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Trauma Pathology

Neurological Examination in Spinal Cord Injury

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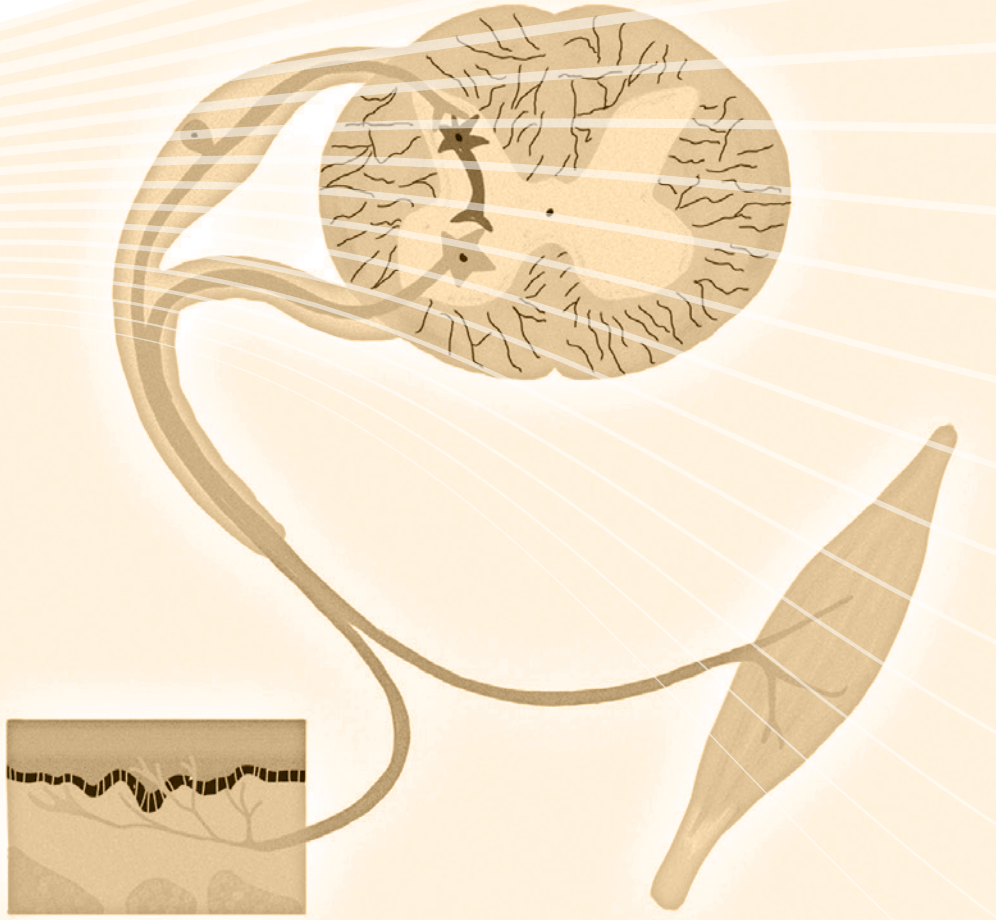

OBJECTIVES

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Trauma Pathology

Neurological examination in spinal cord injury

- To describe a normal neurological examination, as well as the possible abnormalities.
- To identify the dermatome and myotome distribution patterns.
- To highlight the difficulties of the neurological evaluation in unconscious patients.
- To recognize the international scales applied for neurological evaluations.

CONTENTS

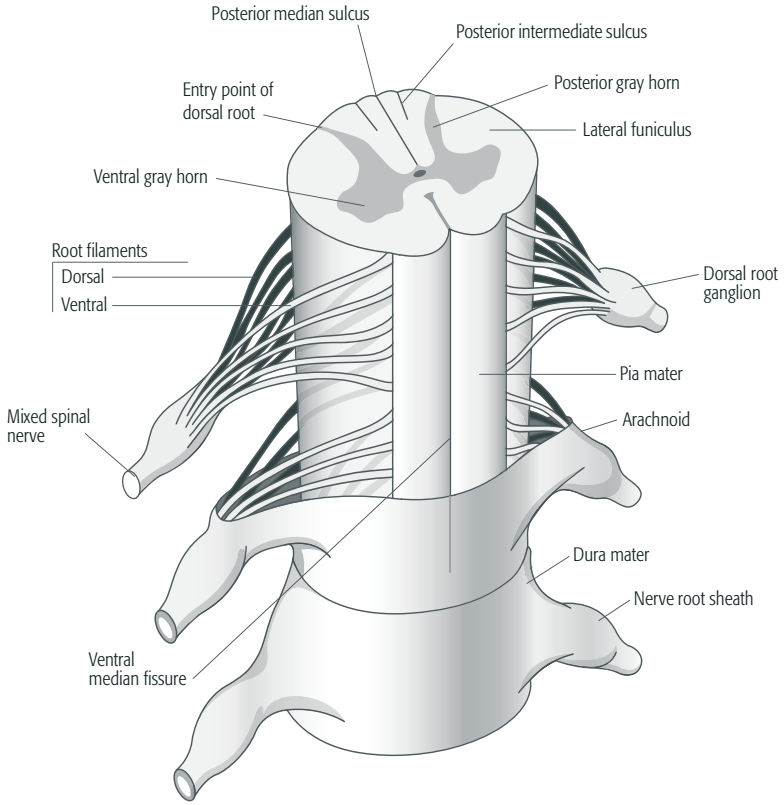
1. INTRODUCTION

Segmentation forms the basis for standard neurological evaluation of the spinal cord.

