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Visual Deficits in Brain Injury: The Adult Neurological Perspective

Subah Gupta MHS, OTR, CBIS

Learning Outcomes

- After this course, participants will be able to list the anatomical as well as the neurological foundations of the visual system.
- After this course, participants will be able to describe differential screening for visual deficits.
- After this course, participants will be able to list appropriate intervention strategies for clients with acquired visual deficits towards independence in daily activities.
Establish eye dominance
Reduced acuity is because of

<table>
<thead>
<tr>
<th>Aging</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brain Injury / Trauma</td>
</tr>
<tr>
<td>Neurological / congenital eye diseases</td>
</tr>
<tr>
<td>All of above or any of above</td>
</tr>
</tbody>
</table>

Distance / Intermediate Visual Acuity

- Snellen Chart
  - Stops at 20/200
  - Testing distance – 20 feet

- Low Vision Distance Chart
  - This extends it to 20/1000
  - Testing distance is 1 meter

- Light source needs to be directed from behind the client
- Charts need to be held at the specified distance
- Chart needs to be evenly and adequately illuminated
- Test each eye separately and then together, wear glasses
Near Visual Acuity and CSF

MNREAD Acuity Chart
- 3rd grade reading level
- Print size is up to 8M
- Contextual

Contrast Sensitivity Function
- Contrast sensitivity is a measure of how faded or washed out an image can be before it becomes indistinguishable from the uniform background

Case Study - 1
- Age is 67
- Occupation – Owns his company and works on designs (bridges, farm equipment, joints)
- Diagnosis - Midline shift and left intra cranial hemorrhage involving the temporal and parietal lobes due to uncontrolled hypertension while driving a RV
- Burr hole with evacuation of the hematoma
- Reached home after month long inpatient intensive rehabilitation for right sided weakness and aphasia
Case Study - 1

Therapy Screen
- VA with bifocals
  - OD 20/40
  - OS 20/40
  - Near 20/20
- CSF – Able to perceive 1.25%

Low Vision Provider
- VA
  - OD 20/400
  - OS 20/500
  - At near - 1.25M @30
- Astigmatism
- Eye health
  - Macular hole bilateral OU

Wears Glasses

WITHOUT GLASSES

WITH GLASSES

TRACING DESIGN FROM A TO B
### Increase contrast by choosing light

<table>
<thead>
<tr>
<th>Incandescent</th>
<th>Fluorescent</th>
<th>LED</th>
<th>Halogen</th>
<th>Full Spectrum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Warm yellowish light</td>
<td>Cool light</td>
<td>Offers a range</td>
<td>Warm light</td>
<td>Mimics natural light</td>
</tr>
<tr>
<td>Glare due to scatter on retina</td>
<td>Fewer shadows but may create glare</td>
<td>Depends on the color chosen</td>
<td>Minimal glare</td>
<td>Reduces glare</td>
</tr>
<tr>
<td>Excellent contrast</td>
<td>May not provide good contrast</td>
<td>Good contrast</td>
<td>Excellent contrast</td>
<td>Good contrast</td>
</tr>
<tr>
<td>Great for task lighting</td>
<td>Provides even lighting, best for overhead lighting</td>
<td>High intensity focused light</td>
<td>Even lighting, good for task and/or overhead</td>
<td>Even illumination though diffuse</td>
</tr>
<tr>
<td>Being phased out, not energy efficient</td>
<td>Can have the strobe effect, light flickers</td>
<td>Expensive but lasts for years</td>
<td>Light gets very hot – risk of burns or fire</td>
<td>Beneficial to have additional task lighting</td>
</tr>
</tbody>
</table>

**ALLOW THE CLIENT TO CHOOSE WHAT LIGHT IS BEST FOR THEM**

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**CONTINUED**

- Position the light behind/next to the dominant eye
- Make sure light is shining on the page and not the eye
- Use the inverse square law of light – bring the light source closer to the surface
- Increase the lumens/wattage as needed

![Table gooseneck lamp](image1.png)
![Long gooseneck lamp](image2.png)
![Dimmable floor gooseneck lamp](image3.png)

Available on Amazon.com
Increase contrast by modifying environment

- Decrease visual clutter / decrease pattern
- Use locator dots
- Use bright duct tape

Font is white on black

Decrease pattern density by spacing text and increasing size

Chose wider monitors for increased field of view, flat screens are preferable

High contrast keyboard, keyboard overlays

For reading try...Settings – General - Accessibility

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Photophobia/Light Sensitivity

