Acquired Brain Injury:
Functional vs. Behavioral Approach to Rehabilitation

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Acquired Brain Injury

- Definition: Injury or damage to the brain, that occurs after birth and results in neurological dysfunction
  - Does not include prenatal brain injury
  - Does not include neurodegenerative disorders***
  - Typically grouped into internal or external causes

Acquired Brain Injury***

- Definition varies within community
- Some studies, definition reflects functional symptoms as opposed to actual structural damage
- Prevalence may be variable due to self reporting studies

Acquired Brain Injury

- Internal Injury
  - Stroke
  - Surgery
  - AVM
  - Tumor
  - Aneurysm

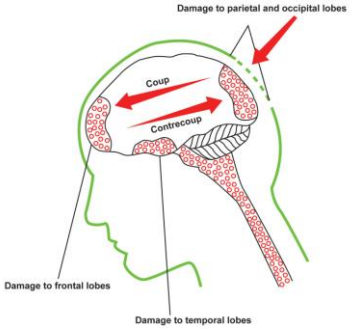
Acquired Brain Injury

- External
  - Closed
  - Penetrating

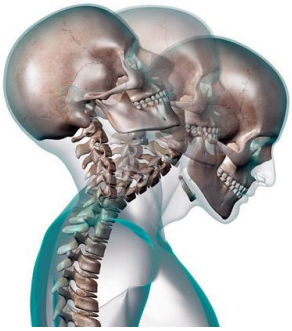
Acquired Brain Injury

- Causes
  - Head Trauma
  - Hypoxia
  - Infection
  - Tumor
  - Chemicals
  - Cerebral Vascular Accident

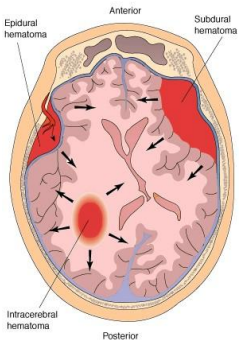
Pathophysiology
Coup Coutrecoup



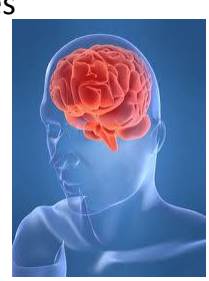
Pathophysiology
Diffuse Axonal Injury



Pathophysiology Hematoma



Brain Injuries



- Prevalence
  - TBIs: 5.3 million
  - Stroke: 5.8 million
- Incidence
  - TBIs: 1.4 million/year
  - Stroke: 700,000/year
    - 500,000 first time CVA
    - 200,000 prior CVA
    - 57 billion in cost
    - Leading cause of long-term disability

Increase in TBI

- According to CDC, between 2002 and 2006
  - 1.7 million civilians sustain TBI annually
  - 1.4 Million treated and released from Emergency treatment
  - 275,000 were hospitalized
  - 52,000 people died from TBI each year

Increase in TBI

- Causes of TBI in US between 2002-2006
  - Falls 35%
  - Motor Vehicle Accidents 17%
  - Strike to head 16.5%
    - Sports and Work-related injuries
  - Assault 10.%
  - Unknown causes 21%

Traumatic Brain Injury

- Causes of TBI resulting in death
  - Firearms 34.8%
  - Motor Vehicle 31.4%
  - Falls 16.7%

TBI…the good news

- Increased survival rates
- TBI awareness and public health
  - Improved medical care
  - Seatbelt use
  - Helmet use
  - Safety education programs

CDC Survey of TBI deaths (1997-2007)

Pediatric Brain Injury

- According to CDC, 475,000 children suffer TBI each year
- 8-11% of patients are hospitalized
- Common cause of acquired childhood disability
  - Cognition and education
  - Adaptive Function
  - Behavior

Pediatric Brain Injury

- More common in males
- Common causes
  - Motor Vehicle accidents
  - Falls
  - Abuse
  - Sports related injuries

Pediatric Brain Injury

- Abuse is more common in children less than 1 year old
  - 29.7 per 100,000 in first year of life
  - 3.8 per 100,000 in second year of life
  - Presence of retinal hemmorhages and subdural hematoma are more common among abuse cases
    - Reese and Seege