Overview

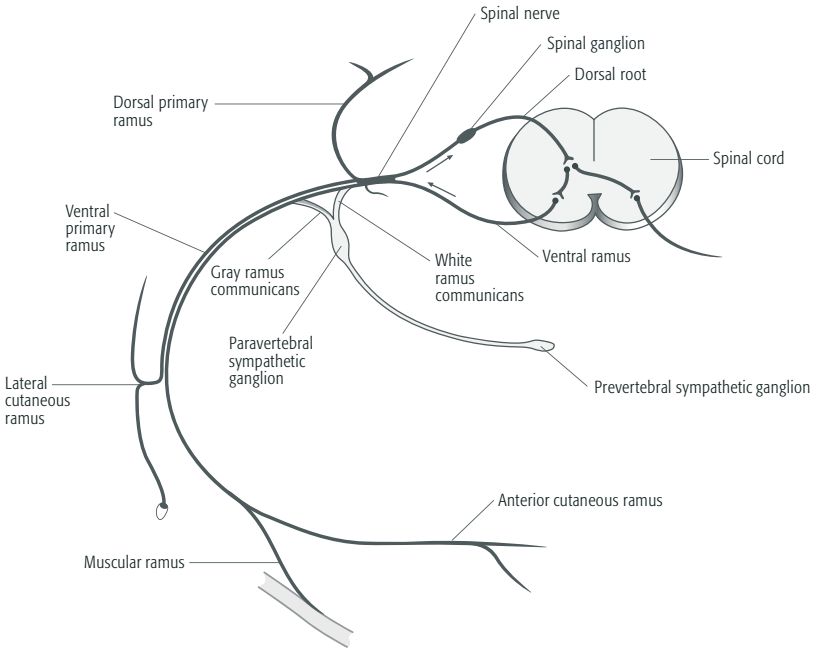
The spinal cord is a long, cylindrical structure enveloped by the meninges and usually extends from the cranium down to the lower margin of the first lumbar vertebra.

It is thicker in the cervical and lumbar regions. Each of the 31 pairs of the emerging spinal nerves defines an external segmentation. Therefore, the cord is considered to be composed of 31 segments containing ventral and dorsal root fascicles



The functional segmentation of the cord is apparent.

Diagram of the spinal cord, roots and spinal nerves



Sensory root, motor ramus and reflex arc: the physiological basis of spinal cord function.

Transverse section of a spinal cord segment

1

The cord contains two types of pathway:

Afferent pathways	Efferent pathways
Receive and conduct sensory information.	Regulate motor function and autonomic visceral fibers.

Complete severance of the spinal cord produces the following signs, below the level of the injury:

- loss of feeling
- loss of motor function
- abolition of muscle tone
- loss of reflex activity

Presented below are the dermatomes and myotomes.

Dermatome	Skin area innervation by the sensory axons of each emerging nerve root, corresponding to a spinal cord segment.
Myotome	Muscle fibers' group innervation by the motor axons of each emerging nerve root also corresponding to a spinal cord segment.

The cord segment damaged by trauma and its consequent inherent neurological impairment, defines the cord injury's level.

By definition, the neurological impairment level is the most caudal segment of the spinal cord preserving a normal sensory and motor function on both sides of the body.

Sensory level	The most caudal segment of the spinal cord preserving a normal sensory function on both sides of the body.
Motor level	The lowest cord segment for which the key muscle presents a strength grade of 3, as long as the strength of the key muscles representing the adjacent superior segments remains normal.
Skeletal or vertebral level	Level corresponding to the major vertebral injury detected by image evaluation.
Area of partial preservation	Dermatomes and myotomes caudal to the neurological level that remain partially innervated (Partial sensory and motor function preserved).

i

2. CLASSIFICATION

Standardization is a crucial step in patient evaluation because the initial presentation of the patient with cord injury remains a key factor when it comes to prognosis and selecting treatment.

The first report highlighting the need to establish common nomenclature for the neurological examination in spinal cord injuries emerged late in the sixties.

The standardization of a unique evaluation terminology would most certainly induce:

- Anincreased consistency and reproducibility for clinical evaluation
- As well as a better documentation and comparison in prognosis and therapy

In the last 50 years several scales have been developed: The Frankel Scale, Lucas and Ducker's Neurotrauma Motor Index, the Sunnybrook, Botsford and Yale Scales, and finally the scale proposed by the American Spinal Injury Association (ASIA) which in recent years has been recognized as the standard evaluation (Evangelista Santos Barcelos, A. C.; Scardino, F. B.; Patriota, G. C.; Rotta, J. M. and Botelho, R. V., 2009).

All of the classifications are based on motor and sensory evaluations, some of them even trying to incorporate a score for functional independence. The most significant differences between them lie in the grading type for the neurological status and in selection of the key dermatomes and myotomes to be assessed as well.

