

# International standards for neurological classification of spinal cord injury (Revised 2011)

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## Introduction

This article represents the content of the booklet, International Standards for Neurological Classification of Spinal Cord Injury, revised 2011, published by the American Spinal Injury Association (ASIA). For further explanation of the clarifications and changes in this revision, see the accompanying article (Kirshblum S., *et al.* J Spinal Cord Med. 2011;DOI 10.1179/107902611X13186000420242

The spinal cord is the major conduit through which motor and sensory information travels between the brain and body. The spinal cord contains longitudinally oriented spinal tracts (white matter) surrounding central areas (gray matter) where most spinal neuronal cell bodies are located. The gray matter is organized into segments comprising sensory and motor neurons. Axons from spinal sensory neurons enter and axons from motor neurons leave the spinal cord via segmental nerves or roots.

In the cervical spine, there are 8 nerve roots. Cervical roots of C1-C7 are named according to the vertebra

*above* which they exit (i.e. C1 exits above the C1 vertebra, just below the skull and C6 nerve roots pass between the C5 and C6 vertebrae) whereas C8 exists *between* the C7 and T1 vertebra; as there is no C8 vertebra. The C1 nerve root does not have a sensory component that is tested on the International Standards Examination.

The thoracic spine has 12 distinct nerve roots and the lumbar spine consists of 5 distinct nerve roots that are each named accordingly as they exit *below* the level of the respective vertebrae. The sacrum consists of 5 embryonic sections that have fused into one bony structure with 5 distinct nerve roots that exit via the sacral foramina. The spinal cord itself ends at approximately the L1-2 vertebral level. The distal most part of the spinal cord is called the conus medullaris. The cauda equina is a cluster of paired (right and left) lumbosacral nerve roots that originate in the region of the conus medullaris and travel down through the thecal sac and exit via the intervertebral foramen *below* their respective vertebral levels. There may be 0, 1, or 2 coccygeal nerves but they do not have a role with the International Standards examination in accordance with the International Standards for Neurological Classification of Spinal Cord Injury (ISNCSCI).

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Each root receives sensory information from skin areas called dermatomes. Similarly each root innervates a group of muscles called a myotome. While a dermatome usually represents a discrete and contiguous skin area, most roots innervate more than one muscle, and most muscles are innervated by more than one root.

Spinal cord injury (SCI) affects conduction of sensory and motor signals across the site(s) of lesion(s), as well as the autonomic nervous system. By systematically examining the dermatomes and myotomes, as described within this booklet, one can determine the cord segments affected by the SCI. From the International Standards examination several measures of neurological damage are generated, e.g., Sensory and Motor Levels (on right and left sides), NLI, Sensory Scores (Pin Prick and Light Touch), Motor Scores (upper and lower limb), and ZPP. This booklet also describes the ASIA (American Spinal Injury Association) Impairment Scale (AIS) to classify the severity (i.e. completeness) of injury.

This booklet begins with basic definitions of common terms used herein. The section that follows describes the recommended International Standards examination, including both sensory and motor components. Subsequent sections cover sensory and motor scores, the AIS classification, and clinical syndromes associated with SCI. For ease of reference, a worksheet (Appendix 1) of the recommended examination is included, with a summary of steps used to classify the injury (Appendix 2). A full-size version for photocopying and use in patient records has been included as an enclosure and may also be downloaded from the ASIA website ([www.asia-spinalinjury.org](http://www.asia-spinalinjury.org)). Additional details regarding the examination and e-Learning training materials can also be obtained from the website<sup>15</sup>.

## Definitions

**Tetraplegia (preferred to “quadriplegia”):** This term refers to impairment or loss of motor and/or sensory function in the cervical segments of the spinal cord due to damage of neural elements within the spinal canal. Tetraplegia results in impairment of function in the arms as well as typically in the trunk, legs and pelvic organs, i.e. including the four extremities. It does not include brachial plexus lesions or injury to peripheral nerves outside the neural canal.

**Paraplegia:** This term refers to impairment or loss of motor and/or sensory function in the thoracic, lumbar or sacral (but not cervical) segments of the spinal cord, secondary to damage of neural elements within the spinal canal. With paraplegia, arm functioning is spared, but, depending on the level of injury, the trunk,

legs and pelvic organs may be involved. The term is used in referring to cauda equina and conus medullaris injuries, but not to lumbosacral plexus lesions or injury to peripheral nerves outside the neural canal.

**Tetraparesis and paraparesis:** Use of these terms is discouraged, as they describe incomplete lesions imprecisely, and incorrectly implies that tetraplegia and paraplegia should only be used for neurologically complete injuries. Instead, the ASIA Impairment Scale (AIS) provides a more precise approach to description of severity (i.e. completeness) of the SCI.

**Dermatome:** This term refers to the area of the skin innervated by the sensory axons within each segmental nerve (root).

**Myotome:** This term refers to the collection of muscle fibers innervated by the motor axons within each segmental nerve (root).

**Sensory level:** The sensory level is determined by performing an examination of the key sensory points within each of the 28 dermatomes on each side of the body (right and left) and is the most caudal, normally innervated dermatome for both pin prick (sharp/dull discrimination) and light touch sensation. This may be different for the right and left side of the body.

