Lecture (1):
Spinal cord I (Anatomy)

Source: First Aid USMLE, **Page:** 446 – 447
Source: Nervous System Basic science and clinical condition. **Page:** 495 & 498
Source: Nervous System Basic science and clinical condition. **Page:** 60.62
Source: Kaplan neuroscience USMLE Lecture notes 2021; Pages: 251-255.

Specific learning Objectives

1- Describe main gross anatomical features of nervous system including: brain stem, spinal cord, spinal and cranial nerves and organs of special sense

Contents:

By the end of the lecture the student will be able to:

1. **Describe** the anatomy of the spinal cord
2. **Describe** the anatomy of the spinal nerves.
3. **List** the body plexuses and their formation.
4. **Interpret** anatomical facts with the clinical manifestations of some vascular lesions (anterior spinal artery infarction and cauda equina and conus medullaris syndromes
5. **Organizes** the landmark dermatomes on a diagram of the human body.
6. **Correlate** the anatomy of the spinal cord with the lumbar puncture procedure (level and structures that the needles pass through).
7. **Correlate** anatomical facts with the injury of spinal cord and vertebral column.

NARS: (4.1,).

ANATOMY OF THE SPINAL CORD

The spinal cord continues caudally from the brain stem as a long cordlike structure. It is about 45 cm long.

It is located within the vertebral canal which provides structural protection.

It is held in place by:

1-Spinal nerves roots. 2- Denticulate ligaments

✧ The spinal cord is a **segmental structure**, giving rise to 31 bilaterally paired spinal nerves along the cord:

- Cervical nerves (C1–C8)
- Thoracic nerves (T1–T12)
- Lumbar nerves (L1–L5)
- Sacral nerves (S1–S5)
- Coccygeal nerve

Levels of the Spinal Cord

- Extends from the foramen magnum to the level of the disc between L1 and L2 vertebra.
- At birth, it extends much lower (to the L3 vertebral level).
- Different spinal **cord segments** levels can be related to specific **vertebral levels:**

Vertebral level	Spinal cord segment level
Cervical vertebrae e.g. C5	Add 1, e.g. C6
Upper thoracic, T1–T6	Add 2 segments
Lower thoracic, T7–T9	Add 3 segments
T10	L1–L2
T11	L3–L4
T12	L5
L1	Conus medullaris