The first widely-used scale was that of Frankel et al. (1969):

Grade	Nomenclature	Definition
A	Complete injury	Complete injury, both in motor and sensory function.
B	Poor sensitivity preservation	Some sensitivity preservation, associated with complete motor paralysis.
C	Non-functional motor preservation	Preservation of some muscle strength without functional use.
D	Functional motor preservation	Functional muscle strength.
E	Normal	Without deficits.

The ASIA scale was created in 1984 by incorporating the Frankel Scale; and classifying the injury into 5 levels, A to E, defining 10 pairs of key muscles which should be assessed, and creating a motor score, at that time without incorporating a sensory score. The scale received subsequent revisions (1992 and 2002) and in 1992, the scale added the sensory score to the motor score, offering both a motor and sensory scale.

The sensory and motor scores are simply the sum of the scored points and reflect the level of neurological deficit associated with cord injury.

3. STANDARDISED NEUROLOGICAL CLINICAL EXAMINATION (ASIA)

Sensory Evaluation (ASIA)

The sensory score is usually assessed by light pain and touch.

Pain is evaluated using a pinprick test, while touch is assessed by lightly touching the area with a piece of cotton-wool.

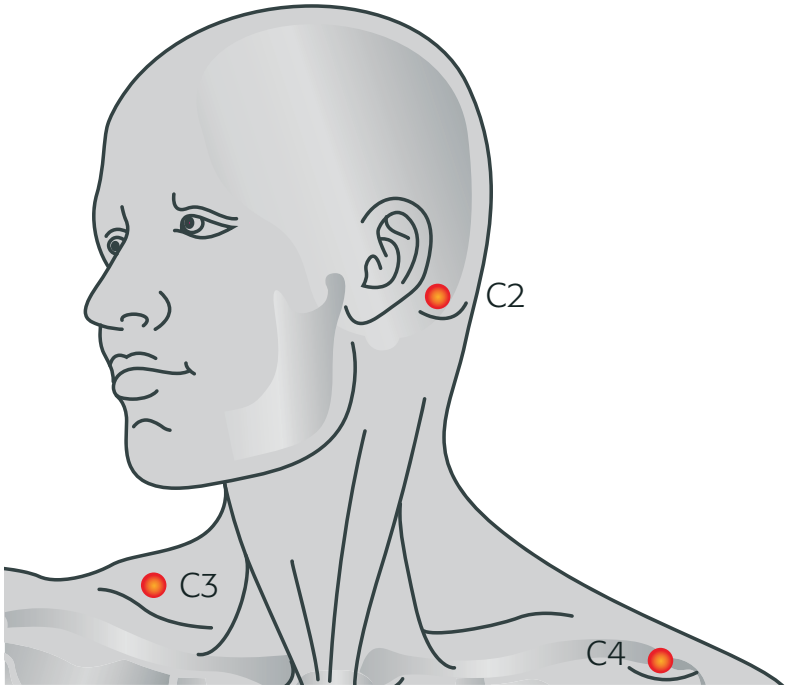
The results are classified as follows:

Pain (pinprick test)	
2	Normal.
1	Deterioration (subject cannot differentiate between light and strong pricks) although there is sensitivity to pain.
0	Without sensitivity.

Light touch	
2	The body and facial phases have equal sensitivity.
1	Some sensitivity, although less is observed in the body than in the facial phases.
0	Without sensitivity.

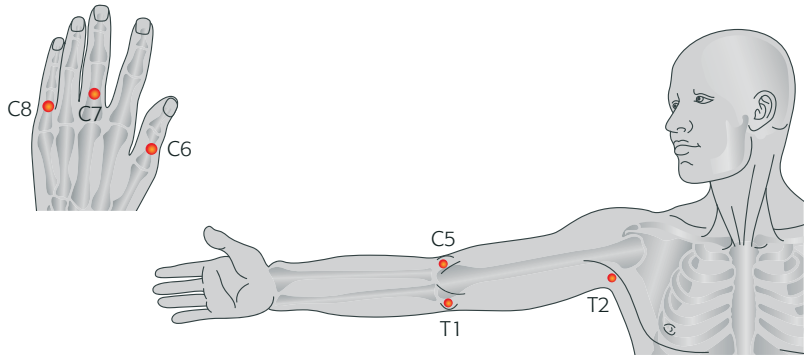
Presented below are the dermatomes and their standardized reference points (American Spinal Injury Association [ASIA], 2008a).

C2	Occipital behind the ear.
C3	Supraclavicular fossa.
C4	Acromioclavicular joint.



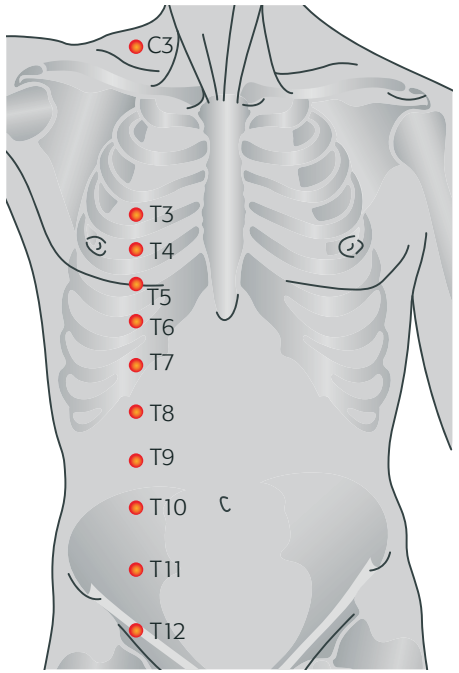
Dermatomes for C2 to C4

C5	Lateral side of the antecubital fossa.
C6	Dorsal surface of the proximal phalanx of the thumb.
C7	Dorsal surface of the proximal phalanx of the middle finger.
C8	Dorsal surface of the proximal phalanx of the little finger.
T1	Medial side of the antecubital fossa.
T2	Apex of the axilla.