**Motor level:** The motor level is determined by examining a key muscle function within each of 10 myotomes on each side of the body and is defined by the lowest key muscle function that has a grade of at least 3 [on manual muscle testing (MMT) in the supine position], providing the key muscle functions represented by segments above that level are judged to be intact (graded as a 5 on MMT). This may be different for the right and left side of the body.

**Neurological level of injury (NLI):** The NLI refers to the most caudal segment of the spinal cord with normal sensory and antigravity motor function on both sides of the body, provided that there is normal (intact) sensory and motor function rostrally. The segments at which normal function is found often differ by side of the body and in terms of sensory and motor testing. Thus, up to four different segments may be identified in determining the neurological level, i.e., R(ight)-sensory, L(ef)-sensory, R-motor, L-motor. The single NLI is the most rostral of these levels.

**Skeletal level:** This term has been used to denote the level at which, by radiographic examination, the greatest vertebral damage is found. The skeletal level is not part of the current ISNCSCI because not all cases of SCI have a bony injury, bony injuries do not consistently correlate with the neurological injury to the spinal cord, and this term cannot be revised to document neurological improvement or deterioration.

**Sensory scores (see worksheet; Appendix 1):** This term refers to a numerical summary score of sensory function. There is a maximum total of 56 points each for light touch and pin prick (sharp/dull discrimination) modalities, for a total of 112 points per side of the body. This can reflect the degree of neurological impairment associated with the SCI.

**Motor scores (see worksheet; Appendix 1):** This term refers to a numerical summary score of motor function. There is a maximum score of 25 for each extremity, totaling 50 for the upper limbs and 50 for the lower limbs. This score can reflect the degree of neurological impairment associated with the SCI.

**Incomplete injury:** This term is used when there is preservation of any sensory and/or motor function below the neurological level that includes the lowest sacral segments S4-S5 (i.e. presence of “sacral sparing”). Sensory sacral sparing includes sensation preservation (intact or impaired) at the anal mucocutaneous junction (S4-5 dermatome) on one or both sides for light touch or pin prick, or deep anal pressure (DAP). Motor sacral sparing includes the presence of voluntary contraction of the external anal sphincter upon digital rectal examination.

**Complete injury:** This term is used when there is an absence of sensory and motor function in the lowest sacral segments (S4-S5) (i.e. no sacral sparing)<sup>14</sup>.

**Zone of partial preservation (ZPP):** This term, used only with complete injuries, refers to those dermatomes and myotomes caudal to the sensory and motor levels that remain partially innervated. The most caudal segment with some sensory and/or motor function defines the extent of the sensory and motor ZPP respectively and are documented as four distinct levels (R-sensory, L-sensory, R-motor, and L-motor).

## Neurological Examination

### Introduction

The International Standards examination used for neurological classification has two components (sensory and motor), which are separately described below. These elements are used in determining the sensory/motor/neurological levels, in generating scores to characterize sensory/motor functioning and in determining completeness of the injury. The examination does not represent a comprehensive neurological examination for a patient with SCI, as it does not include elements that are not used for determining classification, such as deep tendon reflexes, etc. Although more precise measurements of sensory and motor function are available, the current examination uses common clinical measures that can be performed

with minimal equipment (safety pin and cotton wisp) and in virtually any clinical setting and phase of care.

The examination should be performed with the patient in the supine position (except for the rectal examination that can be performed side-lying) to allow for a valid comparison of scores throughout the phases of care. Initially if there is spinal instability, without orthotic stabilization, the patient should be log-rolled (so there is no twisting of the spinal column) on their side to complete the anorectal exam, or alternatively an abbreviated exam can be performed in the supine position.

### *When the patient is not fully testable*

When a key sensory point or key muscle is not testable for any reason, (i.e. because of a cast, burn, amputation, or if the patient is unable to appreciate sensation on the face), the examiner should record “NT” (not testable) instead of a numeric score. In such cases, sensory and motor scores for the affected side of the body, as well as total sensory and motor scores, cannot be generated at that point in treatment. Further, when associated injuries, e.g., traumatic brain injury, brachial plexus injury, limb fracture, etc., interfere with completion of the examination; the neurological level should still be determined as accurately as possible. However, obtaining the sensory/motor scores and impairment grades should be deferred to later examinations.

### *Sensory examination: required elements*

The required portion of the sensory examination is completed through the testing of a key point in each of the 28 dermatomes (from C2 to S4-5) on the right and left sides of the body<sup>5</sup> that can be readily located in relation to bony anatomical landmarks. At each of these key points, two aspects of sensation are examined: light touch and pin prick (sharp-dull discrimination).

