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Vision examination of TBI patients in an acute rehabilitation hospital

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1. Introduction

A high incidence of visual problems is found in patients who have suffered a traumatic brain injury, stroke, aneurysm, or other neurologic disease. According to Gianutsos [1], "There is an extremely high incidence (greater than 50%) of visual and visual-cognitive disorders in neurologically impaired patients (traumatic brain injury, cerebral vascular accidents, multiple sclerosis etc)". Zoltan [2] writes, "Visual-perceptual dysfunction is one of the most common devastating residual impairments of head injury".

Problems include, but are not limited to: double vision, visual field loss, visual inattention, disorders of eye movements, eye sight, acquired monocular vision, eye disease and direct orbital and/or ocular injury [3]. These vision problems are significant in their own right, and further complicate rehabilitation because of the functional limitations they cause.

As with many medical conditions, early diagnosis and treatment is important. The ability to readily examine and treat these patients beginning in an acute care setting is advantageous. The issues range in severity. It may be simple, for example glasses for the patient who has such blurred vision they can't participate in visual tasks, but cannot communicate it. It could be moderately complex, for example a patient with double vision and visual field loss, who is so confused by their vision they resist movement or even getting out of bed. It might be sight threatening, for example if a patient with a neurotrophic cornea goes undiagnosed (discussed later in this journal). Regardless of the level of complexity, the earlier these problems are treated, the better the outcome.

A neuro vision care and rehabilitation team is comprised of specialists in optometry, ophthalmology, physiatry, neurology, occupational therapy, physical therapy, and speech therapy. Neuro-psychologists may have input regarding cognitive and perceptual issues. Sub-specialties consulted include: neuro-ophthalmology, cornea specialist, oculo-plastics and retinal specialists. In our hospital the optometrist usually serves as the primary person for evaluation and management of vision problems. The reason is he or she is best positioned to communicate with all the disciplines involved, oversee and treat the disorders and facilitate referrals to the appropriate specialists.

2. Examination

The general neuro-vision examination has many of the components of a comprehensive vision examination. More emphasis is placed upon cranial nerve examination, neuro-ophthalmic reflexes, eye movements, visual fields and inattention, and the functional implication of the findings in regards to the overall rehabilitation treatment plan.

The exam begins with an introduction to the patient and general observation. If the functionally trained OT has accompanied the patient to the exam, they will facilitate this and review their observations and concerns to the optometrist or ophthalmologist. For the examination, objective testing is preferred to as much of a degree as possible.

3. Review of records

Review of the records including imaging studies of

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the type, location and severity of the brain injury is strongly recommended if at all possible. This is the time when a clinician begins thinking about the involved neuro-anatomy and how it might affect the visual system. Often there are clues to the origins of oculomotor problems based on early reports in the records. Additionally, the mechanism of injury presence or absence of certain types of skull fractures, and so forth, can be helpful in directing the following history taking and vision examination.

4. History

A detailed visual history is conducted to the extent the patient is able to comply. Sometimes patients have expressive, and/or receptive language problems making their input difficult. A patient may be confused or have a lower level of function and be minimally able to cooperate in the exam. History is also obtained with assistance from the family, and other therapists when possible.

5. Observation

One should look critically at facial symmetry, general appearance of the eyes, eye alignment, gaze preference, posture and positioning. Take note of interaction with others in the room, visual, or other perseveration, and general and visual attention. For example; a head tilt might indicate a Cranial Nerve IV injury, a gaze preference may indicate visual inattention and / or Cranial Nerve III or Cranial Nerve VI involvement, and a lagopthalmos a Cranial Nerve VII injury.

6. Visual acuity

Acuities are measured using standard techniques with modification as needed. Distance acuity is usually measured at 10 feet. Letters or shapes to test visual acuity (e.g. Snellen chart) may need to be individually masked to assist with impaired attention. If there is indication of possible neglect, or visual field loss, begin by pointing to letters on the side of the chart to the expected intact side.

7. Ocular alignment

Ocular alignment can be determined by performing the Hirschberg test [5], cover test [6], and Maddoxrod [7] (a striated red lens). With the exception of strabismus from a Cranial Nerve IV involvement, which is usually a fairly small angle deviation, most strabismus deviations in patients with TBI will have a large angle of deviation that is easily seen with observation. When a strabismus is present the examiner should evaluate it both at distance and near, and to all nine fields of gaze. If the strabismus is non-commitant (when the angle of deviation varies with the direction of gaze), it is important to perform a Park Three Step Test [1] (covered in the paper discussing the cycloprism, later in this journal).

