Chapter 13: The Spinal Cord and Spinal Nerves

--together with brain forms CNS

--Functions:
  a. Spinal Cord reflexes
  b. Integration (summation of inhibitory and excitatory) nerve impulses
  c. highway for upward and downward travel of sensory and motor information

--Spinal Cord Protection: vertebral column, meninges, cerebrospinal fluid, vertebral ligaments

--Structures Covering the Spinal Cord
  a. vertebrae
  b. 3 layers = meninges: dura, arachnoid, and pia mater
     *dura: dense irregular CT tube
     *arachnoid: web of collagen
     *pia: thin layer covers BV (denticulate ligaments hold in place)
  c. 3 spaces: epidural, subdural, and subarachnoid
     *epidural: filled with fat
     *subdural: filled with interstitial fluid
     *subarachnoid: filled with CSF

--Spinal Cord:
  *extends from foramen magnum to second lumbar vertebra
  *”segmented”
  *regions: cervical, thoracic, lumbar, sacral
  *gives rise to 31 pairs of spinal nerves
  *not uniform in diameter throughout length

--External Anatomy of the Cord
  *flatended cylinder
  *16-18 inches long and ¾ inch diameter
  *ends at L2 in adults (L4 in newborns)
  *growth of cord stops at age 5
  *Cervical (upper limb) and lumbar (lower limb) enlargements

--Spinal Nerves
  *31 pairs of spinal nerves, mixed sensory and motor nerves
  *named and numbered by the cord level of their origin
    a. 8 pairs of cervical
    b. 12 pairs of thoracic
    c. 5 pairs lumbar
    d. 5 pairs sacral
    e. 1 pair coccygeal

--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: dorsal and ventral roots of lowest spinal nerves
  *Spinal segment: area of cord from which each pair of spinal nerves arises
  *Spinal tap: safe from L3 to L5, used to sample CSF, inject antibiotics, anesthetics, chemotherapy, measure CSF pressure

--Branching of Spinal Nerves
  *spinal nerves formed from dorsal and ventral roots
  *spinal nerves branch into dorsal and ventral rami
a. dorsal rami: supply skin and muscles of the back  
b. ventral rami: form plexus, supply anterior trunk and limbs  
c. meningeal branches: supply meninges, vertebrae, and BV

--A nerve Plexus
*joining of ventral rami of spinal nerves to form nerve networks of plexuses  
*found in neck, arm, low back, and scral regions → NO plexus in thoracic region

--Clinical Correlations
a. Erb-Duchene palsy: waiter’s tip position, fall on shoulder  
b. Radial Nerve injury: wrist drop, improper deltoid injection or tight cast  
c. Median nerve injury: inability to pronate and flex fingers, numb palm and fingers  
d. Ulnar nerve injury: clawhand, inability to adduct/abduct fingers, atrophy of interosseous  
e. Long thoracic nerve injury: winged scapula, paralysis of serratus anterior, c/n abduct above horizontal

--Gray Matter of the Spinal Cord
*Gray matter is shaped like the letter H or a butterfly  
a. contains neuron cell bodies, unmyelinated axons and dendrites  
b. paired dorsal and ventral gray horns  
c. lateral horns only present in thoracic spinal cord  
d. gray commissure crosses the midline  
*Central canal continuous with 4th ventricle of brain

--Summary of Cross Section of Spinal Cord
*White matter  
a. myelinated axons forming nerve tracts  
b. fissure and sulcus  
c. 3 columns/funiculi: ventral, dorsal, lateral  
*Gray matter  
a. neuron cell bodies, dendrites, axons  
b. horns: posterior/dorsal, anterior/ventral, lateral  
c. Commissures: gray—central canal, white

--White Matter of the Spinal Cord
*covers gray matter  
*anterior median fissure deeper than posterior median sulcus  
*anterior, lateral, and posterior white columns contain axons that form ascending and descending tracts

--Tracts of the Spinal Cord
*Function:  
a. highway for sensory and motor information  
b. sensory tracts ascend  
c. motor tracts descend  
*Naming of tracts  
a. indicates position and direction of signal  
b. anterior spinothalamic tract: impulses from spinal cord to thalamus, found in anterior part of spinal cord  
*Location of tracts  
a. Motor tracts: pyramidal tract, extrapyramidal tract  
b. Sensory tracts: spinothalamic tract, posterior column, spinocerebellar  
*Function of Tracts  
a. Spinothalamic tract: pain, temperature, deep pressure, crude touch
b. Posterior Columns: proprioception, discriminative touch, two point discrimination, pressure, vibration
c. Spinocerebellar: proprioception
d. Direct pathways (corticospinal and corticobulbar): precise, voluntary movements
e. Indirect pathways (rubrospinal, vestibulospinal): programming automatic movements, posture, and muscle tone, equilibrium, and coordination of visual reflexes