Appreciation of light touch and pin prick sensation at each of the key points is separately scored on a three-point scale, with comparison to the sensation on the patients’ cheek as a normal frame of reference:

0 = absent

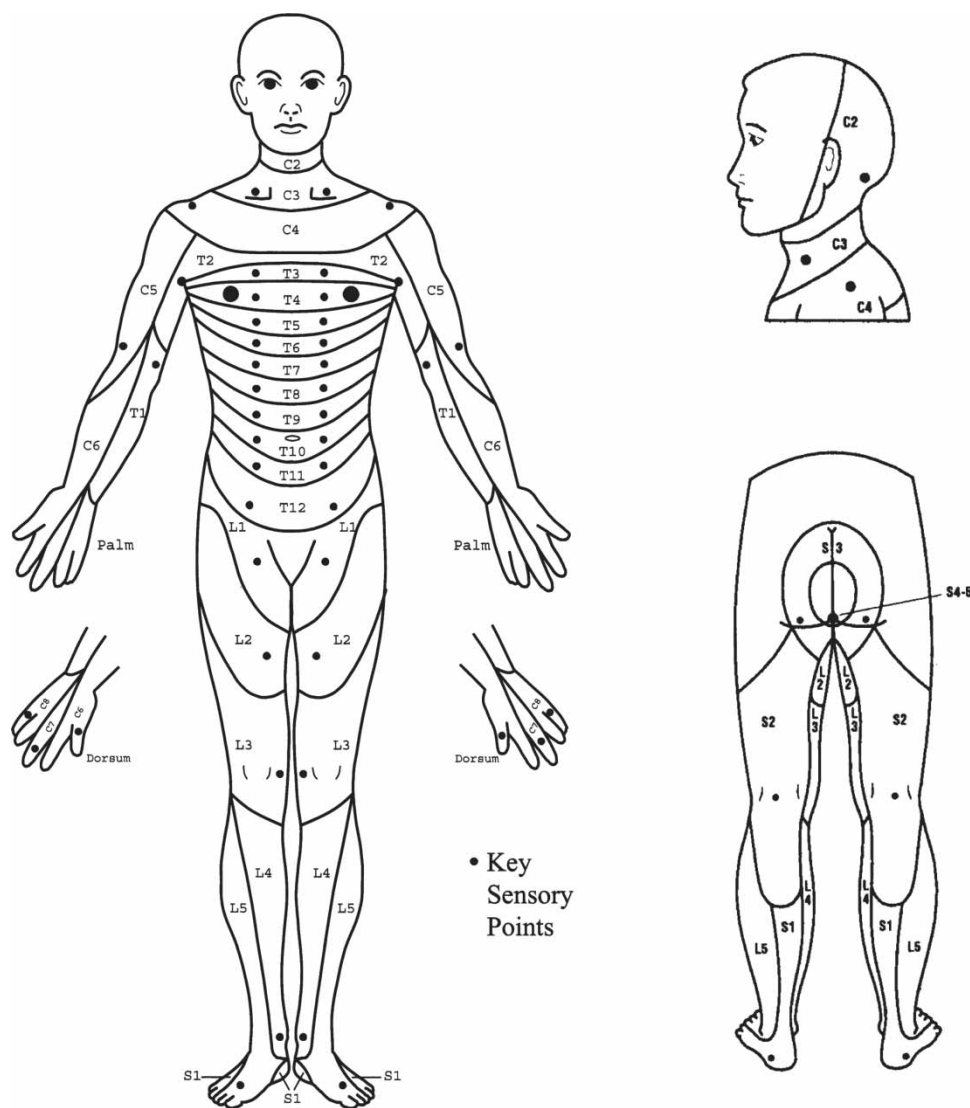
1 = altered (impaired or partial appreciation, including hyperesthesia)

2 = normal or intact (similar as on the cheek)

NT = not testable

Light touch sensation is tested with a tapered wisp of cotton stroked once across an area not to exceed 1cm of skin with the eyes closed or vision blocked.

Pin prick sensation (sharp/dull discrimination) is performed with a disposable safety pin that is stretched apart to allow testing on both ends; using the pointed end to test for sharp and the rounded end of the pin for dull. In testing for pin prick appreciation, the



**Figure 1** Schematic depiction of key points for sensory testing.

examiner must determine if the patient can correctly and reliably discriminate between sharp and dull sensation at each key sensory point. If in doubt, 8 out of 10 correct answers are suggested as a standard for accuracy; as this reduces the probability of correct guessing to less than 5%<sup>4</sup>. The inability to distinguish between dull and sharp sensation (as well as no feeling when being touched by the pin) is graded as 0.

A grade of 1 for pin prick is given when sharp/dull sensation is impaired. In this case, the patient reliably distinguishes between the sharp and dull ends of the pin, but states that the intensity of sharpness is different in the key sensory point than the feeling of sharpness on the face. The intensity may be greater or lesser than the feeling on the face.

The following key points are to be tested bilaterally for sensitivity from C2-S4/5 dermatomes (see Fig. 1 and diagram on the worksheet (Appendix 1).

- C2 – At least 1 cm lateral to the occipital protuberance (alternatively 3 cm behind the ear)
- C3 – Supraclavicular fossa (posterior to the clavicle) and at the midclavicular line
- C4 – Over the acromioclavicular joint
- C5 – Lateral (radial) side of the antecubital fossa (just proximal to elbow crease)
- C6 – Thumb, dorsal surface, proximal phalanx
- C7 – Middle finger, dorsal surface, proximal phalanx
- C8 – Little finger, dorsal surface, proximal phalanx
- T1 – Medial (ulnar) side of the antecubital fossa, just proximal to the medial epicondyle of the humerus
- T2 – Apex of the axilla
- T3 – Midclavicular line and the third intercostal space (IS) found by palpating the anterior chest to locate the third rib and the corresponding IS below it\*