Pediatric TBI

- Recovery rates directly correlated to severity of injury (Anderson, 2009)
  - Study of children age 2-5, at 5 year follow up
    - Severe TBI correlated to lowest cognitive scores
    - IQ reduced in all TBI groups compared to controls
    - Length/depth of coma also correlated to reduced cognitive function
    - Potential for developmental gain after period of recovery

Rehabilitation Professionals

- Optometrist
- Neurologist/neurosurgeon
- Physiatrist
- Occupational Therapist
- Physical Therapist
- Speech Therapist
- Neuropsychologist

Rehabilitation Team

- Rehabilitation requires evaluation and integration of multiple disciplines
- Visual effects of ABI may complicate other areas of rehabilitation
  - Neglect
  - Diplopia

Rehabilitation Team

- Depending on referral source, may have access to extensive information about rehabilitation thus far
- Communication is key
  - Visual rehabilitation
  - Activities and therapies by other specialists
  - Develop relationships

Role of Vision

- 80-90% of what we perceive is through visual system
- Vision problems interfere with mobility, reading, activities of daily living, social life
- Vision problems in Brain Injury are often misdiagnosed as we tend to rely only on patients complaints and not look at a whole patient.

Role of Vision Rehabilitation Doctor

- Diagnose and treat patients with ocular and visual deficits
- Counsel the patient and family as to the visual sequelae resulting from the brain injury
- Counsel the patient, family, physicians and therapists as to how to compensate for the patients visual deficits.
- Focus on patients Function

Neurology

- 20% of peripheral retinal fibers go to midbrain
- Superior colliculus
  - Afferent fibers: Optic tract, occipital cortex, spinotectal tract
  - Efferent fibers: Spinal cord, LGN, cerebral cortex via midbrain
- Visual info matched with kinesthetic, proprioceptive, tactile, and vestibular info
- Organizes spatial info about balance, movement, and orientation in space
- Theory: Feedforward info to occipital cortex to preprogram it how to spatially organize incoming visual info (called ambient visual process)
- Allows awareness of targets before we even look to identify and discriminate detail

Areas of the Brain that are affected

- Frontal
  - Emotions
  - Reasoning
  - Saccadic Control
  - Reduced Blink Rate
- Temporal
  - Memory
  - Visual Processing
  - Visual Field deficit
  - Speech language

- Occipital
  - Cortical visual impairment
  - Homonymous field defects
- Parietal
  - Visual Field deficits
  - Movement
  - Orientation

Areas of the Brain that are affected

- Brainstem
  - Balance
  - Cranial nerves associated with EOM's blinking and pupils
  - Balance, dizziness, nausea

- Cerebellum
  - Coordination of movement
  - Disturbances in visual motor coordination
  - Nystagmus

Efferent system

- Nystagmus
- Diplopia
  - Cerebellum
  - Brainstem
  - Cranial nerves
    - Phoria
    - Vergence dysfunction
    - Skew Deviation

Afferent system

- Blurred Vision
- Visual Field Loss
  - Optic atrophy
  - Chiasm
  - Optic Radiations

Cerebral Edema

- Responsible for approximately 50% of deaths related to TBI
- Level of edema is related to prognosis of recovery

Cerebral Edema

- Cellular
  - Increase in water content of cell
  - Failure of ATP dependent Na2+ and K+ pumps
  - Typically observed in ischemic events and severe TBI
  - Water influx from extracellular to intracellular space
    - No overall change in water content of brain
    - No change in ICP
    - Reduces cellular function

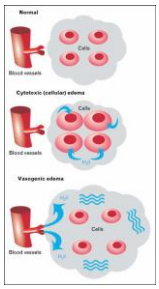
Cerebral Edema

- Vasogenic
  - Increased H20 comes from vasculature to extracellular space
  - Characterized by open Blood-Brain Barrier
  - Results in increase in water content of brain
  - Characteristic of brain tumor, infection, TBI, intracerebral hemorrhage and inflammation
  - Will cause a rise in ICP

Osmotic Edema

- Tissue is high in electrolytes
- Extracellular fluid is low
- Results in increased cell size
- Decreased Cell function
- Contributes the least to cerebral edema