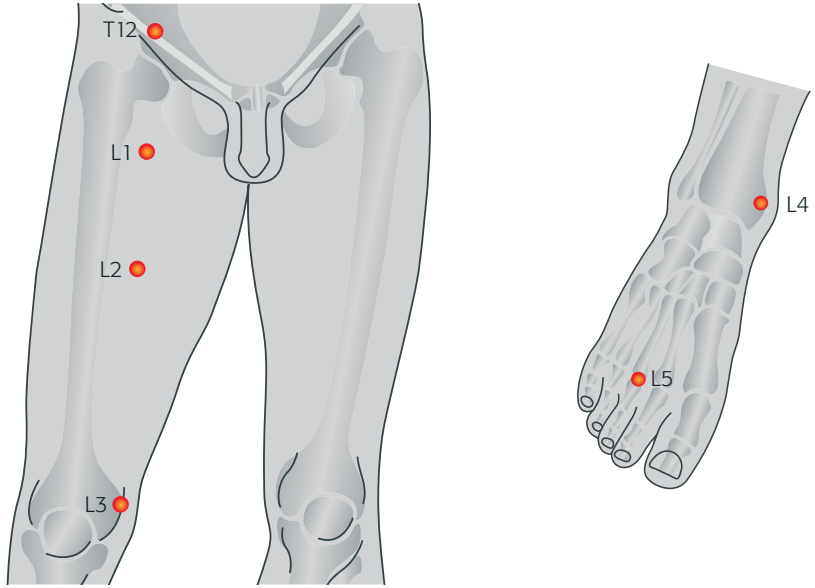
Dermatomes for C5 to T2

T4	Midclavicular line, fourth intercostal space, located at the level of the nipples.
T6	Xiphoid process.
T10	Umbilicus.
T12	Midpoint of the inguinal ligament.



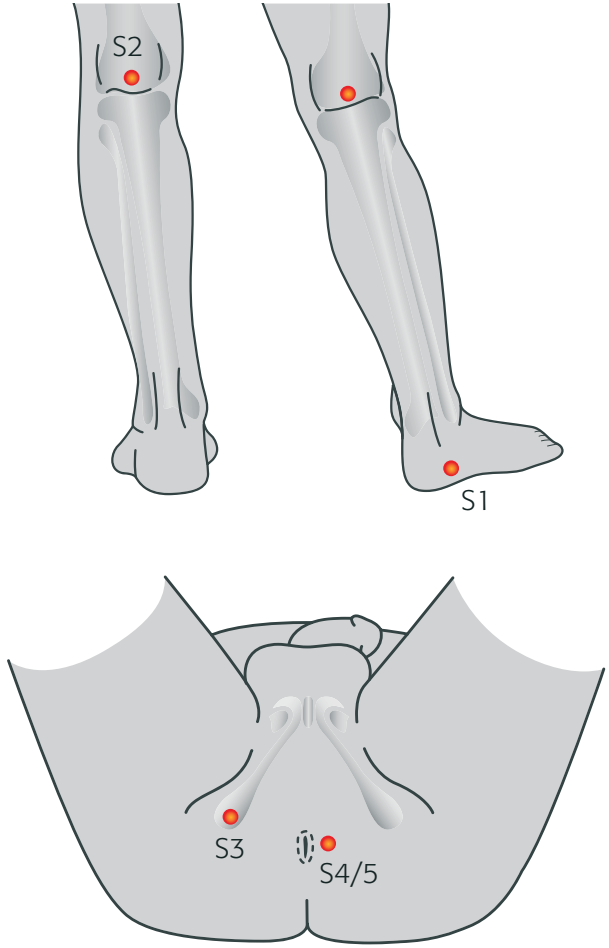
Thoracic dermatomes

L1	Midway between the key sensory points for T12 and L2.
L2	Anterior-medial thigh, at the midpoint drawn on an imaginary line connecting the midpoint of the inguinal ligament 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.



Lumbar dermatomes

S1	Lateral aspect of the calcaneus.
S2	Midpoint of the popliteal fossa.
S3	Ischial tuberosity.
S4, S5	Perianal area.



Sacral dermatomes

3

The sensory level is defined as the most caudal segment of the spinal cord with normal sensory function in both sides of the body.

See the section "Neurological Examination", figure "Example of standard neurological examination (ASIA)".