--Connective Tissue Coverings
a. Endoneurium: wrapping of each nerve fibers
b. Perineurium: surrounds group of nerve fibers forming a fascicle
c. Epineurium: covering of entire nerve (dura mater blends into it at intervertebral foramen)

--Peripheral Nerves
*Consist of:
  a. axon bundles
  b. Schwann cells
  c. CT: endoneurium, perineurium, epineurium

--Dermatomes and Myotomes
*Each spinal nerve contains both sensory and motor nerve fibers
*Myotome: muscles innervated by a spinal nerve
*Dermatome: area of skin supplied by one spinal nerve, overlap prevents complete loss of sensation if one nerve is damaged, sensory anesthesia requires 3 spinal nerves to be blocked
  a. damaged regions of the spinal cord can be distinguished by patterns of numbness over a dermatome region
  b. infusing local anesthetics or cutting roots must be done over 3 adjacent spinal nerves
  c. spinal cord transection: injury that severs the cord leads to loss of sensation and motor control below the injury
*Skin on face supplied by cranial nerve V

--PNS Disorders
*General disorders: Anesthesia: loss of sensation
  a. hyperesthesia: increased sensitivity to pain, pressure, light
  b. paresthesia: tingling, prickling, burning
  c. neuralgia: nerve inflammation causing stabbing pain
  d. sciatica: pain radiating down back of thigh and leg
*Infections
  a. herpes: skin lesions
  b. shingles or herpes zoster: adult disease of chicken pox
  c. poliomyelitis: infantile paralysis
*Genetic and autoimmune disorders
  a. myasthenia gravis: results in fatigue and muscular weakness due to inadequate ACh receptors

--Disorders
  a. Neuritis: inflammation of nerves, caused by injury, vitamin deficiency, or poison
  b. Shingles: infection of peripheral nerve by chicken pox virus, causes pain, skin discoloration, line of skin blisters
  c. Poliomyelitis: viral infection causing motor neuron death and possible death from cardiac failure or respiratory arrest

--Spinal Reflexes
*Automatic response to change in environment
*Integration center for spinal reflexes is gray matter of spinal cord
*Examples: somatic reflexes (result in skeletal muscle contraction) autonomic/visceral reflexes (involve smooth and cardiac muscle and glands)

--Reflex Arc
  *specific nerve impulse pathway
  *5 components of arc:
    a. receptor
d. motor neuron
  b. sensory neuron
e. effector
c. integrating center

*4 important somatic spinal reflexes: stretch, tendon, flexor, and crossed extensor

--Stretch Reflex/Patellar Reflex
  *MONOSYNAPTIC, ipsilateral reflex arc
  *prevents injury from over stretching because muscle contracts when it is stretched
  *Events of stretch reflex:
    a. muscle spindle signals stretch of muscle
    b. motor neuron activated and muscle contracts
  *brain sets muscle spindle sensitivity as it sets muscle tone (degree of muscle contraction at rest)
  *reciprocal innervation (POLYSYNAPTIC—INTERNEURON) antagonist muscle relax as part of reflex
  *muscles contract in response to a stretching force applied to them

--Tendon Reflex
  *POLYSYNAPTIC (more than 2 neurons and more than 1 synapse are involved), ipsilateral
  *controls muscle tension by causing muscle relaxation that prevents tendon damage
  *Golgi tendon organs in tendon
    a. activated by stretching of tendon
    b. inhibitory neuron is stimulated (polysynaptic)
    c. motor neuron is hyperpolarized and muscle relaxes
  *both tendon and muscle are protected
  *reciprocal innervation (polysynaptic): causes contraction of ipsilateral antagonist muscle group

--Flexor/Withdrawal Reflex
  *polysynaptic and ipsilateral
  *intersegmental
  *step on tack—pain fibers send signal to spinal cord
  *interneurons branch to different spinal cord segments
  *motor fibers in several segments are activated
  *more than one muscle group activated to lift foot off of tack

--Crossed Extensor/Contralateral Reflex
  *when a withdrawal reflex is initiated in one lower limb, the crossed extensor reflex causes extension of opposite lower limb
  *lifting left foot requires extension of right leg to maintain one’s balance
  *pain signals cross to opposite spinal cord
  *contralateral extensor muscles are stimulated by interneurons to hold up the body weight
  *Reciprocal innervation: when extensors contract flexors relax, etc.

--Clinical Considerations
  *checking a patient’s reflexes may help to detect disorders/injury
  *Jendrassik’s maneuver: test for facilitation (cord integration)
  *Plantar flexor reflex: stroke the lateral margin of the sole
    a. normal response: curling under the toes
b. abnormal response or response of childer under 18 months is called Babinski sign
    (upward fanning of toes, dorsiflexion, due to incomplete myelination in child or
damage to pyramidal tract in adults)

**Muscle Spindle**

--Note:

a. 2 types of muscle spindle fibers: nuclear bag and nuclear chain
b. 2 types of sensory/affective fibers
   *Ia-large fibers: transmit at 70-120 m/sec