Brain Injury 101: The Basics

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Objectives

- Review the definitions of traumatic brain injury and acquired brain injury.
- Identify basic brain structures and functions.
- Describe brain-behavior relationships.
- Describe how an injury to the brain can result in various behaviors and challenges.
Traumatic Brain Injury

Traumatic brain injury (TBI) has been called the “silent epidemic.”

- This makes brain injury the *second* most prevalent injury and disability in the United States.
- An estimated *10 million* Americans are affected by stroke and TBI.
Definition of TBI

A traumatic brain injury (TBI) is defined as a blow or jolt to the head or a penetrating head injury that disrupts the function of the brain. Not all blows or jolts to the head result in a TBI. The severity of such an injury may range from "mild," i.e., a brief change in mental status or consciousness to "severe," i.e., an extended period of unconsciousness or amnesia after the injury. A TBI can result in short or long-term problems with independent function.
TBI Incidence & Prevalence

- 1.4 million/yr injured
- 1 million/yr seek emergency treatment
- 230,000/yr hospitalized
- 50,000/yr die
- 80,000/yr result in permanent disability

CDC figures as of Mar 2009
Scope of Wisconsin’s Problem*

~5,857 individuals sustain a TBI each year
- This equates to ~15 cases each day

- There are over 4,600 brain injury-related hospital discharges.

- More than 1100 Wisconsin residents die from traumatic brain injuries.

- Many more people who experience a TBI go undiagnosed.

*Source: WI Bureau on Health Information
Injury Severity

Injuries are classified according to mild, moderate and severe injuries.

- **80%** are mild
- 10-30% are moderate
- 5-25% are severe

**Concussion**: mild TBI that often goes undiagnosed as such
Epidemiology of TBI

- Every **23 seconds**, one person in the United States sustains a traumatic brain injury.
- More than **50,000** people die every year as a result of traumatic brain injury.
- 235,000 people are hospitalized each year with traumatic brain injury.
- 80,000-90,000 Americans experience the onset of a long-term disability following traumatic brain injury each year.
Epidemiology of TBI

- After one traumatic brain injury, the risk for a second injury is three times greater; after the second injury, the risk for a third injury is eight times greater.

- 2/3 of all firearm-related traumatic brain injuries are classified as suicidal in intent.

- 91% of firearm-related TBI’s result in death.
Incidence & Gender

- Males Sustain 59% of TBI’s
- Females Sustain 41% of TBI’s
- In other words, males sustain 1.5 times as many brain injuries as females.
- Males have higher rates of Hospitalization, Death and Emergency Department Visits
Causes of TBI

- Falls
- Motor Vehicle Crashes
- Gunshot Wounds
- Sports Injuries
- Workplace Injuries
- Child Abuse
- Domestic Violence
- Military Actions
- Other injuries caused by trauma
Incidence & Gender

- **Intimate violence** is the leading cause of serious injury to American women between the ages of 15 and 44 and frequently results in TBI.
Comparative Incidence

Comparison of Annual Incidence
A Comparison of Traumatic Brain Injury and Leading Injuries or Diseases

- Traumatic Brain Injuries: 1,400,000
- Breast Cancer: 176,300
- HIV/AIDS: 43,681
- Spinal Cord Injuries: 11,000
- Multiple Sclerosis: 10,400
What is a Concussion?

A concussion is a brain injury that:

- Is caused by a bump, blow, or jolt to the head or body.
- Can change the way your brain normally works.
- Can occur during practices or games in any sport or recreational activity.
- Can happen even if you haven’t been knocked out.
- Can be serious even if you’ve just been “dinged” or “had your bell rung.”
- All concussions are serious.
Facts About Concussion

- A concussion is a brain injury
- As many as 3.8 million sports- and recreation-related concussions occur in the United States each year
- Concussion is caused by a bump or blow to the head or body that causes the brain to move rapidly inside the skull
Facts about Concussions

- Concussions can occur in any sport
- All concussions are serious
- Concussions can occur without loss of consciousness
- Repeat concussions can result in brain swelling, permanent brain damage, and even death
Symptoms of a Concussion

You can’t see a concussion, but you might notice one or more of the symptoms or that you “don't feel right” soon after, a few days after, or even weeks after the injury.