Cytotoxic vs. Vasogenic Edema



- Donkin and Vink, 2010

Increased Intracranial Pressure

- Compression of blood vessels
- Reduced tissue blood flow
- Reduced oxygenation of tissue
- Alters position of tissue
  - Leads to Herniation
  - Decreased respiration
  - Reduced cardiac function

Increased Intracranial Pressure

- Blood brain barrier most permeable 4-6 hours after TBI
- Decrease in permeability at 7 days
- Highest water content 2-3 days s/p TBI

Rehabilitation Prognosis vs Pathophysiology

- Symptoms often far worse than signs
- Signs are poor at predicting level of functional impairment
- Often no defects found on MRI or CT scans
- Microtrauma and neuron necrosis from stretching and shearing force on nerves

Rehabilitation Prognosis vs Pathophysiology

- Categorize Brain Injury by presenting signs and symptoms
- Use tests that are easy to perform in any environment, by any professional
- Glascow Coma scale commonly used

Glascow Coma Scale

Table 1: THE GLASGOW COMA SCALE AND SCORE

Feature	Scale Responses	Score Notation
Eye opening	Spontaneous To speech To pain None	4 3 2 1
Verbal response	Orientated Confused conversation Words (inappropriate) Sounds (incomprehensible) None	5 4 3 2 1
Best motor response	Obey commands Localise pain Flexion – Normal – Abnormal Extend None	6 5 4 3 2 1
TOTAL COMA 'SCORE'		**3/15 – 15/15**

Pediatric Brain Injury

- Pediatric Glascow Scale

Table 1 **Modified Glasgow coma score**

Score	Response	Response	Response
Eye opening	> 1 year	0–1 year	
4	Opens spontaneously	Opens spontaneously	
3	Opens to a verbal command	Opens to a shout	
2	Opens in response to pain	Opens in response to pain	
1	No response	No response	
Best motor response	> 5 years	2–5 years	0–23 months
5	Oriented and able to converse	Uses appropriate words	Cries appropriately
4	Disoriented and able to converse	Uses inappropriate words	Cries
3	Uses inappropriate words	Cries and/or screams	Cries and/or screams inappropriately
2	Makes incomprehensible sounds	Grunts	Grunts
1	No response	No response	No response
Best verbal response	> 1 year	0–1 year	
6	Obeys command	Spontaneous	
5	Localizes pain	Localizes pain	
4	Flexion withdrawal	Flexion withdrawal	
3	Flexion abnormal (decorticate)	Flexion abnormal (decorticate)	
2	Extension (decerebrate)	Extension (decerebrate)	
1	No response	No response	

Modified Glascow Coma Scale

- Grades severity of brain injury
  - Important to know for recovery prognosis
- Total score ranges from 3-15
  - Severe=3-8
  - Moderate=9-12
  - Mild=13-15

Pediatric Brain Injury

- 81% are Mild
- 8% are Moderate
- 6% are Severe
- 5% are Fatal

Exam Modifications

- Traditional exam methods may need modification depending on sequelae of ABI
  - Communication Deficit
    - Aphasia
  - Motor Deficit
    - Apraxia
    - Muscle Tone

Visual Acuity

- Visual Discrimination
  - Letters vs. Numbers
  - Shapes
  - Grated Acuity

Visual Field

- Confrontation Field
- Automated Visual Field
- Goldmann Visual Field
- Arc Perimeter

Color Vision

- Ishihara
- HRR
- Color Blocks

Visual Disorders with ABI

- ~30% of people with ABI have visual disorders (Clark 2005)
- Growing area of needed assessment
  - Impact cognitive rehabilitation
  - Worsen rehabilitation progress of physical deficits

Visual Complaints

- Cockerham et al evaluated 108 TBI in Polytrauma site
  - 75% of patients report visual complaints
  - 57% Reading difficulties
  - 40% convergence insufficiency
  - 31% accommodative insufficiency
  - 29% pursuits and saccadic insufficiency

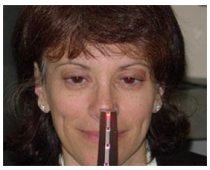
Symptoms

- Blurred vision
- Diplopia
- Headaches
- Vertigo, dizziness, balance disorders (especially with moving visual field)
- Inability to sustain attention on visual tasks
- Objects appear to move
- Spatial disorientation
- Asthenopia
- Poor concentration and attention/staring behavior
- Movement of print when reading