The Hirschberg test involves having the patient look at a pen light. The examiner observes the reflex of the light in the pupil, looking for symmetry of the reflex between the eyes. The normal expected reflex is approximately one quarter millimeter nasal of center, and on the horizontal meridian. So, if that is observed in one eye, and the reflex in the other eye appears higher, lower, inward or outward, that is consistent with a strabismus mal-alignment.

The Cover Test [3] involves having a patient look at a fixation target, and then alternately occluding and uncovering one eye and then the other, allowing both eyes to be open in between, and looking for a refixation of the opposite eye that has not been occluded. The eye may appear to move to refixate, indicative of a strabismus misalignment.

8. Fixations and eye movements

Fixations are evaluated with standard tests. Patients may be photophobic, so the use of a non-illuminated fixation target is indicated. The patient is instructed to look at a steady target (e.g. the examiners' finger) held in front of them and at a distance of about sixteen inches from them. The examiner is observing for signs of steady gaze, unsteadiness, loss of fixation, and nystagmus. For patients with less interactive capacity, examiners can use mirrors for fixation, and / or supplementing with proprioceptive, kinesthetic and auditory cuing.

9. Eye movements

There are two general categories of eye movements to evaluate: 1) Nuclear which are ductions, and 2) Supra-nuclear, which include versions, pursuits, saccades, and vergences. When testing eye movements, keep in mind the neuro-anatomy of the injury or disease, and the findings observed.

Ductions refer to the movement of each eye by itself. These are monocular eye movements and include the range of up, down, right, left, and on the diagonals. Ductions are tested by covering one of the patients' eyes and instructing them to fixate on a small light, or fixation target held approximately sixteen inches from them. The target is then moved slowly at a speed of well less than 40 degrees per second through the above noted ranges. Repeat for the other eye. Look for signs of apraxia, ataxia, nystagmus, loss of fixation, and limitation in range of movement.

10. Supra nuclear eye movements

10.1. Versions

Versions are binocular eye movements. They are evaluated to the nine cardinal positions of gaze. They are tested as above, except done binocularly. The nine positions of gaze are measured by testing to the patients' right and left, up and down, and on the diagonals. Look for signs of apraxia, ability to cross midline, nystagmus, dysconjugate gaze, and limitation of gaze.

10.2. Pursuit movements

Pursuits are smooth tracking movements to maintain foveal fixation when viewing a moving object. The stimulus to initiate and maintain is movement of the object near the fovea. Pursuit movements have a relatively slow maximum velocity of (generally) less than 40 degrees per second.

Hold a small fixation target 16 to 20 inches from the patient. Instruct them to look at the target. Slowly (less than 40 degrees per second) move the target horizontally, vertically, diagonally and circularly. The patient may require additional cuing. Look for signs of apraxia, ataxia, dysconjugate gaze, saccadic movements, and limitation of gaze.

10.3. Saccadic movements

Saccadic eye movements serve to rapidly place an object of regard on the fovea, or to move the eyes quickly from one object to another. These movements are both voluntary and reflexive. They are very fast eye movements occurring at a velocity of between 400 to 700 degrees per second.

Saccades are evaluated by standard methods. During evaluation, consider the impact of potential visual field loss, and / or neglect on test results. Fixation targets should be separated by three to four inches and at a distance of 16 to 20 inches from the patient. Instruct the patient to look back and forth between the objects. Verbal, tactile, auditory, and / or visual cuing may be needed. Look for signs of apraxia, hypometria, dysmetria, inaccuracy, and dysconjugate gaze.

10.4. Vergence movements

Vergence eye movements refer to binocular movements where the two eyes move in a synchronous and symmetrical, but opposite direction. The vergence movements are convergence and divergence.

Testing is done in the following manner. Begin by holding a small fixation target on midline, in front of the patient and at a distance of about 24 inches from them. Instruct the patient to look at the target. Slowly move the target toward the bridge of the patients' nose. Take note of when one or both eyes stop tracking. That eye will typically diverge out. This distance from the patient is the near point of convergence. Next, begin moving the target back out away from the patient. Take note of when both eyes fixate back on the target. This the recovery point of divergence. Next, continue to move the target away from the patient out to about three feet and then back towards the patient, but stay beyond their near point of convergence. Observe for smoothness, ataxia and symmetry of movements.

10.5. Vestibulo-ocular reflex and non-optical eye movements

There are reflexive eye movements that are triggered by vestibular and certain proprioceptive stimuli. Their function is to hold and stabilize eye fixation on a target when the head moves by causing eye movements of an equal speed and opposite direction.

