Bio217: Pathophysiology Class Notes
Professor Linda Falkow

Unit IV: Nervous System Disorders

Chap. 12: Structure & Function of the Nervous System
Chap. 13: Pain, Temperature, Sleep, and Sensory
Chap. 14: Alterations in Cognitive Systems, Cerebral Dynamics, and Motor Function
Chap. 15: Disorders of the Central and Peripheral Nervous Systems

Structure and Function of the Nervous System

Chapter 12

Overview of the Nervous System

- Central nervous system (CNS)
  - Brain and spinal cord
- Peripheral nervous system (PNS)
  - Cranial nerves
  - Spinal nerves
  - Pathways
    - Afferent (ascending)
    - Efferent (descending)

Overview of the Nervous System

- Peripheral nervous system (PNS)
  - Somatic nervous system
    - Motor (efferent) and sensory (afferent) pathways regulating **voluntary** motor control of skeletal muscle
  - Autonomic nervous system (ANS)
    - Motor and sensory pathways regulating body's internal environment through **involuntary** control of organ systems
      - Sympathetic ("Fight or flight")
      - Parasympathetic ("Rest and repose")

Cells of the Nervous System

- Neuron (conducts nerve impulses)
  - Variable size and structure
- Three components
  - Cell body (soma)
    - Nuclei = cell bodies in CNS
    - Ganglia = cell bodies in PNS are ganglia
  - Dendrites
    - Receive impulses
  - Axons
    - Carry impulses away from cell body

Neuron

- Axons
  - Myelin
    - Insulating layer of lipid material
    - Formed by the Schwann cell
  - Endoneurium
    - Delicate layer of CT around each axon
  - Neurilemma
    - Thin membrane between myelin sheath and endoneurium

Neuron

- Axons
  - Nodes of Ranvier
    - Regular interruptions of the myelin sheath
  - Saltatory conduction
    - Flow of ions between segments of myelin rather than along entire length of axon

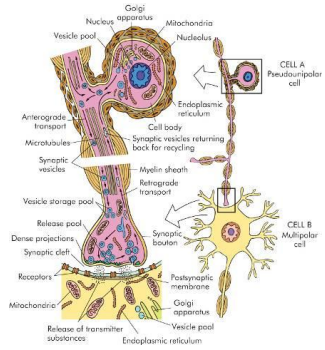
Structural Classification of Neurons

- Based on number of processes extending from cell body
  - Unipolar
  - Bipolar
  - Multipolar

Functional Classification of Neurons

- Sensory (afferent)
  - Transmit impulses from sensory receptors to CNS
- Associational (interneurons)
  - Transmit impulses from neuron to neuron
- Motor (efferent)
  - Transmit impulses from CNS to an effector

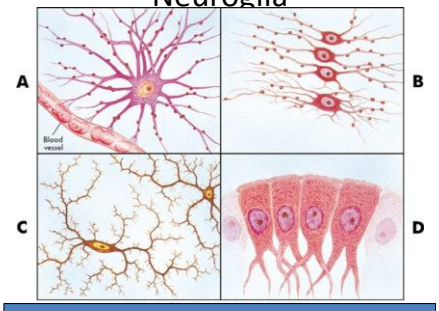
Neurons



Neuroglia

- "Nerve glue"
- Support the neurons of the CNS
  - Astrocytes
  - Oligodendroglia (oligodendrocytes)
  - Microglia
  - Ependemal

Neuroglia



A – astrocyte B – oligodendrocyte
C – microglia D - ependymal

Nerve Impulse

- Neurons generate action potentials by selectively changing the **electrical** portion of their plasma membranes and influencing other nearby neurons by release of neurotransmitters (**chemicals**)

Synapses

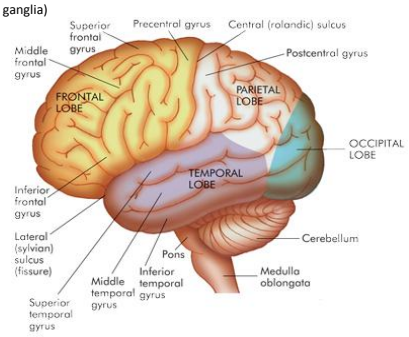
- Region between adjacent neurons (pre- and postsynaptic neurons) is called a synapse
- Impulses are transmitted across synapse by chemical and electrical conduction
- Neurotransmitters
  - More than 30 substances
    - (ACh, serotonin, NE, dopamine)
  - Excitatory or Inhibitory

Central Nervous System

BRAIN:

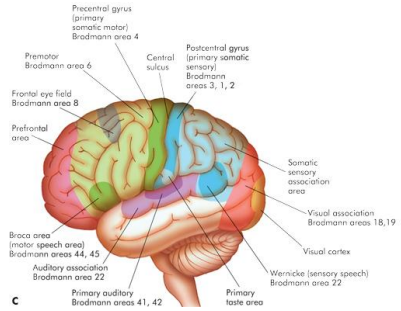
- Forebrain
  - Cerebral hemispheres
- Midbrain
  - Corpora quadrigemina, substantia nigra, and cerebral peduncles
- Hindbrain
  - Cerebellum, pons, and medulla

