Traumatic Brain Injury
Restoring Neuroplasticity

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Disclosure

• Nothing to disclose.

Traumatic Brain Injury
Objectives

- Pathophysiology & Epidemiology
- Injury Patterns
- Restoring Neuroplasticity
- Comprehensive Programs
- Prevention
Pathophysiology & Epidemiology

Annual U.S. TBI Statistics

- 2.5 million new TBIs
- 50,000 deaths
- 85,000 long term disabilities
- >5.3 million suffering in the U.S.

https://www.cdc.gov/traumaticbraininjury/get_the_facts.html

Outcomes

- TBI is Chronic & Evolving
- TBI is a risk factor neurological illnesses:
  - Epilepsy
  - Stroke
  - Neurodegenerative Disease
    - (Parkinson’s > Alzheimer’s)


3 Cardinal Elements of a TBI

- Consciousness
- Post Traumatic Amnesia
- Glasgow Coma Scale
**Consciousness**

<table>
<thead>
<tr>
<th>Coma Duration</th>
<th>Clinical Outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 2 weeks</td>
<td>Good</td>
</tr>
<tr>
<td>&gt;4 weeks</td>
<td>Poor</td>
</tr>
</tbody>
</table>

**Post Traumatic Amnesia**

<table>
<thead>
<tr>
<th>Duration</th>
<th>TBI Severity</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 5 minutes</td>
<td>Very Mild</td>
</tr>
<tr>
<td>5-60 minutes</td>
<td>Mild</td>
</tr>
<tr>
<td>1-24 hours</td>
<td>Moderate</td>
</tr>
<tr>
<td>1-7 days</td>
<td>Severe</td>
</tr>
<tr>
<td>1-4 weeks</td>
<td>Very Severe</td>
</tr>
<tr>
<td>&gt;4 weeks</td>
<td>Extremely Severe</td>
</tr>
</tbody>
</table>

**Glasgow Coma Scale**

<table>
<thead>
<tr>
<th>GCS Score (3-15)</th>
<th>TBI Severity</th>
</tr>
</thead>
<tbody>
<tr>
<td>13-15</td>
<td>Mild</td>
</tr>
<tr>
<td>9-12</td>
<td>Moderate</td>
</tr>
<tr>
<td>3-8 (&lt; 8 = Intubate)</td>
<td>Severe</td>
</tr>
</tbody>
</table>


### Sources of Brain Injury

- **Physical**
- **Physiological**
- **Mental/Emotional**

### Injury Patterns

#### The Spectrum

### Glasgow Coma Scale

<table>
<thead>
<tr>
<th>Response</th>
<th>Points</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eye Opening Response</td>
<td></td>
</tr>
<tr>
<td>Eyes open spontaneously</td>
<td>4 Points</td>
</tr>
<tr>
<td>Eyes open to verbal command, speech, or shout</td>
<td>3 Points</td>
</tr>
<tr>
<td>Eyes open to pain (not applied to face)</td>
<td>2 Points</td>
</tr>
<tr>
<td>No eye opening</td>
<td>1 Point</td>
</tr>
<tr>
<td>Vertical Response</td>
<td></td>
</tr>
<tr>
<td>Oriented</td>
<td>5 Points</td>
</tr>
<tr>
<td>Confused conversation, but able to answer questions</td>
<td>4 Points</td>
</tr>
<tr>
<td>Inappropriate response, words incoherent</td>
<td>3 Points</td>
</tr>
<tr>
<td>Incoherently sounds or speech</td>
<td>2 Points</td>
</tr>
<tr>
<td>No verbal response</td>
<td>1 Point</td>
</tr>
<tr>
<td>Motor Response</td>
<td></td>
</tr>
<tr>
<td>Obey commands for movement</td>
<td>6 Points</td>
</tr>
<tr>
<td>Purposeful movement to painful stimulus</td>
<td>5 Points</td>
</tr>
<tr>
<td>Withdraws from pain</td>
<td>4 Points</td>
</tr>
<tr>
<td>Abnormal (spastic) flexion, decorticate posture</td>
<td>3 Points</td>
</tr>
<tr>
<td>Extensor (rigid) response, decorticate posture</td>
<td>2 Points</td>
</tr>
<tr>
<td>No motor response</td>
<td>1 Point</td>
</tr>
</tbody>
</table>

Minor Brain Injury < 13.5 points. Moderate Brain Injury > 9-12 points. Severe Brain Injury > 3-6 points.
Physical – Trauma

