Spinal Cord and Spinal Nerves

Chapter 12

Spinal Cord
- Extends from foramen magnum to second lumbar vertebra
- Segmented: Cervical, Thoracic, Lumbar & Sacral
- Gives rise to 31 pairs of spinal nerves
- Not uniform in diameter throughout length
  - Cervical enlargement: supplies upper limbs
  - Lumbar enlargement: supplies lower limbs
- Conus medullaris: tapered inferior end.
- Cauda equina: origins of spinal nerves extending inferiorly from lumbosacral enlargement and conus medullaris.

Spinal Meninges
- Connective tissue membranes surrounding spinal cord and brain
  - Dura mater: continuous with epineurium of the spinal nerves
  - Arachnoid mater: thin and wispy
  - Pia mater: bound lightly to surface of brain and spinal cord. (Forms the filum terminale, which anchors spinal cord to coccyx and the denticulate ligaments that attach the spinal cord to the dura mater)
- Spaces
  - Epidural: anesthesia injected. Contains blood vessels, areolar connective tissue and fat.
  - Subdural: serous fluid
  - Subarachnoid: CSF and blood vessels within web-like strands of arachnoid mater.
Spinal Meninges-(Lab)

Cross Section of Spinal Cord (Lab)

- **Anterior median fissure and posterior median sulcus**: deep clefts partially separating left and right halves
- **White matter**: myelinated axons forming tracts
  - Three columns (funiculi): ventral, dorsal, lateral
  - Each of these divided into tracts (fasculi; pathways)
- **Gray matter**: neuron, cell, cell bodies, dendrites, axons
  - Horns
    - Posterior (dorsal)
    - Anterior (ventral)
    - Lateral (associated with ANS)
Cross Section of Spinal Cord (Lab)

- **Commissures:** connections between left and right halves
  - Gray with central canal in the center
  - White
- **Roots:** spinal nerves arise as rootlets then combine to form roots
  - Dorsal (posterior) root has a ganglion
  - Ventral (anterior) roots
  - Two roots merge laterally and form the spinal nerve

Organization of Neurons in the Spinal Cord and Spinal Nerves

- **Dorsal root ganglion:** collections of cell bodies of unipolar sensory neurons forming dorsal roots.
- Motor neuron cell bodies are in anterior and lateral horns of spinal cord gray matter.
  - Multipolar somatic motor neurons in anterior (motor) horn
  - Autonomic neurons in lateral horn
- Axons of motor neurons form ventral roots and pass into spinal nerves

Reflex Arc

- **Basic functional unit** of nervous system and simplest portion capable of receiving a stimulus and producing a response
- **Automatic response** to a stimulus that occurs without conscious thought. Homeostatic.
- **Components**
  - Action potentials produced in 1. sensory receptors transmitted to
Variety of Reflexes
- Some integrated within **spinal cord**; some within **brain**
- Some involve **excitatory** neurons yielding a response; some involve **inhibitory** neurons that prevent an action
- Higher brain centers can **influence**, suppress, or exaggerate reflex responses

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Stretch Reflex
- Muscles contract in response to a stretching force applied to them. Unique because **no interneuron**.
- Muscle spindle: specialized muscle cells that respond to stretch.
- Innervated by specific motor neurons: **gamma motor neurons** (small diameter neurons). Control sensitivity of muscle spindle.
- Sensory neurons innervate the noncontractile centers of the muscle spindle cells.
- These sensory neurons synapse with motor neurons of the spinal cord called **alpha motor neurons** which in turn innervate the muscle in which the muscle spindle is embedded.
Golgi Tendon Reflex
- Prevents contracting muscles from applying excessive tension to tendons.
- **Golgi tendon organ.** Encapsulated nerve endings that have at their ends numerous terminal branches with small swellings associated with bundles of collagen fibers in tendon. Located in tendon near muscle.
- Prevents damage to tendons that could be caused by excessive tension.
- Produces sudden relaxation of the muscles.
  - Example: weight lifter suddenly drops heavy weight. Sudden movements of “clean and jerk” put so much tension on tendons like Achilles, they could break.

Withdrawal Reflex
- Function is to remove a body limb or other part from a painful stimulus.
- **Reciprocal innervation:** causes relaxation of extensor muscle when flexor muscle contracts.
  - Also involved in stretch reflex.
- **Crossed extensor reflex:** when a withdrawal reflex is initiated in one lower limb, the crossed extensor reflex causes extension of opposite lower limb.
Withdrawal Reflex with Reciprocal Innervation

Withdrawal Reflex with Crossed Extensor Reflex

Interactions with Spinal Cord Reflexes

- Sensory information goes to brain; e.g., pain.
- Descending tracts from brain carry info to reflexes.
- Neurotransmitters produce either EPSPs or IPSPs modifying the reflex.
Structure of Peripheral Nerves + (Lab)

- Consist of
  - Axon bundles
  - Schwann cells
  - Connective tissue
    - **Endoneurium**: surrounds individual neurons
    - **Perineurium**: surrounds axon groups to form fascicles
    - **Epineurium**: surrounds the entire nerve

Spinal Nerves

- **Thirty-one pairs** of spinal nerves
- First pair exit vertebral column between skull and atlas
- Last four pair exit via the sacral foramina
- Others exit through intervertebral foramina
- **Eight** pair cervical, **twelve** pair thoracic, **five** pair lumbar, **five** pair sacral, **one** pair coccygeal

Dermatomal Map

- Spinal nerves indicated by capital letter and number
- **Dermatomal map**: skin area supplied with sensory innervation by spinal nerves
Branches of Spinal Nerves

**Dorsal Ramus:** innervate deep muscles of the trunk responsible for movements of the vertebral column and the C.T. and skin near the midline of the back.

