

## **Chapter 13 – Outline**

**Note: Please refer to handout [Spinal Plexuses and Representative Spinal Nerves](#) for what you need to know from Exhibits 13.1 – 13.4**

### **I. INTRODUCTION**

- A. The spinal cord and spinal nerves mediate reactions to environmental changes.
- B. The spinal cord has several functions.
  - 1. It processes reflexes.
  - 2. It is the site for integration of EPSPs and IPSPs that arise locally or are triggered by nerve impulses from the periphery and brain.
  - 3. It is a conduction pathway for sensory and motor nerve impulses.

### **II. SPINAL CORD ANATOMY**

- A. The *spinal cord* is protected by two connective tissue coverings, the *meninges* and *vertebra*, and a cushion of *cerebrospinal fluid*.
  - 1. The *vertebral column* provides a bony covering of the spinal cord.
  - 2. Meninges
    - a. The *meninges* are three coverings that run continuously around the spinal cord and brain. In addition to the meninges, you should know the spaces and what is contained in the spaces as well as their functions as we discussed in class.
      - 1) The outermost layer is the *dura mater*.
      - 2) The middle layer is the *arachnoid*.
      - 3) The innermost meninx is the *pia mater*, a thin, transparent connective tissue layer that adheres to the surface of the spinal cord and brain.
      - 4) Inflammation of the meninges is known as *meningitis*.
      - 5) *Denticulate ligaments* are thickenings of the *pia mater* that suspend the spinal cord in the middle of its dural sheath.

- B. External Anatomy of the Spinal Cord

1. The *spinal cord* begins as a continuation of the medulla oblongata and terminates at about the second lumbar vertebra in an adult.
2. It contains cervical and lumbar enlargements that serve as points of origin for nerves to the extremities.
3. The tapered portion of the spinal cord is the *conus medullaris*, from which arise the *filum terminale* and *cauda equina*.
4. Spinal nerves
  - a. The 31 pairs of spinal nerves are named and numbered according to the region and level of the spinal cord from which they emerge.
  - b. There are 8 pairs of cervical nerves, 12 pairs of thoracic nerves, 5 pairs of lumbar nerves, 5 pairs of sacral nerves, and 1 pair of coccygeal nerves.
  - c. *Spinal nerves* are the paths of communication between the spinal cord and most of the body.
  - d. *Roots* are the two points of attachment that connect each spinal nerve to a segment of the spinal cord.
    - 1) The *posterior* or *dorsal (sensory) root* contains sensory nerve fibers and conducts nerve impulses from the periphery into the spinal cord; the posterior root ganglion contains the cell bodies of the sensory neurons from the periphery.
    - 2) The *anterior* or *ventral (motor) root* contains motor neuron axons and conducts impulses from the spinal cord to the periphery; the cell bodies of motor neurons are located in the gray matter of the cord.

#### C. Internal Anatomy of the Spinal Cord

1. The *anterior median fissure* and the *posterior median sulcus* penetrate the white matter of the spinal cord and divide it into right and left sides.

2. The *gray matter* of the spinal cord is shaped like the letter H or a butterfly and is surrounded by *white matter*.
  - a. The *gray matter* consists primarily of cell bodies of neurons and neuroglia and unmyelinated axons and dendrites of association and motor neurons.
  - b. The *white matter* consists of bundles of myelinated axons of motor and sensory neurons.
3. The *gray commissure* forms the cross bar of the H-shaped gray matter.
4. In the center of the gray commissure is the *central canal*, which runs the length of the spinal cord and contains cerebrospinal fluid.
5. Anterior to the gray commissure is the anterior *white commissure*, which connects the white matter of the right and left sides of the spinal cord.
6. The gray matter is divided into *horns*, which contain cell bodies of neurons.
7. The white matter is divided into *columns*.
  - a. Each column contains distinct bundles of nerve axons that have a common origin or destination and carry similar information.
  - b. These bundles are called *tracts*.
    - 1) *Sensory (ascending) tracts* conduct nerve impulses toward the brain.
    - 2) *Motor (descending) tracts* conduct impulses down the cord.

### III. SPINAL NERVES

- A. Spinal nerves connect the CNS to sensory receptors, muscles, and glands and are part of the peripheral nervous system.
  1. The 31 pairs of spinal nerves are named and numbered according to the region and level of the spinal cord from which they emerge.
  2. Roots of the lower lumbar, sacral, and coccygeal nerves are not in line with their corresponding vertebrae and thus form the *cauda equine*.

3. Spinal nerves connect to the cord via an anterior and a posterior root. Since the posterior root contains sensory axons and the anterior root contains motor axons, a spinal nerve is a mixed nerve, at least at its origin.

#### B. Connective Tissue Covering of Spinal Nerves

1. Spinal nerve axons are grouped within connective tissue sheathes.
  - a. A *fiber* is a single axon within an *endoneurium*.
  - b. A *fascicle* is a bundle of fibers within a *perineurium*.
  - c. A *nerve* is a bundle of fascicles within an *epineurium*.
2. Numerous blood vessels are within the coverings.

#### C. Distribution of Spinal Nerves

1. Shortly after passing through its intervertebral foramen, a spinal nerve divides into several branches; these branches are known as *rami*.
2. Branches of a spinal nerve include the *dorsal ramus*, *ventral ramus*, *meningeal branch*, and *rami communicantes*.
3. The anterior rami of spinal nerves T2-T12 do not enter into the formation of plexuses and are known as *intercostal* or *thoracic nerves*.
  - a. These nerves directly innervate structures they supply in the intercostal spaces.
  - b. Their posterior rami supply the deep back muscles and skin of the posterior aspect of the thorax.
4. The ventral rami of spinal nerves, except for T2-T12, form networks of nerves called *plexuses*. Be sure to know the significance of plexuses (as discussed in class).
  - a. Emerging from the plexuses are nerves bearing names that are often descriptive of the general regions they supply or the course they take.