Forebrain:
Cerebrum
Gyri, sulci, and fissures
Gray matter and white matter
Cerebral nuclei (basal ganglia)



Forebrain

- functional areas



Central Nervous System

- Diencephalon
  - Thalamus
  - Hypothalamus
- Midbrain
  - Corpora quadrigemina
    - Superior and inferior colliculi
  - Tegmentum
    - Red nucleus and substantia nigra (→ dopamine → NE)
    - Cerebral peduncles

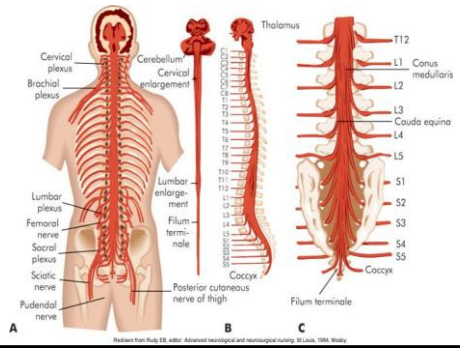
Central Nervous System

- Hindbrain
  - Cerebellum
  - Pons
  - Medulla oblongata

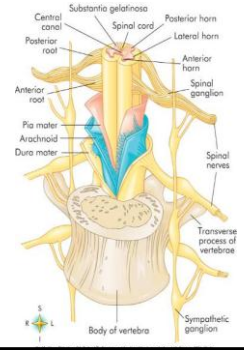
Spinal Cord

- Located in **vertebral canal**, protected by **vertebral column**
  - Connects the brain and the body
  - Conducts somatic and autonomic reflexes
  - Modulates sensory and motor function

Spinal Cord

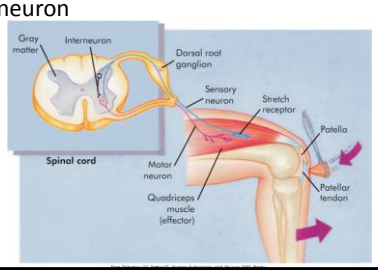


Spinal Cord

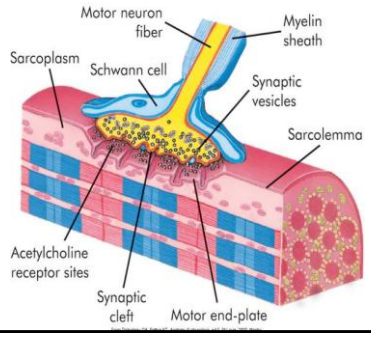


Reflex Arc

- Receptor
- Afferent (sensory) neuron
- Efferent neuron
- Effector



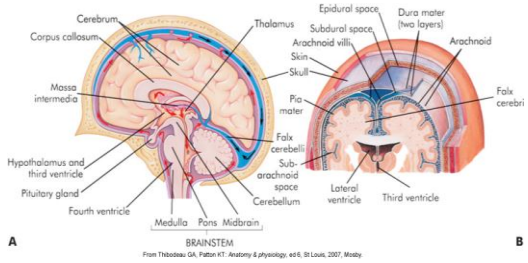
Neuromuscular Junction



Protective Structures

- **Cranium**
  - Eight bones
    - Frontal, Occipital, Temporal (2), Parietal (2), Sphenoid, Ethmoid
  - Galea aponeurotica
- **Meninges**
  - Protective membranes surrounding brain & SC
    - Dura mater
    - Arachnoid
    - Pia mater

Meninges

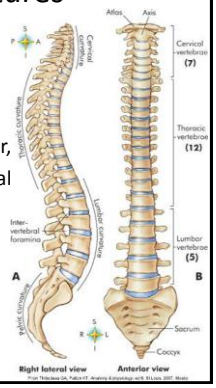


Protective Structures

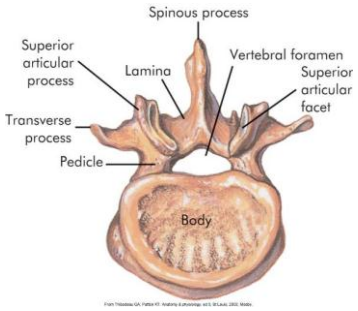
- **Cerebrospinal fluid (CSF)**
  - Clear, colorless fluid similar to blood plasma and interstitial fluid
  - 125 to 150 mL
  - Produced by choroid plexuses in lateral, third, and fourth ventricles
  - Reabsorbed through arachnoid villi

Protective Structures

- Vertebral column
  - 33 vertebrae
    - 7 cervical, 12 thoracic, 5 lumbar, 5 fused sacral, 4 fused coccygeal
  - Intervertebral disks
    - Annulus fibrosus
    - Nucleus pulposus