- Is usually because of meningeal irritation
- Use filters, sunglasses, hats or visors, outdoors and/or indoors
- Sheet covers or overlays (different colors) can be used
- Cover windows with blinds, use stick on window tints
- Use an umbrella outdoors
- Cover surfaces
Binocular Vision

- When information processed from each eye is same in size, detail, and form, it leads to binocular vision.
- If above is not the case then diplopia or double vision will happen.
- Double vision can also be perceived as blurred vision, ghosting of images and distortion.
- Cranial nerve lesion can lead to extra ocular muscle paralysis, hence causing diplopia.

Strabismus

- Could be in any direction
  - Esotropia – Eyes may turn in
  - Exotropia – Eyes may turn out
  - Hypertropia – Eyes may turn up
  - Hypotropia – Eyes may turn down

Non strabismus

- Eyes have a tendency to turn but neuromuscular effort is being exerted to control this tendency
- Patients will try and eliminate it with muscular effort, which can lead to signs and symptoms of
  - Headaches
  - Inability to sustain attention for long periods
  - Eyestrain
  - Intermittent blurred vision and occasional diplopia
  - Difficulty reading
Third Cranial Nerve (Oculomotor) Palsy

- Innervates superior, medial, inferior rectus and inferior oblique
- Horizontal diplopia due to exotropia when viewing near objects
- Eye is “down and out”
- Lack of ability of the lens to focus due to lack of innervation of the ciliary muscle
- Lack of pupillary constriction – dilated pupil
- Ptosis

Wang Y, Wang XH, Tian MM, Xie CJ, Liu Y, Pan QQ, Lu YN [CC BY 4.0 (https://creativecommons.org/licenses/by/4.0)]

Rucker and Tomsak, 2005

Fourth Cranial Nerve (Trochlear) Palsy

- Innervates superior oblique ‘cheater’ muscle
- Eye drifts upwards
- Hypertropia worsens with ipsilateral head tilt
- Compensatory contralateral head tilt
- Hallmark symptom is vertical diplopia, looking down or reading

If bilateral, patient will move head instead of eyes to look down

Wang Y, Wang XH, Tian MM, Xie CJ, Liu Y, Pan QQ, Lu YN [CC BY 4.0 (https://creativecommons.org/licenses/by/4.0)]
Sixth Cranial Nerve (Abducens) Palsy

- Innervates the ipsilateral lateral rectus muscle
- Difficulty moving the eye away from nose (abduct)
- Esotropia at primary gaze
- Horizontal diplopia viewing far away objects

Near Point of Convergence

- Patient is upright with head unsupported if possible.
- Instruction: "Watch the target as long as you can."
- Hold a target (pencil topper) at eye level about 15 inches away from the face. Move the target closer to the nose.
- Observe as one eye usually drifts out (normally this is between 2-4 inches) leading to double vision followed by recovery at 4-6 inches. Importance is placed to what you see over what is reported.
Observations

- Head tilt and to which direction?
- Do the pupils constrict?
- Are the pupils dilated?
- Is there ptosis?
- Is there nystagmus?
- Are they closing one eye? Does vision improve (single vision restored) when one eye is occluded?
- Ask for diplopia?
  - Is double vision horizontal or vertical?
  - Is double vision constant or intermittent?
  - Is double vision at near or at far distances?

Positions of Gaze

- With glasses if patient wears them
- Both eyes open
- Follow the target with eyes, leave the head still
- Excursion (pursuit movement) is 12-15 inches from the face
- Look for deviations
- Ask patient to report if they see double or blurred
What can we do …

Complete Occlusion
- One eye is completely occluded
- Eyes can be switched
- Liked because it is easy to do
- Disliked because peripheral vision is blocked which affects balance and gait and patients may not like their dominant eye being patched

Partial Occlusion
- Spot Occlusion – A small piece of circular tape or strip is applied over the lens to cover the pupil
- 3M transpore frosted plastic tape on the back of the lens is applied
- Peripheral vision is not affected, it is used for balance and spatial orientation, leads to improved compliance
- Taping does not need to be alternated

The physician needs to be informed of occlusion.