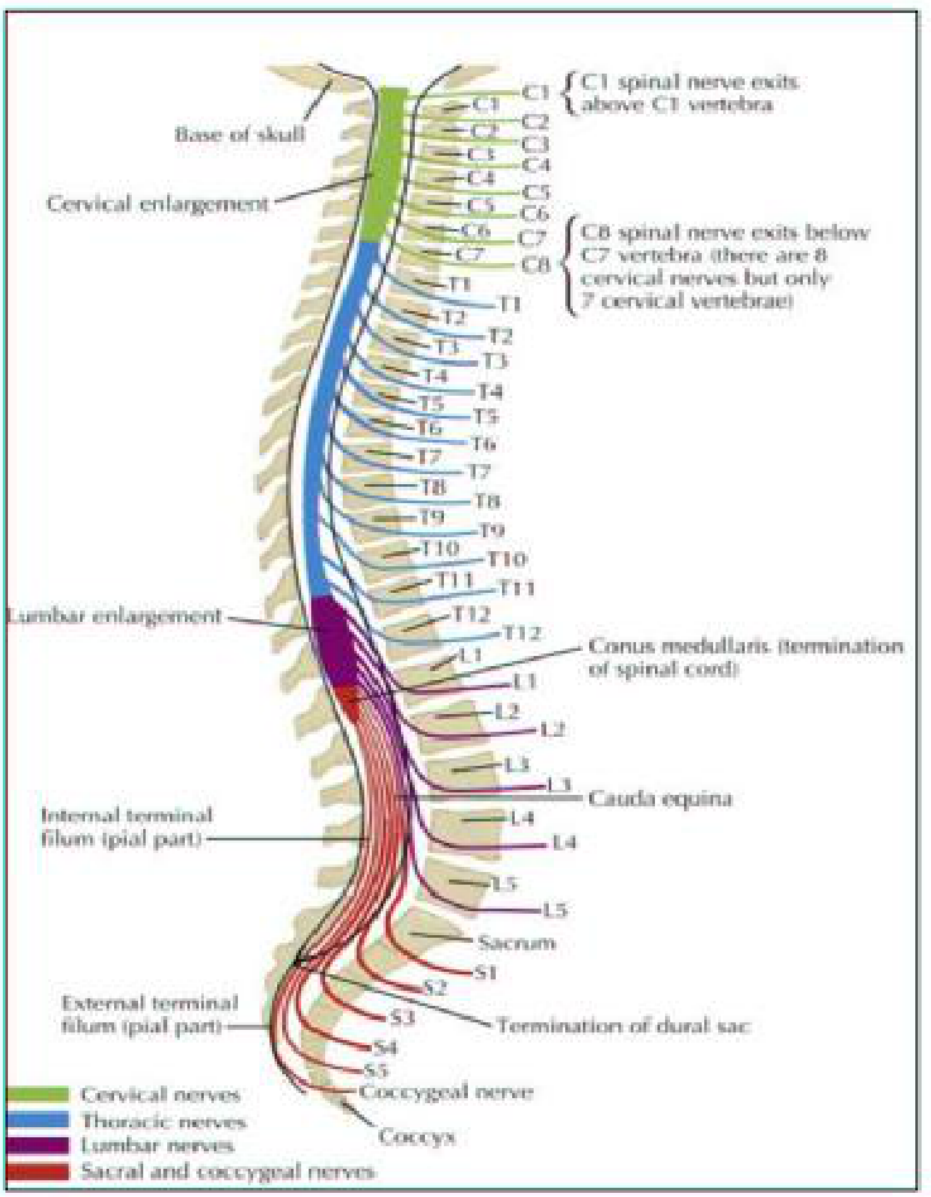

Figure 1-1: Topographic relations of the spinal cord segments, spinous processes, and bodies of the vertebrae, intervertebral foramina

- Cervical spinal nerves C1–C7 exit **above** the vertebra with the same number.
- Spinal nerve C8 exits below the C7 vertebrae.

- Spinal nerves below C8 exit **below** the vertebra with the same number (e.g. L1 nerve exits between L1 and L2).

✧ Each **spinal segment** receives sensory input from dermatomal regions of the body and sends motor output to myotomal regions.

- **Conus medullaris:** it is the terminal end of the spinal cord at L3 in newborns and at the lower border of L1 in adults (Fig.4-1).
- **Cauda equina ("tail of the horse"):** multiple separate motor and sensory roots, which exit the vertebral canal through the lumbar intervertebral and sacral foramina.

Meninges:

➢ The spinal cord and spinal roots are covered by three layers of meninges (Fig. 4-2) the dura, arachnoid and pia mater and further protection is provided by the presence of cerebrospinal fluid (CSF), which surrounds the cord in the subarachnoid space.

Spinal cord enlargements (Fig.4-1):

The size of the spinal cord is not uniform along its length. It has:

➢ ***The cervical enlargement*** (C5 through T1) gives rise to the rootlets that form the brachial plexus, which innervates the upper limbs.

➢ ***The lumbar enlargement*** (L1 through S3) gives rise to rootlets that form the lumbar and sacral plexuses, which innervate the lower limbs.

Cross-Section of the Spinal Cord (Fig.4-3)

➢ The spinal cord has a narrow lumen which is called the central canal.

➢ The spinal cord is incompletely divided into two symmetrical halves by a deep **anterior median fissure** and a shallower **posterior median sulcus** along the longitudinal length of the cord.

The two halves are interconnected by two commissures across the median plane:

✓ **Anterior white commissure** (at the bottom of the anterior median fissure)

✓ **Grey commissure containing** the central canal.

Commissure: is a band of white matter or grey matter connecting a part of the CNS on one side with the same part on the other side