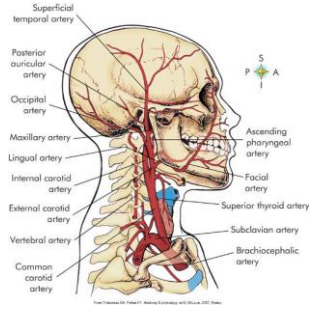
Vertebral Column



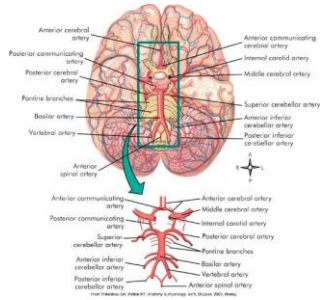
Blood Supply to the Brain

- 800 to 1000 mL per minute
- CO_2 is the primary regulator for CNS blood flow
- Internal carotid and vertebral arteries
- Arterial circle (circle of Willis)

Blood Supply to the Brain



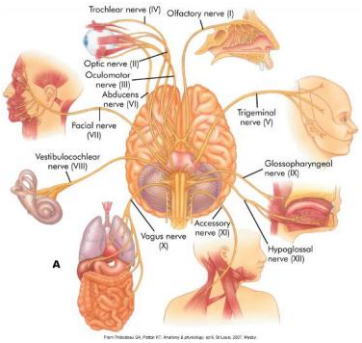
Blood Supply to the Brain



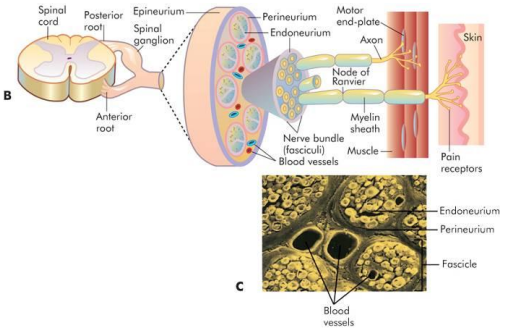
Peripheral Nervous System

- 31 pairs of **spinal nerves**
  - Named for vertebral level from which they exit
  - Mixed nerves
  - Arise from gray matter of the spinal cord
- 12 pairs of **cranial nerves**
  - Sensory, motor, and mixed

Cranial Nerves



Spinal Nerves



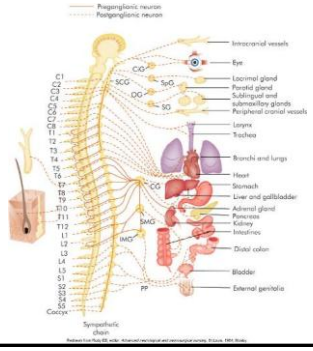
Autonomic Nervous System

- Located in both the CNS and PNS
- Maintains a homeostasis in visceral (internal) organs
- Neurons
  - Preganglionic (myelinated)
  - Postganglionic (unmyelinated)

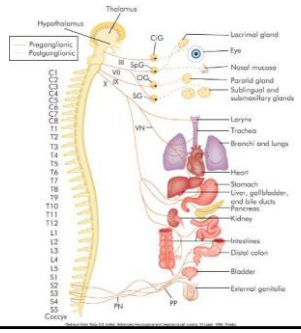
Autonomic Nervous System

- Two divisions
  - Sympathetic
    - "Fight or flight" response
    - Thoracolumbar
    - Sympathetic (paravertebral) ganglia
  - Parasympathetic
    - "Rest or repose" response
    - Craniosacral
    - Preganglionic neurons travel to ganglia close to organs they innervate

Sympathetic Nervous System



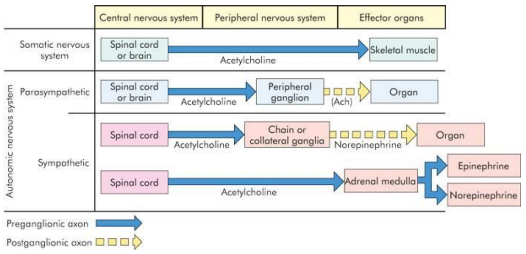
Parasympathetic Nervous System



Neurotransmitters and Neuroreceptors of the ANS

- SNS preganglionic fibers
  - ACh (cholinergic)
- SNS postganglionic fibers
  - NE (adrenergic)
- PSN preganglionic & postganglionic fibers
  - ACh

Neurotransmitters and Neuroreceptors of the ANS



Aging and the Nervous System

- Decrease in the number of neurons
  - Decreased brain weight and size
- Senile plaques
- Neurofibrillary tangles
- Slowing of neurologic responses

Concept Check:

- 1. One function of somatic NS that is not performed by the ANS is conduction of impulses:
  - A. To involuntary muscles and glands
  - B. To the CNS
  - C. To skeletal muscles
  - D. Between the brain and SC
- 2. Neurons are specialized for the conduction of impulses, while neuroglia:
  - A. Support nerve tissue
  - B. Serve as motor end plates
  - C. Synthesize ACh and AChE
  - D. All of the above

