



Spinal Cord Injury - InfoSheet

#5

"Understanding Spinal Cord Injury and Functional Goals & Outcomes "

Level - Advanced

Understanding the physiological effects of a spinal cord injury requires a basic knowledge of the anatomy and physiology of the spinal cord. Knowledge of the pathologic anatomy and physiology of a spinal cord injury (SCI) is also needed. Following this brief summary is a list of additional resources.

ANATOMY AND PHYSIOLOGY

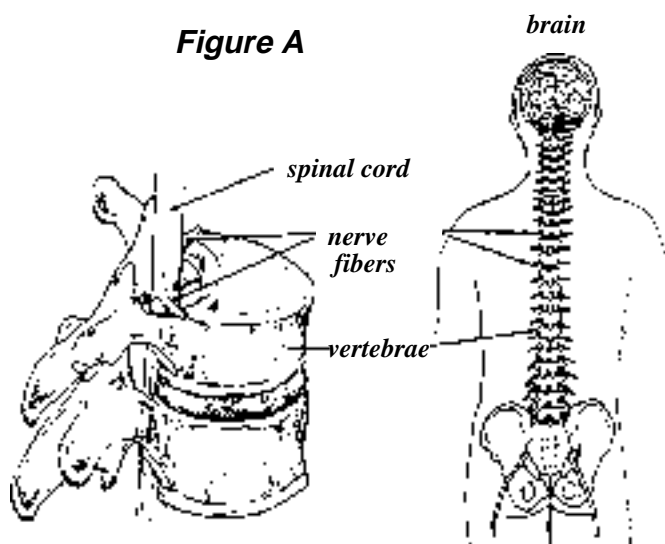
The **spinal cord** is the largest nerve in the body. Nerves are cord-like structures made up of **nerve fibers**. Nerve fibers are responsible for the communication systems of the body, which include sensory, motor, and autonomic functions. The nerve fibers within the spinal cord carry messages between the brain and the rest of the body. Because the spinal cord is such an important part of the nervous system, protective bone segments, called the vertebral column, surround it. [See Figure A]

The nerves that lie within the spinal cord are **upper motor neurons (UMNs)**. They carry the messages back and forth from the brain to the

spinal nerves along the spinal tract. The spinal nerves that branch out from the spinal cord to the other parts of the body are **lower motor neurons (LMNs)**. These spinal nerves exit and enter at each vertebral level and communicate with specific areas of the body. The **sensory** portion of the LMNs carry messages to the brain about sensation from the skin and other body parts and organs. The **motor portion** of the LMNs send messages from the brain to the various body parts to initiate actions such as muscle movement. [See Figure B]

The vertebral column, or spinal column, is made up of 4 regions. Seven **cervical** vertebrae protect the eight cervical nerves; twelve **thoracic** vertebrae protect the twelve thoracic nerves; five **lumbar** vertebrae protect the five lumbar nerves; five sacral vertebrae, which are fused as one bone, help protect the five sacral nerves. [See Figure C]

As the body grows, the vertebral column grows more in length than the spinal cord, which usually ends between the first and second lumbar vertebrae. From this point the lumbar and sacral nerves branch out from the spinal cord and descend inside the spinal column before leaving the vertebral column at their corresponding vertebrae. Because of this fact there is often a discrepancy between the skeletal or bony level of vertebral fracture and the neurological level of spinal cord injury. [See Figure C]



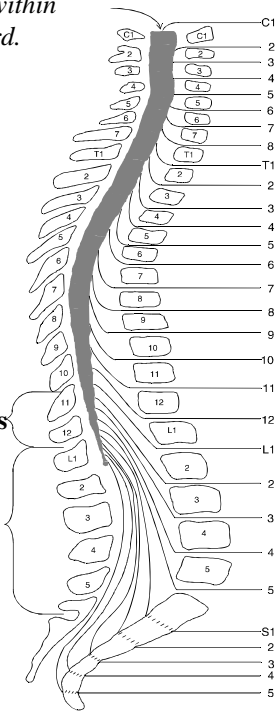
The **spinal cord** runs through the stacked **vertebrae** that make up the **vertebral column**. These bones protect the spinal cord. The **nerve fibers** branch out from the spinal cord to other parts of the body.

WHAT HAPPENS AFTER A SPINAL CORD INJURY?

The term **spinal cord injury (SCI)** refers to any injury of the neural (pertaining to nerves) elements within the spinal canal. SCI can occur from either trauma or disease to the vertebral column or the spinal cord itself. Most spinal cord injuries are the result of trauma to the vertebral column. Such trauma can cause a fracture of bone or tearing of ligaments with displacement of the bony column. This causes a pinching of the spinal cord. The vertebral trauma may cause contusion

Figure B

Upper Motor Neurons lie within the spinal cord.



