The Healthy Brain and Effects of Brain Injury

Samantha Backhaus, Ph.D. HSPP
October 2008

A Healthy Brain

- How we experience ourselves and the environment (the simple act of drinking water)
- Organ of reason, language, complex social relations, and morality.
- What makes us distinctly human.

A Healthy Brain

- A healthy brain must be well-protected and receive a healthy amount of oxygen.

Protection:
- Skal: A hard bone that surround the tissue. While the outside may be somewhat smooth, the inside of the skull is rather bony and has ridges that can easily tear the brain tissue when trauma occurs.
- Dura and arachnoid layers

Cerebrospinal fluid (CSF): fluid that flows through the ventricles (spaces inside the brain) and around the brain and spinal cord. It acts as a “shock absorber” for the brain.

A Healthy Brain

- A healthy brain must be well-protected and receive a healthy amount of oxygen.

Receives oxygen through:
- Blood: Provides oxygen and food for the brain. Without it, cell death can occur.
- Decreased oxygen can result in damage to the brain either from chronic conditions causing decreased oxygen over time or from sudden injury

A Healthy Brain

- Made of neurons (nerve cells), which form tracts that travel through various parts of brain
- Functions include thinking, moving, personality changes, behaviors
- Although each part has a specific function, all interconnected

Overview of Brain Anatomy
**Left Hemisphere**
- Language Abilities
- Control of right side of body
- Verbal Memory
- Seeing the Details

**Right Hemisphere**
- Visual Spatial Abilities
- Control of left side of body
- Memory for visual objects
- Attention
- Awareness
- Seeing the Big Picture
- Understanding subtleties of speech

---

**Functions of the Lobes**

**Occipital Lobe:** At back of brain
- Functions:
  - Locating objects
  - Identifying colors
  - Accurately seeing objects

**Parietal Lobe:** near the back and top of brain
- **Sensory Functions:**
  - Recognizing objects through touch, pressure, fine sensation (judgment of texture, weight, size, shape)
  - Visual spatial functions:
    - Perception of objects
    - Finding your way around new places
    - Bumping into objects
    - Not perceiving objects on one side of the body

**Parietal Lobe (mostly left)**
- Language functions (3 R's)
  - Reading, writing, & arithmetic
  - Distinguishing between left and right side
Functions of the Lobes

- **Temporal Lobe (located around the temples)**
  - Functions:
    - Hearing
    - Memory: Where memory is stored
    - Comprehension of speech

Functions of the Lobes

- **Frontal Lobes:** In front of brain
  - Functions: “higher cognitive functioning” or the CEO of the brain:
    - **Solving problems and planning:** Appropriately
    - **Abstract reasoning:** Seeing the big picture
    - **Initiation:** Getting tasks started and keeping them going
    - **Making proper decisions** and using good judgment

Functions of the Lobes

- **Frontal Lobes:** continued
  - Functions (higher cognitive functions continued):
    - **Impulsivity:** Being able to stop from "acting without thinking"
    - Having **awareness** of our actions and consequences of them
    - **Mental flexibility:** Being able to be flexible in our thinking and not “stuck” on one idea

Functions of the Lobes

- **Frontal lobes also responsible for:**
  - **Movement** of certain body parts: weakness or paralysis
  - Controls **expressive speech:** Not getting speech out or saying wrong words
  - **Attention:** Not being able to focus for long periods of time, or doing several things at once
  - **Emotional responses and personality**
Brain Stem

- Includes Pons, Medulla, Reticular Activating System
- Functions:
  - Breathing and heart rate
  - Swallowing food and water
  - Sleep
  - Arousal / Remaining awake and alert
  - Dizziness and nausea if injured

Subcortex

- Basal Ganglia
- Thalamus
- Hypothalamus
- Limbic System

Cerebellum

- Located at base of skull
- Functions
  - Balance and coordination of movement
  - Coordinating movements that interfere with talking, eating, writing, buttoning shirts, walking, or other self-care tasks
  - can result in dizziness if impaired
  - General thinking ability

Subcortex: Hypothalamus

- Basic regulatory functions: thirst, appetite, sexual arousal
- Lesions: diminished drive states, obesity, and loss of decreased temp. regulation
Subcortex: Thalamus

- Lies near middle of brain and composed of two halves
- **Sensory Relay Station** for most sensory pathways to the cerebral cortex, contributing significantly to conscious experience of sensation
- Where all incoming information goes through first before being routed to appropriate cortex for integration

Subcortex: Basal Ganglia

- Lies at base of cerebral hemispheres
- **Contains 3 structures:** putamen, globus pallidus, and caudate
- Motoric control and voluntary and automatic mvs
- Translates cognition into action
- Contributes to learning, memory, receptive, and expressive language.

Subcortex: Limbic System

- Includes hypothalamus, cingulate, septal region, hippocampus, fornix, and amygdala
- Regulate and adjust emotional tone that accompanies behavior and contributes to motivational aspects of behavior and learning and memory
- **Cingulate lesions:** amotivational or akinetic syndrome: no initiation of behavior and will at times simply sit for hours

Subcortex: Limbic System

- **Septal regions:** expression of intense anger or rage
- **Hippocampus:** learning and memory. Consolidates new info and contributes to transition of ST to LT memory formation
- **Fornix:** originates in hippocampus and is critical interconnection for neurocircuitry w/in system
- **Amygdala:** expression of emotional responses and participates in laying down of new learning, especially those with emotional component.