Some optional sensory factors that can be evaluated are:

- Joint movements that appear in 8 to 10 of the joints assessed and are described as:
  - absent
  - diminished
  - normal
- Sensation of deep pressure, described as:
  - present
  - absent

Sensory Score

Both types of sensation (light touch and pain) have a subscore grading of up to 56 for each side of the body (0 to 2 for each of the 23 defined dermatomes). The total sensory score is out of 112 for each of the two standardized sensory tests (light touch and pinprick).

Motor Evaluation (ASIA)

Muscle force is graded between 0-5, in accordance with the Scale for Muscle Strength (Medical Research Council [MRC], 1981):

0	Paralysis.
1	Slight movement present, unable to overcome gravity.
2	Full motion range with gravity eliminated.
3	Full movement range against gravity.
4	Full movement against gravity and resistance.
5	Normal strength against full resistance.
NT	Not tested (muscles that cannot be tested).

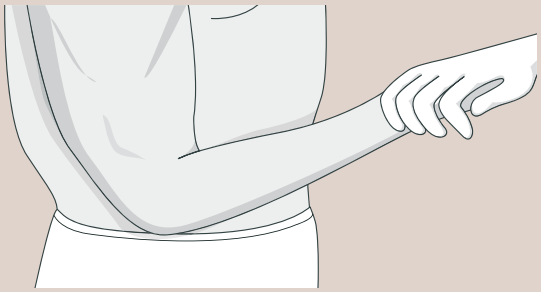
Primary muscles are selected because they are innervated by two myotomes. By convention, if a muscle has at least grade 3 strength, the above located muscle is to be considered normal.

The myotomes are presented below, along with their motor segments and the methods used in neurological examination suggested by ASIA (2008b), as well as their corresponding diagrams (Campbell, Dejong and Haerer, 2005, 127).

C5

Biceps

- Place the patient's hand across the abdomen and ask him to try and reach his nose with the hand, thus eliminating gravity.
- Instruct the patient to bend his arm against gravity and continue the motion.
- If the patient can complete this movement, support the shoulder and apply resistance.

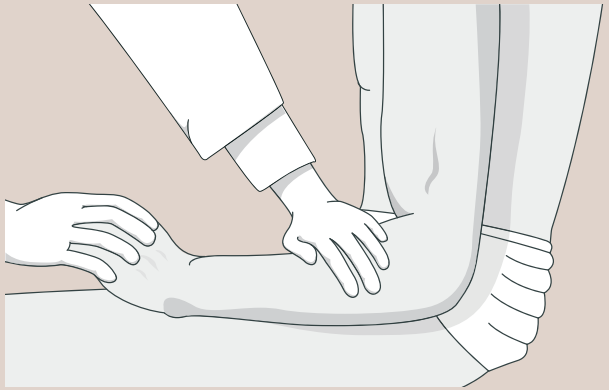


Biceps, elbow flexors

C6

Wrist extensor

- Instruct the patient to move his hand upwards.
- Next, they should move his hand higher and try to hold the position.
- Push the patient's hand downwards.

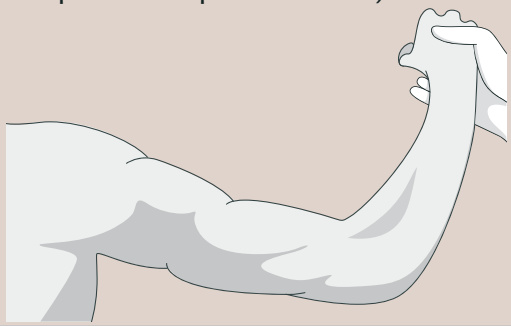


Wrist extensors

C7

Triceps

- Place the patient's hand across the abdomen, ask him to straighten the arm.
- Instruct the patient to bend the arm and hold it close to the ear.
- If the movement is normal, support the elbow and push the arm downwards, testing for counter-resistance (hold the patient's shoulder to prevent a scapular movement).

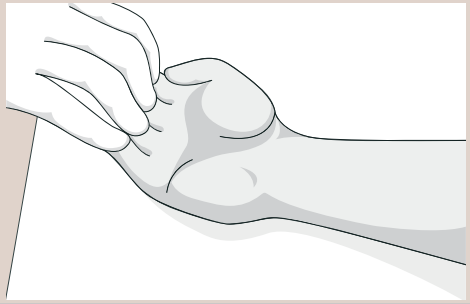


Triceps, elbow extensors

C8

Long finger flexors

- Isolate the middle finger, immobilize the proximal interphalangeal and metacarpophalangeal joints.
- Instruct the patient to bend the finger to the sides.
- Next, ask him to bend the finger upwards and hold the position.
- Finally, push to straighten the finger and instruct the patient to resist your force.

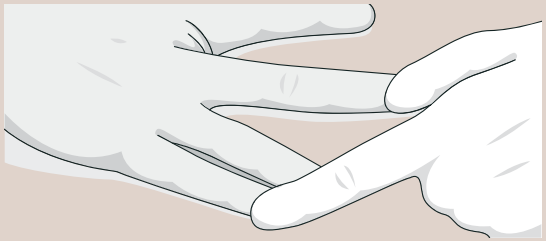


Long finger flexors

T1

Little finger abductor

- Secure the patient's hand and ask him to try and move the small finger outwards. Feel the presence of the movement.
- Ask the patient to try to move the finger outwards and hold the position.
- Finally, test the strength against resistance by opposing the movement in their little finger.