• Falls
• Assault
• Firearms/Blast
• MVA
• Multiple concussions
• Chronic Pain

Physiological

• Anoxic/Hypoxic
  – MI, CVA, Respiratory Failure, Low Blood Pressure, Near Drowning
• Toxic Chemical
  – Insecticides, Carbon Monoxide, Lead Poisoning, Anesthesia
• Infection
  – Encephalitis, Meningitis
• Tumor
  – Mass Effect, Surgical Complication

Mental - Emotional

• PTSD
• Anxiety
• Depression
• Chronic Pain
Chronic Pain & Brain Injury

Chronic Back Pain is Associated with Decreased Prefrontal and Thalamic Matter Density

• Decreased Volume α Pain Duration
• 1.3 cm³ loss of gray matter for every year of chronic pain


Symptoms of Brain Injury

Review of Systems

Unknown, Unidentified, Undetected

• Constitutional
• HEENT
• Cardiovascular/Pulmonary
• Gastrointestinal
• Musculoskeletal
• Neurological
• Psychiatric

Overwhelming ROS

Constitutional

• Constitutional: changes in mood, appetite, sleep, energy, stamina, memory, concentration, mental clarity, cognitive function, vision, balance, coordination
• Body: weight loss, labile mood, anxiety, depression, decreased quality of life

Eyes

• Visual changes (blurry vision), sudden visual loss, light sensitivity, double vision

Head, ears, nose, mouth, and throat

• Sinus pain (CN I), headache
• Stuffy nose, ear pain, ringing in ears (CN VIII), ear infections
• Loss of smell (CN I)
• Disorder of facial expression, taste

Cardiovascular

• Exercise intolerance, nausea, palpitations

Respiratory

• Shortness of breath

Gastrointestinal

• Abdominal pain, indigestion, cramping, diarrhea, constipation

Musculoskeletal

• Spasticity, decreased range of motion, difficulty with walking, poor balance, back pain

Neurological

• Changes in sight (CN II), smell (CN I), hearing (CN VIII) and taste (CN VII & VIII), headache, speech problems, memory problems, increased susceptibility to seizures

Psychiatric

• Depression, anxiety, irritability, loss of energy, sleep disturbances, memory problems, difficulty concentrating, changes in personality
Occam’s Razor vs. Hickam’s Dictum

- Unifying Diagnosis (Occam’s)
  - Assume a single diagnosis for multiple symptoms

- Multiple Diagnoses (Hickam’s)
  - Assume multiple diagnoses for multiple symptoms

Restoring Neuroplasticity

Mechanisms

- Neuronal Sprouting
  - Intact axons establish synaptic connections in the damaged area.

- Functional Reorganization
  - Healthy neuronal structures not previously used for a given purpose are reassigned to take over a lost function.

The Spectrum

A Glorious Mess
### Level of Evidence

<table>
<thead>
<tr>
<th>Quality</th>
<th>Definition &amp; Degree of Certainty</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>High</td>
</tr>
<tr>
<td></td>
<td>Confident in conclusions</td>
</tr>
<tr>
<td></td>
<td>Multiple high-quality studies with consistent results</td>
</tr>
<tr>
<td></td>
<td>Special cases: one large, high-quality multi-center trial</td>
</tr>
<tr>
<td>B</td>
<td>Moderate</td>
</tr>
<tr>
<td></td>
<td>Confident, but open to future research</td>
</tr>
<tr>
<td></td>
<td>One high-quality study</td>
</tr>
<tr>
<td></td>
<td>Several studies with some limitations</td>
</tr>
<tr>
<td>C</td>
<td>Low</td>
</tr>
<tr>
<td></td>
<td>Open to future research</td>
</tr>
<tr>
<td></td>
<td>One or more studies with severe limitations</td>
</tr>
<tr>
<td>D</td>
<td>Very Low</td>
</tr>
<tr>
<td></td>
<td>Uncertain in conclusion</td>
</tr>
<tr>
<td></td>
<td>Expert opinion</td>
</tr>
<tr>
<td></td>
<td>No direct research evidence</td>
</tr>
<tr>
<td></td>
<td>One or more studies with very severe limitations</td>
</tr>
</tbody>
</table>

### Laws of Physics & Matching

- Physical
- Physiological
- Mental/Emotional
Physical

- Restore Physiological Motion
  - Osteopathic Manual Medicine
  - Exercise

Osteopathic Manual Medicine
Knee vs. Cranium

Jugular Foramen
Osteopathy & Brain Injury

• N = 11 retired NFL players with post concussive syndrome
• Manual Therapy – 10 sessions
  – Craniosacral Therapy, Visceral Manipulation, Neural Manipulation
• Results – Systemic Improvements
  – Pain (P = 0.044), ROM (P = 0.037), Memory (P = 0.015) Cognition (0.033)
  – Sleep (2 hour baseline increased to 4 hour, continued increase at 3 month follow up)


