Assessment and Management of Oculomotor and Visual Impairments after Brain Injury: A Case Series

Darcy Bonaventura, PT, DPT, NCS

Objectives

- To be able to identify signs, from either subjective complaints to observation, that warrant further assessment of the visual system.
- To be able to identify appropriate tests and measures to assess visual and oculomotor function.
- Identify treatment strategies to implement in the care of patients presenting with these impairments.
- Identify other team players and their role in managing visual impairments.

Anatomical Review

Visual Processing

- Neural signals initially processed in the retina
- Information travels via optic nerves to optic chiasm
- Information then crosses to the optic tracts that travel to the lateral geniculate nucleus (LGN) in the thalamus
- From the LGN, signals continue to the primary visual cortex via the optic radiations.
Anatomical Review

Visual Processing
- From primary visual cortex (area 17)
- Visual association cortex (areas 18 and 19)
  - Dorsal stream
    - Parieto-occipital association cortex
    - "Where"-position and nature of goal-oriented objects or the environment as it relates to actions that can be performed
  - Ventral stream
    - Occipitotemporal association cortex
    - "What"-object recognition, color, size, shape of an object

H. Blumenfeld. Neuroanatomy through Clinical Cases

Anatomical Review

Descending cortical pathways
- Parieto-occipito-temporal cortex
- Vestibular nuclei
- Cerebellum
- Paramedian pontine reticular formation (PPRF)
- Abducens nuclei
- Frontal eye fields
- Overlap premotor and prefrontal cortices
- Role in eye movements and selective attention
- PPRF assists with generating saccades in contralateral direction

Springer et al
- FMRI increased activation during saccadic eye movements in frontal and parietal cortex, as well as in subcortical structures
- Occipital cortex activation during saccades suggestive of parallel activity in oculomotor and primary visual sensory areas is necessary for voluntary eye movements
- Altered recruitment pattern in patients with stroke
- Decreased activation of fronto-parietal networks
Anatomical Review

Supranuclear control of eye movements
- Horizontal
  - Medial longitudinal fasciculus (MLF)
  - Interconnects oculomotor, trochlear, abducens and vestibular nuclei
  - Project to medial and lateral rectus muscles for conjugate gaze in all directions
- Vertical
  - Rostral midbrain reticular formation and pretectal area
  - Ventral portion: downgaze
  - Dorsal region: upgaze
- Vergence
  - Midbrain reticular formation

Additional contributing systems
- Cerebellar, vestibular, and cervical spinal proprioception control
- Voluntary eye movements
- Reflexive eye movements
  - Optokinetic nystagmus
  - Vestibulo-ocular reflex (VOR)

Categorizing visual impairment
- Low vision
  - Visual acuity less than 20/40 in the better seeing eye with impact on participation with ADL's/AIDL's
- Ocular motility deficit
  - Strabismus, convergence insufficiency, diplopia, gaze paralysis, dysmetric saccades
- Visual field loss
- Perceptual deficit
  - Inattention/neglect, object agnosia, depth perception
Categorizing visual impairment

- Ocular motility deficit
  - Lesions to parietal, occipital, and frontal lobes, thalamus, brainstem, and cerebellum
- Visual field loss
  - Lesions to visual tracts, occipital and parietal lobe
- Perceptual deficit
  - Parietal (contralateral neglect), occipital, and temporal lobes (visual attention and recall), internal capsule, periventricular regions
  - Cerebellar lesion—difficulty judging distances, nystagmus, impaired eye-hand coordination

Incidence of visual impairment post stroke

<table>
<thead>
<tr>
<th>Incidence</th>
<th>Visual Impairment</th>
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</thead>
<tbody>
<tr>
<td>Low (30%)</td>
<td>Eye movement deficit</td>
</tr>
<tr>
<td>High (92%)</td>
<td>Cranial nerve palsy</td>
</tr>
<tr>
<td>Moderate (9)</td>
<td>Saccadic palsy</td>
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<tr>
<td>Moderate (50.5%)</td>
<td>Dysmetria</td>
</tr>
<tr>
<td>Low (3)</td>
<td>Smooth pursuit palsy</td>
</tr>
<tr>
<td>Very low (1.5)</td>
<td>Gaze palsy</td>
</tr>
<tr>
<td>Very low (4)</td>
<td>Visual field impairment</td>
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</tbody>
</table>