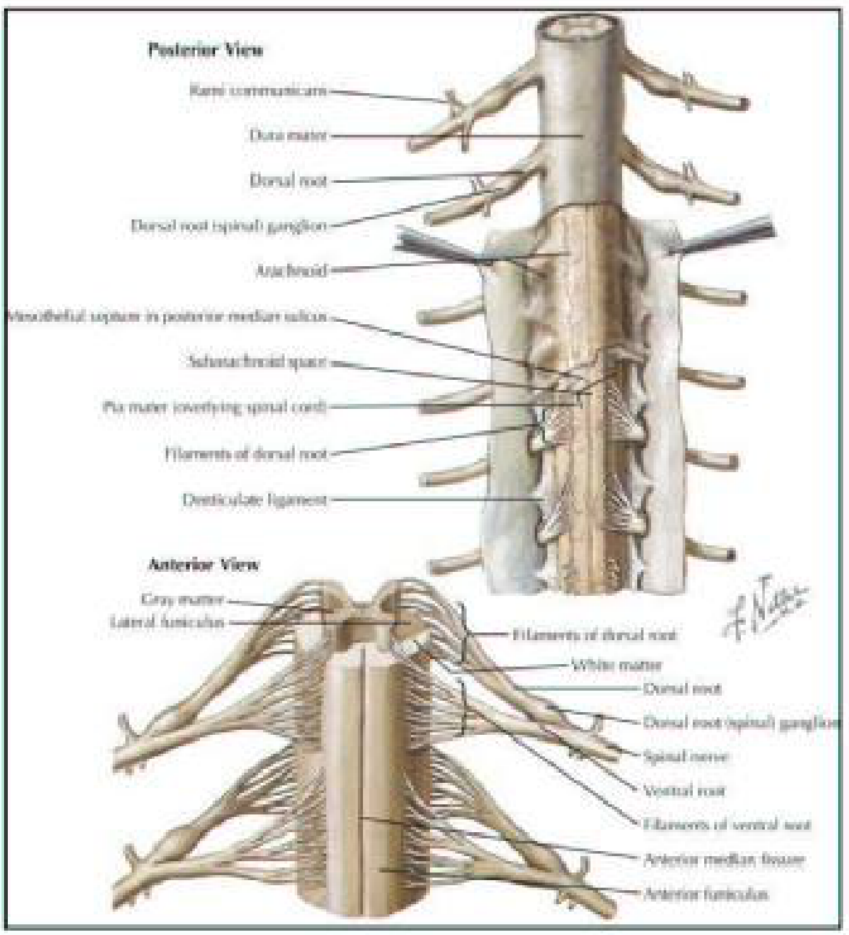

Figure 2-2: The Spinal Cord: Its Meninges and Spinal Roots

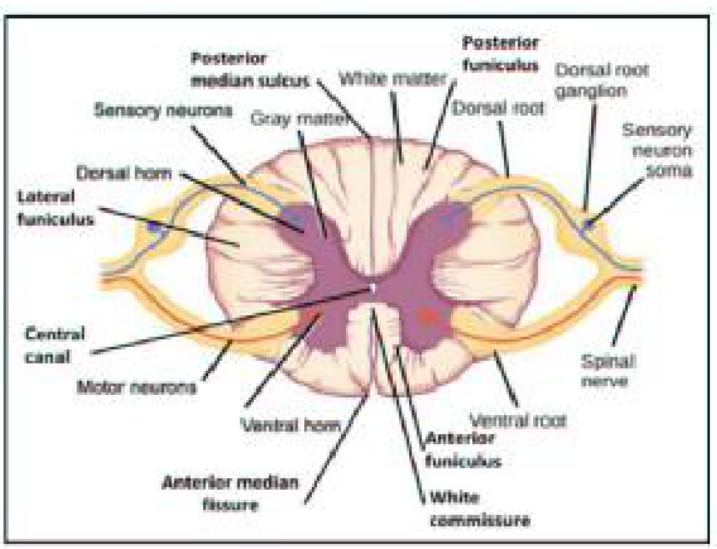

Figure 1-3: Cross section of the spinal cord

■ **Grey matter:** centrally located and shaped like a butterfly that contains the cell bodies of neurons that send projections either to the periphery or up through the spinal cord tracts.

It can be subdivided into different functional regions:

- **The dorsal (posterior) grey column or horn,** which is associated with sensory perception. Neurons in the dorsal horn project to higher levels of the CNS to carry sensations to the brain stem, cerebral cortex or cerebellum(forming ascending tracts).
- **The ventral (anterior) grey column or horn,** contains motor neurons whose axons exit the cord via the ventral root, on their way to the muscles.
- **The lateral horn**, present at thoracic and upper two or three lumbar segments, where the cell bodies of the sympathetic preganglionic fibers are found. In the ***second, third and fourth sacral segments*** similar group of cells found and give rise to preganglionic parasympathetic fibers.

■ **White matter:** is divided into three funiculi: ***anterior, lateral, and posterior***.

The white matter of the spinal cord is occupied by short(intersegmental) tracts, long ascending tracts and long descending tracts.

Tract: is a group of nerve fibers in the central nervous system which have the same origin, the same termination and the same function. Tracts of the spinal cord include:

☺ **Motor** pathways travel **away** from the brain. The names of motor pathways begin with the brain structure and end with **-spinal** (ie, cortico**spinal** tract).