- T4 – Fourth IS (nipple line) at the midclavicular line
- T5 – Midclavicular line and the fifth IS (midway between T4 and T6)
- T6 – Midclavicular line and the sixth IS (level of xiphisternum)
- T7 – Midclavicular line and the seventh IS (midway between T6 and T8)
- T8 – Midclavicular line and the eighth IS (midway between T6 and T10)
- T9 – Midclavicular line and the ninth IS (midway between T8 and T10)
- T10 – Midclavicular line and the tenth IS (umbilicus)
- T11 – Midclavicular line and the eleventh IS (midway between T10 and T12)
- T12 – Midclavicular line and the mid-point of the inguinal ligament
- L1 – Midway distance between the key sensory points for T12 and L2
- L2 – On the anterior-medial thigh at the midpoint drawn connecting the midpoint of inguinal ligament (T12) and the medial femoral condyle
- L3 – Medial femoral condyle above the knee
- L4 – Medial malleolus
- L5 – Dorsum of the foot at the third metatarsal phalangeal joint
- S1 – Lateral heel (calcaneus)
- S2 – Mid point of the popliteal fossa
- S3 – Ischial tuberosity or infragluteal fold
- S4–5 – Perianal area less than one cm. lateral to the mucocutaneous junction (taken as one level)

\*An alternative way of locating T3 is palpating the manubriosternal joint, which is at the level of the second rib. At that point, move slightly lateral to palpate the second rib and continue to move in a caudal direction to locate rib three and the corresponding intercostal space just below it.

**Deep Anal Pressure (DAP):** DAP awareness is examined through insertion of the examiners index finger and applying gentle pressure to the anorectal wall (innervated by the somatosensory components of the pudendal nerve S4/5). Alternatively, pressure can be applied by using the thumb to gently squeeze the anus against the inserted index finger. Consistently perceived pressure should be graded as being present or absent (i.e., enter Yes or No on the worksheet). Any reproducible pressure sensation felt in the anal area during this part of the exam signifies that the patient has a sensory incomplete lesion. In patients who have light touch or pin prick sensation at S4-5, evaluation of DAP is not necessarily required as the patient already has a designation for a sensory incomplete

injury, although still recommended to complete the worksheet. The rectal examination is still required however, to test for motor sparing (i.e. voluntary anal sphincter contraction).

### *Sensory examination: optional elements*

For purposes of the SCI evaluation, the following aspects of sensory function are considered as optional: joint movement appreciation and position sense, and awareness of deep pressure/deep pain. (Note: there is no specific portion for this to be recorded on the worksheet except for the comments section). Joint movement appreciation and position sense are graded using the same sensory scale provided (absent, impaired, normal). A grade of 0 (absent) indicates the patient is unable to correctly report joint movement on large movements of the joint. A grade of 1 (impaired) indicates the patient is able to consistently report joint movement with 8 of 10 correct answers – but only on large movements of the joint and unable to consistently report small movements of the joint. A 2 (normal) indicates the patient is able to consistently report joint movement with 8 out of 10 correct answers on both small (approximately 10° of motion) and large movements of the joint. Joints that can be tested include the interphalangeal (IP) joint of the thumb, the proximal IP joint of the little finger, the wrist, the IP joint of the great toe, the ankle, and the knee.

Deep pressure appreciation of the limbs (applying firm pressure to the skin for 3–5 seconds at different locations of the wrist, fingers, ankles and toes) can be tested for patients in whom light touch and pin prick modalities are graded as 0 (absent). Because this test is electively performed in the absence of light touch and pin prick sensation, it is graded as either a 0 for absent, or 1 for present, in reference to firm pressure, using the index finger or thumb, to the chin.

### *Motor examination: required elements*

The required portion of the motor examination is completed through the testing of key muscle functions corresponding to 10 paired myotomes (C5-T1 and L2-S1) (see later). It is recommended that each key muscle function should be examined in a rostral-caudal sequence, utilizing standard supine positioning and stabilization of the individual muscles being tested. Improper positioning and stabilization can lead to substitution by other muscles, and will not accurately reflect the muscle function being graded.

The strength of each muscle function is graded on a six-point scale<sup>1,6,7,9</sup>

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 = (normal) active movement, full ROM against gravity and full resistance in a muscle specific position expected from an otherwise unimpaired person.

5\* = (normal) active movement, full ROM against gravity and sufficient resistance to be considered normal if identified inhibiting factors (i.e. pain, disuse) were not present.

NT = not testable (i.e. due to immobilization, severe pain such that the patient cannot be graded, amputation of limb, or contracture of >50% of the range of motion).

Plus and minus scores are not used when the International Standards examination is applied in a research setting and not recommended when comparing data across institutions.

In cases of a muscle function whose ROM is limited by a contracture, if the patient exhibits  $\geq 50\%$  of the normal range, then the muscle function can be graded through its available range with the same 0–5 scale. If the ROM is limited to  $< 50\%$  of the normal ROM, “NT” should be documented.