Lower Motor Neurons are spinal nerves that branch off the spinal cord.

Conus Medullaris

Cauda Equina

The **spinal cord** ends between L-1 and L-2. The **nerves** continue to descend in the spinal column, exiting between the vertebrae and through the sacrum.

with hemorrhage and swelling of the spinal cord or it may cause a tearing of the spinal cord and/or its nerve roots. The damage from the spinal cord injury can affect the nerve fibers sending and receiving of messages from the brain to the body's systems that control sensory, motor, and autonomic function below the level of injury.

It is important to distinguish between injuries that occur in the spinal cord proper from those that occur to the **conus medullaris** or to the **cauda equina**. [See Figure B] A spinal cord injury with preservation of segments of spinal cord below the level of injury usually produces an upper motor neuron (UMN) type of injury or **spastic paralysis**. The intrinsic reflexes are now uninhibited and become hyperreflexic and lead to increased muscle tone, spasms, and spasticity.

A conus medullaris injury, without preservation of spinal cord segments below the lesion, or a cauda equina injury produces a lower motor neuron (LMN) type of injury or **flaccid paralysis**. With this type of injury, the stimuli cannot reach the spinal cord; therefore, the reflexes and muscle tone remain decreased or absent (flaccid).

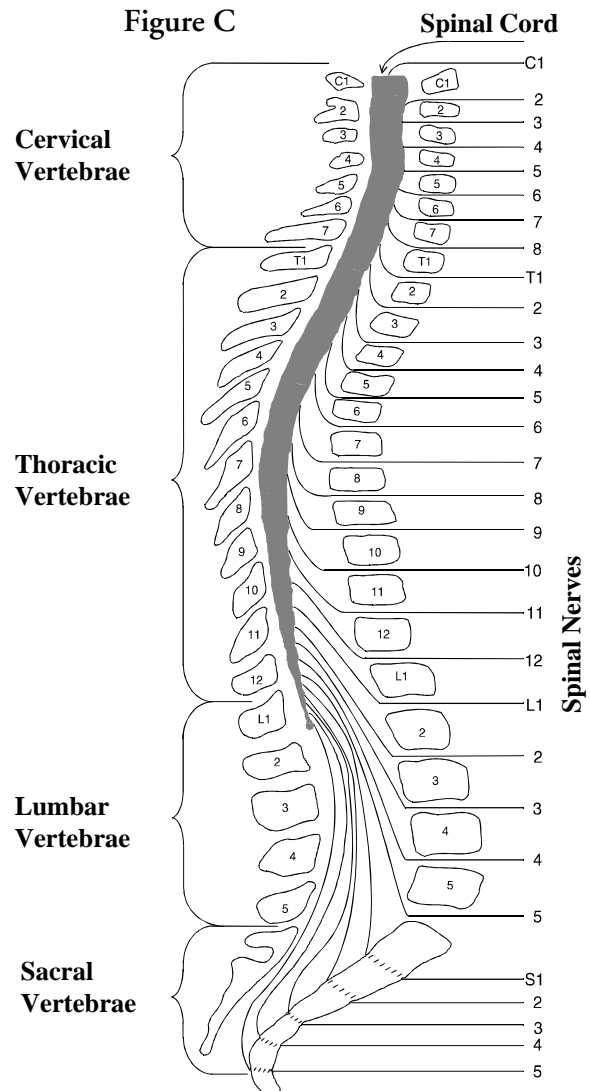
CLASSIFICATION

A complete evaluation of both sensory and motor levels will determine the neurological level of spinal cord injury. The recommended neurological assessment follows the classifications published in the "International Standards for Neurological and Functional Classification of Spinal Cord Injury", revised 1996, endorsed by the American Spinal Injury Association and the International Medical Society of Paraplegia. Radiologic or anatomical abnormalities are not used in this classification system.

LEVEL OF INJURY

The **neurologic level of injury** is determined to be the most caudal (lowest) point on the spinal cord below which there is a decrease or

Figure C



The vertebrae are numbered and named according to their location in the spinal column. The spinal nerves are numbered and indicate their corresponding vertebrae.

absence of feeling (**sensory level**) and movement (**motor level**) on both sides of the body. The physician tests 10 paired groups of index muscles [**myotomes**] to determine the motor level of the patient. A motor score between 0 - 5 is given based on motor function. A "3" is given for active, full range of movement against gravity. This is the minimal score needed to set functional goals with a specific level of injury.

The 28 key sensory points [**dermatomes** - the nerve roots that receive sensory information from the skin areas] are also examined for sensitivity to pin prick and light touch. This determines the sensory level. The sensory and motor levels need to be evaluated for both the right and left sides of the body. It is not unusual to have a discrepancy between the lowest normal motor level and the lowest normal sensory level.

