrome

Cranial nerve examination

For injuries involving the occipito cervical region, a thorough cranial nerve examination should be performed.

Olfactory nerve (CN I).

- Ask patient to identify smell (eg. coffee)

Optic nerve (CN II).

- Assess vision of each eye.

Oculomotor (CN III).

- Check pupil constriction and eye movement.

Theoclear nerve (CN IV).

- Assess patient's ability to look downwards and inwards.

Trigeminal nerve (CN V).

- Assess patient's ability to clench jaw (motor) and facial response to touch (sensory).

Abducens nerve (CN VI).

- Assess lateral deviation of eye.

Facial nerve (CN VII).

- Assess patient's facial assymetry and ability to smile, frown, elevate eyebrows (motor), and taste of anterior 2/3 of tongue (sensory).

Vestibulocochlear nerve (CN VIII).

- Test the patient's ability to hear high and low pitches.

Glossopharyngeal nerve (CN IX).

- Check gag reflex and patients ability to swallow (motor) as well as taste on posterior 1/3 of tongue (sensory)

Vagus nerve (CN X).

- Check symmetry of soft palate and uvula.

Accessory nerve (NC XI).

- Check patient's ability to shrug shoulders against resistance.

Hypoglossal nerve (CN XII).

- Check patient's ability to stick out tongue.

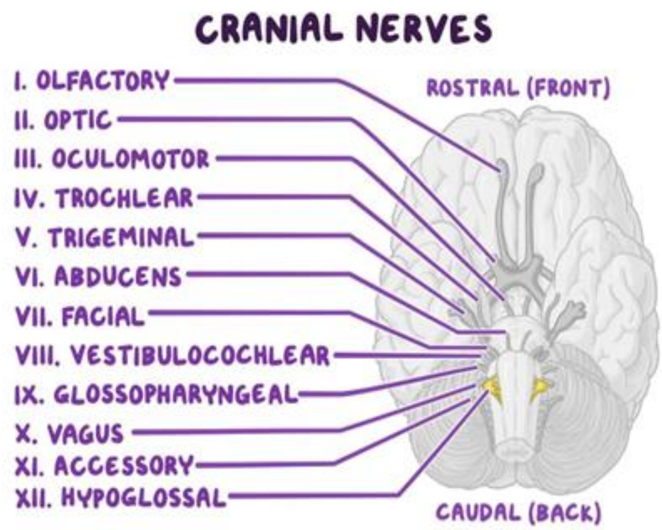


Figure 32: Cranial nerve examination

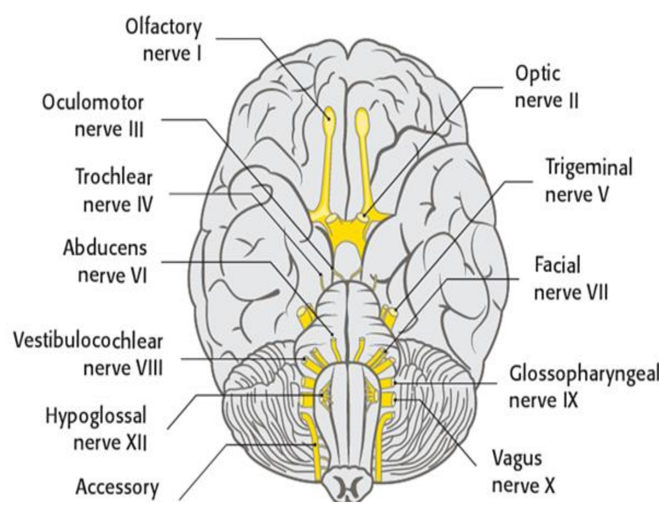


Figure 33: Cranial nerve examination

Spinal cord injury

The majority of patients with a traumatic spinal cord injury will require surgical intervention to deal with the spinal pathology.

In principle, surgical decompression and reconstruction should be undertaken within 24 hours.

It is essential to maintain spinal cord perfusion during surgical intervention in a spinal cord injury patient.

Main arterial blood pressure should be maintained above 85 mm Hg.

If required, an infusion of an inotropic medication (dopamine or levophed) should be instituted.

The use of methylprednisolone in the setting of spinal cord injury can be considered.

Methylprednisolone, if used, should be administered according to NASCIS-2 protocols.

Methylprednisolone should be administered within 8 hours of spinal cord injury.

The dose is 30 mg per kg IV over one hour followed by an infusion of 5.4 mg per kg per hour for 23 hours.

Methylprednisolone is not recommended for the following circumstances (due to an adverse risk benefit ratio):

1. The multiply injured patient
2. Penetrating spinal cord injury
3. Patients with glucose intolerance or diabetes mellitus
4. Patients with multiple medical comorbidities or with impaired immune system
5. Elderly patients
6. Patients with a complete thoracic spinal cord injury (ASIA A)

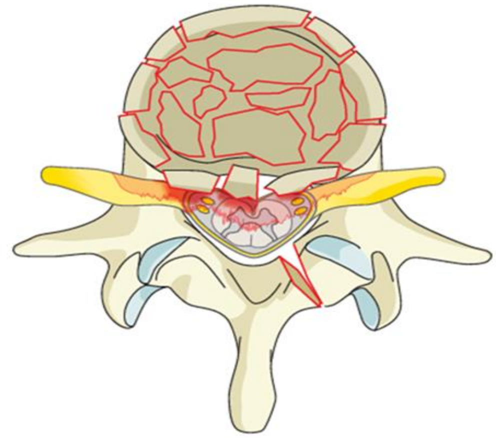


Figure 34: Spinal cord injury

On behalf of all authors, the corresponding author states that there is no conflict of interest.

Declarations

Informed consent

Informed consent was obtained for experimentation with human subjects. The privacy rights of human subjects must always be observed

“Institutional Ethical Committee Approval”

Taken from Institutional Ethical Approval Committee, MGM Medical College & Hospital, Navi Mumbai, Maharashtra, India.

Authors contribution

The author statement file, using the relevant Credit roles: Conceptualization; Data curation; Formal analysis; Funding acquisition; Investigation; Methodology; Project administration; Resources; Software; Supervision; Validation; Visualization; Roles/Writing – original draft; Writing – review & editing: All done by Dr Kshitij Badade. Only 1 Author contributed to everything done.

Availability of data and materials

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