Anatomy and Physiology of the Nervous System

PTA 103 Introduction to Clinical Practice 2

Why do PTAs need neuroanatomy and physiology?

• In order to understand what can go wrong, we need to know what normal function looks like
• It is easier to understand signs and symptoms of disease when you can reference the involved structures and processes
• PT interventions, tests, and measures become more meaningful when you have a general understanding of deficits and potential for rehabilitation

Functions of the Nervous System

1. Sensory input. Monitor internal and external stimuli
2. Integration. Brain and spinal cord process sensory input and initiate responses
3. Controls of muscles and glands
4. Homeostasis. Regulate and coordinate physiology
5. Mental activity. Consciousness, thinking, memory, emotion
Organization of the Nervous System

The Nervous System

- Components
  - Brain, spinal cord, nerves, sensory receptors
- Subdivisions
  - Central nervous system (CNS): brain and spinal cord
  - Peripheral nervous system (PNS): sensory receptors and nerves

Brain

- Brain
  - Part of CNS contained in cranial cavity
  - Control center for many of body's functions
  - Much like a complex computer but more
  - Parts of the brain
    - Cerebrum/cerebral cortex: conscious thought, control
    - Brainstem: connects spinal cord to brain; integration of reflexes necessary for survival
    - Cerebellum: involved in control of locomotion, balance, posture
    - Diencephalon: thalamus, subthalamus, epithalamus, hypothalamus
Cerebrum

- Largest portion of brain
- Composed of right and left hemispheres each of which has the following lobes: frontal, parietal, occipital, temporal, limbic, insular
Primary Functions of Cerebral Lobes

- **Frontal**: executor of function (voluntary motor function, motivation, aggression, sense of smell, mood)
- **Parietal**: sensory integrator for pain, temperature, detection of taste, and touch; coordinates reading
- **Temporal**: reception and evaluation for smell and hearing; memory, abstract thought, judgment
- **Occipital**: reception and integration of visual input
- **Insula**: is within temporal lobe.
- **Central sulcus**: between the precentral gyrus (primary motor cortex) and postcentral gyrus (primary somatic sensory cortex).

Limbic System

- Part of cerebrum and diencephalon
- Basic survival functions such as memory, reproduction, nutrition
- Emotions
- Various nuclei of the thalamus
- Part of the basal nuclei, hypothalamus, olfactory cortex, fornix

Brainstem and Diencephalon
Brainstem

- Comprised of midbrain, pons, and medulla oblongata
- Continuous with spinal cord; has both ascending and descending nerve tracts
- Regulates: sleep, heart rate, blood vessel diameter, respiration, swallowing, vomiting, hiccups, coughing, and sneezing

Brain and Cranial Nerves

MNEMONICS for cranial nerves
Oh
Once
One
Takes
The
Anatomy
Final
Very
Good
Vacations
Are
Heavenly.
Cranial Nerves

• Considered Peripheral Nervous System (PNS)
• These peripheral nerves originate from brain.
• Two pairs arise from cerebrum; ten pairs arise from brainstem

Cranial Nerves

• Indicated by
  – Roman numerals I-XII from anterior to posterior
  – Names
• May have one or more of three functions
  – Sensory (special or general)
  – Somatic motor (control of skeletal muscles)
  – Parasympathetic (regulation of glands, smooth muscles, cardiac muscle)

Table 13.4 Functional Organization of the Cranial Nerves

<table>
<thead>
<tr>
<th>Nerve Function</th>
<th>Cranial Nerve</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sensory</td>
<td>I Olfactory</td>
</tr>
<tr>
<td></td>
<td>II Optic</td>
</tr>
<tr>
<td>Somatic motor</td>
<td>III Oculomotor</td>
</tr>
<tr>
<td></td>
<td>IV Acoustic</td>
</tr>
<tr>
<td>Somatic motor and sensory</td>
<td>V Trigeminal</td>
</tr>
<tr>
<td>Somatic motor and parasympathetic</td>
<td>VI Abducent</td>
</tr>
<tr>
<td>Somatic motor, sensory, and parasympathetic</td>
<td>VII Facial</td>
</tr>
<tr>
<td></td>
<td>VIII Acoustic</td>
</tr>
<tr>
<td></td>
<td>IX Glossopharyngeal</td>
</tr>
<tr>
<td></td>
<td>X Hypoglossal</td>
</tr>
</tbody>
</table>
Cranial Nerve Reflexes

