The occurrence of ocular and visual dysfunctions in an acquired brain-injured patient sample

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Background: *Acquired brain injury* (ABI) is a general term referring to brain injury occurring secondary to trauma, stroke, or post-surgical complications. This paper reports on the occurrence of various ocular and visual conditions in an ABI patient sample.

Methods: The subjects for this study were 62 brain-injured adults who resided in two extended care facilities in the New York area. Subjects ranged from 19 to 70 years of age. The standard protocol for the visual evaluation incorporated a patient interview; cover test; refraction; and assessment of visual acuity, ocular motility, accommodation, binocularity, visual fields, color vision, contrast sensitivity, pupils, and anterior and posterior segments.

Results: Results were reported as a ratio comparing the occurrence of a condition in our ABI sample relative to that in a reference normal population (where normative data are available) and as a comparison to other published data on ABI samples. An increased occurrence of exo deviations, oculomotor dysfunctions, and vertical deviations was evident. An elevated occurrence of dry eye, blepharitis, optic nerve pathologies, and visual field deficits was also manifest.

Conclusion: Our patient sample demonstrates that certain ocular and visual conditions occur more frequently among ABI patients in comparison to a random, adult population.

Key Words: Acquired brain injury, ocular dysfunctions, visual dysfunctions

Acquired brain injury (ABI) is an umbrella term encompassing traumatic brain injury (TBI) and cerebral vascular compromise (e.g., cerebral vascular accident (CVA)/stroke; anoxia; sequelae of surgery; drug overdose).[1] The existence of ocular and visual dysfunctions consequent to ABI is thought to be significant and frequently to go undetected.[2,3] A number of studies have sought to establish the prevalence of oculomotor dysfunctions (i.e., pursuit, saccade, and/or binocular conditions such as strabismus, uncompensated phorias, vergence deficits, and fusional disorders). For example, Lepore,[4] in a retrospective study of 60 patients, found that 51 exhibited nuclear or infranuclear oculomotor abnormalities. Schlageter et al.[5] reported that 30 of 51 of their hospital in-patient sample exhibited compromised performance in one or more of the following: pursuit, saccade, ocular posturing, stereopsis, and vergence. Also included were near/far eso-exotropia. In another study, Hellerstein et al.[6] compared symptoms, refractive status, accommodative function, and various oculomotor sensory and motor functions of 16 patients diagnosed with mild TBI, with 16 non-TBI age-matched control subjects. Significant differences were found between the two groups in virtually all specified areas, indicating more symptoms and poorer oculomotor and binocular functioning in the mild TBI group.

Two other studies (previously cited) are of note because they sought to determine the prevalence not only of oculomotor dysfunctions and symptoms, but also of compromised visual fields. Sabates et al.[2] reported findings of 188 consecutive closed head trauma patients referred for neuro-ophthalmologic examination over a 4-year period. The most commonly reported symptoms from patients were blurred or decreased vision (46%), diplopia (30%), headaches (13%), and difficulty reading (10%). Some 33% experienced a palsy of one or more of the cranial nerves involved with vision, and 5% had optic

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atrophy. Sixty-four patients (35%) showed visual-field defects. Gianutsos et al.[3] presented data on 55 severely brain-injured adult patients in a long-term rehabilitative facility. Their results indicated a high prevalence of decreased visual acuity; oculomotor, binocular, sensory, and motor dysfunctions; and visual-field defects.

These studies are quite valuable in alerting optometrists and ophthalmologists to some of the clinical conditions one should expect as sequelae to ABI. However, there is increasing evidence—particularly in the optometric literature—that the ocular and visual consequences of ABI are more far-reaching.[1,7,8] But, in the five articles cited earlier, only one mentioned ocular health conditions,[2] and in the other articles, this area was not reported, or patients with ocular pathology were not included in the sample.[6] Nor did any of the articles report on impaired contrast sensitivity function, color vision losses, or photophobia. These conditions are not clinically unusual in the ABI population and frequently adversely affect the patient's ability to respond maximally to rehabilitation regimens. Further—with the exception of one article[3]—the subjects were essentially pre-selected (i.e., they were referred for optometric or ophthalmologic care because of suspected ocular or visual dysfunctions). While they probably do give an accurate description of some of the sequelae of ABI in a clinical population, the reported data might be inflated with regard to the total ABI population.