- Headache or “pressure” in head
- Nausea or vomiting
- Balance problems or dizziness
- Double or blurry vision
- Bothered by light or noise
- Feeling sluggish, hazy, foggy, or groggy
- Difficulty paying attention
- Memory problems
- Confusion
What to Do if You Sustain A Concussion

- Talk to a physician
- Do not return to contact sports play until you are symptom free
- This is on average 7 to 10 days
TBI and Soldiers

- Traumatic Brain Injury is one of the signatures wounds of Operation Enduring Freedom/Operation Iraqi Freedom.
- The rate of combat-related traumatic brain injury among soldiers returning home from the wars in Iraq and Afghanistan averages 30% according to Walter Reed Army Medical Center.
- This is 10% more than that of previous wars and can be attributed to blast injuries from improvised explosive devices (IEDs).
10% to 20% of Marines and Soldiers returning from Afghanistan and Iraq might have experienced brain injuries.

As of January 31, 2008: 30,906 servicemembers have been wounded in action and 3,486 killed in action in OIF/OEF.

Battle injuries often result in Traumatic Brain Injury (TBI). Of the patients who require medical evacuation for battle-related injuries from theater to Walter Reed Army Medical Center (WRAMC), 32% had TBI (01/03-01/31/08).
Blast Injury

- The repercussions of the prevalence of this combat injury will be felt in the nation’s military, healthcare and social systems for years to come.
- Blast injuries are the leading cause of traumatic brain injury in an active war zone.
Definition of Acquired Brain Injury (ABI)

An ABI is an injury to the brain that has occurred after birth and is not hereditary, congenital or degenerative. The injury commonly results in a change in neuronal activity, which affects the physical integrity, the metabolic activity, or the functional ability of the cell. The term does not refer to brain injuries induced by birth trauma. Includes TBI and injuries caused by an internal insult to the brain.

Brain Injury Association of America (1997)
Causes of ABI

- TBI
- Tumor
- Blood clot
- Stroke
- Seizure
- Toxic exposure (e.g., substance abuse, ingestion of lead, inhalation of volatile agents)

- Infections (encephalitis, meningitis)
- Metabolic disorders (insulin shock, diabetic coma, liver and kidney disease)
- Neurotoxic poisoning
- Lack of **oxygen** to the brain (airway obstruction, strangulation, cardiopulmonary arrest, carbon monoxide poisoning, drowning)
ABI Effects

Acquired brain injury may result in mild, moderate, or severe impairments in one or more areas including:

- **Cognition** (i.e. speech-language communication, memory, attention and concentration, reasoning and abstract thinking)
- **Physical functions** (i.e. ambulating, seeing, hearing, balancing)
- **Psychosocial behavior** (i.e. social skills, anger management, impulsivity)
Understanding the Definitions

- It is important to understand the different definitions of brain injury,
- WHY?
- Much of the research has been done with persons with \textit{TBI}.
- Funding streams are based on definitions of TBI.
- Only piece of Federal Legislation is based on TBI.
A brain injury is often the result of two injuries:

- A “primary injury” caused by the initial blow or insult to the brain
- A “secondary injury” caused by the swelling, bleeding, compression and contusions (bruises) to the brain.
Mechanisms of Traumatic Brain Injury

After a sudden jolt or bang, the result can be...

- **Coup-Contracoup**: Injury at the site of impact and on the opposite side from the movement of the brain against the skull (either front to back or side to side)
Biomechanical Injury: Translation

Force vector
Biomechanical Injury: Rotation
Mechanisms of Traumatic Brain Injury

After a sudden jolt or bang, the result can be...

- Diffuse Axonal injuries: Delicate (axons) nerve tissues rip, tear, and stretch
- Swelling: Brain tissue swells preventing blood and CSF circulation, can result in anoxic brain injury.

- Hematoma: Accumulation of blood causing pressure
- Hydrocephalus: Blockage of CSF causing pressure
- Anoxia & Hypoxia: Oxygen deprivation from suffocation, drowning, blood loss, or cardiac failure that kills brain cells
- Hemorrhages: Major bleeding occurring when the brain rubs against the inside of the skull, which is ragged with sharp bony ridges, or when blood vessels are damaged due to the forces of the injury on the head.
Severity of Brain Injuries

Post concussion symptoms of cognitive and psychiatric nature that may or may not persist include:

- headache
- dizziness
- vomiting
- sleep disturbance
- irritability
- changes in personality
- memory problems
- depression
- difficulty problem solving
- diminished attention span
The Brain

The brain is the main organ of learning.