C5 – Elbow flexors (biceps, brachialis)

C6 – Wrist extensors (extensor carpi radialis longus and brevis)

C7 – Elbow extensors (triceps)

C8 – Finger flexors (flexor digitorum profundus) to the middle finger

T1 – Small finger abductors (abductor digiti minimi)

L2 – Hip flexors (iliopsoas)

L3 – Knee extensors (quadriceps)

L4 – Ankle dorsiflexors (tibialis anterior)

L5 – Long toe extensors (extensor hallucis longus)

S1 – Ankle plantar flexors (gastrocnemius, soleus)

When testing for a grade 4 or 5 strength the following specific positions should be used. Please refer to the InStEP training or the muscle function testing downloads for details for grades 0–3 testing<sup>15</sup>.

C5 – Elbow flexed at 90 degrees, arm at the patient’s side and forearm supinated

C6 – Wrist in full extension

C7 – Shoulder is neutral rotation, adducted and in 90 degrees of flexion with elbow in 45 degrees of flexion

C8 – Full flexed position of the distal phalanx with the proximal finger joints stabilized in an extended position

T1 – Full abducted position of fingers

L2 – Hip flexed to 90 degrees

L3 – Knee flexed to 15 degrees

L4 – Full dorsiflexed position of ankle

L5 – First toe fully extended

S1 – Hip in neutral rotation, neutral flexion/extension, and neutral abduction/adduction, the knee is fully extended and the ankle in full plantarflexion

In a patient with a potentially unstable spine, care must be taken when performing any manual muscle testing. When examining a patient with a suspected acute traumatic injury below the T8 level, the hip should not be allowed to actively or passively flex beyond 90° due to the increased kyphotic stress placed on the lumbar spine. Examination should be performed isometrically and unilaterally, so that the contralateral hip remains extended to stabilize the pelvis.

**Voluntary anal contraction (VAC):** The external anal sphincter (innervated by the somatic motor components of the pudendal nerve from S2–4) should be tested on the basis of reproducible voluntary contractions around the examiner’s finger and graded as being present or absent (i.e., enter YES or NO on the patient’s worksheet). The instruction to the patient should be “squeeze my finger as if to hold back a bowel movement”. If there is VAC present, then the patient has a motor incomplete injury. Care should be taken to distinguish VAC from reflex anal contraction; if contraction can be produced only with Valsalva maneuver, it may be indicative of reflex contraction and should be scored as absent.

### *Motor examination: optional elements*

For purposes of the SCI evaluation, other non-key muscles may be evaluated; for example, the diaphragm, deltoid, finger extension, hip adductors and hamstrings. The presence of non-key muscle activity can be documented in the comment box on the worksheet. While these muscle functions are not used in determining motor levels or scores, at this time the International Standards allows non-key muscles to determine motor incomplete status; AIS B versus C (see later).

### **Sensory and motor levels/ scores**

**Sensory Level:** The sensory level is the most caudal, intact dermatome for both pin prick and light touch sensation. This is determined by a grade of 2 (normal/intact), in all dermatomes beginning with C2 and extending caudally to the first segment that has a score of less than 2 for either light touch or pin prick. The intact dermatome level located immediately above the first dermatome level with impaired or absent light touch or pin prick sensation is designated as the sensory level.

Since the right and left sides may differ, the sensory level should be determined for each side. Testing will generate up to four sensory levels per dermatome: R-pin prick, R-light touch, L-pin prick, L-light touch. For a single sensory level, the most rostral of all is taken.

If sensation is abnormal at C2, the sensory level should be designated as C1. If sensation is intact on one side for light touch and pin prick at all dermatomes C2 through S4-S5, the sensory level for that side should be recorded as "INT" that indicates "intact", rather than as S5.

**Sensory scores:** Required testing generates scores for each dermatome for pin prick and light touch that can be summed across dermatomes and sides of body to generate two summary sensory scores: Pin prick and Light touch. Normal sensation for each modality is reflected in a score of 2. A score of 2 for each of the 28 key sensory points tested on each side of the body would result in a maximum score of 56 for pin prick, 56 for light touch, and a total of 112. The sensory score cannot be calculated if any required key sensory point is not tested. The sensory scores provide a means of numerically documenting changes in sensory function.

**Motor level:** The motor level is determined by examining the key muscle functions within each of 10 myotomes and is defined by the lowest key muscle function that has a grade of at least 3 (on supine MMT), providing the key muscle functions represented by segments above that level are judged to be intact (graded as a 5). This can be different for the right and left side of

the body. A single motor level would be the more rostral of the two.

### Further considerations for motor level determination

Just as each segmental nerve (root) innervates more than one muscle, most muscles are innervated by more than one nerve segment (usually two segments; see Fig. 2). Therefore, the assigning of one muscle or one muscle group (i.e., the key muscle function) to represent a single spinal nerve segment is a simplification, used with the understanding that in any muscle the presence of innervation by one segment and the absence of innervation by the other segment will result in a weakened muscle.

By convention, if a muscle function has at least a grade of 3, it is considered to have intact innervation by the more rostral of the innervating segments. In determining the motor level, the next most rostral key muscle function must test as 5, since it is assumed that the muscle(s) will have both of its two innervating segments intact. For example, if no activity is found in the C7 key muscle function and the C6 muscle function is graded as 3, then the motor level for the tested side of the body is C6, providing the C5 muscle function is graded 5.