Exercise & Brain Injury

• Exercise Alters Gene Expression to regulate synaptic and cognitive plasticity via Brain-Derived Neurotrophic Factor (BDNF)
  – Cognitive Function & Flexibility
  – Memory
  – Depression, Anxiety

Neuroscience and Biobehavioral Reviews 80 (2017) 443–456

Exercise & CSF Flow

• Accelerated Glymphatic Clearance Efficiency
• Decreased Aβ Accumulation
• Improved Cognition

Physiological

- Anoxic/Hypoxic
  - Hyperbaric Oxygen Therapy
- Toxic Chemical
  - Detoxification – Microbiome
- Infection
  - Restore Immune Function
- Tumor
  - Surgery, Oncology

Hyperbaric Oxygen Therapy

The favorable outcomes seen in patients undergoing hyperbaric therapy substantiate its utility in the treatment of traumatic brain injury.

Hyperbaric Oxygen Therapy
FDA Approved Conditions

- Non-healing wounds
- Carbon monoxide poisoning
- Necrotizing soft tissue infections
- Osteomyelitis
- Intracranial abscess
- Gas gangrene
- Radiation tissue damage
- Air or gas embolism
- Decompression sickness (The Bends)
- Thermal burns / skin grafts
- Exceptional blood loss
- Crush injury
- Artificial insufficiencies

Hyperbaric Oxygen Therapy
Non-FDA Approved Conditions

- Traumatic brain injury
- Stroke
- Myocardial infarction
- Cerebral Palsy
- Coma
- Bell's palsy
- Parkinson's disease
- Chronic fatigue syndrome
- Macular degeneration
- Cancer
- Chemotherapy recovery
- Amputation recovery
- Limb / digit injuries
- Surgical recovery
- Arthritis
- CRPS
- Multiple sclerosis
- Migraines / headaches
- Staph infection
- Dementia
- Epstein-Barr
- Lyme disease
- Tuberculosis
- Aids
- Autism
- Spider / snake bites

Detoxification – Microbiome

Microbiota-Gut-Brain Axis & CNS.
- Bidirectional communication
  - Nervous, Endocrine, Immune
- All organs are connected
- Gut microorganisms α CNS function

Microbiome & Brain Function

- Microbiota composition influences miRNA which has implications for appropriate:
  - Neuronal development
  - Neurogenesis
  - Brain-Derived Neurotrophic Factor signaling

Immune Function

Brain Lymphatic Drainage

- Glymphatic System
  - Glial-Dependent CSF/Lymphatic System
- CSF Drainage Routes
  - Olfactory/Cervical Lymphatic Drainage Route
    - cribriform plate of the ethmoid bone, between the olfactory bulbs and the nose at the anterior aspect of the brain is a key extracranial site of CSF outflow to cervical lymph nodes

Brain Lymphatic Drainage System Function

- Pressure Regulation (ICP, ISF, & CSF)
- Maintain Water & Ion Balance
- Clearance & Reabsorption of Macromolecular Solutes
- Immune Surveillance & Communication

Dysfunctional Brain Lymphatic Drainage Consequences

Accelerated Brain Degeneration
- Neuroinflammatory
- Neurodegenerative
- Neurovascular

Brain Lymphatic Drainage System Regulation

- Respiration
- Body Posture
- Cardiac Pulsations
- Sleep-wake cycle
- Aging
- Genetics

Dysregulation
- Traumatic Brain Injury
- Stroke
- Alzheimer’s Disease
- Neuroinflammation
- Brain Edema
- Lymphedema (Brain)
Mental - Emotional

- Low BDNF levels = High Depression
- Mood Disorder Prior to TBI → Increased Likelihood of Developing a Depressive Disorder

Presse Med. 2017 Sep 14

Comprehensive Programs

Address The Source

Physical - Motion
Physiological
Mental/Emotional

Dean Ornish - Model of Care

Nutrition
Mindfulness
Exercise
Social Support
Restore Neuroplasticity

Address The Risks

Physical
Physiological
Mental/Emotional

Resilience

Higher Post TBI Resilience Associated With:
• Greater Life Satisfaction
• Low Disability Level
• Lower Anxiety
• Absence of Pre-Injury Substance Abuse
• Socioeconomic Status

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