Another general classification used to refer to a spinal cord injury are the terms **tetraplegia** or **paraplegia**. Tetraplegia [formerly called quadriplegia] generally describes the condition of a person classified with a spinal cord injury between C1 and T1. These individuals experience a loss of feeling and/or movement in their head, neck, shoulder, upper chest, arms, hands, and/or fingers. Paraplegia is the term that describes the condition of a person who has been classified with an injury between levels T2 and S5. The body's motor and/or sensory function(s) affected with paraplegia can include the middle of the chest, the stomach, hips, legs and feet, and/or toes.

TYPE OF INJURY

A complete injury means that there is no motor or sensory function preserved in the S4 and S5 area, or anal area. A rectal exam determines if there is rectal sensation and voluntary sphincteric contraction. If there is evidence of any motor or sensory function in this area, one of three incomplete injury classifications is given according to the ASIA Impairment Scale.

OTHER CLASSIFICATIONS

Also included in the neurological assessment is the classification of **Clinical Syndromes**. The syndromes include Central Cord, Brown-Sequard, Anterior Cord, Conus Medullaris, and Cauda Equina Syndrome. A mixed or unclassified

syndrome is sometimes present.

A classification used in the evaluation process is the **Functional Independence Measure (FIM)**. The **FIM** is a method for monitoring and evaluating progress associated with treatment. It measures daily life activities in the areas of self-care, sphincter control, mobility, locomotion, communication and social cognition. Activities such as eating, toileting, and dressing are rated on a scale which measures dependence/independence.

FUNCTIONAL GOALS

Functional goals are a realistic expectation of activities that a person with spinal cord injury eventually should be able to do with a particular level of injury. These goals are set during rehabilitation by the individual with the assistance of the medical team. They help the individual with spinal cord injury learn new ways to manage his/her daily activities and stay healthy. Achievement of functional goals can also be affected by other factors, such as an individual's body type and health related issues. By striving to reach these functional goals, the hope is to give individuals with SCI the opportunity to achieve **MAXIMUM INDEPENDENCE**.

The chart, "Functional Goals for Specific Levels of Complete Injury", shows the muscle and muscle activity tested and what functional goals can be expected for a person with a complete injury at a particular level. Motor and sensory functions improve with lower levels of injury.

ASIA Impairment Scale⁵

- A= Complete:** No motor or sensory function is preserved in the sacral segments S4-S5.
- B= Incomplete:** Sensory but not motor function is preserved below the neurological level and includes the sacral segment S4-S5.
- C= Incomplete:** Motor function is preserved below the neurological level, and more than half of key muscles below the neurological level have a muscle grade less than 3. Sensory function is present below the neurological level and includes sacral segments S4-S5.
- D= Incomplete:** Motor function is preserved below the neurological level, and at least half of key muscles below the neurological level have a muscle grade of 3 or more. Sensory function is present below the neurological level and includes sacral segments S4-S5.
- E= Normal:** motor and sensory function is normal.

INCIDENCE¹⁰

Spinal cord injury occurs with an incidence of approximately 40 cases per million population in the U.S. or approximately 10,000 new cases each year. Spinal cord injury is primarily an injury of young men. The ratio of males to females is approximately 4 to 1 with 82% males and 18% females.

The greatest number of injuries occur between the ages of 16 and 30 (55%). The mean age at time of injury has increased from 28.6 in 1979 to 35.1 in 1990.

Since 1990, motor vehicle crashes account for 37.4% of the SCI cases reported. The next largest contributor is acts of violence (25.9%), primarily gunshot wounds. The third most common cause is

falls at 21.5%, with sports injuries ranking fourth at 7.1%.

Spinal cord injury can occur at any level of the spinal column or at multiple levels. The most common area of injury is the lower part of the neck at the C-4, C-5, and C-6 levels. The second most common area is between T-12 and L-1, which is at the bottom of the rib cage. Since 1990 the most frequent neurologic category is incomplete tetraplegia (29.5%), followed by complete paraplegia (27.9%), incomplete paraplegia (21.3%), and complete tetraplegia (18.5%).

Individuals with a spinal cord injury designated as having tetraplegia are slightly more common than paraplegia, 51.7% and 46.7%, respectively.

