



***THE SPINAL CORD AND THE INFLUENCE OF
ITS DAMAGE ON THE HUMAN BODY***



THE SPINAL CORD.

▶ A part of the Central Nervous System

The nervous system is a vast network of cells, which carry information in the form of nerve electrical impulses to and from all parts of the body. It is the base for all bodily activities. In human and vertebrates, the brain and the spinal cord compose a unique, continuous organ called the central nervous system (CNS).

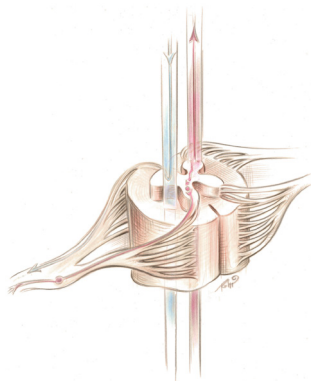
Its basic units of communication are the nerve cells (neurons), which consist of a bulbous cell body, and an axon that extends from the cell body. An axon carries signals to other cells. To date, any lesion of the spinal cord will lead to irreversible damage.



▶ **Nerve fibre tracts**

Two major systems of nerve cells operate in the spinal cord to relay information from the brain to the body and vice-versa. The descending pathway sends commands from the brain to the body to control the muscles (motor pathway) and to supervise the vegetative (autonomic) nervous system, which is in charge of controlling the heart, intestines and other organs. In contrast, the ascending pathway transmits signals from the skin, muscles, and internal organs to the brain (sensory pathway).

The descending and the ascending pathways are formed by over 20 million axons, organized into spinal tracts (bundles of nerve fibres). The names of different tracts reflect where they begin and end. For example, the corticospinal tract (also called the pyramidal tract) connects the motor cortex (motor centrum of the brain) with the spinal cord.



▶ **Glial**

Several types of cells and neighbouring structures “help” neurons to carry out spinal cord functions. Three types of support cells, known collectively as the glia (oligodendrocytes, microglia and astrocytes), produce substances that influence neuronal survival and axonal growth during CNS development. Furthermore, glia provide the structural integrity of the adult CNS. The oligodendrocytes are e.g. the myelin sheaths of axons, which act as an insulating layer and are essential for the transmission of nerve signals. The spinal cord is also a highly vascularised structure, as the neurons of the central nervous system have a very high rate of metabolism and rely upon blood glucose for energy.

▶ **Segments of the Spinal Cord**

Nerves are the connection between the brain and different areas of the body. They protrude from each segment of the spinal cord and connect to specific regions of the body.

The segments of the cervical region control signals to the neck, arms and hands. Nerves in the thoracic region relay signals to the torso and to some parts of the arms. Those in the lumbar region control signals to the hips and legs. Fibres protruding from the sacral segments control signals to the toes and to some parts of the legs.





SPINAL CORD INJURY.

► The Lesion

Spinal cord injury usually results from trauma to the vertebral column. A displaced bone or disc then compresses the spinal cord (contusion). Spinal cord injury can occur without obvious vertebral fractures and one can have spinal fractures without spinal cord injury. It can also result from loss of blood flow to the spinal cord (spinal cord “stroke”) or from infections.

However, in most injuries the spinal cord is compressed and the extent of the damage depends primarily on the force of the compression, and to a lesser extent its duration.

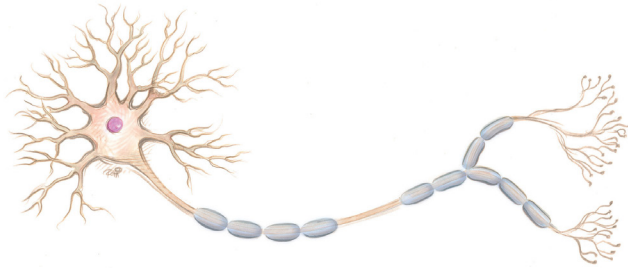
► Secondary Damage

In addition to immediate mechanical trauma, ongoing secondary damage continues to spread through spinal cord tissue, which progressively enlarges the lesion longitudinally through the spinal cord and thus increases the extent of functional impairment. As a result, the destruction can encompass several spinal segments above and below the initial lesion site.

As so much damage arises after the initial injury, clarifying how that secondary destruction occurs and blocking those processes is critical to maintain as many functions as possible.