- 3. Which of the following best describes the SC?
  - A. Descends inferior to the lumbar vertebrae
  - B. Conducts motor impulses from the brain
  - C. Descends to L4
  - D. Conducts sensory impulses to the brain
- 4. Which is not a protective covering of the CNS?
  - A. Cauda equina
  - B. Dura mater
  - C. Arachnoid
  - D. Cranial bone

- 5. The SNS:
  - A. Mobilizes E in times of need
  - B. Is innervated by cell bodies from T1 → L2
  - C. Is innervated by cell bodies located in the cranial nerve nuclei
  - D. Both A and B are correct
- 6. The PSN :
  - A. Conserves and stores E
  - B. Has relatively short postganglionic neurons
  - C. Both A and B are correct
  - D. Has paravertebral ganglia

Pain, Temperature, Sleep, and Sensory Function

Chapter 13

Pain

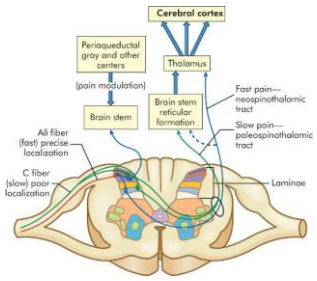
- "Pain is whatever the experiencing person says it is, existing whenever he says it does" —McCaffrey

Neuroanatomy of Pain

- Nociception
  - Perception of pain
- Nociceptors
  - Free nerve endings in skin, muscle, joints, arteries, and the viscera that respond to chemical, mechanical, and thermal stimuli

Pathways of Nociception

- Spinothalamic tracts



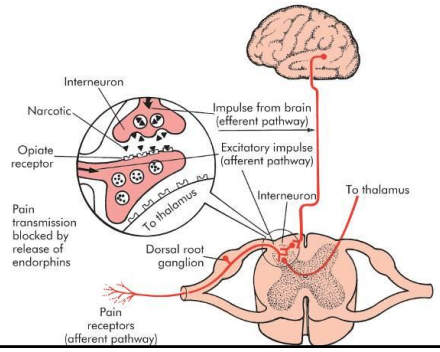
Neuromodulation of Pain

- Neuromodulators
  - Located in pathways of NS
  - Triggered by tissue injury and or inflammation
  - Excitatory neuromodulation
    - Substance P, glutamate, somatostatin
  - Inhibitory neuromodulation
    - GABA, glycine, serotonin, NE, endorphins

Neuromodulation of Pain

- Endorphins (endogenous morphines)
  - Neuropeptides – inhibit pain transmission in CNS
  - Bind opioid receptors
- Beta-endorphins (rel. from hypothalamus & pit. gland)
- Enkephalin (weaker than other endorphins)
- Dynorphins (can stimulate pain)
- Endomorphins (cause VD due to NO_2 released from endothelial cells)

Endorphin Response

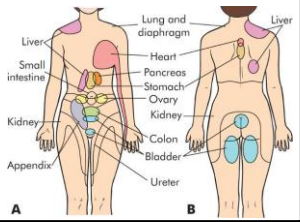


Acute Pain

- Manifestations
  - Fear and anxiety
    - Tachycardia, hypertension, fever, diaphoresis, dilated pupils, outward pain behaviors, elevated BG, decreased gastric acid secretion and intestinal motility, and a general decrease in blood flow

Acute Pain

- Referred pain
  - Pain present in an area removed or distant from point of origin
  - Area of referred pain is supplied by same spinal segment as the actual site
    - Myocardial infarction pain



Chronic Pain

- May be sudden or develop insidiously
- Usually defined as lasting at least 3 to 6 months
- Produces significant behavior and psychologic changes
- Types:
  - Low back pain
  - Myofascial pain syndromes
  - Chronic postoperative pain
  - Cancer pain

Neuropathic Pain

- Result of trauma or disease of nerves
- Peripheral
  - Painful diabetic neuropathy
- Central
  - Phantom limb

Temperature Regulation

- Peripheral & central thermoreceptors
- Hypothalamic control (range ~37° ± 0.7°)
- Heat production
  - Metabolism
  - Skeletal muscle contraction
  - Chemical thermogenesis
- Heat conservation
  - Vasoconstriction
  - Voluntary mechanisms

Heat Loss

- Radiation, Conduction, Convection
- Vasodilation
- Decreased muscle tone
- Evaporation
- Increased respirations
- Voluntary measures
- Adaptation to warmer climates

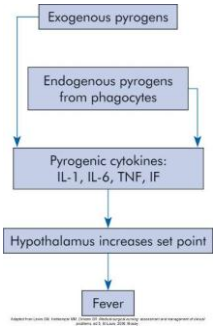
Temperature Regulation

- Aging
  - Slow blood circulation, vasoconstrictive response, and metabolic rate
  - Decreased sweating and perception of heat and cold

Fever

- Resetting of the hypothalamic thermostat
- Activate heat production and conservation measures to a new "set point"
- Pyrogens (exogenous or endogenous) toxins from pathogens → PG (which reset thermostat)