Subcortical Lesions

- Typically result in
  - Motor deficits
  - Slowed learning and retrieval
  - Emotional difficulties
  - Slowed processing speed
  - Attention difficulties
  - Slowed naming and other language deficits

Traumatic Brain Injury (TBI)

- **TBI** occurs when a sudden trauma causes damage to the brain
- Leading causes of TBI
  - Motor vehicle accidents
  - Acts of violence
  - Falls
  - Sports and recreational injuries
  - Lightning strikes
  - Electric shocks
  - Blows to the head
**Traumatic Brain Injury (TBI)**

- **TBI** sudden trauma resulting in damage to the brain
- **Closed head injury**: the head suddenly and violently hits an object
  - A person turns reflexively from impact
  - Skull stops, brain rotates
  - Areas next to ridges most vulnerable
    - Temporal lobe
    - Frontal lobes
- **Open head injury**: object pierces the skull and enters brain tissue

**Contra-coup injury – damage on side opposite of impact**

**TBI: Diffuse Injury**

- Diffuse Axonal Injury: widespread pulling and stretching of cells
  - Bony structures carry surface brain tissue forward while deeper brain remains momentarily stationary because of inertia
  - Axons are torn, twisted, or broken
  - DAI tends to cause some similar patterns as subcortical and cortical injuries mixed together

**TBI: Focal Injuries**

- **Subarachnoid hemorrhage**: bleeding around the subarachnoid space surrounding the brain
- **Hematoma**: rapidly growing mass of blood that puts pressure on brain.
- **Contusion**: bruising of the brain tissue. Can result in tearing of tiny blood vessels that leak into the tissue
**TBI: Secondary effects**

- **Swelling:** collection of fluid in and around damaged tissue. Can compress brainstem, leading to death.
- **Ischemia**—insufficient blood flow
- **Hypoxia**—lowered availability of oxygen

---

**Traumatic Brain Injury (TBI)**

- Symptoms of a TBI can be mild, moderate, or severe, depending on the extent of the damage to the brain.

---

**Hypoxia**

- Lack of oxygen supply to the brain. Brain cells are extremely sensitive to lack of oxygen.
- In mild to moderate cases: poor attention, memory, judgment, initiation, awareness and coordination.
- Severe cases: complete unawareness and unresponsiveness (coma)

**Hypoxia: Causes**

- Drowning
- Drug overdose
- Smoke inhalation
- Very low blood pressure
- Strangulation
- Injuries during birth
- Cardiac arrest (when the heart stops pumping)
- Carbon monoxide poisoning
- High altitudes
- Choking
- Compression of the trachea
- Complications of general anesthesia
- Diseases that paralyze the respiratory muscles

---

**STROKE**

- **Types:**
  - Blockage of a blood vessel within the brain
    - can lead to lack of oxygen to part of the brain resulting in cell death (ischemia)
- **Causes**
  - Narrowing of the (internal carotid) artery
  - Heart defect (atrial fibrillation or heart attack)

---

**STROKE**

- **Types:**
  - Rupture of a blood vessel within the brain (cerebral hemorrhage) – causes a distortion of the structure of the brain tissue because of pressure from the released blood
- **Causes**
  - Hypertension
  - Aneurysm
**STROKE: Risk Factors**
- Increase in age
- High blood pressure
- Smoking
- Diabetes
- High cholesterol
- Obesity / Lack of exercise
- Stress
- Sleep apnea
- Previous Stroke

**STROKE: Signs and Symptoms**
- Sudden numbness or weakness in face, arm, or leg, especially on one side of body
- Sudden confusion or trouble speaking or understanding
- Sudden trouble seeing with one or both eyes
- Sudden trouble walking, dizziness, loss of balance, or coordination
- Sudden severe headache with no known cause
- 1-888-4-Stroke (www.StrokeAssociation.org)

**Physical effects of BI**
- Decreased muscle movement and coordination (walking and using arms)
- Disturbed sleep
- Decreased smell
- Decreased ability to taste
- Problems with swallowing
- Problems hearing

**Physical effects of BI**
- Headaches
- Energy level
- Affected speech
- Sexual functioning
- Fitness and tolerance of pain
- Other

**Cognitive effects of BI**
- Slowed thinking or moving
- Short-term memory problems
- Can’t see the details / or big picture
- Indecisiveness
- Easily off task
- Cannot redirect self
- Cannot focus for long periods of time

**Cognitive effects of BI**
- Cannot multitask
- Difficulties problem-solving
- Very concrete thinking: everything has to be spelled out
- Difficulties developing goals for self
- Problems self-monitoring behaviors
- Decreased self-awareness
Cognitive effects of BI
- Problems with visual spatial functioning
- Difficulties expressing oneself or understanding others
- Disorganized thoughts
- Inflexibility of thinking
- Difficulties learning new problems

Emotional effects of BI
- Feelings of being “on edge”
- Feeling down and sad
- Feeling nervous and anxious
- Hitting, yelling, or punching
- Appearing as if one “doesn’t care about things”
- Feeling more frustrated and helpless
- Not wanting to live anymore
- Emotionally labile

Behavioral effects of BI
- Decreased initiation: Difficulty getting started on tasks
- Impulsive: Act before thinking
- Increased suspiciousness of others or paranoia
- Over-optimism
- Verbal outbursts or temper outbursts

Behavioral effects of BI
- Sees the world around oneself
- Unusual social pragmatics or gestures
- Increased talking

Important
- The brain is a system, each area heavily connected with other areas
- Damage to any one area usually causes a variety of difficulties
- Most common problems are memory, attention, and higher level thought functions
- If a person had problems before with thinking, memory, behavior, etc., it is likely to become worse after an injury