Symptoms - Photosensitivity

- 44% report specific discomfort
  - Fluorescent > incandescent
- 30-60% report general sensitivity
- Treatment
  - General sensitivity - brown tints
  - Fluorescent – light blue tints
  - Outdoor – dark brown
  - Coatings – AR

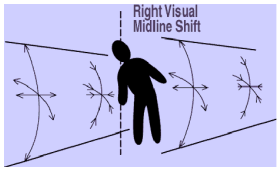
Signs



- Most Common in TBI patients
  - Vergence disorder 56%
    - Convergence Insufficiency
- Most Common in CVA Patients
  - Version disorder 57%
    - Saccades
- Cranial Nerve palsy
  - Rare 7%
- Extraocular Muscle Palsies
  - 75% Resolve 6-12 months by themselves

Signs

- Poor fixations and saccades, jerky pursuits
- Subsequent exotropia or exophoria
- Reduced accommodative amplitudes and facility
- Reduced vergence ranges
- Visual midline shifts
- Postural shifts
- Nystagmus



Functional Rehabilitation

- Functional vision encompasses more than visual discrimination
  - How vision and environment interact
  - How available vision information and visual processing interact
  - Related to visual skills and cognitive abilities

Warren's Hierarchal Model

- Basic function: vision, ocular motor control, visual fields
  - Aids in scanning, obtaining visual information
- Mid level: Visual memory and pattern recognition
  - ability to manipulate visual information in mind
- Higher level: Visual cognition
  - Integration of all levels of information and use information with other senses and visual information

Brain Plasticity

- Adaptive capacity to change, learn and remember (Zoltan)
  - Three mechanisms
    - Regeneration of damaged nerves
    - Create new connections among remaining neurons
    - Circumvent damaged areas and train new processing pathways

Restore vs. Compensation

- Functional vision rehabilitation requires decision to implement appropriate strategies
  - Restorative strategy
  - Compensatory strategy

Compensatory teaching

- When brain plasticity is less likely to be trainable
  - Significant damage to visual pathway/processing pathway
  - Less time for in office therapy
- Use alternate processing mechanism to obtain visual or cognitive information

Warren's Hierarchal Model of Visual Processing

- Integration of differently levels of visual skills within the matrix of visual processing
- Complex visual tasks require integration of basic visual skills to build a foundation
- Deficits of basic function impact complicated visual tasks

Restore vs Substitute

- Nihls identifies "restitution vs substitution
  - Is recovery possible?
  - Is damage reversible or permanent?
  - Is another area of the brain able to contribute to visual function and awareness?

Is recovery possible?

- What can be restored?
- What can be improved?
- What is not fixable?
- How do we know?

If recovery is possible

- Develop rehabilitation plan to restore function
- Assess current function and set realistic goals for improvement
- Utilize Vision therapy techniques
- Utilize low vision rehabilitation techniques

When recovery isn't possible

- Severe damage to visual pathways
- Patients not able to participate in rehabilitation
  - Proximity
  - Insurance
- Limited access to resources
- Poor support system

When restoration isn't possible…

- Use Compensatory techniques
  - Sight substitution
    - Talking clocks
    - Books on Tape
  - Enlargement of text
    - Reduce saccades

Patient centered success

- Cognition
- Learning capacity
- Awareness of potential
- Complexity of task

Improving outcomes

- Family awareness
- Interaction with all caregivers
  - Need to ensure caregiver is able to function in proper capacity
  - Motivation of all in care plan

Field Enhancement

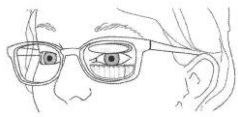
- When field loss is present, field enhancement devices can be useful to improve awareness
- Prism is one of most well known devices among rehab professionals
- Need to ensure cognition and visual acuity are able to respond to such techniques
- Need to ensure patient has adequate scanning skills

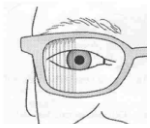
Field Enhancement

- Mobility
  - Prism
  - Mirror system
- Near point tasks
  - High contrast borders
  - Tactile

Peli vs Sectoral Prism

Peli Peripheral Prism	Sectoral Prism
Gaze directed into the prism free area	Gaze directed into the prism
Peripheral Diplopia	Central Diplopia (Foveal Double Vision)
20 degree field expansion	10 degree field expansion
Passive Looking	Attentive Looking
No prismatic jump	Prismatic jump
Carrier lens is unaffected	Carrier lens is affected
Cosmetically noticeable	Cosmetically pleasing once ground in





To Fresnel or not Fresnel???

