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Acquired Brain Injury in Children: More Common than You Think

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Disclosure of Conflicts of Interest

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Title: Acquired Brain Injury in Children: More Comment Than You Think

I have NO RELEVANT FINANCIAL relationships and/or commercial interest.
Directed To Primary Care OD’s

• At the end of this two hour presentation the participants will:
• 1. Have a higher sensitivity to Acquired Brain Injury (ABI) and particularly among the young athlete
• 2. Have a better understanding of the diagnosis of ABI, including a review of the Glasgow COMA scale
• 3. Understand basic optometric diagnostic and therapeutic strategies that include ergonomics, lens systems, and therapeutics
• 4. Be better able to integrate their patient care with specialty areas in optometry, physiatry, neurology, psychology, physical and occupational therapy.
Brain Damage: Stroke/Trauma

“Life is never the same after brain damage... but it can still be great”
Stroke Review: An Older Problem

Embolism
Aneurysm/Hemorrhage
Epidemiology of Stroke

• Mostly Older: 1/10 Deaths from Stroke
• 3 or 4th Leading Cause of Death
• 100,000 Deaths/Year
• 4-700,000 Incidents/Year
• Thrombi & Emboli = 65% to 80%
• Hemorrhage = 20% to 35%
Newspaper Man with a Stroke

• 65 year old man Encounters Brain Stem Stroke
• Undergoes Physiatry and Ophthalmological Tx
  – Occupational and Physical Therapy for Motor Skills
• Sees Diplopic
  – Ophthalmological Tx-Wear a Patch
  – Diplopia Interferes with Driving and Golf Game
  – Referred by Golf Partner who works at SCO
Visual Signs

- VA’s Good c Rx (Bifocal)
- Ocular Motility Good (Monocularly)
- Binocular (Appx 40 ^ Esotropia-Far and Near)
- Perceptual, Cognitive and Executive Skill Normal for Age
- **Stereo Test at about 6 inches elicits Binocularity**
Vision Rehabilitation

• Stereo Rock
  – Sits at about 6 inches and appreciates Stereo (Quoits in Polachrome Orthopter)
  – Slowly begins to Rock Back
  – Eventually Stands and can appreciate Stereo
  – Slowly begins to walk backwards: If Stereo is lost-rocks forward until Stereo is regained
  – 9th Session: At the back of the room with Stereo
  – Released without Diplopic Sx for Driving or Golf
Your Brain

• Circulation
• Anatomy
• Function
Cerebral Lobes and Vision
With Knowledge of Brain Function, One Can Deduce Part of Brain that is Impacted by Stroke

Based on actions that are abnormal
1. Primary Visual Cortex (Retina, Optic Nerve, Optic Tract, Lateral Geniculate, Radiations, Cortex) Chiasm: Temporal half retina projected to same side of brain and Nasal half to opposite side
2. Superior brain projects inferior field & Inferior brain projects superior field
3. Spatial map of the retinal field
4. One occipital lobe damaged, homonymous heminopsia
5. Occipital lesions can cause visual hallucinations
6. Lesions in the parietal-temporal-occipital (POT) associated with color, movement and eye hand (writing skills)
Occipital Lobe

• The Further One Moves Anterior in the Cortex the More Abstract the Function
  – Posterior: Visual Fields
  – More Anterior: Eye Hand Coordination
  – At the Junction of the Parietal, Temporal and Occipital Lobes
    • Color
    • Eye Hand Coordination
    • Hand Writing Skill
Occipital Stroke

- 60 Year Old Female Native American
- Visiting Relatives and on the trip Begins to Have a Headache That Worsens with Time
- Eventually Notes that She is Not Seeing as Well as She Should
Cerebral Lobes and Vision
Parietal Lobe