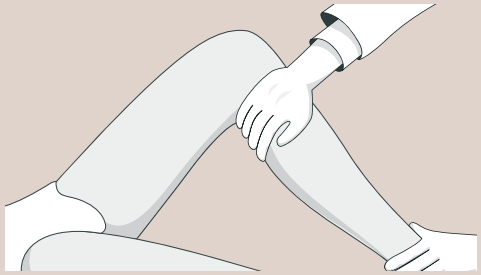


Small finger abductor

L2

Iliopsoas

- With the patient in dorsal decubitus, lift the thigh up towards the midriff.
- Ask the patient to reproduce the movement and feel as they do it.
- Lift the thigh from the bed to avoid dragging the foot. In a neutral position, ask the patient to lift their thigh up to 90° and hold the position.
- If possible, secure the other thigh and press down on the thigh being tested, to evaluate the strength against resistance.

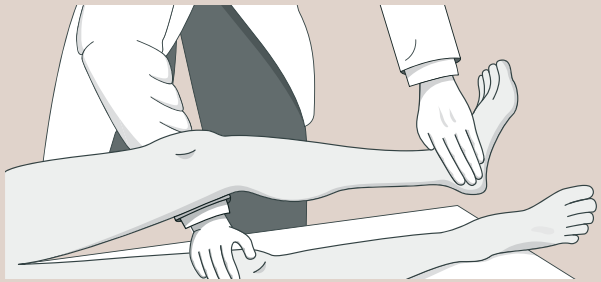


Iliopsoas, hip flexors

L3

Quadriceps

- Raise the leg from the bed to avoid resistance and ask the patient to straighten his knee and hold the position.
- Push the patient's foot downwards and assess the counter-resistance strength.



Quadriceps, knee extensors

L4

Ankle dorsiflexors

- Ask the patient to put his feet up towards the knee.
- Then ask him to repeat the movement and hold the position.
- Finally, push down on ankle to evaluate the counter-resistance strength.

Tibialis anterior, ankle dorsiflexors

L5

Hallux extensors

- Ask the patient to lift his hallux towards the knee.
- Then ask him to hold the position.
- Next, push the big toe downwards, supporting the ankle and testing the counter-resistance.

Extensor hallucis longus, long toe extensors

S1

Ankle flexors

- Ask the patient to press his foot down towards the floor, as if accelerating in a car.
- Next, he should raise his thigh towards the abdomen, bending the knee and resting his foot on the bed.
- Ask the patient to raise his heel away from the bed.
- Finally, hold the patient's foot and ask him to push against your hand, as if accelerating in a car.

Gastrocnemius and soleus, ankle plantarflexors

Motor Score

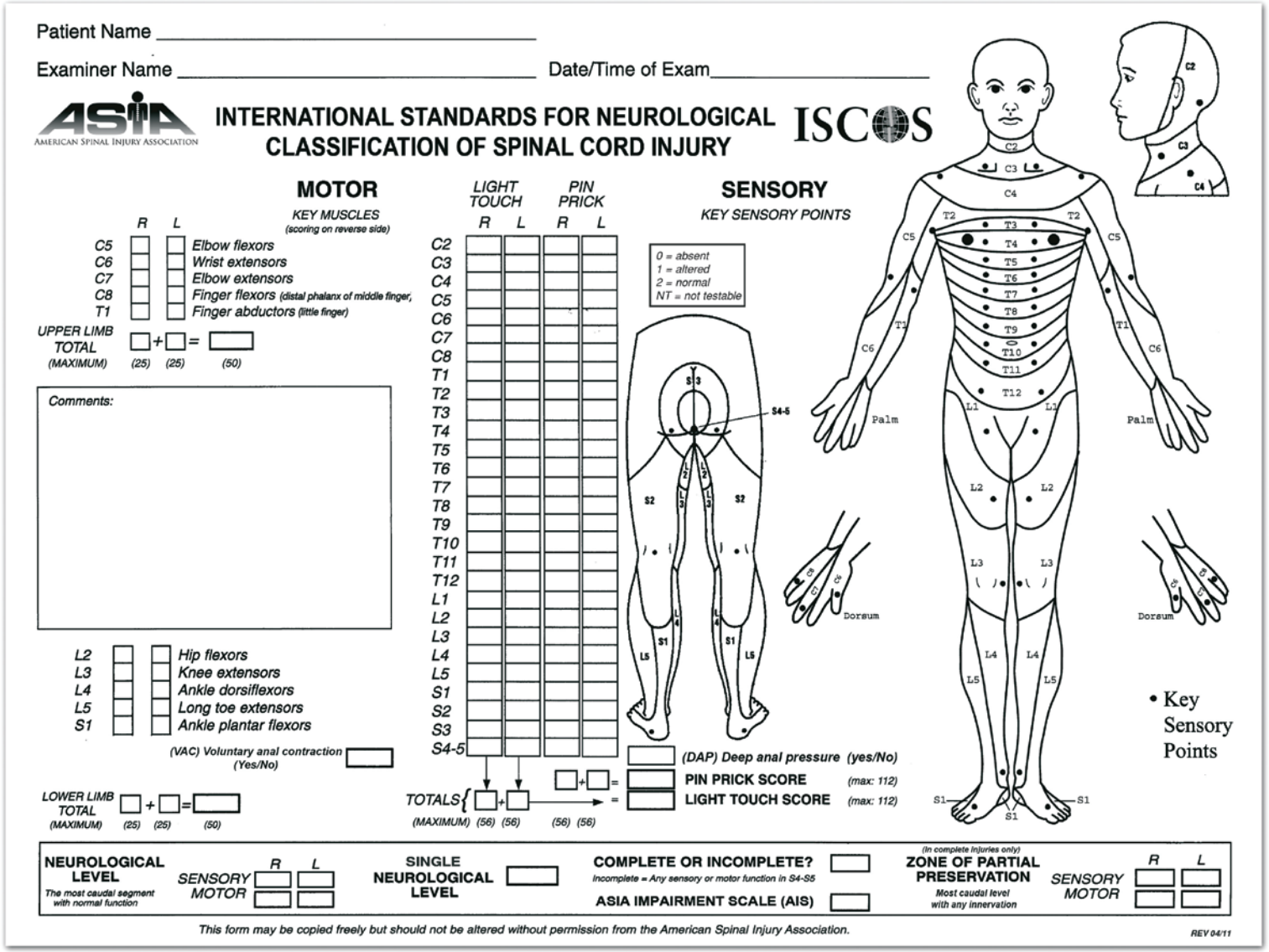
For each side of the body, each motor segment receives a score from 0 to 5, creating a subscore of 50 per side and an overall motor score of 100 points for a neurologically intact patient. As the motor level ascends, that is, the injury is higher up, so the motor score decreases.