Fever



Benefits of Fever

- Kills many microorganisms
- Decreases serum levels of Fe, Zn, and Cu
- Promotes lysosomal breakdown and autodestruction of cells
- Increases lymphocytic transformation and phagocyte motility
- Augments antiviral interferon production

Hyperthermia

- Not mediated by pyrogens (no resetting of thermostat)
- 41° C (105.8° F): nerve damage produces convulsions
- 43° C (109.4° F): death results
- Forms
  - Heat cramps (abdom. pain, incr. sweat, loss Na+)
  - Heat exhaustion (collapse, profuse sweat, high core temp.
  - Heatstroke (→ death, brain cannot tolerate temperatures >40.5° C (104.9° F)

Hypothermia

- Body temperature less than 35° C
- Produces:
  - VC, alterations in the microcirculation, coagulation, and ischemic tissue damage
  - Ice crystals, which form inside the cells, causing them to rupture and die

Hypothermia

- Accidental hypothermia
  - Commonly the result of sudden immersion in cold water or prolonged exposure to cold
- Therapeutic hypothermia
  - Used to slow metabolism and preserve ischemic tissue during surgery or limb reimplantation
  - May lead to ventricular fibrillation and cardiac arrest

Sleep

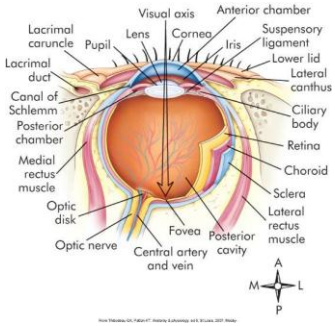
- Infants : 16-17 hours /day; about half in REM
- Elderly: decrease in sleep time, longer to fall asleep; increase in sleep apnea

REM = rapid eye movement sleep; 90 minute cycles after non-REM sleep

Sleep Disorders

- Insomnia
  - not able to fall asleep or stay asleep
  - idiopathic, abuse of drugs or alcohol, chronic pain, depression, or certain drugs, age, obesity
- Obstructive sleep apnea
  - Upper airway blockage
  - → snoring
  - Apneic episodes > 10 sec.

The Eye



Vision

- Blepharitis
  - Inflammation of the eyelids
- Hordeolum (stye)
  - Infection of the sebaceous glands of the eyelids
- Chalazion
  - Infection of the meibomian (oil-secreting) gland
- Keratitis
  - Infection of the cornea

External Eye Disorder

- Conjunctivitis
  - Inflammation of the conjunctiva
  - Acute bacterial conjunctivitis (pinkeye)
    - Highly contagious
    - Mucopurulent drainage from one or both eyes
  - Viral, Allergic, or Trachoma (chlamydial) conjunctivitis

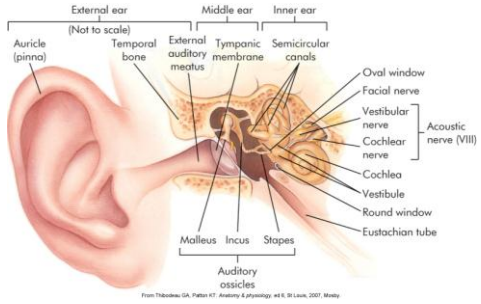
Vision Changes and Aging

- Cornea
- Anterior chamber
- Lens
- Ciliary muscles
- Retina

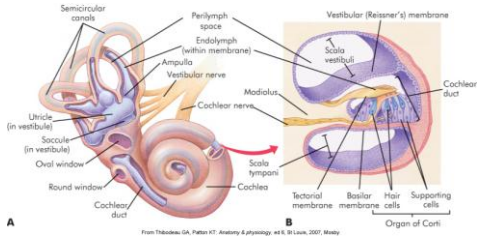
Visual Dysfunctions

- Alterations in visual acuity
  - Cataracts – cloudy lens due to degeneration (age)
  - Glaucoma – increase in intraocular pressure
  - Age-related macular degeneration (AMD)
    - major cause of blindness in elderly; increased risk due to HT, smoking, DM

The Ear



The Ear



Aging and Hearing

- Cochlear hair cell degeneration
- Loss of auditory neurons in spiral ganglia of organ of Corti
- Degeneration of basilar conductive membrane of cochlea
- Decreased vascularity of cochlea
- Loss of cortical auditory neurons

Ear Infections

- Otitis externa
  - Infection of the outer ear
  - Commonly caused by prolonged moisture exposure (swimmer's ear)
- Otitis media
  - Acute otitis media
  - Otitis media with effusion

Auditory Dysfunction

- Mixed hearing loss – combination of conductive and sensorineural loss
- Functional hearing loss – no known cause
- Ménière disease – middle ear affected, hearing and balance are impaired

Concept Check

- 1. Endorphins:
  - A. Increase pain sensations
  - B. Decrease pain sensations
  - C. May increase or decrease pain
  - D. Have no effect on pain
- 2. IL -1:
  - A. Raises hypothalamic set point
  - B. Is an endogenous pyrogen
  - C. Is stimulated by exogenous pyrogens
  - D. All of the above