☺ **Sensory** pathways travel **toward** the brain. The names of sensory pathways begin with **spino-** and end with the brain structure (ie, **spino**thalamic tract)

Blood Supply

Arterial supply

1-Anterior spinal artery: formed by union of two arteries each arises from the vertebral artery. It supplies **the anterior two thirds of the cord**.

2-Posterior spinal arteries arise from vertebral arteries, supply the posterior third of the cord.

3-Segmental radiculospinal arteries. Give rise to anterior and posterior radicular arteries that accompany the anterior and posterior roots of the spinal nerves. (Fig. 4- 4)

Venous drainage

Veins of the spinal cord drain into six longitudinal channels that communicate with the dural sinuses superiorly and drain into the internal (epidural) and external vertebral venous plexus.

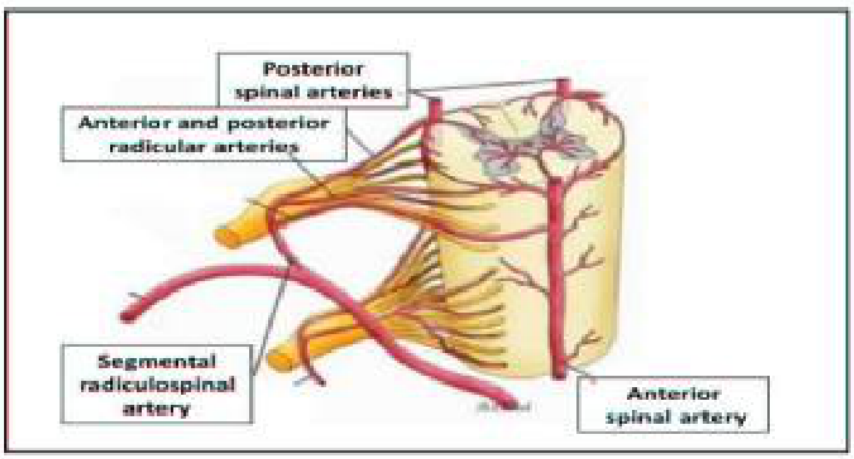

Figure 1-4: Blood supply of the spinal cord

SPINAL NERVES

The peripheral nervous system (PNS) consists of:

1. 12 pairs of cranial nerves.
2. 31 pairs of spinal nerves.
3. The peripheral part of the autonomic nervous system.

Spinal nerves are formed by the union of dorsal and ventral roots.

☆ **Dorsal roots** transmit sensory information from skin, muscle and joints. The dorsal root contains a swelling called the **dorsal root ganglion** that houses the first order neurons of all the sensory pathways (Fig.4-5).

☆ **Ventral roots** transmit motor and autonomic information to the periphery.

Spinal nerves divide into dorsal and ventral rami.

✧ **The dorsal rami**: serve sensorimotor functions of the back.

✧ **Ventral rami:** Cervical, lumbar and sacral ventral rami merge with adjacent rami to form four major plexuses:

Cervical plexus	C1-C4	Brachial plexus	C5-T1
Lumbar plexus	L1-L4	Sacral plexus	L4-S4

The thoracic ventral rami project directly to the thoracic and abdominal walls.

White communicating rami: Contain myelinated preganglionic sympathetic fibers. Found only from T1 to L3 in conjunction with the lateral horn and intermediolateral cell column.

Gray communicating rami: Contain unmyelinated postganglionic sympathetic fibers.

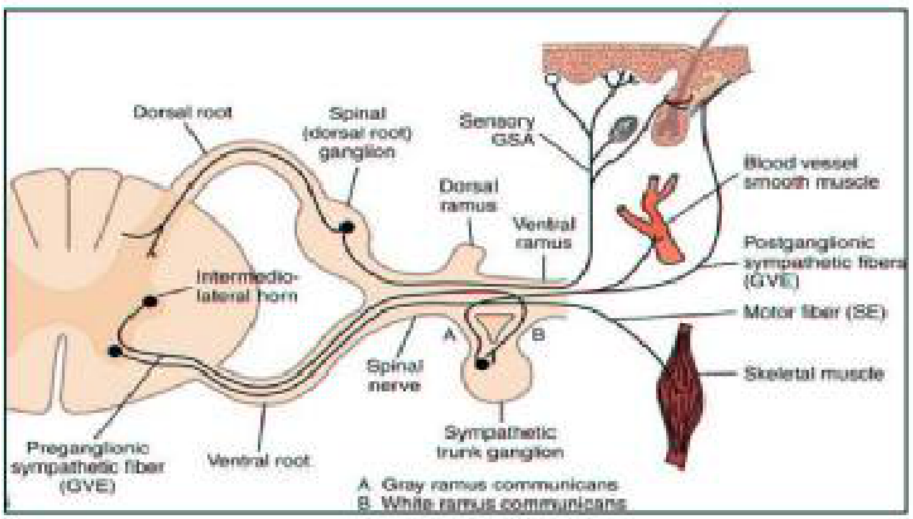

Figure 1-5: Formation of the spinal nerve

Spinal nerves possess:

