

Human Anatomy & Physiology II - Dr. Sullivan
Unit I – The Brain – Chapter 14

I. The Brain

- a. There is no glucose stored in the brain, so there must be a constant supply entering the brain
 - i. Brain related symptoms are always the first of hypoglycemia (low blood sugar)
 - ii. i.e. light headedness, dizziness, irritability, headache.
- b. The brain gets its blood supply carrying glucose and oxygen from the bilateral common carotid arteries and bilateral vertebral arteries.
- c. Blood returns to the lungs from the brain via the bilateral internal jugular veins
- d. **Blood-brain barrier (BBB):** prevents passage of many substances from the blood into brain tissue
 - i. Comprised mostly of astrocytes which protects the brain from many harmful substances.
 - ii. Also makes it challenging to make drugs for CNS disorders because it is difficult to cross the BBB.
 - iii. A few water-soluble substances, such as glucose, cross the BBB quickly.
 - iv. Creatinine, Urea, and most ions cross slowly from the blood into the brain.
 - v. Some substances, such as proteins and antibiotics, do not cross the BBB at all.
 - vi. Lipid-soluble substances, such oxygen, carbon dioxide, alcohol, & most anesthetic agents cross easily into brain tissue.
 - vii. The BBB can be broken down by trauma, inflammation, and certain toxins.
 - viii. Certain drugs cannot pass, making it difficult to treat some diseases and infections.

II. Protective coverings of the brain

- a. The cranial meninges: a three-layer connective tissue protective covering of the brain.
 - i. **Dura Mater:** superficial layer made of dense irregular CT.
 - 1. surrounded by a layer of fat and connective tissue between the dura mater and the internal wall of the vertebral canal called the **epidural space**.
 - ii. **Arachnoid Mater:** the middle layer
 - 1. avascular (no blood supply)
 - 2. the space between the arachnoid mater and the dura mater is called the **subdural space**
 - iii. **Pia Mater:** The innermost layer made of a thin, transparent layer of CT that adheres to the brain and spinal cord.
 - 1. contains many blood vessels that supply oxygen and nutrients to the brain and spinal cord.
 - a. Blood vessels are sheathed by pia mater as they penetrate the brain from the surface inward.
 - 2. space between the arachnoid mater and pia mater is called the **subarachnoid space**
- b. The parts of the brain are separated by three extensions of the dura mater.
 - i. **Falx cerebri:** separates the left & right hemispheres of the brain
 - ii. **Falx cerebelli:** separates the two hemispheres of the cerebellum
 - iii. **Tentorium cerebelli:** separates the cerebrum from the cerebellum

III. Cerebrospinal Fluid (CSF)

- a. Clear colorless liquid that protects the CNS against harmful chemicals and physical damage. Also carries oxygen, glucose and other needed chemicals.
- b. Produced by the **choroid plexuses** found in the ventricles of the brain.
- c. **Choroid Plexus:** a network of capillaries and blood vessels inside the ventricles that produce CSF.
- d. **Ventricles:** cavities within the brain that contain large amounts of CSF.

- i. **Lateral Ventricle:** Surrounded by the genu of the corpus callosum
- ii. **Third Ventricle:** inferior to the corpus callosum
- iii. **Fourth Ventricle:** between the pons and the cerebellum
 - a. **Cerebral Aqueduct:** CSF-filled channel through the midbrain of the brainstem that connects the 3rd & 4th ventricles to each other.