3. In heatstroke-
- A. Blood viscosity increases
- B. Core temp. increases as regulatory center fails
- C. Stimulates VC
- D. Ice crystals form in cells

Matching:

__ 4. Meniere disease — A. due to airway obstruction during breathing
___ 5. AMD — B. Vestibular & hearing disruption
___ 6. AOM — C. Retinal detachment & loss of photoreceptors
___ 7. Sleep apnea — D. Effusion behind tympanic membrane

Matching:

- 8. Blepharitis — A. Increase intraocular pressure
- 9. Vertigo — B. Infected eyelid
- 10. Glaucoma — C. Inflammation of semicircular canals

Alterations in Cognitive Systems, Cerebral Dynamics, & Motor Function

Chapter 14

Alterations in Cognitive Networks

- Consciousness
  - State of awareness of oneself and env.
  - Arousal
    - State of awakeness
  - Content of thought

Levels of Consciousness

- Consciousness – alert and aware of person, place, time
- Confusion – not able to think
- Lethargy – limited speech, may/maynot be oriented to PPT
- Obtundation – stimulation needed for arousal
- Stupor – unresponsive except for vigorous stimuli
- Coma – no vocalization or arousal

Alterations in Arousal

- Coma is produced by either:
  - Bilateral hemisphere damage or suppression
  - Brain stem lesions or metabolic derangement that damages or suppresses the RAS
    - RAS (reticular activating system = maintains wakefulness; consists of nuclei in brainstem and extends to cerebral cortex)
  - No verbal responses to stimuli
  - No reaction to deep pain

Alterations in Arousal

- Clinical manifestations of Coma
  - Level of consciousness changes
  - Pattern of breathing
    - Posthyperventilation apnea (PHVA)
    - Cheyne-Stokes respirations (CSR)
  - Vomiting
  - Pupillary changes
  - Oculomotor responses
  - Motor responses

Seizures

- Sudden, transient alteration of brain function caused by an abrupt *explosive, disorderly* discharge of cerebral neurons
- Motor, sensory, autonomic, or psychic signs
- Convulsion
  - Tonic-clonic (jerky, contract-relax) movements associated with some seizures

Dementia

- Progressive failure of cerebral functions that is not caused by an impaired level of consciousness
- Classifications
  - Cortical
  - Subcortical

Alzheimer Disease (AD)

- Familial, early and late onset
- Nonhereditary (sporadic, late onset)
- Theories
  - Mutation for encoding amyloid protein
  - Alteration in apolipoprotein E
  - Loss of neurotransmitter ACh

Alzheimer Disease (AD)

- Neurofibrillary tangles
- Senile plaques
- Clinical manifestations
  - Forgetfulness, emotional upset, disorientation, confusion, lack of concentration, decline in abstraction, problem solving, and judgment
- Diagnosis is made by ruling out other causes of dementia

Alterations in Movement

- Huntington disease
  - Also known as “chorea”
  - Autosomal dominant hereditary-degenerative disorder
  - Severe degeneration of the basal ganglia (caudate nucleus) and frontal cerebral atrophy
    - Depletion of gamma-aminobutyric acid (GABA)

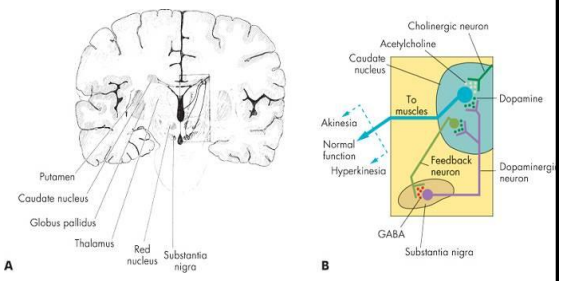
Alterations in Movement

- Hypokinesia
  - Decreased movement
  - Akinesia
  - Bradykinesia
  - Loss of associated movement

Parkinson Disease

- Severe degeneration of the basal ganglia (corpus striatum) involves dopamine secreting cells
  - Parkinsonian tremor
  - Parkinsonian rigidity
  - Parkinsonian bradykinesia
  - Postural disturbances

Parkinson Disease



Concept Check

Matching:

1. Confusion
2. Lethargy
3. Obtundation
4. Stupor
5. Coma

a. No speech or arousal

b. Only responses to strong stimuli

c. Stimulation necessary for arousal

d. Speech limited, may or may not be oriented

e. Not able to think straight

- 6. AD — a. Autosomal dominant, GABA decreased
- 7. HD — b. Decreased dopamine, resting tremors
- 8. PD — c. Neurofibrillary tangles, amyloid proteins

