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FINAL (1 JUNE 2015)
VCE and PAO-APPROVED SCRIPT FOR USE BY DIGITAL CREATIVE PRODUCTION

Podcast 1

VISION CONCERNS AFTER MILD TRAUMATIC BRAIN INJURY

Introduction.
This series of podcasts is hosted by the Vision Center of Excellence, a joint program of the Department of Defense and Department of Veterans Affairs.

The podcast series provides concise summaries of issues and reports targeted to Department of Defense and Veterans Affairs vision providers overseeing care for our Service members and Veterans.

Body.
Mild traumatic brain injury, also called mTBI, is often referred to as the signature injury of the recent military conflicts in Iraq and Afghanistan. As a result, there has been an increased focus in recent years on understanding the mechanisms of mTBI and identifying the associated acute and chronic sequelae. This podcast summarizes a 2015 review article entitled "Vision Concerns After Mild Traumatic Brain Injury." It was published in Current Treatment Options in Neurology and coauthored by Brad P. Barnett, MD, PhD and Eric L. Singman, MD, PhD from The Wilmer Eye Institute at Johns Hopkins Hospital in Baltimore, Maryland.

Unlike moderate to severe TBI, mTBI or concussion, is not characterized by gross pathology, hemorrhage or other obvious tissue abnormalities that often can be detected on routine diagnostic neuroimaging tools such as CT scans or MRIs. Instead, the damage caused by mTBI largely occurs at the cellular and sub-cellular levels, resulting in damage that is primarily only detectable using more sensitive imaging tools. While most people who have sustained mTBI will fully recover, some of them may experience long-lasting effects that span the behavioral, cognitive, attentional, physiological and sensory domains. In their review, entitled "Vision Concerns after Mild Traumatic Brain Injury", Barnett and Singman describe the visual consequences of mTBI with a specific focus on: (1) acute and chronic visual sequelae; (2) proposed underlying pathophysiological mechanisms; (3) clinical screening and diagnostic techniques; and (4) current and future treatment options. The authors grouped mTBI-related visual dysfunctions into three distinct categories - afferent visual dysfunctions, efferent visual defects and higher order deficits – for the purposes of discussion.

Afferent or sensory visual dysfunctions are the result of damage to the incoming visual pathways, which subsequently affects how visual information enters the eye. As such, these conditions are frequently manifested as problems with overall visual acuity, color perception and contrast deficits that may not be immediately apparent, particularly when the visual problem is monocular. Monocular visual deficits occurring in mTBI populations are most often caused by ocular or orbital trauma. While direct ocular trauma can often be diagnosed using standard ophthalmologic techniques, retro-bulbar trauma, or ocular damage occurring behind the globe, may be too subtle to be detected with standard methods. Afferent visual dysfunctions, such as afferent pupillary defect, visual field deficits or ptosis, are often strong indicators of possible retro-bulbar trauma. The authors were absolute in their clinical recommendation for performing a CT scan including the orbits to rule out possible retro-bulbar hemorrhage in emergency settings. When CT scans are non-revealing, the authors also recommended examining visual acuity, color discrimination and contrast sensitivity, as declines in these areas may indicate traumatic optic neuropathy. Visual field defects and other visuospatial disorders such as visual attention deficits and midline shifts can also result following damage to the afferent system. Confrontation testing is often sufficient for detecting severe visual field deficits, however, automated perimetry is recommended to detect more subtle injuries. Visuospatial attention deficits are characterized by a reduced ability to easily change visual focus by shifting, engaging, and disengaging visual attention to and from targeted objects. The Attention Network Test is recommended to diagnose this disorder. While additional research is needed before Visual Midline Shift Syndrome (VMSS) can be confirmed as a distinct medical condition, patients who have received a diagnosis of VMSS have been treated with yoked prisms to shift the altered image of the perceived midline back to center.

Many of the oculomotor dysfunctions are often the result of damage to the efferent visual system, or outgoing visual pathways. For example, mTBI patients often develop deficits in accommodation and, as a result, have difficulty focusing and defocusing at near and far distances, respectively. Nystagmus is another TBI-related visual disorder that is characterized by involuntary rhythmic movement of the eyes. Although this condition can be detected by visual inspection, Barnett and Singman discuss the usefulness of video nystagmography to quantify and characterize the type of nystagmus. Deficits in saccades and pursuits can manifest as reductions in the ability to move eyes between targets. Pursuits allow the eyes to smoothly follow a moving target, while saccades are the rapid eye movements involved in fixation. While detailed evaluation by a skilled practitioner may uncover gross deficits in pursuits and saccades, automated eye tracking may be needed to uncover more subtle abnormalities. The occurrence of an mTBI can worsen a pre-existing heterophoria, or latent strabismus, turning it into manifest strabismus, or heterotropia. Mild TBI can also lead to frank strabismus with diplopia as a result of palsies to the third, fourth, and sixth cranial nerves. While gross defects can be easily measured in the field, the authors state that synoptophores and other automated devices for measuring heterophorias can be used to detect more subtle defects. Patients with affected ocular alignment may have a reduction in stereopsis, reflected by an inability of the brain to accurately determine depth. Although the authors don't recommend any specific tests in the review, a number of sensitive tests of stereo-acuity are reported to exist. Finally, slowed pupil responses have been commonly reported in mTBI patients even when other tests for TBI are normal. As a result, automated pupillometry is now being considered as a potential method of screening.

