Neuroanatomy and Neuroimaging

**Learning Objectives**

- Understand the anatomy of the brain, spine, and spinal cord.
- Compare the incidence of spinal cord injury to TBI.
- Distinguish between symptom patterns due to brain injury and syndromes in spinal cord injury.
- Articulate the methods of neuroimaging which support diagnostic and treatment decisions when a patient has sustained either a brain injury or spinal cord injury.

**Skull Anatomy**

- The skull is a rounded layer of bone designed to protect the brain from penetrating injuries.
- The inside of the skull is rough with many bony protuberances.
- These ridges can result in injury to the brain during rapid acceleration.
The Meninges

- The meninges are layers of tissue that separate the skull and the brain.
- There are 3 layers:
  - Pia Mater
  - Arachnoid
  - Dura Mater

**Essential Tip!**
The Meninges P-A-D the Brain

Cerebrospinal Fluid

- 3rd & 4th Ventricles
- Lateral Ventricles

Brain Cells

- Neurons: Communicate via Synapses

Brain Stem

Essential TIP!

Neurons Communicate via Synapses

- Neuron A
- Neuron B
- Neuron C

Brain Cells

- Neuron
- Synapse
- Glial Cells
- AXON Terminals
- Dendrites
- NEURONS

**Essential TIP!**
The Meninges P-A-D the Brain

Pia Mater Arachnoid Dura Mater
Brain Stem Anatomy

- Midbrain
- Pons
- Medulla

Reticular Activating System

- Arousal
- Alertness
- Concentration
- Basic biological rhythms

Diencephalon

- Thalamus
- Hypothalamus

Limbic System

- Hippocampus
- Amygdala
Basal Ganglia and Cerebellum

- Basal Ganglia
- Cerebellum

THE CEREBRAL CORTEX

- Two Hemispheres
- Four Lobes
- Interconnected

Information Processing

<table>
<thead>
<tr>
<th>Right Hemisphere</th>
<th>Left Hemisphere</th>
</tr>
</thead>
<tbody>
<tr>
<td>Holistic</td>
<td>Linear</td>
</tr>
<tr>
<td>Visual Spatial</td>
<td>Verbal-analytic</td>
</tr>
<tr>
<td>Intuitive</td>
<td>Logical</td>
</tr>
<tr>
<td>Controls left side of body</td>
<td>Controls right side of body</td>
</tr>
<tr>
<td>Music, art, shapes</td>
<td>Speaking, reading, writing</td>
</tr>
</tbody>
</table>

Cerebral Features

- Gyri: Elevated ridges that wind around the brain
- Sulci: Small grooves dividing the gyr
- Fissures: Deep grooves, usually dividing large regions/lobes of the brain

Frontal Lobe Functions

- Planning
- Organizing
- Problem Solving
- Judgment
- Impulse Control
- Decision Making
- Working Memory
Temporal Lobe

Expressive and Receptive Speech
Broca’s Area
Wernicke’s Area

Occipital Lobe
Primary Visual Cortex

Visual Pathway
Left Visual Field
Right Visual Field

Parietal Lobe
Primary Sensory Cortex
Somatosensory Cortex

SPINE AND SPINAL CORD
Spinal Column Divisions

- Cervical Spine showing Lateral, Anterior, and Posterior views
- Thoracic Vertebrae showing Lateral, Anterior, and Posterior views
- Lumbar Vertebrae showing Lateral, Anterior, and Posterior views

Vertebral Bodies

- Spinal Cord
- Disk
- Meninges
- Nerve Root
- Vertebra

Spinal Cord

- Essential Tip: Afferent Nerves Ascend upward

Spinal Cord Syndromes

- Central Cord Syndrome
- Brown-Sequard Syndrome
- Anterior Cord Syndrome
- Posterior Cord Syndrome

Computed Tomography (CT)
Magnetic Resonance Imaging (MRI)

Diffusion Tensor Imaging (DTI)

Functional MRI (fMRI)

Brain Symmetry & Imaging

Mechanisms of Traumatic Injury

**Categories of brain injury**

- **Focal**
  - Contusions
  - Lesions
  - Hematomas
- **Diffuse**
  - Diffuse Axial Injury
  - Hemorrhage

**Mechanism of Injury**

Acceleration-Deceleration (Traumatic Inertial)


Mechanism of Injury

**Coup Contrecoup**

- The bouncing of the brain in the skull can result in injury in two sites

The initial site of injury (coup)
The contrecoup injury

**Mechanism of Injury:**

Intracranial Pressure

Mechanism of Injury: Acceleration-Deceleration (Traumatic Inertial)
Neuroprotection and Neuroplasticity

Learning Objectives

- Understand the conceptions of neuroprotection, neuroplasticity, and neurodegeneration
- Be able to explain factors leading to neurodegeneration following TBI
- Be able to articulate the effects of brain injury and injury severity
- Be able to articulate the two main areas of the brain known to be sites of neurogenesis
- Be able to distinguish between rehabilitative training models appropriate for TBI and those for stroke

NEUROPLASTICITY

Early Research on Neuroplasticity

Synaptogenesis

Definition: the formation of synapses between neurons

The greater the numbers of synapses within a grouping of neurons, the greater the speed and efficiency with which those neurons communicate

Dendritic spines have the ability to change in response to experience

Neuroplasticity Post-TBI

- Plasticity: the ability of the nervous system to change, grow or compensate for injury
Neuroplasticity: TBI Research

Biological Cascade Following TBI
- Primary Injury - direct damage to the brain
- Secondary Injury - causes additional damage
  - Excitotoxicity
  - Edema
  - Apoptosis

Potential Neuroprotective Agents for TBI
- Neuroprotective agents limit neuronal death following injury and/or enhance recovery

<table>
<thead>
<tr>
<th>Neuroprotective Agent</th>
<th>Intervention Target</th>
<th>Animal Models Showing Efficacy (Stroke)</th>
<th>Human Studies Showing Efficacy (TBI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Magnesium</td>
<td>Increase Mg2 (decreased Mg2 results in excessive production of free radicals and mild inflammation)</td>
<td>✔️</td>
<td>Failed</td>
</tr>
<tr>
<td>Progesterone</td>
<td>Decrease cerebral edema</td>
<td>✔️</td>
<td>✗</td>
</tr>
<tr>
<td>Nicotinimide</td>
<td>Reduce injury volume; decrease glutamate release; reduce BBB breaches; reduce edema</td>
<td>✔️</td>
<td>Unknown</td>
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