1. The parietal lobe: **integrates sensory information from body parts**
2. Knowledge of **numbers and their relations**
3. **Manipulation of objects**
4. **Processing** information related to **touch**
5. **Visuo-spatial processing (Non Optic Pathway)**
   - No synapse in LGN-Goes to Tectal Area/Superior Colliculus-To Pulvinar-To Parietal Cortex
6. Posterior parietal cortex: the **dorsal stream of vision**: 'where‘ stream (**Location**) & 'how' stream (**Action**) 
7. The posterior parietal cortex (PPC) receives somatosensory and/or visual input (2nd **Ocular Pathway**)
8. Motor signals to control **movement of: arm, hand and eye**
Cerebral Lobes and Vision
Temporal Lobe

• Combines **auditory** and **visual** information

• **Superior** (upper) and medial (central) aspect **auditory input** from thalamus from ears

• **Inferior** (lower) part of the temporal lobe processes **visual objects and pattern recognition**

• **Medial and anterior** parts involved in very high-order visual recognition (faces, for example) and recognition
Cerebral Lobes and Vision
Frontal Cortex

1. Executes behavior from control of muscles to high level abstract planning about what to do

2. Frontal cortex “polarized” from back to front of cortex (4 Areas)

3. 
Frontal Cortex

Area 1

Farthest back (central sulcus)

Primary Motor-little man): neural wires go almost directly to muscles
4. More Anterior:

*Pre-Motor* areas to *organize and sequence movements (Plans for Movement)*

In front of this area but within the *Pre-Motor* are *abstract planning levels, muscles sequences, (tennis or golf shot)* or decision to (or not) to move
Pre-Frontal Cortex Area 3

The prefrontal cortex:

In humans **majority** of the frontal lobe:

- Crucial to **performance of skills requiring intelligence**

- Larger in primates, **larger in humans** than in other primates

- Correlated with **high level planning**
Orbito-Frontal Cortex Area 4

1) The orbito-frontal cortex:
Anterior and medial part of the prefrontal cortex Governs risk and reward (morals)
May have normal or superior intelligence (IQ tests) but lack concept of manners/appropriate actions and may lose almost all risk aversion
The Classic Brain Trauma Case

- Phineas Gage (1823-1860)
- Railroad Construction Foreman
- Blasting Rock: Accident Drives a Tamping Iron into his Head
- "the most efficient and capable foreman in their employ"....same employers, after Gage's accident, "considered the change in his mind so marked that they could not give him his place again": 
Gage

• Previous to his injury, although untrained in the schools, he possessed a well-balanced mind, and was looked upon by those who knew him as a shrewd, smart businessman, very energetic and persistent in executing all his plans of operation. In this regard his mind was radically changed, so decidedly that his friends and acquaintances said he was "no longer Gage".
Gage

- The equilibrium or balance... between his intellectual faculties and animal propensities... have been destroyed.... fitful, irreverent, indulging at times in the grossest profanity (which was not previously his custom), manifesting but little deference for his fellows, impatient of restraint or advice when it conflicts with his desires... obstinate, yet capricious and vacillating, devising many plans of future operations, which are no sooner arranged than they are abandoned in turn for others appearing more feasible. A child in his intellectual capacity and manifestations, he has the animal passions of a strong man.
Visual Rehabilitation Uses the Frontal Lobe (Top-Down Processing)

**Cognitive Awareness**
Prefrontal cortex involved in selection of goals
Coordinates steps to reach that goal
- What to pay attention to (complicated motor sequences)
- What to do when stuck at some particular point

**Practice Effect**
Premotor cortex: Consciously monitors movement sequences (Practice Effect) using sensory feedback. (Found next to primary motor cortex)

*Habituates* (Hebb’s Law) (Synapses that fire together, wire together)
Primary motor cortex: Next to central sulcus (Little Man)
Takes direct control of the muscles to ACT sends signals to spinal cord
Trauma Review: A Younger Problem

A Different “Ball Game”: Brain Scrambled

Much More Difficult in Most Cases than Stroke
An Obvious TBI Case (Mild)
Previous Care