- It makes it possible for us to think, communicate, act, behave, move about, and create.
Anatomy of the Brain

The brain . . .

- Is a soft organ, like the consistency of gelatin or a raw egg.
- Weighs less than 1 lb. at birth and grows to about 3 lbs.
- Sits inside a rough and bony skull and is bathed in a *cerebrospinal fluid* (CSF)
- Receives oxygen and glucose through a sophisticated system of blood vessels that carry blood to and from the heart
Three membranes or **meninges** cover the brain:

- The outer **dura mater** or hard matter, which is like a heavy plastic covering.
- The **arachnoid**, which is like a spider web that bridges the brain's many wrinkles and folds.
- The **pia mater** or tender matter, which molds around every tiny crook and crevice on the brain's surface.
- Between the pia mater and the arachnoid, there is 145cc of cerebrospinal fluid.
Anatomy of the Brain

There are four **ventricles** which make, store, and circulate cerebrospinal fluid.

- The fluid helps cushion the brain and protect brain tissue when swelling occurs.
Neurons

- Neurons: the billions and billions of tiny brain cells making up the nervous system
- Three main parts of the neuron:
Neurons

- The neurons communicate with each other via a unique “electro-chemical” process.

- **Neurotransmitters** are chemical messengers that relay the electrical signal of one nerve cell to the next.

- Neurochemical transmitters leap the *synaptic gaps*.

- After a person sustains a brain injury, many of the neuron pathways may be torn apart or stretched so that information processing is no longer possible.
Brain Stem

- **Midbrain**
  - Alertness & arousal
  - Elementary forms of seeing & hearing

- **Pons**
  - Facial movement & sensation, hearing, & coordinating eye movements

- **Medulla**
  - Basic living functions
  - Vital to life and death
  - Controls involuntary functions like breathing, heart-rate, blood pressure, swallowing, vomiting and sneezing.
Diencephalon

- **Thalamus**
  - Major relay station for incoming and outgoing sensory information
  - The input for every sense (except smell) travels through the thalamus

- **Hypothalamus**
  - Control center for hunger, thirst, sexual response, endocrine level & temperature regulation.
  - Controls complex responses like anger, fatigue, memory and calmness.
Limbic System

- Houses basic elemental drives, emotions and survival instincts.
- Injury to the limbic system can result in serious problems with basic emotional perceptions, feelings & responses.
- Behavior and mood can be very erratic
Limbic System

○ Amygdala
  - Fight or flight structure
  - The front door to our emotions
  - When perceptions reach the cerebral cortex, it is transmitted to the amygdala to be evaluated for emotional content

○ Hippocampus
  - Associated with memory functions
  - Injury can result in problems with short term memory, and turning short term memories into long term memories
  - Disrupts the encoding and retrieval of long term memory
The Cerebral Cortex

- **Cerebral Cortex**: the most complicated structural component of the brain
- Made up of two hemispheres: the right hemisphere and left hemisphere
- Dedicated to the highest levels of thinking, moving, and acting.
- Each hemisphere is divided into four lobes—frontal, parietal, temporal, and occipital
- The cortex is full of wrinkles and folds.
The Cerebral Cortex

- The two hemispheres of the brain have unique ways of processing information.
  - The right hemisphere is more holistic, visual–spatial, and intuitive.
  - The left hemisphere processes language and is more linear, verbal–analytic, and logical.
  - The cerebral hemispheres control opposite sides of the body.

- The cerebral hemispheres communicate to each other a thousand times a second through the *corpus collosum* (the 4 inch long, pencil thick band of complex nerve fibers).
Lateralized Skills of the Brain

- The brain is divided into two hemispheres
  - The left hemisphere controls the right side of the body.
  - The right hemisphere controls the left side of the body
- The two hemispheres control input and regulate output
Lobes of the Brain

- Frontal lobe
- Temporal lobe
- Parietal lobe
- Occipital lobe
- Cerebellum
Brain & Behavior Relationships

**Frontal Lobe**
- Initiation
- Problem solving
- Judgment
- Inhibition of behavior
- Planning/anticipation
- Self-monitoring
- Motor planning
- Personality/emotions
- Awareness of abilities/limits
- Organization
- Attention/concentration
- Mental flexibility
- Speaking

**Temporal Lobe**
- Memory
- Hearing
- Expressive and receptive language
- Comprehension of language
- Musical awareness
- Organization & sequencing skills