Higher order visual deficits include several other common TBI-related visual complaints, such as photophobia, sensitivity to glare, decreased reaction time to sensory stimuli, reading deficits, and acute and chronic memory impairment. These conditions result from abnormal processing in the primary visual pathways as well as the non-visual portions of the brain. Although not confirmed, photophobia and increased sensitivity to glare in mTBI populations are believed to be the result of deficits in dark adaptation. Nevertheless, more research is needed in this area. Mild TBI patients also experience reading deficits which include difficulty in transitioning between lines of text, paraphrasing, and processing visual information. The King-Devick test a is well-known test used to identify concussion in athletes that is recommended by the authors as an automated test of reading deficits. Reaction time to visual, auditory and tactile stimuli can also be slowed following mTBI. The authors suggest measuring these changes using automated software. The authors also note that memory impairment, both acute and chronic, has been observed in mTBI patients. The Rapid Screen of Concussion was recommended to assess the severity of TBI in such patients.

Any of these visual complications can manifest as significant barriers to completing simple tasks and activities of everyday living. As a result, they are potential causes for patient referral to vision therapy. When vision therapy is not the proper method of treatment, such as in patients with non-comitant strabismus and complex diplopia patterns, the authors strongly recommended referral to a neuro-ophthalmologist for medical and/or surgical intervention. Nevertheless, vision therapy is recommended for individuals with abnormal vergences, versions and accommodation. Vision therapy primarily focuses on improving binocular vision, stereopsis, accommodative amplitude and visual field function. Optometrists may also recommend a specific form of vision therapy called oculomotor vision rehabilitation, or OVR, which combines motor and attention training to assist with overcoming these visual deficits. OVR has been shown to provide significant vision improvement in patients.

The authors provided the following recommendations for OVR therapy in patients with mTBI:

- Sequential step and ramp training is recommended for patients with vergence dysfunction following mTBI. In these exercises, visual targets are sequentially presented to a patient at varying distances, thus altering the vergence or divergence required to maintain binocular vision. This method is considered a success when patients can maintain binocular vision at both far and near distances for at least 20 minutes.
- The treatment of strabismus can include both surgical and non-surgical methods depending on the severity. The minimum goal of OVR for a patient with strabismus is to eliminate diplopia. If the patient is able to fuse images, vergence training and/or prisms and surgery may be able to be used. Surgical treatments for strabismus involve adjusting the extra-ocular muscles to facilitate repositioning of the globe.
- OVR for deficits in pursuits should seek to minimize complications when tracking a target in motion while maintaining a conjugate, or connected, gaze. After establishing that a deficit in pursuits exists, the authors note that standard therapy should involve repeatedly slowly moving a visual target horizontally from the midline of the patient to ±5 degrees from midline. After a break, the exercise should then be repeated horizontally for ±10 degrees and then vertically for both ±5 and ±10 degrees.
- For patients with deficits in saccades, the authors recommend sequentially presenting targets in the four quadrants (up, right, down, left) ± 20 degrees from midline. After repeating this exercise for 10 repetitions, the target should be adjusted to ±10 degrees from midline and a similar repetition should be undertaken.
- Similar to vergence dysfunction, therapy for accommodative dysfunction involves both ramp and step training. OVR for these patients seeks to improve accommodative amplitude and accuracy, and thus reduce the experience of blurring. The authors recommend that therapy be performed both monocularly, with optically-imposed vertical diplopia, and binocularly. The target size should also be decreased as accommodative function improves in order to increase the level of difficulty for the patient.
- OVR for visual field deficits primarily involves compensating for decreased awareness of deficits in the visual field. Using automated perimetry, such as a Humphrey visual field, deficits are identified

by the presentation of visual targets in both affected and unaffected fields of vision. Once patients are aware of the deficit areas, they are trained to routinely scan those locations that may be missed.