• “Charged” in Basketball-Hits Head on Floor
• OD finds < VA’s and Constricted Fields
• Diagnoses macular edema OU
• Consults with OMD
  – SEVERELY RESTRICTED FIELDS: OD more
  – NO macular edema
  – Dx: Unexplained visual loss
    • Refer to family physician for headache
    • Refer to Muskogee Regional for MRI
Letter from OMD to OD

- VA s/c Rx (+.50) OD 20/50; OS 20/40-1
- Ref: OD -.25+1 x106 OS +.5 +.25 x 83
- Pupils normal No APD
- EOM/Alignment: Full, No Tropia III, IV, VI OK
- Confrontation Fields Constricted OD
- Slit Lamp: WNL
- Fundus: WNL
Letter to OD from OMD

• “...I do not have a good handle on why her visual acuity is reduced. Her ocular examination, other than a minimal refractive error is unremarkable. From her eye examination there is no sign of a neurological condition. Shortly we will be obtaining central and peripheral fields and go from there. I have asked that she see her personal physician for an evaluation.”
Radiological Results

• Cx: post-head trauma Dec 99 c blurred vision, headaches and tunnel vision
• Impression: “The brain parenchyma appears normal on T1, T2 and flair imaging.”
  – Normal Magnetic Resonance Imaging of Head
Initial Optometric Findings Feb of 2000

• COVD Score 32
• Headaches and no side vision
• VA 20/50’s; pupils reactive; Maples pursuits 5’s, Saccades 5,3,2,3; NPC 13/16 cm x 3
• NFN Difficult to converge; CT/Ph 0 f/n; pl distance +1.5 near on ret
• Initial: +0.50 loaner; Hart Chart;- lens rock
• RTC for further evaluation
Supplemental Testing

- **VO Star**: Symmetrical but disorganized;
- **Cannot clear -2 on rock**;
- **VO Series (Fusional Facility)** slow (37-60 sec) on 6-12;
- **Stereo 50 sec**;
- **DEM 115 sec vertical; 127 sec horizontal and ratio 1.1 (<6 yr vert/hor and > 14yr ratio)**;
- **+/- lens @near (20/21) c 20/60 target only .5D range +2.00/+1.50**
- **VEP Latency slow; Fields constricted more OD**
- **Dx**: HA 784.0; Constricted VF 368.45
- **Rx**: +.50c+1.00Add-In Office/Home VT
VT and Home Support

• Home Support
  – -3.5 Lens Rock with Near Hart Chart;
  – Cat Card;
  – Lifesaver Card;
  – Battleship Hart Chart

• In-Office VT-6 Sessions from 2-24/4-21, 00
  – Wayne Fixator (dark room) alternate hands;
  – Wayne NFN Mono/Bino;
  – Yoked ^ c Harmon Bd;
  – 12*c RR-Mono OD more;
  – Parquetry Alt Hands;
  – Marsden Ball ^
Optometric VT Goals

• Maples (NSUCO) to 5’s
• VO * Organized
• VO Series < 30 sec
• DEM to 9 yrs
• VA’s 20/30
• > JND’s on 20-21 (Plus and Minus to Blur at Near)
Results of VT

- COVD from 32 to 14 Nothing more than 1
- Normal Fields
- 20/21 -4.00/+2.75
- VA 20/20 (2 eso)
- VO * Organized, Symmetrical, Eso
- VO Series 6-12 (9-24sec)
- DEM 40 Vert; 45 Hor; 0 Errors; Ratio 1.11 (Maxed)
- Released for regular follow up
Extended Progress Examination

- COVD Checklist (2) Occasional HA
- Standard VA far and near
- Ortho far and Eso near
- NPC 1/3 x 3
- NFN = In and Out
- Stereo a Slow 20 arcsec
- Maples 5’s for Pursuits and Saccades
- VO Star Symmetrical Disorganized on Horizon
- VO Series 6-12 15 sec 13/14 Bottom Not Fused
Traumatic Brain Injury Pathophysiology