Incidence of visual impairment

- Incidence of visual impairments after stroke range from as low as 30 to as high as 92%
- Co-existent ocular disease in approximately 1/3 of cases
- In one study, 89% of patients admitted for TBI rehabilitation had impairments in one or more visual systems (Ripley)
- A significant proportion of patients in stroke units have unrecognized visual problems resulting in little or no advice or management (Rowe)
- Approximately 60% of visual deficits identified with formal visual screening in the acute care setting had not been previously reported in the chart following general examination (Harron)
Importance of the visual screen

- Ali et al indicates that the fastest rate of recovery of visual deficits occurs in the first 30 days following stroke.
- Importance of early detection and specific intervention during interdisciplinary care.
- Visual dysfunction can adversely affect one's ability to participate in ADLs/IADLs.
  - Strong link between visual dysfunction and rehabilitation potential (Wolter).

Symptoms of visual deficits

Subjective reports
- Inability to read
- Photophobia
- Diplopia
- Blurred vision
- Distress or imbalance
- Eye strain or fatigue

Observation
- Bumping into objects
- Missing objects when attempting to pick up
- Head tilt
- Difficulty locating items
- Difficulty with stair/obstacle negotiation
- Ptosis

Assessment

- Acuity
  - Distance vision
  - Based on particular chart
  - General reference for driving is 20/40 or better
  - Consider referral for detailed testing if previously did not wear prescription lenses and presents with decreased acuity.
### Assessment

#### Oculomotor Function

**Convergence**
- Reference the eyes ability to rotate inward together to focus on a target
- Normal reference range for ages 30 and younger vary from 6-10 cm

**Smooth pursuits**
- Ability of the eyes to track a moving target
- Test all quadrants
- Test slow and fast speeds

**Saccades**
- Rapid movement of the eyes between two fixed targets
- Observe for speed and coordination of eye movements and possible compensatory strategies

#### Visual field testing
- Patient to fixate straight ahead
- In each visual quadrant ask pt to identify either number of fingers or where moving fingers are detected
- Monocular vs binocular

#### Spatial Neglect
- Double simultaneous stimulation
- Visual extinction
- Line bisection test
-Cancellation test
- Clock Drawing Test

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**Assessment**

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Case Study #1

Subjective complaints
- Tendency to bump into objects on (L) side
- Poor awareness of traffic when walking in a parking lot
- Walks slow when in crowded environments
- Decreased confidence
- Slow reading
- Dizziness with community reintegration
- Large crowds

Focal Visual Process
- Central visual function
  - Aiming your eyes on an object causes focalization through the macula

Ambient Visual Process
- Spatial orientation
  - Used for balance, movement, coordination, and posture
  - Sensory-motor feedforward mechanism with cortex
  - Involves communication with oculomotor, proprioceptive, vestibular and tactile inputs for the purpose of orientation
  - Following a neurologic event, the brain loses its ability to match all this information properly

Pt is a 43 y/o male presenting with BLE weakness and difficulty with gait and balance. Bumping into furniture starting in early a.m. Wife took pt to ER at that time. At ER pt noting difficulty seeing out of both eyes and # temporal and neck pain.

CTH (+), MB/MRA (+) for # PCA infarct (non-hemorrhagic, no stenosis), transthoracic echocardiogram revealing patent foramen ovale. No medical indication for closure at this time.

Not a candidate for tPA. Monitored until stable then t/f for short IPR stay

D/C home to outpatient therapies with driving restrictions until further follow-up with orthotistology
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Case Study #1

Examination

Functional Mobility
- Gait speed 0.8 m/s
- Supervision: level surface
- Dynamic Gait Index (DGI) - 19/24
- Functional Gait Assessment (FGA) - 16/20
- Romberg EO/EC 30/30’, increased sway EC condition
- Foam EO/EC 30/30
- LE MMT WNL

Visual Assessment
- Left visual field cut bilaterally
- Central vision seemingly spared
- Monocular assessment bilaterally
- Hypometric saccades
- Pursuits and convergence WNL