- To Fresnel
  - >12 diopters
  - Temporary treatment
  - Cost
  - Sectoral Placement
  - Clarity and appearance are not important
  - Weight is a factor

– Sutter

To not Fresnel

- Permanent prescription
- Low amount of prism
- Clarity and cosmesis is necessary
- Cost
- Prism is prescribed throughout the full field

• Sutter

Filters

- Assess glare complaints
  - Disability
  - Discomfort
- Assess contrast complaints
  - Indoors
  - Outdoors

Lighting

- Lighting is critical in patients with ABI
  - Warmth of bulb
  - Flicker
  - Positioning of light
  - Wattage vs Dimmer
  - Environmental evalution
    - Home
    - Office
    - School

Contrast Enhancement

- Lighting
- Filters
- Adaptive writing
- Typoscopes (check writing, envelope)
- Assistive technology??

Assistive Technology

- Is there a place in ABI rehabilitation for assistive technology?
  - Limited research for use of such devices with ABI patients
  - Stigma of low vision devices
  - Access to assistive tech in some rehabilitation settings

Assistive Technology

- Benefits of electronic magnification:
  - Reduce photophobia with inverted contrast
  - Enlarged text may reduce saccadic errors
  - Can reduce figure ground
  - Alter color scheme and reduce brightness
  - Portable options

Assistive Technology

- Benefits of auditory devices
  - Auditory pathways may be more efficient than visual
  - Eliminates visual fatigue
  - Keeps desirable pace
    - Students /vocation
    - Leisure activities

Computer based

- Basic contrast and color settings
- Windows accessibility
- Apple
- Zoom Text
  - Later version allow text or speech

Assistive Technology

- Microsaccadic dysfunction reduces reading efficiency
  - Convert text to speech
  - Enlarge text to reduce need for

Behavioral Rehabilitation

- Behavioral/Developmental
  - Visual information processing
  - Bimodal
  - Ambient system (where)
  - Focal system (what)

Post Trauma Vision Syndrome (PTVS)

- Patients exhibit the following characteristics:
  - Exotropia
  - High exophoria
  - Reduced near point of convergence
  - Accommodative dysfunction
  - Oculomotor dysfunction

Visual Midline Shift Syndrome

Signs and Symptoms

- Floor may appear tilted
- Walls and/or floor may appear to shift and move
- Veering during mobility
- Person leans away from the affected side
- Feelings of imbalance or disorientation similar to vertigo

Perceptual Testing

- VIP: Visual Analysis and Visual Motor Testing
  - DTVP-A
    - Form Constancy
    - Figure Ground
    - Visual Closure
    - Visual Motor Search
    - Visual Motor Speed
    - Copying
  - CTMT
  - TVPS-3
    - Visual Memory
    - Visual Sequential Memory

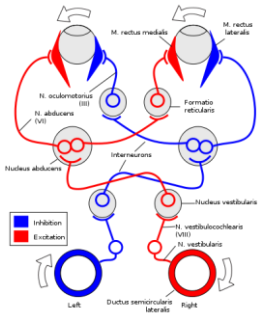
Visual-Vestibular Dysfunction (Gaze Stabilization)

- CN III and VI communicate with CN VIII via the MLF to generate the horizontal vestibulo-ocular reflex
- VOR
  - Stabilizes the visual world while the head is in motion
  - Maintains stable vision w/rapid head motion up to 400º per second

TBI and Vestibular Dysfunction

- Symptoms more than signs
- Visually-stimulating environments
- Stores, new enviroments
- Dizziness/nausea/motion sickness

VOR – Vestibulo Ocular Reflex Testing



Conclusion

- Vision Rehabilitation of ABI is essential and optometry plays a key role in the complicated puzzle of brain rehabilitation.
  - Should be considered in patients with any kind of brain injury
  - Especially in cases when patients symptoms do not match signs.