• Open
  – Skull is Opened and Brain is Exposed
  – Almost Always Fatal (Mortality Factor)

• Closed
  – Brain not Exposed
    • Mild, (75%) Moderate, Severe
  – Almost Always Disabled More or Less (Morbidity Factor)
  – Optometric Involvement
Mechanics of TBI

• Acceleration
  – Saturday Night Special
  – Blows to the Head/Gunshot
  – “Coup” Injury

• Deceleration
  – Accidents
  – Head Moving
  – “Contrecoup”
Closed Head Injury

- Diffuse Symptoms
- Trauma Involves many parts of the Brain
- Primary Damage
  - Tearing, Shearing, Tension, Pressure
- Secondary Damage
  - Edema, Hematoma, Rotated Brain Stem, Pressure, Hernia, Ischemia, Necrosis,
Shaken Baby Syndrome

• Retinal, vitreous hemorrhage in the presence of intracranial injury without external signs of head trauma
• Cortical blindness
• Optic nerve sheath hemorrhage
• Circumferential retinal folds
• Retinoschisis
Child Abuse TBI: Signs

• Decreased Weight-Age Graph
• Chronic Malnutrition/Illness
• Scalp Damage (Hair Pulling-Bruises-Scars)
• Fundoscopy: Retinal Hemorrhage
• Mouth, Skin Bruises, Marks
• Trunk: Rarely Bruises Accidentally
• Arm/Leg: Spiral Fractures Rare Accidentally
Glasgow Coma Scale: (Classic Measure of Concussion)

- Three Levels
  - Mild =/> 13
  - Moderate 9-12
  - Severe < 9

- Three Areas of Testing
  - Visual
  - Verbal
  - Motor
<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Eyes</strong></td>
<td>Does not open eyes</td>
<td>Opens eyes in response to <strong>painful stimuli</strong></td>
<td>Opens eyes in response to voice</td>
<td>Opens eyes spontaneously</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td><strong>Verbal</strong></td>
<td>Makes no sounds</td>
<td>Incomprehensible sounds</td>
<td>Utters inappropriate words</td>
<td>Confused, disoriented</td>
<td>Oriented, converses normally</td>
<td>N/A</td>
</tr>
<tr>
<td><strong>Motor</strong></td>
<td>Makes no movements</td>
<td>Extension to painful stimuli <strong>(cerebellar response)</strong></td>
<td>Abnormal flexion to painful stimuli <strong>(cortex response)</strong></td>
<td>Flexion / Withdrawal to painful stimuli</td>
<td>Localizes painful stimuli</td>
<td>Obeys command</td>
</tr>
</tbody>
</table>
# Behavioral & Cognitive Signs

<table>
<thead>
<tr>
<th>Behavioral</th>
<th>Cognitive</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Changes in Personality</td>
<td>• Space Confusion</td>
</tr>
<tr>
<td>• Increased Anger</td>
<td>• Time Confusion</td>
</tr>
<tr>
<td>• Increased Depression</td>
<td>• Loss of Attention</td>
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<tr>
<td>• Dramatic Mood Changes</td>
<td>• Loss of Memory</td>
</tr>
<tr>
<td>• Frustration</td>
<td>• Loss of Stamina</td>
</tr>
<tr>
<td></td>
<td>Loss of Cognitive Function</td>
</tr>
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</table>
OD Measures Significant @ .05

- Cover Test Near: TBI > xo, p = .01
- BI Bk Far: TBI > ^, p = .03
- NPC Bk: TBI Receded, p = .001
- NPC Rec: TBI Receded, p = .002
- Refract OD/OS: TBI > +, p = .006
- Stereo: TBI < arcsec, p = .007