Disorders of the Central & Peripheral Nervous Systems

Chapter 15

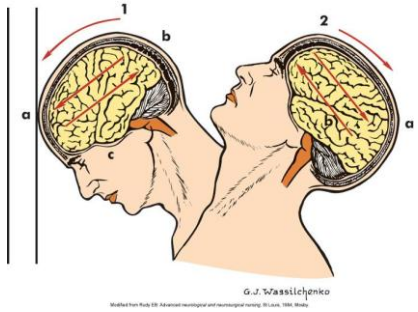
Brain Trauma

- Major head trauma
  - Traumatic insult to the brain →physical, intellectual, emotional, social, and vocational changes
  - Transportation accidents
  - Falls
  - Sports-related event
  - Violence

Brain Trauma

- Closed (blunt, nonmissile) trauma
  - Head strikes hard surface or a rapidly moving object strikes the head
  - The dura intact, brain tissue not exposed to the env.
  - Causes focal (local) or diffuse (general) brain injuries
- Open (penetrating, missile) trauma
  - Injury breaks dura, exposes cranial contents to env.
  - Causes primarily focal injuries

Brain Trauma

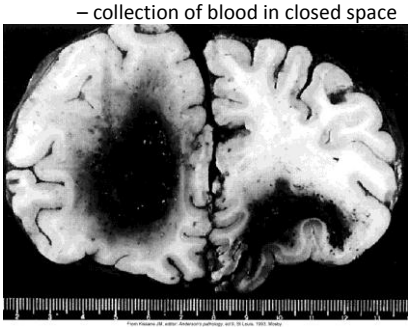


Focal Brain Injury

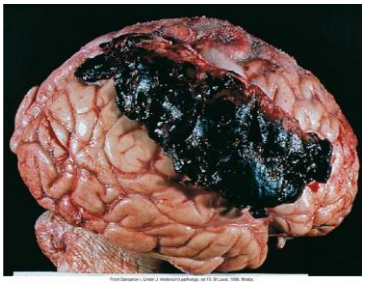
- Observable brain lesion
- Force of impact produces contusions (bruise)
- Contusions can cause:
  - Extradural (epidural) hemorrhages or hematomas
  - Subdural hematomas
  - Intracerebral hematomas

Hematomas

– collection of blood in closed space



Subdural Hematomas



Mild Concussion

- Temporary axonal disturbance →
  - attention and memory deficits but no loss of consciousness
- I: confusion, disorientation, and momentary amnesia
- II: momentary confusion and retrograde amnesia
- III: confusion with retrograde (events preceding trauma) and anterograde amnesia (unable to form recent memories)

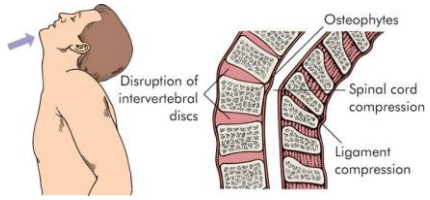
Classic Cerebral Concussion

- Grade IV
  - Disconnection of cerebral systems from the brain stem and reticular activating system
  - Physiologic and neurologic dysfunction without substantial anatomic disruption
  - Loss of consciousness (<6 hours)
  - Anterograde and retrograde amnesia
  - Postconcussive syndrome (headaches, anxiety, insomnia, depression, unable to concentrate)

Spinal Cord Trauma

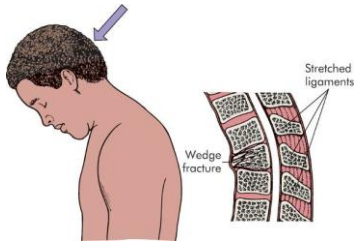
- Most commonly occurs due to vertebral injuries
  - Simple fracture, compressed fracture, and comminuted fracture and dislocation
- Traumatic injury of vertebral and neural tissues as a result of compressing, pulling, or shearing forces

Spinal Cord Trauma



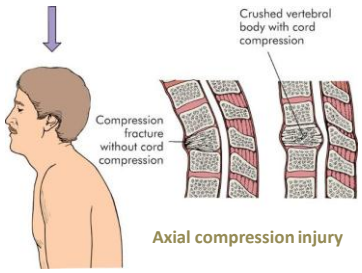
Hyperextension of vertebral column→ fracture or non-fracture w/ SC injury

Spinal Cord Trauma



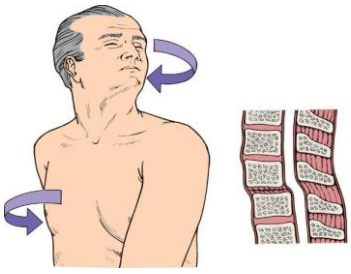
Flexion injury of vertebral column

Spinal Cord Trauma



Axial compression injury

Spinal Cord Trauma



Flexion-rotation injury

Spinal Cord Trauma

- Spinal shock
  - Normal activity of the SC ceases at and below the level of injury. Sites lack continuous nervous discharges from brain.
  - Complete loss of reflex function below level of lesion

Degenerative Disorders of the Spine

- Degenerative disk disease (DDD)
  - Spondylolysis – structural defect of lamina or vertebral arch (lumbar)
  - Spondylolisthesis- vertebra slides forward
  - Spinal stenosis – narrowing of spinal canal, puts pressure on nerves (sciatica)
- Low back pain
- Herniated intervertebral disk – protusion of nucleus pulposus