Examination

Case Study #1

Treatment
- Balance training
- Gait
- Dynamic standing
- Sensory reorganization
- Oculomotor training
- Saccadic eye function
- Visual scanning
- Optokinetic/gaze stability training
Case Study #1

Physical Therapy Outcomes
- Goal speed 1.21 m/s
- DGI 23/24
- FGA 29/30
- Mod(I) ambulating complex environments with compensatory strategies without dizziness
- Dizziness 0/10 in community settings

Further Management
- Co-managed with occupational therapy
- Neuroophthalmologist
- Visual fields of 20% improvement with visual field testing
- Underwent trial with prism without significant reported change
- Referred to OVR for assistance with return to work

Evidence
- Spontaneous recovery of visual field defects occurs in 10-30% of patients with visual field defects (Pouget)
- Most recovery occurs within the first 3 months, with minimal progress after 6 months (Zhang)
- Less spontaneous recovery associated with older age
- Size of the visual field defect did not impact search time or reading (Blyth)
- Mixed evidence on predicting return to driving
- HVFD patients with macular sparing were found to read faster and make less of patient eye movements (de Haan)
- Right sided HVFD patients show a higher number of progressive saccades and a longer fixation duration compared to left sided HVFD patients (de Haan)

Optical Assistance
- Prism lenses
  - Used to relocate the blind visual field to the healthy visual field (rear view mirror)
  - As high as 20% of visual field recovered
  - Poor compliance rate with 42% limited utilization past 8 months
  - Reported difficulty with stairs, in crowds, and reading tasks

Blindsight stimulation
- Increased cortical activity through applied stimuli to "blindspots"
- Primary visual cortex via subcortical pathways
- Improved detection rates of low contrast and motion stimuli in trained locations

Compensation
- Oculomotor activity
  - Large saccades to/from the blind visual field
  - Carried out visual search to enhance spatial organization
  - Striate/extrastriate pathways and frontoparietal network
  - Intensity to promote reorganization varies from 30-40 minutes daily for 1-6 months

Treatment Options

Evidence

Optical Assistance

Blindsight stimulation

Compensation

Pouget 2011
Case Study #2

- Pt is a 46 y/o female with onset of headache. 30 minutes later pt with onset of aphasia and apraxia lasting 5-8 minutes.
- MR (+) (L) temporoparietal infarcts
- Transesophageal echocardiogram revealing patent foramen ovale, possible venous origin
- D/C home with follow up with PCP in one week
- Later follow up with neurology revealed increased issues with dizziness and visual processing with community reintegration
- Referred to vestibular therapy

Subjective complaints
- Dizziness 0-9/10 when in crowded stores
  - Feel as though people are coming at me and moving faster than they actually are
- Increased anxiety in these settings
  - (+) activity avoidance
- Photophobia
- Motion sickness in the car
- Words jumping when attempting to read
- Commonly losing place in line when reading
### Case Study #2

**Examination**
- **Functional Mobility/Balance Assessment**
  - Level gait and transfers
  - Modified stair negotiation
  - Gait speed 1.03 m/s
  - DG1 22/24
  - FGA 23/30
  - Foam EO/EC 30/30”, increased sway EC

**Visual Vestibular Assessment**
- Smooth pursuits WNL
- Saccades hypometric at 12” spacing
- 36” spacing dysmetric and slow
- Convergence WNL
- Ocular alignment WNL
- VOR abnormal and symptomatic
- VOR Co normal and symptomatic

### Case Study #2

**Vestibulo Ocular Reflex (VOR)**
- Stabilizes vision during head movements
- Normal response: target remains focused and still and eyes stay on target
- Abnormal response: eyes may deviate off of target and/or pt may report blurring or moving of target

**VOR Cancellation (VOR Co)**
- Suppression of VOR
- Normal response: eyes stay on target as body stabilizes back and forth
- Abnormal response: saccades as pt stabilizes back and forth

### Case Study #2

**Treatment**
- Gait and balance training
- Sensory reorganization
- Oculomotor training
- Tracking and visual scanning
- Case stability training
- Optokinetic training
- Incorporation of relaxation techniques and compensatory strategies
Case Study #2