Rehabilitative Optometric Care Post TBI

• Brain can and does Reorganize Self
• Repair/Reorganization Influenced by Stimulation
• Stimulation: Perceptuo-Sensory & Motor
• Reorganization Tx Generalizes to all Perceptual Activities
• Top-Down Model (Learning to Drive)
• Functional Activities Require Perception
• Perceptual Remediation Improves Function
OD Therapies for Brain Injury

**Therapy**
- Ergonomics
- Multi-Disciplinary Management
- Home Therapy
- In-Clinic Therapy

**Optical Aids**
- Refract
- Added Plus for Near
- Microscopes
- Telescopes
- Field Expanders
Ergonomics

• Plenty of Contrast in Home
• Wide Halls without Obstacles
• No Clutter in House
• High Lumen Lighting
• Properly Designed Furniture
  – Allows one to comfortably position self close to the material
Multi-Disciplinary Management

- Physiatry
- Physical Therapy
- Occupational Therapy
- Low Vision Specialists
- Family Medicine
- Education
- Counseling
Specific OD Home Therapy

• Relate Procedures/Techniques to Life
  – Visualization of ‘Blind’ Area to Obstacles
  – Scanning into ‘Blind’ Area c Field Expanders
  – Eye Movements to Driving, Walking, etc

• Start Low

• Start Slow

• Small Bursts of Work
In Office Vision Therapy

- Orientation/Mobility
- Eye Movements
- Binocularity
- Accommodation (Use Multifocals)
- Perception
- Cognition
- Executive Function
Orientation/Mobility

• Motoric Activities
  – Body Awareness (Feel Which Body Part Moves Where)

• Balance Activities
  – Walking Rails and Balance Boards

• Rhythm/Timing

• Yoked Prisms
Vision Rehabilitation and TBI: Objective Data (5 Year Study)

• Does VT have an effect on the objective measures of Mild TBI?
• Separated into two groups VT & No VT
• 3 Successive Groups: Groups Sampled for:
  – P100 Wave Slow by 15%; Amp < 50%
  – P100 Wave Slow by 15%; Amp < 50%; 15% difference between the two eyes
  – Those which showed normal VEP Responses
Group 1 %: Slow P100 Wave & Amp Down 50% or More
Group 2%: P100 Slow, Amp Down 50%, 15% ^ Between Eyes
Group 3% Normal VEP’s

- Base
- 6-12 Mo
- 12-18 Mo

No VT
VT
Conclusions From VEP Studies

• The two groups were not statistically significant at the baseline measurement.
• The VT group improved significantly over the no VT group at the
  – 6-12 Month Examination
  – 12-18 Month Examination
CONCUSSIONS FROM SPORTS
NFL Statistics

- Increased incidence of diagnosis of MEMORY LOSS and DEMENTIA among retired professional football players. Such symptoms are believed related to the effects of concussion.
- Such injuries may potentially affect high school and college players also.
- The risk of death associated with NEURODEGENERATIVE DISORDERS: 3 times higher among NFL Players.
NFL Statistics Continued

• Risk for death from **Alzheimer’s Disease** and **Amyotrophic Lateral Sclerosis** and were 4 times higher among NFL Players

• **Mortality risks** from **speed players** (Quarterbacks, Running Backs, Fullbacks, Wide Receivers, Tight Ends, Linebackers, Cornerbacks and Safeties) higher than for nonspeed players

• Greater number of deaths attributable to neurodegenerative disorders were present in speed players than nonspeed players (increased momentum of collisions)
IDENTIFYING CONSUSSION AND BRAIN INJURY WITH EYE MOVEMENT TESTING
King-Devick Test

A test of rapid number naming (RNN) & saccades

Planning and execution of saccades & RNN involves wide network of anatomical structures in the brain:

- Frontal eye field (Frontal Cortex)
- Dorsolateral prefrontal cortex
- Supplementary motor area
- Posterior parietal cortex
- Middle temporal Area
- Occipital Lobe, Striate cortex
- Thalamus
- Superior Colliculus
- Brainstem structures