**Parietal Lobe**
- Sense of touch
- Differentiation of size, color, shape
- Spatial perception
- Visual perception

**Occipital Lobe**
- Visual perception and input
- Reading (perception and recognition of printed words)

**Cerebellum**
- Coordination
- Balance
- Skilled motor activity

**Brain Stem**
- Breathing
- Heart rate
- Arousal/Consciousness
- Sleep/wake functions
- Attention/concentration
Frontal Lobes

- Vulnerable to injury since they sit just inside the front of the skull near a rough bony area.
- Have extensive connections with many brain regions, especially with the parietal lobe and the limbic system (emotions, memory).
- Includes the motor strip:
  - Sends signals to the muscles of the body, telling them what to do.
- **Prefrontal cortex**: located at the very front part of the frontal lobes:
  - Helps hold information in memory for several minutes (referred to as working memory).
  - Regulates emotional responses, motivation, executive functions, working memory.
  - Responsible for teaching a person to learn from consequences.
Frontal Lobes

Motor Strip

Prefrontal Cortex

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Frontal Lobe Injury

Injury damages an individual's ability to . . .

- Synthesize signals from the environment
- Assign priorities
- Make decisions
- Initiate actions
- Attend to tasks
- Control emotions
- Behave and interact socially
- Make plans
Parietal Lobe

- Situated behind the frontal lobes
- Includes the primary sensory cortex which is posterior to the motor strip.
  - The first part of the brain to consciously register physical sensations.
- Regulates responses to touch, heat, cold, pain, and body awareness
When one side of the P lobe is injured, a person may not recognize that anything is wrong with movement on the other side of the body.

Even more complex functions like attention can be affected by damage to the parietal lobes.
Occipital Lobe

- Located in the lower back part of the brain
- The primary **visual** center of the brain
- Involves the visual cortex
  - Connected to the eyes by **optic nerves**
  - Optic nerves carrying signals meet at a "crossing" called the **optic chiasm**
  - The left optic track carries signals from the right-side field of vision, and the right optic track takes signals from the left so that both sides of the brain "see" the same thing.
- Most of what a person "sees" derives its meaning from prior learning and symbolic representations.
Temporal Lobes

- Rest on both sides of the brain
- The centers for language & hearing (left)
  - Broca’s Area
    - located in the lower portion of the motor cortex in the left inferior frontal lobe
    - Controls muscles of the face and mouth and enables the *production* of speech
  - Wernicke’s Area
    - located left temporal–parietal lobe
    - Governs a person’s *understanding* of speech
- With their connections to the *hippocampus*, the temporal lobes help in the long–term storage of permanent memories.
The Possible Effects of Brain Injury

- There may be many changes in how a person thinks, feels, and acts after a brain injury.
- Cognitive, physical, behavioral and emotional changes can greatly affect a person's ability to live independently.
- These changes can affect virtually every aspect of a person's daily existence.
- Most people who have survived brain injury have impairments in several areas, which complicate living independently, working, and relationships with others.
- Changes in behavior after brain injury presents special difficulties.
Functional Impact

- Cognitive impairments can affect activities of daily living
- **Memory problems** are considered to be the most disabling consequence of brain injury
- **Executive functioning** refers to the ability to plan, initiate, direct, and monitor one's activities and are often impacted
  - With impaired executive functioning, a person may not respond to stimulation from the environment in the same way as before a brain injury
- **Initiation problems** may result in a person failing to engage in an important activity unless prompted repeatedly.
Changes in Thinking

- Lack of awareness of deficits (*anosognosia*)
- Confusion about who one is, where one is, and the time (disorientation to person, place, and time)
- Distractibility
- Reduced ability to pay attention
- Difficulty with changes in routine
- Difficulty with basic calculations
- Difficulty with sequencing activities/tasks
Changes in Thinking  

- Impaired ability to evaluate what is important versus trivial (discrimination)
- Relating information or events believed to be true, that have not happened
- Impaired ability to think abstractly
- Perseverative verbal behavior (repeating)
- Difficulty understanding cause and effect
- Impaired safety awareness
- Lack of empathy – doesn’t see other perspective
- Poor insight
Speech and Language Impairments

- Speech and language problems can be either **Receptive** (the ability to understand others) or **Expressive** (the ability to express oneself to others).
- Common Deficits:
  - Impaired word-finding abilities
  - Repetition of words or phrases
  - Disorganized spoken or written communication
  - Incomplete or incoherent expression of thoughts
Sensorimotor Impairments

