Chapter 13

The Spinal Cord & Spinal Nerves

Spinal Cord

- Together with brain forms the CNS
- Functions
  - spinal cord reflexes
  - integration (summation of inhibitory and excitatory) nerve impulses
  - highway for upward and downward travel of sensory and motor information

Spinal Cord Protection

- The spinal cord is protected by two connective tissue coverings, the meninges and vertebrae, and a cushion of cerebrospinal fluid (CSF)

Meninges

- The meninges are three coverings that run continuously around the spinal cord and brain
  - The outermost layer is the dura mater
  - The middle layer is the arachnoid mater
  - The innermost layer is the pia mater
Structures Covering the Spinal Cord

- **Vertebrae**
- **Epidural space filled with fat**
- **Dura mater**
  - thick, durable layer
  - subdural space filled with interstitial fluid
- **Arachnoid mater**
  - spider web of collagen fibers
  - CSF in subarachnoid space
- **Pia mater**
  - thin, transparent layer
  - adheres to the surface of spinal cord
  - denticulate ligaments hold in place

Applications

- The *subarachnoid space* is between the arachnoid mater and pia mater and contains cerebrospinal fluid (CSF).
- Inflammation of the meninges is known as *meningitis*.
- Removal of cerebrospinal fluid from the subarachnoid space is called a *spinal tap (lumbar puncture)*.
  - used to diagnose pathologies and to introduce antibiotics, contrast media, anesthetics, and chemotherapeutic drugs.

External Anatomy of Spinal Cord

- 16-18 inches long & 3/4 inch diameter
- In adult ends at L2
- In newborn ends at L4
- Growth of cord stops at age 5
- Cervical & lumbar enlargements
  - origin of nerves to upper & lower limbs

Inferior End of Spinal Cord

- **Conus medullaris**
  - cone-shaped end of spinal cord
- **Filum terminale**
  - thread-like extension of pia mater
  - stabilizes spinal cord in canal
- **Caudae equinae (horse’s tail)**
  - dorsal & ventral roots of lowest spinal nerves
Spinal nerves

- The 31 pairs of spinal nerves are named according to the region of the spinal cord from which they emerge
  - 8 pairs of cervical nerves
  - 12 pairs of thoracic nerves
  - 5 pairs of lumbar nerves
  - 5 pairs of sacral nerves
  - 1 pair of coccygeal nerves
- **Spinal nerves** are the paths of communication between the spinal cord and most of the body

Spinal Nerves

- Spinal nerves begin as roots
  - Dorsal root is incoming sensory fibers
    - dorsal root ganglion (swelling) = cell bodies of sensory nerves
  - Ventral (anterior) root is outgoing motor fibers

Gray Matter of the Spinal Cord

- 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
- Gray matter is shaped like the letter H or a butterfly
  - contains neuron cell bodies & dendrites
  - paired dorsal (posterior) and ventral (anterior) gray horns
  - lateral horns only present in thoracic spinal cord
  - gray commissure crosses the midline
- Central canal contains CSF

Internal Anatomy of the Spinal Cord

- 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
- The white matter is divided into columns
  - Each column contains distinct bundles of nerve axons that have a common origin or destination and carry similar information
  - These bundles are called tracts
White Matter of the Spinal Cord

- White matter covers gray matter
- Anterior, Lateral and Posterior White Columns contain axons that form ascending & descending tracts

SPINAL CORD PHYSIOLOGY

- The spinal cord has two principal functions.
- The white matter tracts are highways for nerve impulse conduction to and from the brain.
- The gray matter receives and integrates incoming and outgoing information.