It is important to remember that the motor level is defined as the lowest cord segment for which the key muscle has a strength grade of 3, as long as the strength of key muscles representing more superior segments is normal.

See the section "Neurological Examination" below, figure "Example of standard neurological examination (ASIA)".

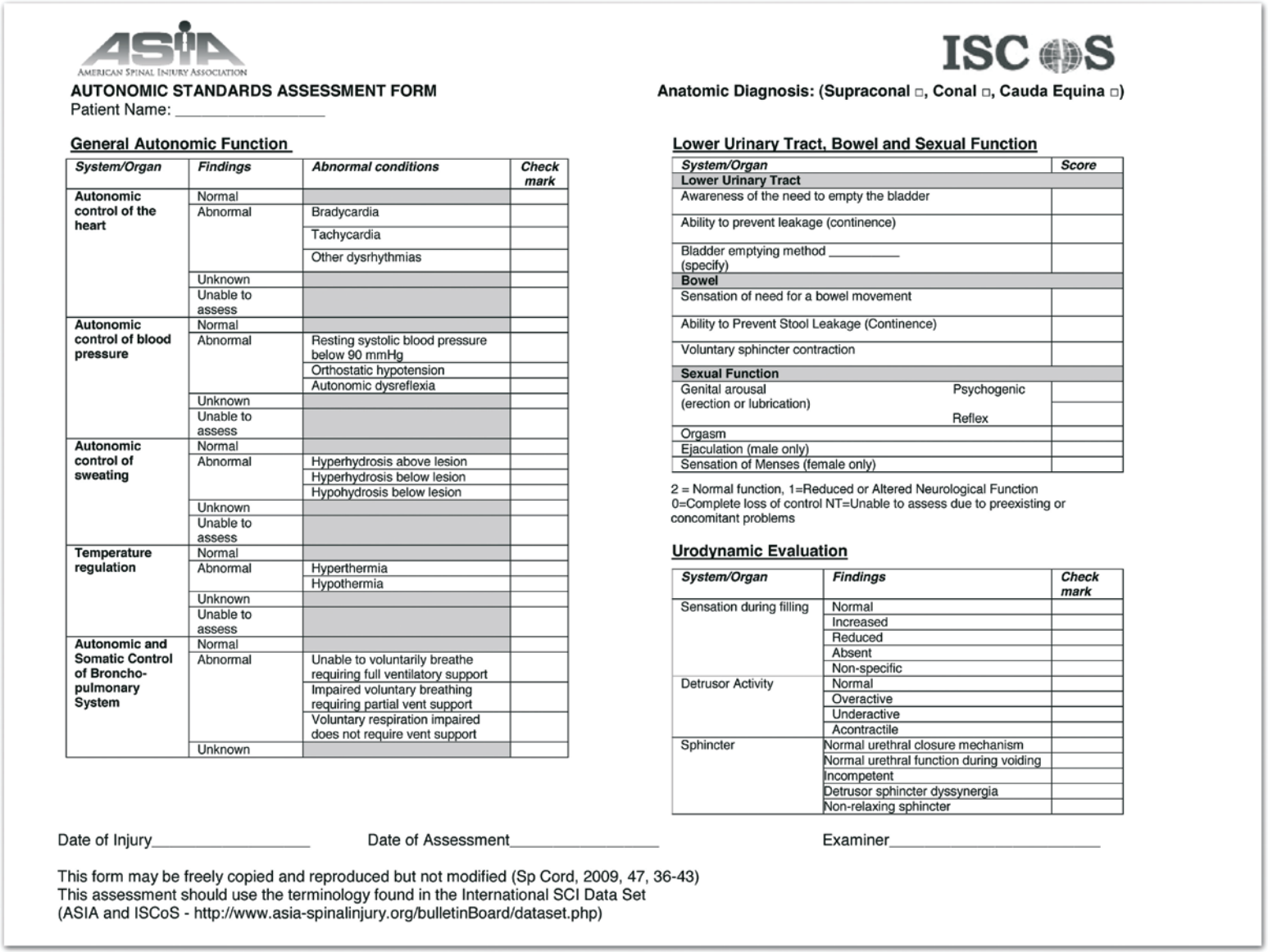
Neurological Examination (ASIA)