- **Localized** impairments: affect one extremity or side of the body
- **Generalized** impairments: affect most muscle groups and sensory modalities
Sensorimotor Impairments continued

- Decreased muscle tone (*flaccidity*)
- Paralysis of one or more limbs
- *Paresis* (weakness) in one or more limbs
- Balance problems
- Coordination problems (*ataxia*)
- Difficulty planning muscle movements (*apraxia*)
- Decreased endurance
- Increased muscle tone (*spasticity*)
Sensorimotor Impairments continued

- Vision problems
  - Depth perception
  - Involuntary eye movements (*nystagmus*)
  - Increased sensitivity to light (*photophobia*)
- Swallowing difficulties (*dysphagia*)
- Impaired hearing
  - Ringing in ear (tinnitus)
  - Increased sensitivity to sound (sonophobia)
- Impaired taste
- Impaired ability to smell (*anosmia*)
- Chronic pain
- Increased sensitivity to touch (tactile defensiveness)
Behavioral and Emotional Changes

- Delayed or unresponsive to requests
- Aggression
- Property destruction
- Depression
- Yelling and angry outbursts
- Self-injurious behavior
- Decreased frustration tolerance
- Impulsivity
- Decreased sensitivity to others' feelings
- Paranoia
- Inappropriate sexual behavior
- Hyperactivity
- Immature self-focused behavior
- Hoarding
- *Emotional swings* (affective lability)
Substance Abuse

Immediate or delayed substance abuse can be related to any of the following factors:

- Re-involvement with friends who misuse substances
- Denial that substance abuse is a problem
- Poor coping strategies
- Limited therapeutic recreation outlets
- Limited vocational opportunities
- Pre-injury pattern of use of abuse
- Increased access
- Depression and isolation
- Increased awareness of limitations
Understanding Behavior

- Human behavior is complex.
- Behavior is purposeful and occurs for specific reasons.
- Behavior is controlled by the human nervous system and the environment.
- When brain functioning is altered by an injury, behavior can change.
- Altered behavior occurs as a result of brain injury and is further affected by environmental influences.
Neurologic Influences on Behavior

- When the brain is injured, the ability to perform certain tasks can be affected as can the ability to control unwanted behaviors.
- Damage to the limbic system, or temporal lobes, is often associated with aggression and other emotional responses.
- Damage to the frontal lobe can also result in inappropriate and emotional responding, as well as disinhibition.
- Problems with arousal and lethargy can be related to injury to the brain stem.
Environmental Influences on Behavior

The environment consists of everything in an individual’s immediate surroundings that can affect his/her behavior:

- People
- Stimuli
- Sounds
- Temperature
- Smells
- Lighting
Interaction Guidelines

- Positive: Only discuss the person's successes when the person is nearby.
- Treat everyone with dignity and respect: The most effective staff are those who treat people as unique individuals.
- Don’t talk down to people: Persons in rehabilitation are people like you and I.
- Stay calm: It is most effective to stay calm during crisis situations.
- Don’t take things personally.
- Avoid arguments: Little good comes from arguments.
- Maintain a sense of humor.
General Guidelines for Treatment Planning

- **Person-centered**: Include the individual as much as possible, in the development and design of the treatment plan.
- **Supportive**: Design a plan that makes it very likely the individual will succeed.
- **Simplicity**: Make the plan easy for staff and the individual to understand.
- **Consistency**: Implement the plan consistently.
- **Flexibility**: Make the plan flexible enough to adapt to changes in the individual.
TAKE AWAYS

- A traumatic brain injury can happen to a child or adult of any age, race, gender, religion or socioeconomic status.
- A TBI is a life changing event. It happens in an instant and without warning.
- A TBI changes the family emotionally, socially, physically, and financially.
- A TBI happens every 23 seconds.
- 1 in 5 of you will be affected by this growing public health issue.
Resources

Brain Injury Association of America
www.biausa.org
Brain Injury Association of Wisconsin
www.biaw.org
National Association of State Head Injury Administrators
www.nashia.org
Federal TBI Grant Program
http://www.mchb.hrsa.gov/programs/tbi.htm
Centers for Disease Control and Prevention
www.cdc.gov
Traumatic Brain Injury Model Systems
http://www.tbims.org/
Defense and Veterans Brain Injury Center
http://www.dvbic.org/
Thank you