The examiner's judgment is relied upon to determine whether a muscle function that tests as less than normal (5) may in fact be fully innervated. This may occur when full effort from the patient is inhibited by factors such as pain, positioning and hypertonicity or when weakness is judged to be due to disuse. If any of these or other

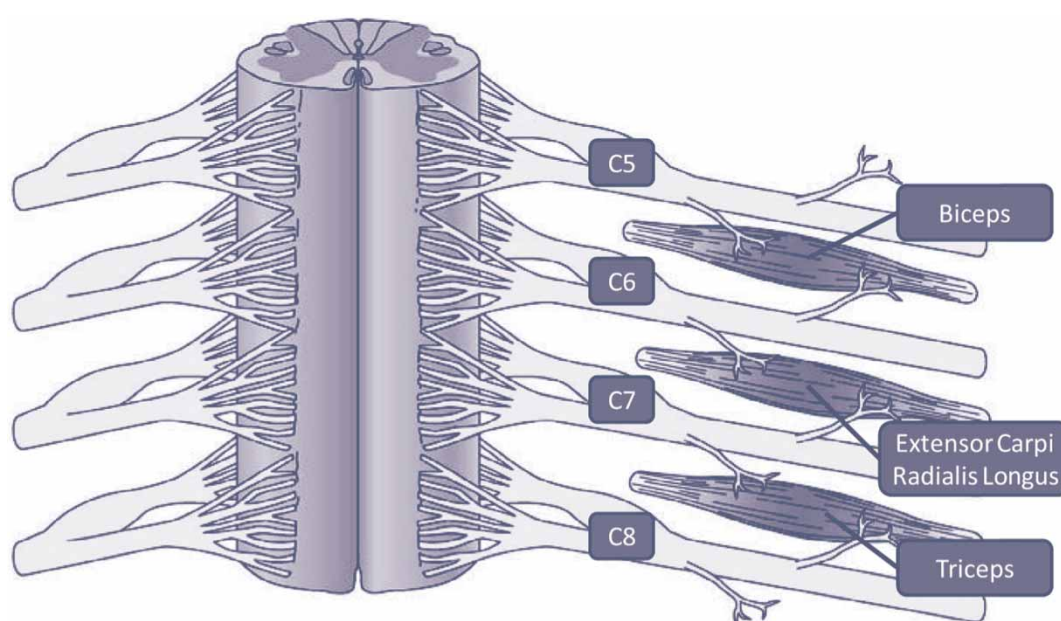


Figure 2 Schematic depiction of innervation of each of three key muscles by two nerve segments.

factors impedes standardized muscle testing, the muscle function should be graded as not testable (NT). However, if these factors do not prevent the patient from performing a forceful contraction and the examiner's best judgment is that the muscle function would test normally (a supine MMT grade of 5) were it not for these factors, it may be graded as 5\*.

For those myotomes that are not clinically testable by a manual muscle exam, i.e., C1 to C4, T2 to L1, and S2 to S5, the motor level is presumed to be the same as the sensory level if testable motor function above (rostral) that level is normal as well. Examples will help clarify.

Example 1: If the sensory level is C4, and there is no C5 motor function strength (or strength graded <3), the motor level is C4.

Example 2: If the sensory level is C4, with the C5 key muscle function strength graded as  $\geq 3$ , the motor level would be C5 because the strength at C5 is at least 3 with the "muscle function" above considered normal: presumably if there was a C4 key muscle function it would be graded as normal since the sensation at C4 is intact.

Example 3: If the sensory level is C3, with the C5 key muscle function strength graded as  $\geq 3$ , the motor level is C3. This is because the motor level presumably at C4 is not considered normal (since the C4 dermatome is not normal), and the rule of all levels rostral needing to be intact is not met.

Similar rules apply in the lower extremity where L2 is the first key muscle function. L2 can only be considered a motor level if sensation at L1 and more rostral is intact.

Example 4: If all upper limb key muscle functions are intact, with intact sensation to T6, the sensory level as well as the motor level is recorded as T6.

Example 5: In the case similar to #4, but the T1 muscle function graded a 3 instead of a 5, while T6 is still the sensory level, the motor level is T1, as all the muscles above the T6 level cannot be considered normal.

**Motor scores:** The required motor testing generates two motor grades per paired myotome: right and left. As indicated on the worksheet enclosed, these scores are then summed across myotomes and sides of body to generate a single motor score each for the upper and for the lower limbs. The motor score provides a means of numerically documenting changes in motor function. Normal strength is assigned a grade of 5 for each muscle function. A score of 5 for each of the five key muscle functions of the upper extremity would result in a maximum score of 25 for each extremity, totaling 50 for the upper limbs. The same is true for

the five key muscle functions of the lower extremity, totaling a maximum score of 50 for the lower limbs. The motor score cannot be calculated if any required muscle function is not tested.

Although in the past a total motor score of 100 for all extremities was calculated, it is no longer recommended to add the upper limb and lower limb scores together. Examination of the metric properties of the motor score indicate that it should be separated into two scales, one composed of the 10 upper limb muscle functions, and one of the 10 lower limb muscle functions, with a maximum score of 50 each<sup>10</sup>.

**Neurological level of injury (NLI):** The NLI refers to the most caudal segment of the cord with intact sensation and antigravity muscle function strength, provided that there is normal (intact) sensory and motor function rostrally.