- Common mTBI-related visual complaints such as photophobia and sensitivity to glare can be treated with tints and filters. Spectacles with colored filtered lenses, specifically those that block the blue-green wavelengths of light, such as FL-41 lenses, are commonly prescribed for treating photophobia as well as for increasing contrast sensitivity and reading rates in individuals with mTBI. Testing with sample lenses must be completed with varying levels of illumination to identify the optimal filter for the individual. Different lenses may be needed for indoor versus outdoor use. Clip-on tinted lenses are also available for individuals requiring a particular filter.
- Mild TBI patients often experience deficits in fixation, including gaze instability, slow drift, and jerk nystagmus. OVR involves asking the patient to focus on a target at midline for 3 seconds then close their eyes for the same amount of time. The provider should then move the target ±20 degrees vertically and horizontally with 3 second rest periods in-between. The authors note that these exercises should be performed at arm's length and distance. They can also be performed monocularly or binocularly.

In conclusion, medical professionals whose patients have a history of mTBI must be acutely aware of the signs and symptoms of mTBI-related vision dysfunction. Identification of gross and subtle changes in an individual's vision may indicate a condition that requires management and treatment. Proper intervention and therapy is paramount to optimizing treatment results. In addition to the ability to identify possible visual dysfunctions, medical practitioners must have access to a referral directory or resource to properly guide and advocate for most accurate and optimum clinical rehabilitative care.

Conclusion.

This production was brought to you by the Vision Center of Excellence. Our mission is to lead and advocate for programs and initiatives to improve vision health, optimize readiness and enhance quality of life for Service members and Veterans. Working with TRICARE, the Military Health System, other Centers of Excellence and the Veterans Health Administration, the Vision Center of Excellence works to enhance collaboration between Department of Defense and Department of Veterans Affairs vision care providers, provide guidance for clinical practice and facilitate patient-centered support. For more information, visit us online at vce.health.mil or on Facebook.

APPENDIX

A: Phonetic Guide.

Phonetic Guide			
1	Neurology	neu·rol·o·gy	nu̇r-ə-ˈlä-ji
2	concussion	con·cus·sion	kən-ˈkə-shən
3	pathology	pa·thol·o·gy	pəˈTHäləjē
4	hemorrhage	hem·or·rhage	hem-rij
5	neuroimaging	neu·ro·im·ag·ing	n(y)u̇r-ō-ˈi-mə-jiŋ
6	tensor	ten·sor	ten(t)-sər
7	Preclinical	pre·clin·i·cal	prē-ˈkli-ni-kəl
8	pathophysiological	path·o·phys·i·o·log·i·cal	pa-thō-ˌfi-zē-ə-ˈlä-ji-kəl
9	axonal	ax·o·nal	ak-sə-nəl
10	afferent	af·fer·ent	a-fə-rənt
11	efferent	ef·fer·ent	e-fər-ənt
12	occipital	oc·cip·i·tal	äk-ˈsi-pə-təl
13	acuity	acu·ity	ə-ˈkyü-ə-tē
14	accommodation	ac·com·mo·da·tion	ə-ˌkä-mə-ˈdā-shən
15	ductions	duc·tions	duk´shuns
16	photosensitivity	pho·to·sen·si·tiv·i·ty	fōt-ō-sen(t)-sə-ˈti-və-tē
17	saccade	sac·cade	sa-ˈkäd
18	orthoptic	or·thop·tic	ȯr-ˈthäp-tik
19	retina	ret·i·na	ret-ən-ə

Phonetic Guide (cont)			
20	striate	stri·ate	strī-ət
21	adnexa	ad·nexa	ad-ˈnek-sə
22	retrobulbar	ret·ro·bul·bar	retro-bəl-bər
23	yoked	yoked	Yōkt
24	motilities	mo·til·i·ty	mō-ˈtil-ət-ēs
25	pursuits	pur·suits	pər-ˈsüts
26	heterophoria	het·ero·pho·ria	het-ə-rō-ˈfōr-ē-ə
27	heterotropia	het·ero· tro·pia	het-ə-rō-ˈ trō-pē-ə
28	cranial	cra·ni·al	krā-nē-əl

Phonetic Guide (cont)			
29	diplopia	dip·lo·pia	dip-ˈlō-pē-ə
30	vergences	ver·gence	vər-jən(t)s-es
31	versions	ver·sions	vər-zhəns
32	stereopsis	ste·re·op·sis	ster-ē-ˈäp-səs
33	oculomotor	oc·u·lo·mo·tor	äk-yə-lə-ˈmōt-ər
34	non-comitant	non·com·i·tant	nän-ˈkä-mə-tənt
35	strabismus	stra·bis·mus	strə-ˈbiz-məs
36	photophobia	pho·to·pho·bia	fō-tə-ˈfō-bē-ə