Tracts of the Spinal Cord

- Function of tracts - highways for sensory & motor information
  - sensory tracts ascend
  - motor tracts descend
- Naming of tracts
  - indicates position & direction of signal
  - example = anterior spinothalamic tract
    - found in anterior part of spinal cord
    - impulses travel from spinal cord towards brain (thalamus)

Location of Tracts inside Cord
**Function of Spinal Tracts**

- **Spinothalamic tract**
  - pain, temperature, deep pressure & crude touch
- **Posterior columns**
  - proprioception, discriminative touch, two-point discrimination, pressure and vibration
- **Direct pathways (corticospinal & corticobulbar)**
  - precise, voluntary movements
- **Indirect pathways (rubrospinal, vestibulospinal)**
  - programming automatic movements, posture & muscle tone, equilibrium & coordination of visual reflexes

**Reflexes and Reflex Arcs**

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

**Reflex Arc**

- Specific nerve impulse pathway
- 5 components of reflex arc
  - receptor
  - sensory neuron
  - integrating center
  - motor neuron
  - effector

**Stretch Reflex (Patellar Reflex)**

- It operates as a feedback mechanism to control muscle length by causing muscle contraction.
  - Prevents injury from over stretching because muscle contracts when it is stretched
- Monosynaptic, ipsilateral reflex arc
- Events of stretch reflex
  - muscle spindle signals stretch of muscle
  - motor neuron activated & muscle contracts
Illustration of the Stretch Reflex

Clinical Considerations

- Checking a patient’s reflexes may help to detect disorders/injury
- Plantar flexion reflex -- stroke the lateral margin of the sole
  - normal response is curling under the toes
  - upward fanning of toes - Babinski sign
    - normal response in children under 18 months
    - due to incomplete myelination
    - abnormal response in adults

Spinal Nerves

- 31 Pairs of spinal nerves
- Named & numbered by the cord level of their origin
  - 8 pairs of cervical nerves (C1 to C8)
  - 12 pairs of thoracic nerves (T1 to T12)
  - 5 pairs of lumbar nerves (L1 to L5)
  - 5 pairs of sacral nerves (S1 to S5)
  - 1 pair of coccygeal nerves
- Mixed sensory & motor nerves

Connective Tissue Coverings

- Spinal nerve axons are grouped within connective tissue sheathes
  - A fiber is a single axon within an endoneurium.
  - A fascicle is a bundle of fibers within a perineurium.
  - A nerve is a bundle of fascicles within an epineurium.
Branching of Spinal Nerve

- Spinal nerves form from dorsal & ventral roots
- Spinal nerves branch into dorsal & ventral rami
  - dorsal rami supply skin & muscles of back
  - ventral rami form plexus & supply anterior trunk & limbs

A Nerve Plexus

- Joining of ventral rami of spinal nerves to form nerve plexuses (networks)
- Found in neck, arm, low back & sacral regions
- No plexus in thoracic region

Cervical Plexus

- Ventral rami of spinal nerves (C1 to C5)
- Supplies parts of head, neck & shoulders
- Phrenic nerve (C3-C5) connects to the diaphragm
- Damage to cord above C3 causes respiratory arrest

Sacral Plexus

- Supplies the buttocks, perineum, and part of the lower extremities
- Sciatic nerve
  - arising from the sacral plexus
  - largest nerve in the body
  - injury results in sciatica, pain from the buttocks down the back of the leg
  - injury can occur due to
    - herniated disc
    - dislocated hip
    - osteoarthritis of the lumbosacral spine
    - pressure from the uterus during pregnancy
    - improperly administered gluteal injection
Branches of Sacral Plexus

Dermatomes

- The skin over the entire body is supplied by spinal nerves that carry somatic sensory nerves impulses into the spinal cord
  - All spinal nerves except C1 innervate specific, constant segments of the skin; the skin segments are called dermatomes
  - Knowledge of dermatomes helps a physician to determine which segment of the spinal cord or which spinal nerve is malfunctioning
  - Skin on face supplied by Cranial Nerve V

Dermatomes

- Damaged regions of the spinal cord can be distinguished by patterns of numbness over a dermatome region
- Spinal cord transection
  - injury that severs the cord causes loss of sensation & motor control below the injury

Shingles

- Infection of peripheral nerve by chicken pox virus
- Causes pain, skin discoloration & line of skin blisters along affected dermatome