- **Two types of sensory fibers**:

  General somatic sensory --- General visceral sensory

- **Two types of motor fibers:**

  General somatic motor --- General visceral motor

AUTONOMIC NERVOUS SYSTEM

The autonomic nervous system (ANS) is concerned with the motor innervation of smooth muscle, cardiac muscle, and glands of the body.

Anatomically and functionally, the ANS is composed of 2 motor divisions:

(1) sympathetic and (2) parasympathetic

In both divisions, 2 neurons form an autonomic pathway (Fig. 4-6).

1-**Preganglionic neurons** have their neuronal cell bodies in the CNS, their axons exit in cranial and spinal nerves.

2 **Postganglionic neurons** have cell bodies in autonomic ganglia in the peripheral nervous system (PNS)

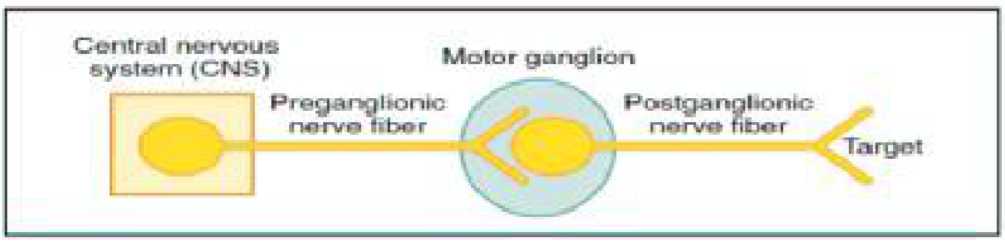

Figure 1-6. Autonomic Nervous System

Sympathetic Nervous System:

- ✧ The preganglionic cell bodies of the sympathetic nervous system are found in the lateral horn grey matter of spinal cord segments T1– L3 (thoracolumbar outflow).
- ✧ The postganglionic cell bodies of the sympathetic system are found in one of 2 types of motor ganglia in the PNS:

l-Sympathetic chain 2-Collateral or prevertebral (found only in abdomen or pelvis)

Parasympathetic Nervous System:

- ✧ The preganglionic cell bodies of the parasympathetic nervous system are found in the CNS in one of 2 places (craniosacral outflow):

l -Parasympathetic nuclei of cranial nerves III, VII, IX, and X.

2 -Sacral segments S2, 3 and 4

The postganglionic cell bodies of parasympathetic nervous system are found in **terminal ganglia** that are usually located near the organ innervated or in the wall of the organ.

Dermatomes

A dermatome is the area of skin supplied by the cutaneous branches of an individual spinal nerve (Fig.4-7). knowledge of the skin regions corresponding to particular dermatomes plays an important role in the clinical diagnosis of peripheral nerve lesions.

Landmark dermatomes

C2	Posterior half of skull
C3	High turtleneck shirt
C4	Low-collar shirt
C5	Lateral shoulder

↗ *When the diaphragm or the surrounding abdominal structures are inflamed and cause diaphragmatic irritation (ie, cholecystitis, ruptured spleen), the patient often feel pains in the shoulder because the corresponding dermatome shares a C3–C5 nerve root with the phrenic nerve (referred pain).*

C6	lateral forearm and thumb.
T7	At the xiphoid process
T10	At the umbilicus (Important point of referred pain in early appendicitis)
L1	At the Inguinal Ligament
L4	Front of the knee
S2, S3, S4	Perianal area (Saddle area)

Myotome: the muscles innervated by a single ventral root.

☆ Muscles sharing a common primary action are supplied by the same segment and opposing muscles by segments in sequence with the former.

☆ **Reflexes** are used to test the integrity of the spinal cord at their corresponding levels.

- Achilles reflex = S1, S2
- Patellar reflex = L3, L4
- Biceps and brachioradialis reflexes = C5, C6
- Triceps reflex = C6, C7

Herniation of the intervertebral disc:

Over 90% of clinically evident herniated discs occur at L4/L5 and L5/S1.