The purpose of this article is to report the occurrence of a number of ocular and visual sequelae in a sample of patients who have incurred ABI and require sub-acute extended care. Unlike virtually all of the previous studies, the patients in our study were scheduled for an optometric evaluation not because of a suspected ocular or visual condition, but rather as an integral part of their general health care.

Subjects

The Life Line Brain Injury Rehabilitation Unit (BIRU) is a sub-acute in-patient traumatic brain injury (TBI) program located within two extended care facilities in Queens, New York. These facilities include Park Terrace Care Center (PT) and Queens-Nassau Nursing Care Center (QN). Each facility has established a distinct unit of at least 40 beds to provide comprehensive rehabilitation services for adult brain injury survivors.

Table 1. Breakdown of subjects according to type of acquired brain injury

Etiology	No. of residents	% of residents
TBI male	34	55.0%
TBI female	3	4.8%
Vascular male	6	9.7%
Vascular female	9	6.5%
Anoxia	4	6.5%
Drug overdose	4	6.4%
Tumor resection	2	3.2%

TBI, Traumatic brain injury.

Individuals admitted to the BIRU are sufficiently disabled as a result of their brain injury to currently preclude independent or supervised living within the community. Brain injury survivors admitted for treatment within the BIRU have moderate-to-severe levels of disability, as determined by a series of measures such as the Glasgow Coma Scale and a disability rating scale. Residents within the BIRU may exhibit several categories of disability, including difficulties with fine and gross motor functioning, disorientation, pervasive confusion, and impaired functioning for activities of daily living (ADLs). These residents may also exhibit difficulties with expressive and receptive communication, as well as problems with sensory and perceptual integration, short- and/or long-term memory, simple problem solving, and novel learning. They may also manifest problems with impulse control, interpersonal relationships, and effective mood modulation. Multiple levels of rehabilitation services are provided for brain injury survivors to accommodate the spectrum of disability. While most residents of BIRU exhibit considerable rehabilitation needs, the basic goal for many of the program participants is community re-integration.

The subjects for this study were 62 adult brain-injured residents located in two geographically distinct units. The mean age of the 49 male residents was 42 years, 2 months, with ages ranging from 19 to 70 years. The mean age of the 13

female residents was 44 years, 9 months, with ages ranging from 28 to 65 years. The mean age for the total sample is 43 years, 5 months, with ages ranging from 19 years to 70 years.

The etiological conditions are exhibited in Table 1. Of the total sample of 62 residents, 34 residents (55%) were males recovering from TBI. A comparison between male and female ABI residents reveals only three residents (4.8%) were females recovering from TBI. Thus, of the total sample, almost 60% exhibited deficits consistent with TBI and approximately 24% had been previously diagnosed with CVA. The remaining subjects had histories of anoxia, drug overdose, and tumor resection.

Methods

All patients from both locations whose findings constitute the data in this report were scheduled for optometric evaluation, performed by clinical faculty of the Head Trauma Vision Rehabilitation Unit (HTVRU). The HTVRU is a component of the University Optometric Center of the State University of New York State College of Optometry (SUNY). A memorandum of agreement was executed between SUNY and the Life Line Brain Injury Rehabilitation Unit in this regard. Patients from the QN facility were transported to the College by ambulette. The College provided equipment for optometric examinations at the PT facility, and an HTVRU optometrist was assigned for this purpose 2 days per week. Patients from QN were examined at SUNY in the HTVRU one afternoon per week. The data that will be reported were collected from June 1996 through May 1997.

The HTVRU functions 5 days per week and, in addition to the patient sample described in this article, provides ocular and visual diagnostic and treatment services to individuals referred by physiatrists; optometrists; clinical and neuropsychologists; occupational, physical, and vestibular therapists; and other rehabilitation professionals. These individuals are either in private settings or staff at several neighboring New York City hospital-based departments of rehabilitation medicine. The HTVRU limits its patient population to those individuals who have experienced brain injury by virtue of penetrating or non-penetrating trauma (TBI), those who have required surgery of the brain or its immediate structures, and those who have incurred a CVA.