Physical Therapy Outcomes
- Able to tolerate 40 minutes of shopping in non-crowded store without symptom increase, 30 minutes with crowds and dizziness 3/10
- DGI 24/24
- FGA 29/30
- Gait speed 1.25 m/s
- VOR normal but symptomatic
- Saccades abnormal

Further Management
- Anxiety
  - Neuropsychologist started on low-dose clonazepam but with limited effect on tolerance to crowds
- Cognitive behavioral therapy
- Persisting abnormal oculomotor function
  - Neuroophthalmology referral
  - Vision therapy
  - Recommendation to vestibular PT for compensation therapy

Evidence
- Vision training rendered measurable improvements in the quality of eye movements in patients with stroke (Khan)
  - Noted improvements with the patient's overall proficiency with reading
  - Reading comfort and duration, not speed
- 76% improvement with visual search response times (Ajina)

Evidence
- Herron et al
- 8/16 symptoms screened were identified in over 40% of stroke patients
- Saccades, convergence, and pursuit were top visual impairments identified.
Case Study #3

Pt is a 67 y/o female with PMHx of lung CA with recurrent brain metastasis to (R) parietal lobe
- Underwent elective resection of tumor on 6/17/16
- Prior tx includes (L) lung tumor resection in 2007, Cyberknife ® parietal lobe mass 2012, retreated with reoccurrence in 2013, parietal lesion resection 2014, whole brain radiation therapy 2015
- Post operative MRI showing ® frontal subacute infarct
- 3 week stay in IPR and referred for outpatient PT, OT, SLP

Subjective complaints
- Difficulty with household and community ambulation
- Still requires a significant degree of physical (A) from family for bathing, dressing, cooking, cleaning
- Frustrated and down over changes in function
- Fatigued

Functional Mobility Assessment
- (S) with verbal cues amb with WW,
- Safety issues
- Gait speed .33 m/s
- Gait quality – shuffled, decreased foot clearance (L)
- BBS 28/56
- Gross (L) weakness slightly > (R)
- Tendency to bump into objects on (L) side, difficulty with direction changes to the (L)
- Poor recall

Visual Assessment
- Smooth pursuits WNL
- Saccades hypometric (3-4 corrective saccades with 24''+ spacing)
- Binocular visual field testing – no (L) sided awareness until target reached midline
- Clock test (OT) – only able to identify numbers 12 to 5, prompt to focus on other numbers variously, demonstrated understanding the locations of clock numbers without naming the clock hands
- Had difficulty discriminating R/L without (A)

Case Study #3
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Case Study #3

Visual Assessment
- Saccades
  - 12", 24", 36"

Case Study #3

Treatment
- Strength and endurance training
- Transfer and gait training
- Balance training
- Oculomotor training
  - Saccades
- Visual scanning
- Patient education

Case Study #3

Physical Therapy Outcomes
- (Mod) bed mobility and 1TC (1c WW)
- (S) c VC STS for proper technique (1/5x, otherwise Mod(I))
- (Mod) stair negotiation and amb c WW on level/uneven surfaces
- (S) c VC amb with cane
- Goal speed 3.6 m/c WW
- BBS 43/56
- Saccades abnormal

Further Management
- Long term PT follow-up
  - Revealed poor compliance with HEP, further depression
  - Reference to PCT
  - Educated on intensity/frequency of exercise

Case Study #3

7th Annual Current Concepts of Brain Injury Rehabilitation
November 5, 2016
Evidence

- The direction of the first saccade in a visual search is sensitive to the presence of neglect with more ipsilesional than contralateral saccades (Bourgeois 2015)
- Prisms can be used with the intent of shifting images onto the neglected side
- Mixed evidence on efficacy of this treatment strategy
- Thought that poorer outcomes may be related to weaker prism prescription vs limited training sessions with prisms (Kerkhoff 2012)
- Mixed evidence on patching (Pierce 2012)

In Summary...

- Visual system connections are vast and so are the impairments that stem from various neurologic injuries
- Early identification and management of visual impairments can have a profound impact on a patient's outcomes
- Consider referring for detailed assessment and for further management of visual dysfunction