Cerebrovascular Disorders

- Cerebrovascular accident (CVA) – stroke
  - Impairment of cerebral circulation
  - Leading cause of disability
  - 3rd leading cause of death in US
  - Classified
    - Global hypoperfusion (as in shock)
    - Ischemia (thrombotic, embolic)
    - Hemorrhagic

Cerebrovascular Disorders

- Cerebrovascular accidents (CVAs)
  - **Thrombotic stroke**
    - Arterial occlusions caused by thrombi formed in arteries supplying the brain
    - Due to obesity, smoking, OC, surgery
    - Transient ischemic attacks (TIAs)
  - **Embolic stroke**
    - Fragments that break from a thrombus formed outside brain
    - Can also be from fat, tumor, bacteria, air
    - Middle cerebral artery is site of emboli

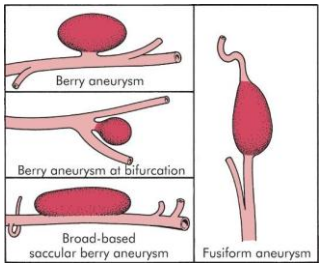
Cerebrovascular Disorders

- **Hemorrhagic stroke** (intracranial hemorrhage)
  - Due to HT, aneurysms
  - Causes sudden rupture of cerebral artery
  - → blood accumulating deep in brain
    => further neural tissue compromise

TIA (transient ischemic attack)

– Recurring episode of neurologic deficit
– Lasts seconds to hours (clears in 12-24 hours)
– Microemboli → temporary interruption of blood flow
– Also small spasms of brain arterioles
– Double vision, blindness (unilateral), uncoordinated gait, fall due to weakness in legs, dizzy, slurred speech
– **T**emporary – clears in 12-24 hours
– **I**mpending stroke sign – warning of stroke
– **A**spirin or **A**nticoagulant is given to minimize blood clots

Intracranial Aneurysm



Intracranial Aneurysm

- Due to: atherosclerosis, congenital, trauma, inflammation
- Pathophysiology: no single mechanism
- Classified: based on shape
- Clinical manifestations: asymptomatic or various cranial nerve compression, or hemorrhage

Infection and Inflammation of the CNS

- Meningitis
  – Bacterial meningitis
  – Aseptic (viral, nonpurulent, lymphocytic) meningitis
  – Fungal meningitis
  – Tubercular (TB) meningitis

Demyelinating Disorders

- Multiple sclerosis (MS)
  – MS is a progressive, inflammatory, demyelinating disorder of the CNS
  – Involves optic, oculomotor & spinal tracts
  – Ups and downs of MS – exacerbations & remissions
  – Occurs in women mostly (18-40yrs.)
  – Causes: viral, autoimmune, genetic, stress
  – Symptoms: optic neuritis & sensory impairment (paresthesia)
  – Prognosis varies

Understanding Demyelination

- Myelin (white matter)= lipoprotein that speeds nerve impulse conduction
- Injury to myelin by hypoxemia, chemicals, or autoimmune responses
- Leads to inflammation, breakdown of layers and formation of plaque (scar tissue)
- Damaged myelin sheath not able to conduct AP→ neurologic dysfunction

Neuromuscular Junction Disorders

Myasthenia gravis ("grave muscular weakness")

- Chronic autoimmune disease
- Antibodies produced against ACh receptors
- Weakness and fatigue of muscles head and neck → diplopia, difficulty chewing, talking, swallowing
- Causes: unknown, autoimmune, disorders of thymus
- Symptoms: progressive muscle weakness, respiratory distress (if diaphragm is involved)
- Treatment: AChase drugs, Corticosteroids

NMJ

- During normal NMJ transmission- motor neuron AP travels to axon terminal → release of ACh (neurotransmitter) → diffuses across cleft and attach to receptor sites on motor end plate → depolarization of muscle fiber.
- In MG – antibodies attach to ACh receptors and block the ACh from attaching → blocked neuromuscular transmission

Concept Check

- 1. If an individual struck the car windshield in a car accident, the coup/contrecoup injury would be in the :
  - A. Frontal/parietal region
  - B. Frontal/occipital region
  - C. Parietal/occipital region
  - D. Occipital/frontal region

2. Injury of the cervical SC may be life threatening due to:
   - A. Increased intracranial pressure
   - B. Spinal shock
   - C. Loss of bladder and rectal contrao
   - D. Impairment of the diaphragm

- 3. TIAs are:
  - A. Neurological deficits that slowly resolve
  - B. Neurological deficits that occur every hour
  - C. Focal neurological deficits that dev. suddenly, last for a few minutes, and clear in 24 hours
  - D. Events that never indicate an impending stroke

Matching:

4. MG	a. Autoimmune disorder, antibodies attack ACh receptors at NMJ
5. MS	b. Protrusion of nucleus pulposus
6. Herniated disc	c. Demyelination of nerves