**Ventral Ramus:** what they innervate depends upon which part of the spinal cord is considered.

- Thoracic region: form intercostal nerves that innervate the intercostal muscles and the skin over the thorax
- Remaining spinal nerve ventral rami (roots of the plexus): form five plexuses (intermingling of nerves).
  - Ventral rami of C1-C4= cervical plexus
  - Ventral rami of C5-T1= brachial plexus
  - Ventral rami of L1-L4= lumbar plexus
  - Ventral rami of L4-S4= sacral plexus
  - Ventral rami of S4 and S5= coccygeal plexus
- Communicating Rami: communicate with sympathetic chain of ganglia.

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**Cervical Plexus**

- C1-C4
- Innervates superficial neck structures, skin of neck, posterior portion of head
- Ansa cervicalis: loop between C1 and C3
- Phrenic nerve
  - From C3-C5 (cervical and brachial plexuses)
  - Innervate diaphragm

**Brachial Plexus**

- C4 from cervical plus C5-T1
- Five ventral rami form three trunks that separate into six divisions then form cords that give rise to:
  - Branches/nerves
    - Axillary
    - Radial
    - Musculocutaneous
    - Ulnar
    - Median
    - Smaller nerves such as pectoral, long thoracic, thoracodorsal, subscapular, suprascapular
Axillary Nerve (Lab)

- Lateral rotation of arm
- Abduction of arm - deltoid
- Skin: inferior lateral shoulder

Radial Nerve (Lab)

- Movements at elbow and wrist, thumb movements
- Skin: posterior surface of arm and forearm, lateral 2/3 of dorsum of hand

Musculocutaneous Nerve (Lab)

- Movements at shoulder, elbow and wrist
- Skin: lateral surface of forearm
Ulnar Nerve (Lab)

- Movements at wrist, fingers, hand
- Skin - medial 1/3 of hand, little finger, and medial 1/2 of ring finger

Median Nerve (Lab)

- Movement of hand, wrist, fingers, thumb
- Skin - lateral 2/3 palm, thumb, index and middle fingers; lateral 1/2 of ring finger and dorsal tips of same fingers

Other Nerves of the Brachial Plexus

- Small nerves that innervate muscles acting on scapula and arm
  - Pectoral
  - Long thoracic
  - Thoracodorsal
  - Subscapular
  - Suprascapular
- Supply cutaneous innervation of medial arm and forearm
Lumbosacral Plexus

- Lumbar plexus: ventral rami of L1-L4
- Sacral plexus: ventral rami of L4-S4
- Usually considered together because of their close relationship
- Four major nerves exit and enter lower limb
  - Obturator
  - Femoral
  - Tibial
  - Common fibular (peroneal)

Obturator Nerve (Lab)

- Adduction of the thigh and knee
- Skin - superior middle side of thigh

Femoral Nerve (Lab)

- Movements of hip and knee: iliopsoas, sartorius, quadriceps femoris
- Skin - anterior and lateral thigh; medial leg and foot
Tibial Nerve (Lab)

- The two nerves together referred to as the **sciatic (ischiadic)** nerve
- **Tibial**
  - Movement of hip, knee, foot, toes
  - Skin: none
  - Branches are *medial* and *lateral plantar* nerves, sural nerve

Common Fibular (Peroneal) Nerve -Lab

- **Common fibular**
  - Anterior and lateral muscles of the leg and foot
  - Skin distribution: lateral and anterior leg and dorsum of the foot.
  - Branches are *deep* and *superficial fibular (peroneal) nerves*

Other Lumbosacral Plexus Nerves(Lab)

- Nerves that innervate the skin of the suprapubic area, external genitalia, superior medial thigh, posterior thigh
  - Gluteal nerves
  - Pudendal nerve
  - Iliohypogastric nerve
  - Ilioinguinal nerve
  - Genitofemoral nerve
  - Cutaneous femoral
Coccygeal Plexus (Lab)

- S5; coccygeal nerve
- Muscles of pelvic floor
- Sensory information from skin over coccyx

PNS Disorders

- General disorders
  - Anesthesia: loss of sensation
  - Hyperesthesia: increased sensitivity to pain, pressure, light
  - Paresthesia: tingling, prickling, burning
  - Neuralgia: nerve inflammation causing stabbing pain
  - Sciatica: pain radiating down back of thigh and leg

- Infections
  - Herpes: skin lesions
  - Shingles or herpes zoster: adult disease of chickenpox
  - Poliomyelitis: infantile paralysis
  - Anesthetic leprosy: bacterial infection of peripheral nerves

- Genetic and autoimmune disorders
  - Myasthenia gravis: results in fatigue and muscular weakness due to inadequate ACh receptors