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ORGANIZATIONS

American Spinal Injury Association (ASIA)

www.asia-spinalinjury.org
345 E Superior St, Rm 1436n Chicago, IL 60611
312-238-1242

Paralyzed Veterans of America (PVA)

www.pva.org
801 18th St. NW, Washington, DC 20006
800-424-8200 or Email: info@pva.org

National Spinal Cord Injury Statistical Center

UAB-Spain Rehabilitation Center, Rm 544
619 19th St. S, SRC 544., Birmingham, AL 35249-7330
205-934-5359 or Email: nsisc@uab.edu

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RRTC on Secondary Conditions of SCI
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Spinal Cord Injury - Functional Goals for Specific Levels of Complete Injury

Level	Action / Muscles Tested	Abilities	Functional Goals
C1-C3		C3-limited movement of head and neck	<p>Breathing: Depends on a ventilator for breathing.</p> <p>Communication: Talking is sometimes difficult, very limited or impossible. If ability to talk is limited, communication can be accomplished independently with a mouth stick and assistive technologies like a computer for speech or typing. Effective verbal communication for the individual with SCI to direct caregivers in the person's daily activities, like bathing, dressing, personal hygiene, transferring as well as bladder and bowel management.</p> <p>Daily tasks: Assistive technology allows for independence in tasks such as turning pages, using a telephone and operating lights and appliances.</p> <p>Mobility: Can operate an electric wheelchair by using a head control, mouth stick, or chin control. A power tilt wheelchair also for independent pressure relief.</p>
C3-C4		Usually has head and neck control. Individuals at C4 level may shrug their shoulders.	<p>Breathing: May initially require a ventilator for breathing, usually adjust to breathing full-time without ventilatory assistance.</p> <p>Communication: Normal.</p> <p>Daily tasks: With specialized equipment, some may have limited independence in feeding and independently operate an adjustable bed with an adapted controller.</p>
C5	<i>Elbow flexors (biceps brachii)</i>	Typically has head and neck control, can shrug shoulder and has shoulder control. Can bend his/her elbows and turn palms face up.	<p>Daily tasks: Independence with eating, drinking, face washing, brushing of teeth, face shaving and hair care after assistance in setting up specialized equipment.</p> <p>Health care: Can manage their own health care by doing self-assist coughs and pressure reliefs by leaning forward or side -to-side.</p> <p>Mobility: May have strength to push a manual wheelchair for short distances over smooth surfaces. A power wheelchair with hand controls is typically used for daily activities. Driving may be possible after being evaluated by a qualified professional to determine special equipment needs.</p>
C6	<i>Wrist extensors (extensor carpi ulnaris, extensor carpi radialis longus and radialis brevis)</i>	Has movement in head, neck shoulders, arms and wrists. Can shrug shoulders, bend elbows, turn palms up and down and extend wrists.	<p>Daily tasks: With help of some specialized equipment, can perform with greater ease and independence daily tasks of feeding, bathing, grooming, personal hygiene and dressing. May independently perform light housekeeping duties.</p> <p>Health care: Can independently do pressure reliefs, skin checks and turn in bed.</p> <p>Mobility: Can independently do transfers but often require a sliding board. Can use a manual wheelchair for daily activities but may use power wheelchair for greater independence.</p>

Level	Action / Muscles Tested	Abilities	Functional Goals
C7	<i>Elbow extensors</i> (triceps brachii)	Has similar movement as an individual with C6, with added ability to straighten his/her elbows.	Daily tasks: Able to perform household duties. Need fewer adaptive aids in independent living. Health care: Able to do wheelchair pushups for pressure reliefs. Mobility: Daily use of manual wheelchair. Can transfer with greater ease.
C8	<i>Finger flexors</i> (Flexor digitorum profundus-distal phalanx of the middle finger)	Has added strength and precision of fingers that result in limited or natural hand function.	Daily tasks: Can live independently without assistive devices in feeding, bathing, grooming, oral and facial hygiene, dressing, bladder management and bowel management.
T1	<i>Finger abductors</i> (Abductor digiti minimi)		
T2-T6		Has normal motor function in head, neck, shoulders, arms, hands and fingers. Has increased use of rib and chest muscles, or trunk control.	Mobility: Has increased ability to do some unsupported seated activities. A few individuals capable of limited walking with orthodic aids. This requires extremely high energy and puts stress on the upper body, offering no functional advantage. Can lead to damage of upper joints.
T7-L1		Has added motor function from increased abdominal control.	Daily tasks: Able to perform unsupported seated activities. Health care: Has improved cough effectiveness.
L2	<i>Hip flexors</i> (Iliopsoas)	Has additional return of motor movement in the hips and knees.	Mobility: Walking can be a viable function, with the help of specialized leg and ankle braces. Lower levels walk with greater ease with the help of assistive devices.
L3	<i>Knee extensors</i> (Quadriceps femoris)		
L4	<i>Ankle dorsiflexors</i> (Tibialis anterior)		
L5	<i>Long toe extensors</i> (Hallucis longus)		
S1-S5	<i>Ankle plantar flexors</i> (Gastrocnemius)	Depending on level of injury, there are various degrees of return of voluntary bladder, bowel and sexual functions.	Mobility: Increased ability to walk with fewer or no supportive devices.