Saccadic eye movements are a highly *coordinated & complex* task
King-Devick Test

- King-Devick Test for Concussions
  - Test of rapid number naming & eye movements
  - Speed & error compared to baseline time
    - Best of 2 trials to determine Baseline Time (learning effect)
    - Retest after suspected head injury: INCREASED time or ERRORS → Concussion

*Can be administered by coaches/parents (non-medical professional)

*May help coaches/trainers with game time decisions

Galetta et al., 2011
King-Devick Test for Concussion

“Because the K-D test does not require a medical professional and can be administered in 1-2 min, it is practical for sideline use at all levels of sports. The K-D test has the potential to capture brain impairment not observed in standard neurocognitive testing.”

“…able to identify players with a suspected concussion, players with a concussion that was not reported or witnessed.”

“…the ease-of-use made it more acceptable to team management and players and, as it provided immediate feedback to the player and coach.”

“… the K-D test served to provide support for the decision made by the team medic to rule out the player from further match participation.”
**King-Devick Test for Concussion**

*Concussions in amateur rugby union identified with the use of a rapid visual screening tool*

“Three football players whose concussion diagnosis was confirmed by a neurologist did in fact demonstrate diminished KD test performances times.”

“Two players tested rink-side immediately following concussion had KD scores worsened from baseline. These athletes had no differences found for SCAT2 SAC components, but reported symptoms of concussion.”

“...suitable for rapid assessment in a limited time frame on the sideline such as a five-minute window to assess and review suspected concussed players in rugby union.”

“The KD test was associated with reductions in Immediate Memory Scores and the overall SAC score.”

*Saccades and Memory: Baseline associations of the King-Devick and SCAT2 SAC tests in professional hockey players*

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*J Neurol Sci. 2013;326(1-2):59-63*

*Poster Presentation at ARVO 2013 Annual Meeting*

Concussion Screening in High School Football Using the King-Devick Test
Saccades & Memory

Professional Ice Hockey: Philadelphia Flyers

• 27 athletes, 2011-2012 season

• Worse KD scores associated with:
  – Lower SCAT2 SAC Memory score
  – Lower overall SAC score

• 2 concussed athletes exhibited:
  – Abnormal KD test
  – Normal SCAT2 SAC test
  – +Symptoms

Working memory and saccades share closely related anatomical structures, including the dorsolateral prefrontal cortex (DLPFC)

EyeProtectBrain

• **Sports Concussion Identification Outreach Program.** Collaboration by the College of Optometrists in Vision Development (COVD) and joined by the Southeastern Congress of Optometry (SECO).

• Initiative is to introduce a **Sideline Screening Test** for Sports (Public/Private School, College/University, Professional).
  
  – KD Test administered before Sport Begins Training
  
  – If Concussion is suspected in **Practice or a Game**-The athlete is given the KD (**on sideline**) and if performance is hampered; the athlete is not allowed to return until cleared by a medical professional.
EYEProtectBrain
A COVD Project to Identify Undiagnosed Concussion in Sports

• **GOAL:** Identify Undiagnosed Concussion (Sub Clinical Coma)
  – Athletes with their “Bell Rung”
  – Prevent and Treat **Post Concussion Syndrome** (CI?)
  – Prevent Multiple **Sub-Clinical Concussions**
    • Identify the First Concussion
      – EYE MOVEMENT SCREENING DETECTS SUBCLINICAL CONCUSSION
      – KD: **AVAILABLE TO ALL LEVELS OF SPORTS** FROM ELEMENTARY SCHOOL TO PROFESSIONAL
      – **OPTOMETRISTS:** THE PRIME MOVER IN THIS EFFORT
More Information

• College of Optometrists in Vision Development
  – www.covd.org
  – 1-888-COVD770 (1-888-268-3770)

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