The sensory and motor levels are determined for the right and left side, based upon the examination findings for the key sensory points and key muscle functions. Therefore, four separate levels are possible: a right sensory level; left sensory level; right motor level; and a left motor level. The single NLI is the most rostral of these 4 levels, and is used during the classification process. In cases such as this, however, it is recommended that each of these segments be separately recorded since a single NLI, may be misleading from a functional standpoint if the sensory level is rostral to the motor level.

**Note:** It is important to indicate on the worksheet, any weakness due to neurological conditions unrelated to SCI. For example, in a patient with a T8 fracture who also has a left brachial plexus injury, it should be noted that sensory and motor deficits in the left arm are due to the brachial plexus injury, not the SCI. This will be necessary to classify the patient correctly.

### ASIA Impairment Scale (AIS) (modified from Frankel)<sup>3,8,12,14</sup>

Injuries are classified in general terms of being neurologically "complete" or "incomplete" based upon the sacral sparing definition. "Sacral Sparing" refers to the presence of sensory or motor function in the most caudal sacral segments as determined by the examination (i.e. preservation of light touch or pin prick sensation at the S4-5 dermatome, DAP or voluntary anal sphincter contraction). A complete injury is defined as the absence of sacral sparing (i.e. sensory and motor function in the lowest sacral segments, S4-5), whereas an incomplete injury is defined as the presence of sacral sparing (i.e. some preservation of sensory and/or motor function at S4-5).



The following ASIA Impairment Scale (AIS) designation is used in grading the degree of impairment:

**A = Complete.** No sensory or motor function is preserved in the sacral segments S4-S5.

**B = Sensory incomplete.** Sensory but not motor function is preserved below the neurological level and includes the sacral segments S4-S5, AND no motor function is preserved more than three levels below the motor level on either side of the body.

**C = Motor incomplete.** Motor function is preserved below the neurological level\*\*, and more than half of key muscle functions below the single neurological level of injury have a muscle grade less than 3 (Grades 0–2).

**D = Motor incomplete.** Motor function is preserved below the neurological level\*\*, and at least half (half or more) of key muscle functions below the NLI have a muscle grade >3.

**E = Normal.** If sensation and motor function as tested with the ISNCSCI are graded as normal in all segments, and the patient had prior deficits, then the AIS grade is E. Someone without a SCI does not receive an AIS grade.

\*\*For an individual to receive a grade of C or D, i.e. motor incomplete status, they must have either (1) voluntary anal sphincter contraction or (2) sacral sensory sparing (at S4/5 or DAP) with sparing of motor function more than three levels below the motor level for that side of the body. The Standards at this time allows even non-key muscle function more than 3 levels below the motor level to be used in determining motor incomplete status (AIS B versus C).

**Note:** When assessing the extent of motor sparing below the level for distinguishing between AIS B and C, the **motor level** on each side is used; whereas to differentiate between AIS C and D (based on proportion of key muscle functions with strength grade 3 or greater) the **single neurological level** is used.

**Zone of partial preservation (ZPP):** The ZPP is used only with complete injuries (AIS A), and refers to those dermatomes and myotomes caudal to the sensory and motor levels that remain partially innervated. The most caudal segment with some sensory or motor function defines the extent of the sensory or motor ZPP respectively, and should be recorded for the right and left sides and for sensory and motor function. A single segment (not a range of segments) is designated on the worksheet for each of these. For example, if the right sensory level is C5, and some sensation extends from C6 through C8, then “C8” is recorded in the right sensory ZPP block on the worksheet. If there are no partially innervated segments below a motor or sensory level, the motor and sensory level should be entered in the box for the ZPP on the worksheet.

Note that motor function does NOT follow sensory function in recording ZPP, but rather the caudal extent of the motor ZPP must be based on the presence of voluntary muscle contraction below the motor level. In a case of where the motor, sensory, and therefore NLI is T4, with sparing of some sensation at the left T6 dermatome, T6 should be entered for the left sensory ZPP, but the box for motor ZPP should remain T4. Non-key muscles are not included in the ZPP.

With an incomplete injury, the ZPP is not applicable and therefore “NA” is recorded in the block on the worksheet.

### Clinical syndromes

While not a part of the International Standards examination or AIS classification, these incomplete syndromes have previously been described in this booklet, and as such have been maintained.