Parts of the Brain

IV. The Brain Stem

- a. **Medulla Oblongata:** most inferior part of the brain stem. Contains the ascending sensory and descending motor tracts.
 - i. **Pyramids:** two lateral, external bulges formed by the two largest motor tracts.
 - ii. **Decussation of the pyramids:** the pyramids cross within the medulla oblongata taking most of the motor axons with it.
 - 1. most skeletal muscles are controlled by the contralateral part of the cerebral cortex.
 - iii. The medulla contains the cardiovascular center controlling rate and force of heartbeat as well as diameter of blood vessels.
 - iv. The medulla also contains the medullary rhythmic area of the respiratory center controlling the rhythm and rate of breathing.
 - v. The medulla also controls reflexes such as vomiting, coughing, and sneezing.
 - vi. **Cranial Nerves emerging from the Medulla Oblongata**
 - 1. **Vestibulocochlear (CN VIII) cochlear branch:** *sensory and motor* associated with hearing (cochlear branches)
 - 2. **Glossopharyngeal (CN IX):** *sensory and motor* control taste, swallowing, and salivation
 - 3. **Vagus (CN X):** *sensory and motor* associated with voice production, digestive secretions, taste, and slowing of heart rate
 - 4. **Accessory Nerve (CN XI):** *motor* swallowing and shoulder shrug (spinal portion)
 - 5. **Hypoglossal (CN XII):** *motor* tongue movement and swallowing
- b. **Pons:** Directly superior to the medulla and anterior to the cerebellum.
 - i. Helps control breathing with the pneumotaxic and apneustic areas.
 - ii. **Cranial Nerves emerging from the pons**
 - 1. **Trigeminal (CN V):** *sensory and motor* sensory from the head an face, motor for chewing (mastication)
 - 2. **Abducens (CN VI):** *motor* eyeball movement
 - 3. **Facial (VII):** *motor and sensory* associated with sensory for taste and motor for saliva secretion, tears, and facial expression.
 - 4. **Vestibulocochlear (CN VIII): vestibular branch:** *sensory and motor* associated with balance and equilibrium
- c. **Midbrain** (also known as mesencephalon): directly superior to the pons
 - i. **Cerebral peduncles:** anterior part of the midbrain containing axons of the sensory and motor tracts.
 - ii. **Tectum:** posterior part of the midbrain divided into the corpora quadrigemina
 - 1. **Superior Colliculi:** two superior elevations that are reflex centers controlling movements of the eyes, head, and neck in response to visual and other stimuli.
 - 2. **Inferior Colliculi:** two inferior elevations that are reflex centers for movements of the head and truck in response to auditory stimuli.
 - iii. **Cerebral Aqueduct:** CSF-filled channel between the tectum & the cerebral peduncles that connects the 3rd & 4th ventricles to each other.
 - iv. **Cranial Nerves emerging from Midbrain**

1. **Oculomotor (III):** *motor* movements of the ipsilateral eyeball, constriction of the pupil, changes in lens shape.
2. **Trochlear (IV):** *motor* movements of the ipsilateral eyeball

V. The Cerebellum

- a. Posterior and inferior to the cerebrum, posterior to the occipital lobe.
- b. Main structures
 - i. cerebellar hemispheres on the left and right
 - ii. *Vermis*: the raised structure along the median line
 - iii. *Arbor vitae*: highly branched, internal white matter
- c. **Role of the cerebellum**
 - i. monitors intentions for movement
 - ii. monitors actual movement
 - iii. compares the command signals
 - iv. sends out corrective signals
 - v. summary: important in learning and performing coordinated, highly skilled movements.
- d. Function: compares intended movements with what is actually happening to coordinate and smooth out complex, skilled movements. Also regulates balance and posture.

VI. Diencephalon

- a. Extends from the brain stem to the cerebrum
- b. Includes the thalamus, hypothalamus, epithalamus, and subthalamus
- c. **Thalamus:** Relays sensory input to the cerebral cortex, provides crude perception of touch, pressure, pain, and temperature. Also contributes to emotions, memory, cognition and awareness.
- d. **Hypothalamus:** just inferior to the subthalamus.
 - i. Contains the mamillary bodies, infundibulum, and median eminence (encircles the infundibulum)
 - ii. Controls and integrates the autonomic nervous system and pituitary gland
 - iii. Regulates emotional and behavioral patterns
 - iv. Body temperature, eating and drinking behavior
 - v. Maintains waking state and established sleeping patterns
- e. **Subthalamus:** just posterior to the hypothalamus
 - i. Help control body movements
- f. **Epithalamus:** superior and posterior to the thalamus
 - i. Contains the pineal gland (endocrine) which secretes melatonin (thought to promote sleepiness).

VII. Cerebrum

- a. Supported on top of the diencephalon
- b. Contains the **cerebral cortex** (the outer layer of gray matter of the cerebrum)
 - i. Made up of sulci, gyri, and fissures.
- c. The cerebrum is divided into bilateral hemispheres.
- d. Each hemisphere of the cerebrum is divided into lobes:
 - i. **Frontal Lobe:** anterior most lobe
 1. Chiefly concerned with voluntary motor functions, motivation, foresight, planning, memory, mood, emotion, social judgement, and aggression.
 2. **Precentral Gyrus:** the posterior most gyrus of the frontal lobe.
 - a. The somato-motor center of the cerebral cortex.
 - b. Voluntary motor impulses begin here
 - c. Located anterior to the central sulcus
 - ii. **Parietal Lobe:** divided from the frontal lobe by the central sulcus
 1. Concerned with sensory reception and the integration of somatosensory, taste, and some visual information.
 2. **Postcentral Gyrus:** The anterior-most gyrus of the parietal lobe.
 - a. The somatosensory center of the cerebral cortex

- b. All nerve impulses from perceived somatic sensations have their CNS destination here.
- c. Located posterior to the central sulcus