Within minutes of the trauma, small bleeding from broken blood vessels appears and the spinal cord swells. This also causes an

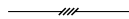
abnormal delivery of nutrients and oxygen to cells, causing many of them to starve to death. Meanwhile damaged cells, axons and blood vessels release toxic chemicals that destroy intact neighbouring cells (“excitotoxicity”).



In the healthy spinal cord, many axons secrete minute amounts of the neurotransmitter glutamate at their synapses. When this chemical binds to its receptors on target neurons, it stimulates those cells to fire impulses. But when spinal neurons, axons, or astrocytes are injured, they release a flood of glutamate.

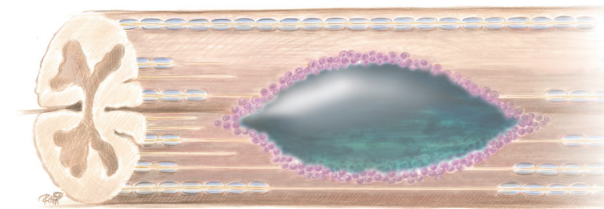
The high levels overexcite neighbouring neurons, inducing them to admit waves of ions that then trigger a series of destructive events in the cells—including the production of free radicals. These highly reactive molecules can attack and kill membranes and other components of formerly healthy neurons.

Such excitotoxicity, also seen after stroke, was thought to be lethal to neurons alone, but new results suggest it kills the myelin producing oligodendrocytes as well. This effect may help explain why even intact axons become demyelinated, and are thus unable to conduct impulses, after spinal cord trauma.



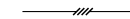
▶ The Consequences

The remaining status quo is a complex, enlarged condition of disrepair. Axons that have been damaged become useless stumps and their severed terminals disintegrate. Intact axons are rendered useless by loss of their insulating myelin, which is essential for the conduction of a nerve signal. Damaged neurons, glial cells and axonal fibres are removed from the body’s own system, and form a fluid-filled cavity or cyst.



In parallel, glial cells proliferate abnormally, creating dense cell clusters constituting one component of the glial scar. Together the cyst and scar pose a formidable barrier to any damaged axons that might try to regrow and connect to cells they once innervated. An additional problem arises from the fact that the cord environment contains an over-abundance of molecules that actively inhibit axonal regeneration – some of which lie in the myelin itself.

Many other inhibitory molecules have now been found as well, including some produced by astrocytes and others that reside in the extracellular matrix. A few axons may remain intact, myelinated and able to carry signals up or down the spinal cord, but often their numbers are too small to convey useful directives to the brain or muscles.



▶ **Extent of impairment**

The types of disability associated with spinal cord injury vary greatly depending on the severity of the injury, the segment of the spinal cord at which the injury occurs (lesion height), and which nerve fibres are damaged.

In spinal cord injury, the destruction of nerve fibres that carry motor signals from the brain to the torso and limbs leads to muscle paralysis. Destruction of sensory nerve fibres can lead to loss of sensations such as touch, pressure and temperature.

Largely unknown is that the spinal cord controls not only the muscles, but also the bladder, bowel, sexual function, blood pressure, skin blood circulation, regulating body temperature / sweating and many other functions.

People with injuries above C4 (4th cervical vertebra) may require a ventilator in order to breathe. In this case a paralysis in all four extremities – the arms and legs - is induced. This is called tetraplegia.

People with an injury between TH2 and TH8 (2nd and 8th thoracic vertebra) can use their arms and hands, but may have a poor trunk control. In this case “only” the legs are paralyzed (paraplegia).

People with injuries at lumbar level L1-L5 experience reduced control of their legs. The sacral nerves, S1 to S5, are responsible for bowel, bladder and sexual function as well as controlling the foot musculature.

Because of the fact that the spinal cord below the injury site still has a normal reflex circuitry, which become “uncontrolled” as it is disconnected from the brain, other serious consequences like exaggerated reflexes and spasticity can arise. Spinal cord injuries can

lead to many secondary complications, including, in order of occurrence: pressure sores, increased susceptibility to infections (respiratory and urinary system) and autonomic dysreflexia. Autonomic dysreflexia leads to a potentially life-threatening, increase in blood pressure or even cardiac arrest, sweating, and other autonomic reflexes in reaction to bowel impaction or some other stimuli.

Medical intervention and skilled supportive care or years of experience is necessary to treat and to prevent these complications.

Please find more information and a glossary with technical terms on www.wingsforlife.com