#### Central cord syndrome

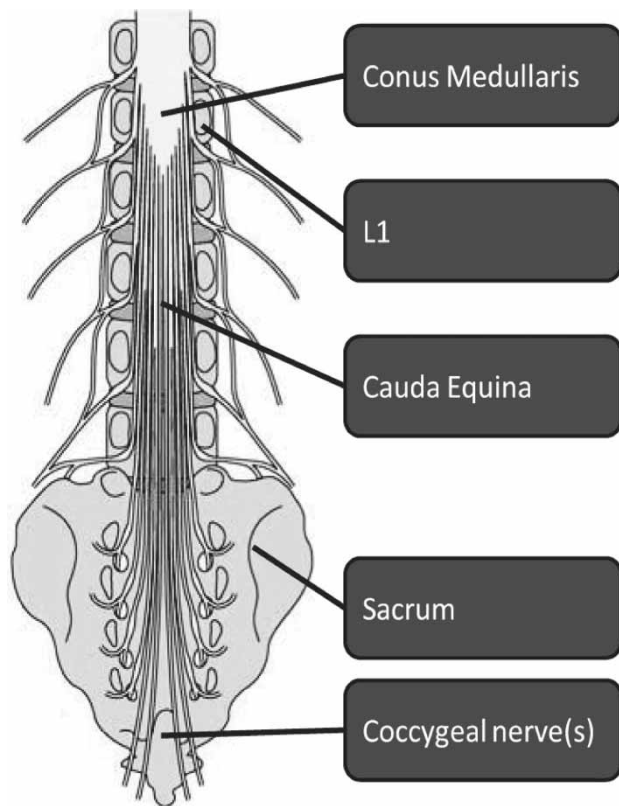
Central cord syndrome is the most common of the clinical syndromes, often seen in individuals with underlying cervical spondylosis who sustain a hyperextension injury (most commonly from a fall); and may occur with or without fracture and dislocations. This clinically will present as an incomplete injury with greater weakness in the upper limbs than in the lower limbs.

#### Brown-Sequard syndrome

Brown-Sequard syndrome (historically related to a knife wound) represents a spinal cord hemisection in its pure form, which results in ipsilateral loss of proprioception and vibration and motor control at and below the level of lesion, sensory loss of all modalities at the level of the lesion, and contralateral loss of pain and temperature sensation. This specific syndrome in its pure form is rare, more often resulting in a clinical examination with some features of the Brown-Sequard and central cord syndrome. Some refer to this variation as Brown-Sequard-Plus Syndrome<sup>11</sup>.

#### Anterior cord syndrome

The anterior cord syndrome is a relatively rare syndrome that historically has been related to a decreased or absent blood supply to the anterior two-thirds of the spinal cord. The dorsal columns are spared, but the corticospinal and spinothalamic tracts are compromised. The clinical symptoms include a loss of motor function, pain sensation and temperature sensation at and below the injury level with preservation of light touch and joint position sense.



**Figure 3** Figure of the lower spinal cord highlighting conus medullaris and cauda equina.

### *Cauda equina syndrome*

Cauda Equina syndrome involves the lumbosacral nerve roots of the cauda equina (Figure 3), and may spare the spinal cord itself. Injury to the nerve roots, which are, by definition, lower motor neurons, will classically produce a flaccid paralysis of the muscles of the lower limbs (muscles affected depend upon the level of the injury), and areflexic bowel and bladder. All sensory modalities are similarly impaired, and there may be partial or complete loss of sensation. Sacral reflexes i.e. bulbocavernosus and anal wink will be absent.

### *Conus medullaris syndrome*

Conus Medullaris Syndrome may clinically be similar to the Cauda Equina Syndrome, but the injury is more rostral in the cord (L1 and L2 area), relating to most commonly a thoraco-lumbar bony injury. Depending on the level of the lesion (Figure 3), this type of injury may manifest itself with a mixed picture of upper motor neuron (due to conus injury) and lower motor

neuron symptoms (due to nerve root injury). In some cases, this may be very difficult to clinically distinguish from a cauda equina injury. Sacral segments may occasionally show preserved reflexes (i.e. bulbocavernosus and anal wink) with higher lesions of the conus medullaris.

### **Acknowledgements**

Permission has been given by Lawrence Vogel, M.D., President of the American Spinal Injury Association, for publication of the 2011 Revision. Copies of the booklet can be obtained by contacting the ASIA Office at 2020 Peachtree Road, NW, Atlanta, Georgia 30309 or through the ASIA website at <http://www.asia-spinalinjury.org>.

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REV 04/11

## Appendix 2: Steps in Classification

The following order is recommended in determining the classification of individuals with SCI.

1. Determine sensory levels for right and left sides.
2. Determine motor levels for right and left sides.

*Note: in regions where there is no myotome to test, the motor level is presumed to be the same as the sensory level, if testable motor function above that level is also normal.*

3. Determine the single neurological level.

*This is the lowest segment where motor and sensory function is normal on both sides, and is the most cephalad of the sensory and motor levels determined in steps 1 and 2.*

4. Determine whether the injury is Complete or Incomplete (i.e. absence or presence of sacral sparing)

*If voluntary anal contraction = No AND all S4-5 sensory scores = 0 AND deep anal pressure = No, then injury is COMPLETE. Otherwise, injury is Incomplete.*

5. Determine ASIA Impairment Scale (AIS) Grade:

**Is injury Complete?**

If YES, AIS = A and can record ZPP (lowest dermatome or myotome on each side with some preservation)

NO ↓

**Is injury motor Incomplete?**

If NO, AIS = B

YES ↓

(Yes = voluntary anal contraction OR motor function more than 3 levels below the motor level on a given side, if the patient has sensory incomplete classification.)

**Are at least half of the key muscles below the single neurological level graded 3 or better?**

NO ↓  
AIS = C

YES ↓  
AIS = D

**If sensation and motor function is normal in all segments, AIS = E**

*Note: AIS E is used on follow-up testing when an individual with a documented SCI has recovered normal function. If at initial testing no deficits are found, the individual is neurologically intact; the ASIA Impairment Scale does not apply.*