

CHAPTER 13

LECTURE OUTLINE

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, to the brain, and motor impulses to effectors.

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 (Figure 13.1).
 - 2. Meninges
 - a. The protective meninges are three coverings that run continuously around the spinal cord and brain (Figures 13.1a, 14.2a, respectively).
 - b. The outermost layer is the dura mater
 - c. The middle layer is the arachnoid.
 - d. The innermost meninge is the pia mater,
 - (1) Denticulate ligaments are thickenings of the pia mater that suspend the spinal cord in the middle of its dural sheath.
 - 3. The subarachnoid space carries cerebrospinal fluid, (CSF).
 - 4. **Clinical Connection:** A spinal tap is done to withdraw CSF for diagnostic purposes

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 (Figure 13.2).
- 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.

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 (Figure 13.3).
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.
3. The white matter consists of bundles of myelinated axons of motor and sensory neurons
4. The gray commissure forms the cross bar of the H-shaped gray matter.
 - a. In the center of the gray commissure is the central canal, which runs the length of the spinal cord and contains cerebrospinal fluid.
 - b. 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.
5. The gray matter is divided into horns, which contain cell bodies of neurons.
6. The white matter is divided into columns.
7. Each column contains distinct bundles of nerve axons that have a common origin or destination and carry similar information.
 - a. These bundles are called tracts.
 - (1) Sensory (ascending) tracts conduct nerve impulses toward the brain.
 - (2) Motor (descending) tracts conduct impulses down the cord.
8. The internal organization of the spinal cord allows reflexes to be processed and to inform the brain of the results of those reflexes (Figure 13.4)
9. Table 13.1 reviews the cross section of the spinal cord at different segments.

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 (Figure 13.2).
 - a. 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.
 2. Spinal nerves are the paths of communication between the spinal cord and most of the body.
 3. Roots are the two points of attachment that connect each spinal nerve to a segment of the spinal cord (Figure 13.3).

- a. 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.
- b. 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.

B. Connective Tissue Covering of Spinal Nerves

1. Spinal nerve axons are grouped within connective tissue sheathes (Figure 13.5).
2. A fiber is a single axon within an endoneurium.
3. A fascicle is a bundle of fibers within a perineurium.
4. A nerve is a bundle of fascicles within an epineurium.
5. 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 (Figure 13.6).
 - a. Branches of a spinal nerve include the dorsal ramus, ventral ramus, meningeal branch, and rami communicantes.
 - (1) The anterior rami of spinal nerves T2-T12 do not enter into the formation of plexuses and are known as intercostal or thoracic nerves.
 - i. These nerves directly innervate structures they supply in the intercostal spaces.
 - (2) Their posterior rami supply the deep back muscles and skin of the posterior aspect of the thorax.
 - (3) The ventral rami of spinal nerves, except for T2-T12, form networks of nerves called plexuses (Figure 13.2 and Exhibits 13.1-13.4).
 - (4) 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 (Figure 13.7, Exhibit 13.1).
 - (5) Emerging from the plexuses are nerves bearing names that are often descriptive of the general regions they supply or the course they take.
 - (6) Damage to the spinal cord above the origin of the phrenic nerves (C3-C5) causes respiratory arrest.
 - (7) **Clinical Connection:** Breathing stops because the phrenic nerves no longer send impulses to the diaphragm

- D. The brachial plexus constitutes the nerve supply for the upper extremities and a number of neck and shoulder muscles (Figures 13.8, Exhibit 13.2).
1. A number of nerve disorders may result from injury to the brachial plexus (Figure 13.9)
 - a. **Clinical Connection:** Among these injuries are Erb-Duchene palsy or waiter's tip palsy, ulnar and radial injuries, wrist drop, claw hand, and winged scapula
- E. The lumbar plexus supplies the anterolateral abdominal wall, external genitals, and part of the lower extremities (Figure 13.10, Exhibit 13.3).
1. The largest nerve arising from the lumbar plexus is the femoral nerve.
 - a. **Clinical Connection:** 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.
 - b. **Clinical Connection:** 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.
- F. The sacral plexus supplies the buttocks, perineum, and part of the lower extremities (Figure 13.11, Exhibit 13.4).
1. The largest nerve arising from the sacral plexus (and the largest nerve in the body) is the sciatic nerve.
 - a. **Clinical Connection:** 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
 - (1) 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

G. Sacral and Coccygeal Plexus (figure 13.10)

1. Situated in the anterior sacrum
2. Supplies buttocks, perineum, and lower limbs

H. 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 (Figure 13.12).
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 to perform reflexes.

B. Sensory and Motor Tracts

1. Figure 13.12 shows the principal sensory and motor tracts in the spinal cord.
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.

C. Reflexes and Reflex Arcs

1. The spinal cord serves as an integrating center for spinal reflexes. This occurs in the gray matter (Figure 13.13).
2. A reflex is a fast, predictable, automatic response to changes in the environment that helps to maintain homeostasis.
3. Reflexes may be spinal and cranial in location, and somatic, or autonomic in function.

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 (Figure 13.13).
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 (Figure 13.14).
- (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.
 - i. 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 (Figure 13.15).
- (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

- (1) The flexor (withdrawal) reflex is ipsilateral and is a protective withdrawal reflex that moves a limb to avoid pain (Figure 13.16).
- (2) This reflex results in contraction of flexor muscles to move a limb to avoid injury or pain.
- (3) It works with the crossed extensor reflex to maintain balance.

i. Crossed Extensor Reflex

1. 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 (Figure 13.17).
2. The crossed extensor reflex, which is contralateral, helps to maintain balance during the flexor reflex.

a. **Clinical Connection:** Reflexes are often used for diagnosing disorders of the nervous system and locating injured tissue.

- i. If a reflex is absent, or abnormal, the damage may be somewhere along a particular conduction pathway.
- ii. Among the clinically important reflexes are the Patellar reflex, Achilles reflex, Babinski reflex, Abdominal reflex and Pupillar reflex.

V. DISORDERS; HOMEOSTATIC IMBALANCES

- A. The damage that results from Traumatic injuries depends on the degree of spinal cord section, and or compressions and the segments involved. Complete transection results in paralysis of a variety of forms. Lessor effects include incomplete paralysis to loss of sensation and motor function. Spinal shock often occurs immediately after injury with associated swelling. Administration of corticosteroids is one treatment to reduce the swelling.
- B. Shingles is an acute infection of the peripheral nerves by the herpes zoster virus; the virus migrates down peripheral nerves, causing pain, skin discoloration, and a characteristic line of skin blisters.

C. Poliomyelitis (infantile paralysis or polio) is a viral infection characterized by fever, headache, stiff neck and back, deep pain and weakness, and loss of certain somatic reflexes. Paralysis is produced when the virus destroys motor neuron cell bodies.