- b. The *cervical plexus* supplies the skin and muscles of the head, neck, and upper part of the shoulders; connects with some cranial nerves; and supplies the diaphragm.
  - 1) Damage to the spinal cord above the origin of the phrenic nerves (C3-C5) causes respiratory arrest.
  - 2) Breathing stops because the phrenic nerves no longer send impulses to the diaphragm.
- c. The *brachial plexus* constitutes the nerve supply for the upper extremities and a number of neck and shoulder muscles.
  - 1) A number of nerve disorders may result from injury to the brachial plexus.
- d. The *lumbar plexus* supplies the anterolateral abdominal wall, external genitals, and part of the lower extremities.
  - 1) The largest nerve arising from the lumbar plexus is the femoral nerve.
  - 2) Injury to the femoral nerve is indicated by an inability to extend the leg and by loss of sensation in the skin over the anteromedial aspect of the thigh.
  - 3) Obturator nerve injury is a common complication of childbirth and results in paralysis of the adductor muscles of the leg and loss of sensation over the medial aspect of the thigh.
- e. The *sacral plexus* supplies the buttocks, perineum, and part of the lower extremities.
  - 1) The largest nerve arising from the sacral plexus (and the largest nerve in the body) is the sciatic nerve.

- 2) Injury to the sciatic nerve (common peroneal portion) and its branches results in sciatica, pain that extends from the buttock down the back of the leg.
- 3) Sciatic nerve injury can occur due to a herniated (slipped) disc, dislocated hip, osteoarthritis of the lumbosacral spine, pressure from the uterus during pregnancy, or an improperly administered gluteal injection.

#### D. Dermatomes

1. The skin over the entire body is supplied by spinal nerves that carry somatic sensory nerve impulses into the spinal cord.
2. All spinal nerves except C1 innervate specific, constant segments of the skin; the skin segments are called *dermatomes*.
3. Knowledge of dermatomes helps a physician to determine which segment of the spinal cord or which spinal nerve is malfunctioning.

### IV. SPINAL CORD PHYSIOLOGY

#### A. The spinal cord has two principal functions.

1. The white matter tracts are *highways for nerve impulse conduction* to and from the brain.
2. The gray matter receives and integrates incoming and outgoing information.

#### B. Sensory and Motor Tracts

1. Note the principal sensory and motor tracts in the spinal cord. You should understand how the tracts are named and the information you can get from the name (as discussed in class). We will cover the functions of the tracts in a later chapter.

2. Sensory information from receptors travels up the spinal cord to the brain along two main routes on each side of the cord: the *spinothalamic tracts* and the *posterior column tract*.
3. Motor information travels from the brain down the spinal cord to effectors (muscles and glands) along two types of descending tracts: direct pathways and indirect pathways.
4. The axons of various nerves and CNS tracts develop myelin sheaths at different times which explains the poor sensory and motor development of newborns.

#### C. Reflexes and Reflex Arcs

1. The spinal cord serves as an *integrating center for spinal reflexes*. This occurs in the gray matter.
2. A *reflex* is a fast, predictable, automatic response to changes in the environment that helps to maintain homeostasis.
3. Reflexes may be *spinal, cranial, somatic, or autonomic*.

#### D. Reflex Arc

1. A *reflex arc* is the simplest type of pathway; pathways are specific neuronal circuits and thus include at least one synapse.
2. The five functional components of a reflex arc are the *receptor, sensory neuron, motor neuron, integrating center neuron, and effector*.
3. Reflexes help to maintain homeostasis by permitting the body to make exceedingly rapid adjustments to homeostatic imbalances.
4. Somatic spinal reflexes include the *stretch reflex, tendon reflex, flexor (withdrawal) reflex, and crossed extensor reflex*; all exhibit reciprocal innervation.

##### a. Stretch Reflex

- 1) The *stretch reflex* is ipsilateral and is important in maintaining muscle tone and muscle coordination during exercise.

- 2) A two-neuron or monosynaptic reflex arc contains one sensory neuron and one motor neuron. A stretch reflex, such as the patellar reflex, is an example.
- 3) It operates as a feedback mechanism to control muscle length by causing muscle contraction.

b. Tendon Reflex

- 1) The *tendon reflex* is ipsilateral and prevents damage to muscles and tendons as a result of stretching.
- 2) It operates as a feedback mechanism to control muscle tension by causing muscle relaxation when muscle force becomes too extreme.

c. Flexor and Crossed Extensor Reflexes – intersegmental reflexes

1) Flexor or Withdrawal Reflex

- a) The *flexor (withdrawal) reflex* is ipsilateral and is a protective withdrawal reflex that moves a limb to avoid pain.
- b) This reflex results in contraction of flexor muscles to move a limb to avoid injury or pain.
- c) It works with the crossed extensor reflex to maintain balance if a lower limb is involved.

2) Crossed Extensor Reflex

- a) This is a balance-maintaining reflex that causes a synchronized extension of the joints of one limb and flexion of the joints in the opposite limb.
- b) The *crossed extensor reflex*, which is contralateral, helps to maintain balance during the flexor reflex.

5. Reflexes are often used for diagnosing disorders of the nervous system and locating injured tissue. (Clinical Application)



- a. If a reflex is absent, or abnormal, the damage may be somewhere along a particular conduction pathway.
- b. Among the clinically important reflexes are the *plantar flexion* and *Babinski reflexes*.