Cauda equina syndrome:

Lesion of the L3-Co **nerve roots**. Is characterized by **unilateral** muscle atrophy, ***radicular*** pain and areflexia with loss of pain in saddle area. It has a **gradual** onset.

Conus medullaris syndrome:

Lesion of S3-Co **segments**. Is characterized by **bilateral** loss of sensation in saddle-shaped area and severe incontinence with **sudden** onset.

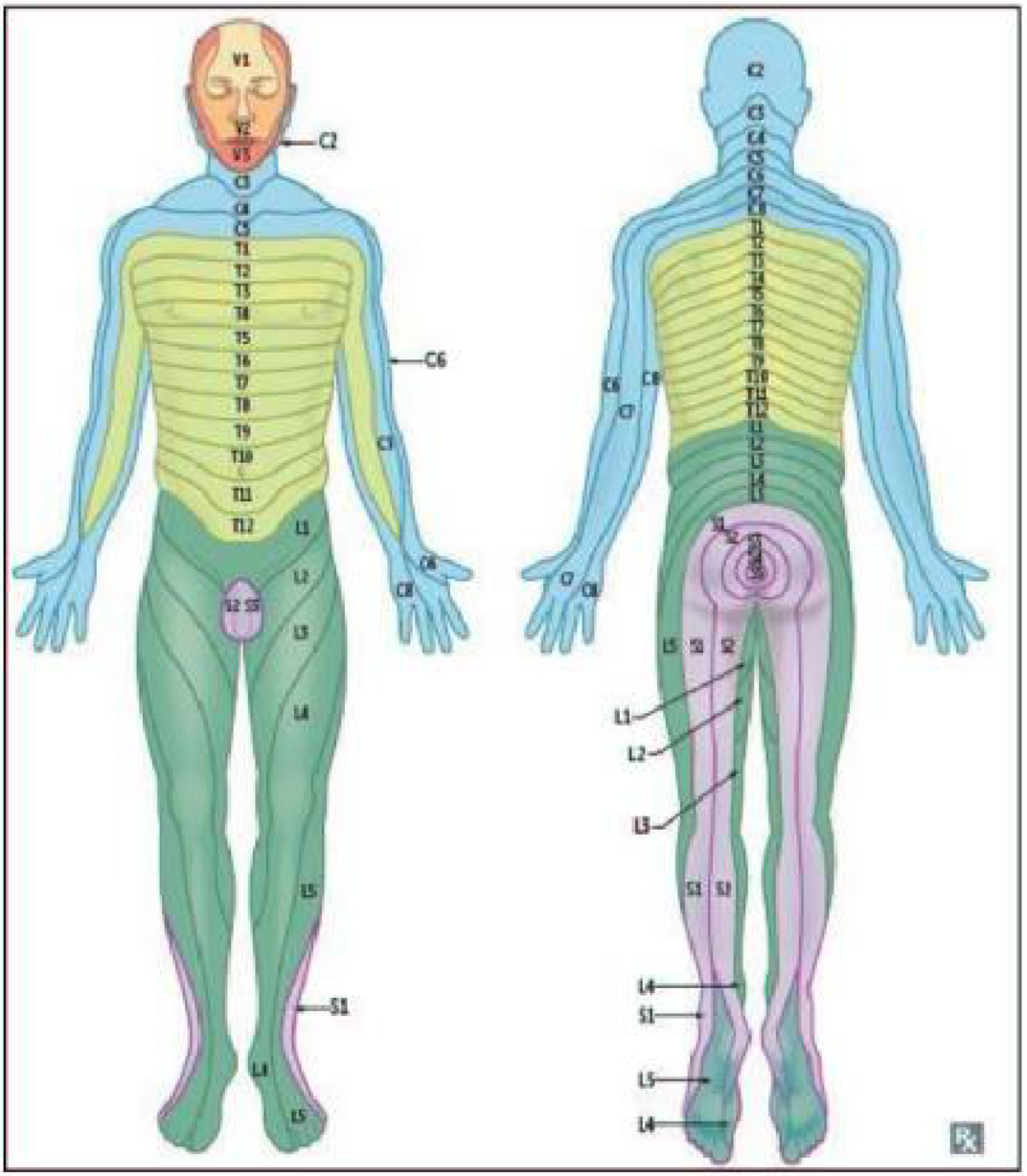

Figure 1-7: Dermatomes distribution.