Partial Occlusion
- Third Nerve Palsy - Diplopia viewing near objects
  - Tape the nasal portion of the lens of the paretic eye
- Fourth Nerve Palsy - Diplopia in reading position
  - Tape lower half of the lens in front of the paretic eye

Tape is applied from the nasal / bottom of the rim to the center till the patient reports ‘No diplopia’, width of the tape is reduced as the paresis resolves.
Case Study 1

**Therapy Screen**
- Pupils constrict
- Patient reports blurred vision
- Ocular motility (cardinal points of gaze) – Unsure of exotropia
- Near point of convergence – break at 8 inches
- Subjectively saccades were accurate, pursuits on the right were impaired

**Low vision findings**
- Pupils constrict
- Cover Test – Distance -8 Exo XT, R Hypertropia, near – intermittent XT
- Near point of convergence - break at 8 inches
- His prescription included bifocals with prisms

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**Visual Pathways and Hemianopia**

[Image: https://commons.wikimedia.org/wiki/File:Human_visual_pathway.svg]
Common Presentation

- Right homonymous hemianopia is a result of involvement of left geniculocalcarine tract and vice-versa
- A posterior or a middle cerebral artery stroke can lead to homonymous hemianopia
- Involvement of parietal loop of the geniculocalcarine tract leads to inferior quadrantanopia
- Involvement of the temporal loop leads to superior quadrantanopia
- With macular sparing patient will have central vision and can read

Visual Field Tests

Confrontation Testing

- Patch one eye of the patient (right), conversely patch your left eye
- Have the patient fixate on a central target
- Present the stimuli half way in between you and the patient in 4 different quadrants
- Test each quadrant by counting the number of fingers shown

VSRT

- 6th to 8th grade reading level
- Print size is up to 4M
- Non contextual

Select a reading chart in their primary language
Select a chart at an appropriate reading grade level
Test is completed using both eyes
Client wears glasses
Be aware which test requires a reading distance and which doesn’t

https://www.lowvisionsimulators.com/products/pepper-vsrt
Functional Deficits

Functional Mobility
- Do not want to ambulate alone
- Do not want to navigate alone
- Less reaction time
- Slow, stiff gait
- Decreased arm swing
- Stop multiple times
- Shoe gazing
- Bump into objects or doors
- May have hand out for identifying objects

Reading and Writing
- Reduced speed as well as accuracy
- Reading span is decreased within is with disappear is appear
- Right HH is more debilitating as perceptually we have a bigger reading span on the right with a loss of anticipatory parafoveal scanning
- With Left HH, patient may skip lines
- May write uphill or downhill if the hemianopic side is same as the dominant hand

Samples

[Images of sample text]
Case Study 1

- Confrontation testing was negative, patient has expressive as well as receptive aphasia and is very aware of his central and peripheral vision as he was a pilot
- Complains that he misses words on his right, attempted 1 min. informal read aloud test which was frustrating
- Did a walk activity where he completely missed a hospital bed on his right and was surprised when he saw it on his way back

- Perimeter Evaluation – Gray Scale Diagram (Black area is the loss of visual field)
- Incomplete Incongruent Right Homonymous Hemianopia
- No optical aids recommended as there is enough sparing

Case Study 1

Screens and test for visual perceptual skills, visual motor skills and cognition

- Trails A
- Trails B
- MOCA
- VMI
- MVPT
Case Study 2

- Age 15
- Occupation – Student
- Patient underwent a right parietooccipital frontal craniectomy, elevation of depressed skull fractures, removal of bone and bullet fragments and debridement of necrotic bone tissue.
- Rehabilitation stay – PICU to rehabilitation hospital to outpatient clinic. Referred to OT by outpatient ST as she noticed motor deficits on the left. Patient also mentioned to her that vision is blurry. Patient wears a helmet.
- Patient reported that she did wear glasses but had no idea where they were
- Confrontation test was completed in quadrants using fingers, no deficit was identified
- Considering the diagnosis, patient was also being evaluated for left inattention

Recreated drawing from study by Ting et al., 2011
Left Homonymous Hemianopia

Visual Search Training

- Find sticky notes placed in order of 1-20 on the blind side
- Place sticky note on affected (more) and non affected (less) side
- Equally place the sticky notes on either side
- Notes can be placed in sequence and then random order
- Add visual detail (Adapted from Warren)
- Increase difficulty
  - speed - slow to fast
  - uncluttered wall to cluttered
  - predictable points to unpredictable
  - completing the activity in a busy environment

Use light boards, stickers, flashlights, laser pointers and pathways/courses
Ocular Motility Skills