- X (Vagus): reflexes having to do with heart rate, blood pressure, and respiration
- Reflexes involving both cranial nerves and brainstem:
  - Turning the eyes toward sudden noise, touch on skin, flash of light
  - Eyes tracking a moving object.
  - Reflex using VIII, V, and VII to contract muscles associated with middle ear that protect ear ossicles
  - Chewing reactions to textures of food, movement of tongue pushing food under tooth-row and out of harm's way

Cerebellar Functions

- Key Point: COORDINATION; Ataxia = lack of coordination
- Makes comparisons between the motor plan from the cortex and the position sense from the muscles/joints and facilitates movement precision/correction
- Influences timing and force of voluntary muscular contraction
- Finger-to-nose test

Cerebrum vs. Brainstem

- Brainstem and diencephalon maintain homeostasis of basic/primitive functions
- Cerebrum and cerebellum coordinate, plan, and memorize higher level sensori-motor function
- Two systems interact in automatic and conscious ways throughout the life cycle.
Arteries of the Brain

Circle of Willis
- Ring of 9 arteries
- Provides multiple sources of circulation to cerebrum
Circulation to the Brain

• Basilar artery
  – Includes anterior inferior cerebellar artery (AICA), superior cerebellar artery
  – Supplies pons and cerebellum
  – Primary blood supply to midbrain
  – Complete occlusion can be fatal

Circulation to the Brain

• Vertebral Arteries
  – Carry one-third of blood supply to the brain
  – Originate from the subclavian artery
  – Branches into three parts
    • Anterior Spinal
    • Posterior Spinal
    • Posterior Inferior Cerebellar Artery (PICA)
  – All three branches supply blood to medulla
  – PICA supplies inferior cerebellum

Circulation to the Brain

• Internal Carotid Arteries
  – Originate from the common carotid
  – Becomes the posterior communicating arteries (PCA)
  – Divides into anterior and middle cerebral arteries
Circulation to the Brain

- **Anterior Cerebral Artery (ACA)**
  - Frontal, parietal, and basal ganglia
- **Middle Cerebral Artery (MCA)**
  - Lateral surfaces of the frontal, parietal, temporal, and occipital lobes
- **Posterior Cerebral Artery (PCA)**
  - Midbrain, thalamus, occipital lobe, medial, and inferior temporal lobe

Meninges

- Connective tissue membranes
  - Dura mater: superficial
  - Arachnoid mater
  - Pia mater: bound tightly to brain
- Spaces
  - Subdural: serous fluid
  - Subarachnoid: CSF

Ventricles

- Ventricles are interconnected by aqueducts and wall openings
- Blockage in the central canal or fourth ventricle can lead to hydrocephalus (enlarging ventricles) and may require an external shunt for treatment
Cerebrospinal Fluid (CSF)

- Similar to serum, but most protein removed
- Bathes brain and spinal cord
- Protective cushion around CNS
- Choroid plexuses produce CSF which fills ventricles and other parts of brain and spinal cord
  - Blood-cerebrospinal fluid barrier
    - Substances do not pass between cells
    - Substances must pass through cells
    - Makes the barrier very selective

Divisions of PNS

- Sensory (afferent): transmits action potentials from receptors to CNS.
- Motor (efferent): transmits action potentials from CNS to effectors (muscles, glands)

Motor Division of PNS

- Somatic nervous system: from CNS to skeletal muscles.
  - Voluntary.
  - Single neuron system.
  - Synapse: junction of a nerve cell with another cell. E.g., neuromuscular junction is a synapse between a neuron and skeletal muscle cell.
Autonomic Nervous System

- Sympathetic (thoracolumbar)
  - Fight or flight
- Parasympathetic (craniosacral)
  - Rest, relax, digest, eliminate
- Enteric
  - Specific and independent innervations of the digestive tract
- Organs receive dual innervations from both sympathetic and parasympathetic branches to maintain homeostasis

Types of Neurons

- Functional classification
  - Sensory or afferent: action potentials toward CNS
  - Motor or efferent: action potentials away from CNS
  - Interneurons or association neurons: within CNS from one neuron to another

Electrical Signals

- Cells produce electrical signals called action potentials
- Transfer of information from one part of body to another
Changes Associated with Aging

• Decreased sensory receptors on skin
  – Increased skin injury
• Slowing of action potential propagation
  – Decreased neurons, decreased neurotransmitter receptors, decreased speed of transmission
• Decreased autonomic sensory function
  – Bowel/bladder, BP regulation, H2O regulation