Somatic Motor Pathways

- a. Control of body movements involves several regions of the brain.
 - i. Cerebral Cortex: precise, discrete muscular movements.
 - ii. Basal Ganglia: establish a normal level of muscle tone, integrate semivoluntary, automatic movements.
 - iii. Cerebellum: assists cortex and basal ganglia in making body movements smooth and coordinated by maintaining balance and posture.
 - iv. The Primary motor area of the brain is known as the **precentral gyrus**.
- b. Direct Motor Pathways: propagate motor command impulses from the brain to the skeletal muscles.
 - i. Also known as Pyramidal pathways because they travel through the pyramids.
- c. Indirect Motor pathways
 - i. Also known as extrapyramidal
- d. **Upper motor neurons:** Neurons that within the brain and spinal cord gray matter (second and third order neurons)
- e. **Lower motor neurons:** from the anterior horn of the spinal cord to the skeletal muscles. Also, from the motor nuclei of a cranial nerve to its effector.
- f. **Upper motor neurons** travel down the spinal cord and synapse with an interneuron which then synapses with a **lower motor neuron**.
 - i. If there is a lesion of a lower motor neurons, the result is ipsilateral flaccid paralysis.
 - ii. If there is a lesion of an upper motor neuron, the result is contralateral spastic paralysis.
 - iii. **Occipital Lobe:** The posterior most lobe. Separated from the parietal lobe at the **parieto-occipital sulcus**.
 - 1. The principal visual center of the brain.
 - iv. **Temporal Lobe:** lateral, horizontal lobe. Divided from the parietal lobe by the **lateral sulcus**.
 - 1. Concerned with hearing, smell, learning, memory, visual recognition, and emotional behavior.
- e. **Insula:** A small mass of cortex deep to the deep to the lateral sulcus.
 - i. Not accessible to study in living people because of its location.
 - ii. Thought to play a role in understanding spoken language, the sense of taste, and in integrating information from visceral receptors.
- f. The cerebrum's white matter is divided into tracts of neurons that allow communication throughout the brain.
- g. The two cerebral hemispheres communicate with each via masses of white matter in the cerebrum called **commissural tracts**.
 - i. **Corpus Callosum:** the largest commissural tract.
 - ii. **Anterior & Posterior Commissures:** smaller masses of white matter tracts located anterior and posterior to the corpus callosum.
- h. **Projection tracts:** allow different vertical levels of the brain (brainstem, diencephalon, cerebrum) to communicate with each other and the spinal cord.
 - i. Motor tracts carry impulses from the cerebral cortex to the spinal cord and sensory tracts carry impulses from the spinal cord or brainstem to the thalamus or cerebrum.
- i. **Association Tracts:** allow different regions of the same cerebral hemisphere to communicate with other.
 - i. Association tracts link perceptual and memory regions of the brain so a person can identify a sensation.
 - 1. i.e. you can taste an orange, name it, and picture it in your mind.

- j. The cerebrum interprets sensory impulses and controls muscular movement as well as functioning in emotional and intellectual processes.
- k. **Basal Nuclei (aka ganglia):** inferior masses of cerebral gray matter buried deep in the white matter lateral to the bilateral thalamus.
 - i. Contains the **caudate nucleus, putamen, and globus pallidus.**
 - 1. **Lentiform Nucleus:** globus pallidus and putamen together
 - 2. **Corpus Striatum:** Lentiform nucleus and caudate nucleus together.
 - ii. Receives information from the substantia nigra of the midbrain and the motor area of the cerebral cortex.
 - 1. Also sends information back to both of these areas.
- iii. **Role of the Basal Nuclei**
 - 1. programs habitual or automatic movements
 - a. Automatic movements: movements that happen without your approval, but can be stopped if you wish (i.e. arm swing while walking or laughing at a joke).
 - b. Habitual movements: highly practiced movements that require little cognitive thought
 - i. i.e. driving a car, tying your shoelaces, etc.
 - 2. Inhibits motor neurons that are intrinsically active
 - a. Regulates muscle tone in this way making sure that muscles that intrinsically contract are controlled equally.
 - i. This creates a balance between contracting agonists and atagonists.
 - b. Parkinson's disease is damage to the basal ganglia and results in uncontrolled tremors
 - 3. Damage results in abnormal rigidity, flailing of the limbs (ballismus), and/or tremors.
 - 4. Functions to coordinate gross automatic muscle movements and regulate muscle tone.
 - a. When agonistic muscles contract to create a desired movement, antagonistic muscles are inhibited to create smooth, easy motion.
 - b. If the basal nuclei do not inhibit the antagonist, that motion becomes spastic and difficult.
- 1. **Limbic System (gray matter) Figure 14.7:** A group of structures encircling the corpus callosum that function in the emotional aspects of behavior related to survival.
 - i. Consists of the cingulate gyrus, hippocampus of the temporal lobe, and the amygdala of the temporal lobe.
 - 1. Also, possibly the mamillary bodies, parts of the hypothalamus and thalamus, parts of the basal nuclei, and the prefrontal cortex.
 - 2. There is a limbic system in each hemisphere.
 - ii. Associated with the emotions associated with pain, pleasure, docility, affection and anger.