**Fixation**
- Patient should be able to maintain precise fixation on a target for 10 seconds with no observable movement

**Saccades**
- Eye movements should be effortless, quick and should land precisely on a target

**Pursuits**
- When tracking, eye movements should be smooth

**Treatment Guidelines**
1. Saccades – large to small, horizontal, vertical and circular
2. Pursuits – small to large
3. Eliminate head movements - use weights on head or have the patient tuck a ball under the chin and hold it
4. Increase difficulty by using bosu, astro turf, balance beam, metronome or adding cognitive tasks
5. Add distractors to the environment
6. Change environment to help with transfer of learning - same demands with same accuracy
7. Have the patient instruct the therapist to complete the task for internalization of the task
Saccades

- Workbooks/Mazes
- Patient can use the pencil as a motor and visual aid
- Patient then uses the finger as a motor aid
- Patient has to use the eyes only.

Pursuits
Unilateral Neglect

- It is a disorder of spatial exploration, orientation and cognition (Sprenger, Kompf, Heide, 2002)
- It is the inability to integrate and use perceptual information from one side of the body and/or environment. Left neglect as compared to right neglect is frequent, severe and long lasting
- It is not a disorder of sensory processing but can be made worse if hemianopia is present
- Predominantly it is a result of damage to right fronto-parieto-temporal circuitry
- It is a visual attention deficit and is multimodal

Cause

Disruption of the network in between prefrontal, frontal, temporal, parietal and occipital lobes and the network between brainstem, thalamus and cerebellum (Adair & Barrett, 2008)

Spatial Bias - Right hemisphere can attend to left and right space where as left can attend to right space only
Manifestation

- Conceptualization of space is impaired because of impaired spatial cognition and orientation where the brain loses the ability to map left space
- Working visual memory is severely impaired
- Spatial bias is exacerbated where there is complete unawareness of the left side, patient misses landmarks, objects, events on the left with poor or no insight into the deficit

- Difficulty sustaining attention
  - Patient drifts off, lose their train of thought
  - Decreased ability to respond
  - Patients cannot sustain active search patterns

- These patients lack cognitive flexibility, which is why it is very difficult for them to be independent

- They lack internally generated maps to show goal directed behavior
Behaviors and Evaluation

- **Personal neglect** – Does not shave one side of the face, anchors eye glasses over one ear only
- **Peripersonal neglect** – Ignores objects placed on one side of the body like coffee mug and phone
- **Extrapersonal neglect** – Patient is unable to wheel self through doorways, hits the door frame, gets stuck on the right side, unable to incorporate left side even with cuing

**Asymmetrical search patterns**

- Search is initiated on the right
- Search is limited to the right side
- Cannot engage with left space
- Results in difficulty reading
  - Dyslexia

(Warren, 2016)

Cancellation Tasks

**Left Unilateral Neglect**

**Left Hemianopia**
Collect Evidence

- Engage with objects in left space and if possible identify visual detail.
- Repetitive motor memory may assist conceptualization of left space.

Visual Scanning Training

- Start search from the left by using the ‘pop out’ effect.
- Use a linear left to right pattern for near space tasks like reading and a circular left to right pattern (clockwise or counterclockwise) for far away tasks like scanning a room (Cicerone et al., 2000).
- Engage with objects in left space and if possible identify visual detail.
- Repetitive motor memory may assist conceptualization of left space.
Provide Sensory Input

- Visual – Occlude the right half of the visual field in each eye, prism adaptation (Newport & Schenk 2012; Smania et al., 2013)
- Vibratory – Neck muscle vibration induces lasting recovery when given as a supplement to conventional exploration training (Schindler et al., 2002)
- Tactile – Do compression, weighing down the left side, therapeutic brushing to improve attention to left space?
- Vestibular – Do postural or equilibrium righting reactions improve attention to left space?
Elicit Sustained Attention

- Choose activities that are emotionally relevant and meaningful
- Provide clear goals
- Provide context
- Meta cognitive approaches – Use language and cognition to redirect search
- Examples – Hobbies, Dynavision

Thank You
subahg06@gmail.com
References

References


References

Resources

- www.visionaware.org
- www.nei.nih.gov
- www.loc.gov/nls/
- www.strokelink.ca/
- www.strokecenter.org
- National Federation for the Blind
  https://www.nfb.org
- American Foundation for the Blind
  https://www.afb.org/