The vestibulo-ocular reflex (VOR) is mediated by the vestibular system. It can be triggered by non-visual stimulus as with caloric stimulus testing. The VOR is evaluated by having the patient fixate a steady object and then instructing them to move their head side to side, and up and down while maintaining fixation. Assess steadiness of gaze and consider how this might relate to symptoms of dizziness, or imbalance.

The oculocephalic reflex (OCF, also known as "Doll's Eyes") is an eye movement in response to proprioceptive changes in head and neck movement. This test is of importance in the unconscious patient or when voluntary or pursuit movements are impaired. The examiner physically rotates the patients' head in a horizontal plane to one side and looks for an ocular turn to the opposite side. The examiner should also test by pushing the patients' chin down looking for an upward movement, and elevating their chin looking for a downward movement. In the patient with impaired consciousness, there is typically a short delay in the eye movement response. Full movements indicate an intact brain-stem, ocular motor nuclei and efferent motor nerves. Absence of this reflex is possibly indicative of a significant brain stem injury.

11. Visual field

A careful and extended confrontation visual field test can pick up even subtle defects. Understanding the neuro-anatomy and pathophysiology of the injury will give clues as to what type of loss, if any, can be expected. The examiner should evaluate monocular and binocular visual fields. The more common types of visual field losses encountered are:

Hemianopsia secondary to occipital or significant temporal lobe involvement
Quadrantanopsia from injury to the temporal or parietal optic radiations
Monocular from pre-chiasmal involvement
Diffuse and scattered secondary to hypoxic or anoxic brain injury

12. Visual inattention/neglect

Visual inattention is a term used to describe a perceptual loss of vision. It arises from a parietal lobe injury and is most typically a left inattention from a right parietal lobe hemispheric involvement. It can mimic a hemianopic visual field loss, but is actually a perceptual loss of vision with actual vision still intact. When the inattention is quite dense, the patient will present with a strong right gaze preference and virtual inability to cross midline tracking to their left. It can also be as mild as to manifest in only extremely stimulating and demanding environments.

Evaluating for visual inattention is done in a number of ways. It frequently is not a clear cut diagnosis because of the varying depth of involvement. While performing a confrontation visual field one can test for neglect with double simultaneous stimulation. Double simultaneous stimulation (DSS) is performed by presenting a different number of fingers to the patients' right and left peripheral vision simultaneously while they fixate on the examiner. If the patient has a visual neglect, the typical response is to have full monocular and binocular fields, but on DSS the neglect side will be extinguished and they will only accurately report the fingers seen on the intact side. Additional tests are done by Occupational Therapists, Physical Therapists, and Speech Language Pathologists. Tests include, for example, line bisection, drawing a clock and more sophisticated tests of visual perception such as the Hooper [8].

13. Pupil reflexes

The examiner should look for signs of mal-position, anisocoria, sluggish pupils, minimally reactive pupils, miosis, afferent pupil defect (complete, partial, unilateral, or bilateral), and a fixed or dilated pupil (CNIII). Anisocoria of up to one millimeter can be considered physiologic in the absence of other abnormalities. Less commonly seen is a random episodic dilation, or miosis that can arise from dysautonomia. Consider the effect of medications on pupil responses. In patients who have suffered an associated cervical spinal cord injury one should look for signs of Horner's syndrome with ipsilateral miosis, anhydrosis and ptosis.

14. Health evaluation

External exam is evaluated by observation, slit-lamp exam, and sensory testing. Test for corneal sensitivity (corneal branch of CNV). Look for signs of ptosis (CNIII, Horner's), lagophthalmos (CNVII), blepharitis, conjunctivitis, diffuse keratitis, filamentary keratitis, neurotrophic cornea, hyphema, iris tears, and cataract.

A dilated funduscopic exam is preferable when possible. Pay special attention for signs of vitreous hemorrhage (Terson's syndrome which can be recognized by absence of the normal red reflex seen on direct ophthalmoscopy), papilledema, optic nerve pallor, and retinal detachment

15. Red desaturation

The optic nerve is particularly sensitive to the color red. The patient is instructed to look at a red target. One eye and then the other are covered. The patient is instructed to inform the examiner if the intensity of the red changes between eyes, and to report if one eye appears more muted or gray than the other. This is indicative of optic nerve damage.

16. Intraocular pressure

Tonometry can be performed with a portable contact tonometer. This measures the intra-ocular pressure of the eye.

17. Refraction

Objective refraction by retinoscopy is a preferred method and performed by standard methods using loose lenses, and or a lens rack. As a general rule, 20/40 acuity is considered adequate functional vision for normal daily activities.