VIII. **Cognition**

- a. refers to mental processes such as awareness, perception, thinking, knowledge, and memory.
- b. 75% of our brain consists of cognitive areas
- c. Most of what's known of the cognitive functions of different areas was obtained by studying people who've had injuries or lesions to specific areas.
- d. **Parietal Lobe** lesions cause people to be unaware of objects or limbs of their own body contralaterally.
 - i. Cases have shown men to shave only half their face, women to apply makeup to only half their face or people to deny that one of their limbs is their own.

- e. **Temporal lobe** lesions cause *agnosia*: The inability to recognize, identify, or name familiar objects.
 - i. **Prosopagnosia**: the person can't remember familiar faces or their own face in the mirror.
- f. **Frontal Lobe** lesions result in changes in personality. Only primates and humans have a well developed frontal lobe.
 - i. The frontal lobe integrates information from the sensory and motor regions of the cortex.
 - ii. Provides a sense of relationship with the world enabling us to think about and plan and execute appropriate behavior.
 - iii. Responsible for giving appropriate expressions of our emotions

IX. Memory

- a. **Amnesia**: a defect in *declarative memory (the ability to describe past events)*
 - i. **Procedural memory**: remembering how to perform specific tasks (i.e. tie your shoes)
- b. Hippocampus: important memory-forming center
 - i. Does not store memories, rather organizes sensory & cognitive experiences while they are happening (short-term memory)
 - ii. Later, the hippocampus replays these memories to the cerebral cortex repeatedly while the cerebral cortex stores them as long-term memories.
 - 1. called **Memory Consolidation**
 - iii. The temporal lobe stores memories of faces and familiar objects while the frontal lobe stores memories of our plans and social roles.
 - iv. **Anterograde Amnesia**: inability to store new information
 - 1. caused by lesions of the hippocampus
 - v. **Retrograde amnesia**: Inability to recall things that took place prior to the injury
 - 1. caused by lesions of the cerebral cortex

X. Emotion

- a. The expression of our emotions is controlled by the prefrontal cortex (the deeper portion of the frontal lobes cortex).
- b. Our feelings and emotional memories take place deeper in the brain's tissue (hypothalamus and amygdala), but the prefrontal cortex is where we decide the appropriate way to express those emotions and feelings.
- c. **Amygdala**: part of the limbic system that causes us to jump back from a frightening stimulus or miss someone you love.
 - i. Feelings associated with emotions such as fear and love.
 - ii. Also thought to be associated with food intake, sexual activity, and our attention being drawn to something new.
- d. The hypothalamus and amygdala control important aspects of personality. When specific regions of those structures are destroyed or stimulated animals exhibit altered expressions of anger, fear, aggression, self-defense, pleasure, pain, love, sexuality, and parental affection.
 - i. Also affected are learning, memory, and motivation.

XI. Language

- a. Reading, writing, speaking, and understanding words.
- b. **Wernicke Area**: posterior to the lateral sulcus usually in the left hemisphere
 - i. Responsible for the recognition of spoken & written language.
 - ii. Formulates words and phrases based on learned rules of grammar and transmits a plan for speech to the **Broca Area**.
- c. **Broca Area**: located in the posterior/inferior portion of the frontal lobe ipsilateral to Wernicke's Area.
 - i. Generates a motor program for the muscles of the larynx, tongue, cheeks, and lips to produce speech.
 - ii. Transmits this program to the primary motor cortex (precentral gyrus), which executes it.

- d. The emotional aspect of language is controlled by the contralateral portions of the cortex that mirror the Wernicke & Broca area.
 - i. **Affective language area:** opposite the Broca Area
 - 1. creates emotion and intonation in speech
 - 2. lesions cause flat, emotionless speech
 - ii. Opposite the Wernicke Area is a cortical region that is concerned with recognizing the emotional content of another person's speech.
 - 1. i.e. understanding sarcasm or a joke
- e. **Aphasia:** any language deficit resulting from lesions of the Wernicke or Broca area.
 - i. Nonfluent Aphasia results from lesions in Broca's area.
 - 1. Slow speech and difficulty choosing the right words.
 - ii. Fluent Aphasia results from lesions of Wernicke's Area
 - 1. Speaks normally but uses made-up words that make little sense to others.
 - 2. Person also cannot comprehend written and spoken words.
 - iii. Anomic Aphasia: person can understand speech and speak normally but cannot understand written words or pictures.