The following standard is recommended for neurological examinations:



Example of standard neurological examination (ASIA, 2006)

Autonomic nervous system status and sphincter control were also standardized (ASIA, 2009).



AMERICAN SPINAL INJURY ASSOCIATION

AUTONOMIC STANDARDS ASSESSMENT FORM

Patient Name: _____

Anatomic Diagnosis: (Supraconal □, Conal □, Cauda Equina □)

General Autonomic Function

System/Organ	*Findings*	*Abnormal conditions*	*Check mark*
Autonomic control of the heart	Normal		
	Abnormal	Bradycardia	
		Tachycardia	
		Other dysrhythmias	
	Unknown		
	Unable to assess		
Autonomic control of blood pressure	Normal		
	Abnormal	Resting systolic blood pressure below 90 mmHg	
		Orthostatic hypotension	
		Autonomic dysreflexia	
	Unknown		
	Unable to assess		
Autonomic control of sweating	Normal		
	Abnormal	Hyperhydrosis above lesion	
		Hyperhydrosis below lesion	
		Hypohydrosis below lesion	
	Unknown		
	Unable to assess		
Temperature regulation	Normal		
	Abnormal	Hyperthermia	
		Hypothermia	
	Unknown		
	Unable to assess		
Autonomic and Somatic Control of Broncho-pulmonary System	Normal		
	Abnormal	Unable to voluntarily breathe requiring full ventilatory support	
		Impaired voluntary breathing requiring partial vent support	
		Voluntary respiration impaired does not require vent support	
	Unknown		

Lower Urinary Tract, Bowel and Sexual Function

System/Organ		*Score*
Lower Urinary Tract		
Awareness of the need to empty the bladder		
Ability to prevent leakage (continence)		
Bladder emptying method _____ (specify)		
Bowel		
Sensation of need for a bowel movement		
Ability to Prevent Stool Leakage (Continence)		
Voluntary sphincter contraction		
Sexual Function		
Genital arousal (erection or lubrication)	Psychogenic	
	Reflex	
Orgasm		
Ejaculation (male only)		
Sensation of Menses (female only)		

2 = Normal function, 1=Reduced or Altered Neurological Function
0=Complete loss of control NT=Unable to assess due to preexisting or concomitant problems

Urodynamic Evaluation

System/Organ	*Findings*	*Check mark*
Sensation during filling	Normal	
	Increased	
	Reduced	
	Absent	
	Non-specific	
Detrusor Activity	Normal	
	Overactive	
	Underactive	
	Acontractile	
Sphincter	Normal urethral closure mechanism	
	Normal urethral function during voiding	
	Incompetent	
	Detrusor sphincter dyssynergia	
	Non-relaxing sphincter	

Date of Injury_____ Date of Assessment_____ Examiner_____

This form may be freely copied and reproduced but not modified (Sp Cord, 2009, 47, 36-43)
This assessment should use the terminology found in the International SCI Data Set
(ASIA and ISCoS - http://www.asia-spinalinjury.org/bulletinBoard/dataset.php)

Example of a standardized autonomic system, lower urinary tract, bowel and sexual function assessment form

4. EXAMINING AN UNCONSCIOUS PATIENT

The standard neurological examination of patients with traumatic spinal cord injuries depends on the qualitative and quantitative evaluations of both strength and sensation.

As such, it is impossible to perform a full evaluation of patients with an altered mental state or even of those in a coma.

However, an altered level of consciousness following trauma is considered to be a predictor of spinal cord injury in a high percentage of cases (Domeier, Evans, Swor, Rivera-Rivera and Fredriksen, 1995).

All patients with a significant trauma and impaired consciousness must be considered as spinal cord injury patients, until otherwise confirmed.

Signs which suggest spinal cord injury in unconscious patients are:

- abdominal breathing
- asymmetry of the abdominal skin reflex (being a cortical reflex, the asymmetry suggests cord injury)
- priapism
- absence of anal skin reflex
- focal deficit evidenced by movement asymmetries
- absence of muscle stretch reflex (occurs in acute cord injuries, but reflexes may be altered in comatose patients or those suffering exogenous intoxication)

The cervical spine of unconscious patients should be immobilized until:

- a fluoroscopic control X-rays yields normal results
- an MRI of the cervical spine, 48 hours after the trauma, proves to be normal
- or, is medically necessary

The bulbocavernosus reflex is a normal reflex that produces contraction of the anal sphincter when stimulated by squeezing the gland. It has been used as an indicator of incomplete injury but its presence cannot always be considered as a good prognosis of recovery (Domeier et al., 1995).

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