18. Vision as related to dizziness and balance

Certain visual problems can cause or aggravate dizziness and balance problems. The most common ones to consider and evaluate are:

18.1. Aneisokonia

Aneisokonia is a visual where there is a difference in perceived magnification of images between the eyes. When the difference becomes excessive (generally greater than 7%) the effect can cause diplopia, disorientation, eyestrain, headache, and dizziness and balance disorders. Most cases of aneisokonia are corneal and refractive.

This is tested by determining the magnitude and nature of the difference in image size perception between the eyes.

18.2. Double vision

Double vision can be caused from monocular or binocular disorders. Monocular double vision is perceived with only one eye open; whereas binocular diplopia is perceived with both eyes open and disappears when either eye is closed. Typical causes of monocular diplopia include cataract, refractive error (most often astigmatism), corneal scarring, dislocated lens, keratoconus, and retinal detachment. Binocular diplopia arises from an improper alignment (dysconjugate gaze) of the eyes and is referred to as strabismus. Binocular diplopia can be constant, or intermittent; commitant (equal in all directions of gaze) or non-commitant (variable depending on direction of gaze; and horizontal, vertical, angular, and / or rotary in misalignment. Causes of intermittent binocular double vision include myasthenia gravis and latent eye deviation (phoria) that becomesuncompensated. Causes of constant binocular diplopia are most commonly from a palsy (weakness), or ophthalmoplegia (paralysis) of the 3rd, 4th, or 6th cranial nerve. Test:

1. Binocular vision is evaluated to determine the exact type of the strabismus. Standard phorometric and free space lens and prism tests are done for ocular muscle balance and phoria.
2. Park's 3-step [9] and single and double Maddox rod testing help identify the involved muscle(s) and / or cranial nerve(s).

18.3. Binocular vision dysfunction

In the absence of Cranial Nerve palsy, or ophthalmoplegia, binocular coordination problems can exist where the eyes have a tendency to drift inward, outward, upward, or downward. This latent tendency is referred to as a phoria (as compared to tropia when the eyes actually become misaligned with a strabismus).

18.4. Vertical imbalance

A vertical misalignment between the eyes can arise from a phoria, or a tropia. The most common cause of an acquired vertical imbalance is from Fourth cranial nerve palsy. The Fourth Cranial Nerve innervates the superior oblique muscle. This muscle is responsible for lowering the eye when adducted and for incyclorotation.

18.5. Eye movement disorders

Eye movement disorders may present as nystagmus, ataxia, apraxia, hypo-metric, and / dys-metric. With acquired eye movement disorders it is important to identify and treat (if possible) any underlying cause.

Oscillopsia, the abnormal perception of movement, will frequently accompany acquired nystagmus. This, in turn, disrupts visual spatial stability and will cause dizziness and balance problems.

19. Treatment planning

Medical management of eye disease and trauma should be initiated as soon as possible and coordinated with the attending physician and if indicated an ophthalmology specialist. Functional vision treatment should logically follow from the diagnoses found and be in agreement and coordination with the goals as determined by the entire rehabilitation team. Many times these decisions are straight forward, but not always. For example, consider the patient with a left hemianopic visual field loss and with a left exotropia from a CNIII paresis. The left eye turning out causes double vision, but also expands and helps to compensate for the hemianopic visual field loss. If the strabismus is treated, the patients' effective useable field of vision will be reduced. In this case it would be recommended to not treat the strabismus. The rationale is that reducing the useable visual field by eliminating the strabismus is a much less desirable functional outcome for the patient than teaching them to manage their diplopia.

20. Conclusion

Caring for neurologic patients in a hospital setting can be rewarding experience. To be successful in the medical team approach and in good patient care several things are required. The clinician must be able to work with a team; have superb observation, diagnostic and therapy skills; think quickly and "on their feet", and be able to view achieving good outcomes from a function based approach. The clinician must also have a thorough grasp of the sensory and motor aspects of vision, medical aspects of vision, and functional aspects of vision. Finally, all of this must be combined with a good understanding of neurology, neuro-anatomy, physiology, occupational therapy, physical therapy, and speech therapy.

Appendix 1

The list of recommended equipment includes:

Portable bio-microscope with fundus lens
Portable tonometer
Ophthalmoscope
Retinoscope with retinoscopy lenses
Transilluminator, or penlight
Trial lens kit with loose prisms and trial frame
Spectacle magnifiers
Portable lensometer
Occluder with Maddox rod on one end
Distance and near acuity charts

A small bag can hold dilation drops, anesthetic, temporary lid weights, and bandage contact lenses. A supply of Fresnell prisms can be carried, or left at the hospital.

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