A protocol developed for the HTVRU includes the following:

a. **Patient interview**: including major symptom; nature of injury; rehabilitation, medical, ocular/visual, social/occupational and personal histories; family medical and ocular/visual histories; current medications and allergies to medication.
b. **Visual acuities (corrected and uncorrected) at distance and near**.
c. **Cover test at distance and near**: for assessment of strabismus or phorias.
d. **Oculomotor status**: including tests of fixation, pursuit, and saccade.
e. **Objective and subjective refraction**: for determination of the presence and amount of ametropia.
f. **Binocular vision motor status**: near point of convergence, distance and near prism dissociating tests of binocular alignment, and prism measures of divergence and convergence.
g. **Accommodative status**: including amplitude (using the minus lens or push-up technique), lag (using monocular estimate and fused cross cylinder techniques) and facility.
h. **Binocular vision sensory status**: including fusion and stereopsis.
i. **Visual field testing**: including confrontation and automated perimetry (Humphrey Visual Field Analyzer).
j. **Color vision and contrast sensitivity testing**: utilizing the Ishihara color plates[9] and the Vistech Contrast Sensitivity tests.[10]
k. Anterior ocular segment assessment: including pupillary testing, biomicroscopy, and applanation tonometry.
l. **Dilated fundus examination**: including assessment of the eye's posterior pole and peripheral retina using binocular indirect ophthalmoscopy.

Diagnostic criteria for the various conditions were determined by the SUNY–State College of Optometry Clinical Protocols document. These protocols follow the American Optometric Association Optometric *Clinical Practice Guidelines* and are similar to those used in the references for the normative data. (This document is available from the authors on request).

The subjects in this study received all or some of the testing outlined earlier. There were instances when

Table 2. Percentage of visual and ocular conditions for our sample and for a random adult population (where available) is tabulated

Ocular/visual condition	Occurrence in an ABI sample	Occurrence in a random adult population	ABI occurrence/ random adult occurrence
Exo deviations	26/62 = 41.9%	0.0211 = 2.11%[23]	19.9
Eso deviations	1/62 = 1.6%	0.0128 = 1.28%[23]	1.3
Vertical deviations	6/62 = 9.7%	0.016 = 1.6%[23]	6.1
Oculomotor dysfunctions	24/62 = 39.7%	†	†
Accommodative dysfunctions	6/62 = 9.6%	†	†
External eye pathologies: dry eye/blepharitis/ keratitis/pterygium/corneal degeneration	14/62 = 22.6%	0.112 = 11.2% (dry eye, blepharitis conjunctivitis)[23] 0.13 = 13% (frequent dry eye symptoms, ages 25 to 45 years) [24]	2.0[23]
Lid defects: ptosis/dermatochalasis/ blepharochalasis	3/62 = 4.8%	0.021 = 2.1% (elastosis of lid, ages 55 to 64 years) [23]	2.3
Aphakia/pseudophakia/ cataracts	15/62 = 24.1%	0.123 = 12.3% (overall cataracts) [25]	2.0
Optic nerve cupping/optic atrophy/glaucoma suspect/ glaucoma	12/62 = 19.4%	0.08 = 8%[26]	2.4
Color vision defect	0/20 = 0	0.0833/0.005 (m/f) = 8.333%/ 0.5% (some type of inherited color vision anomaly)[27]	†
Contrast sensitivity defect	0/20 = 0	†	†
Posterior pole anomalies: retinopathies (including diabetic retinopathy, hypertensive retinopathy, and maculopathies)	6/62 = 9.7%	0.015 = 1.5%[15] 0.022/0.014 (m/f) = 2.2%/1.4% (background diabetic retinopathy, ages 52 to 64 years)[25] 0.008/0.014 (m/f) = 0.8%/1.4% (macular degeneration, ages 52 to 64 years)[25]	6.5[15]
Retinal defects/detachments	1/62 = 1.6%	0.0008 = 0.08%[28]	20.0
Peripheral retinal degenerations/vitreoretinal degenerations	6/62 = 9.7%	0.026 = 2.6% (lattice degeneration)[29]	3.7
Blindness/enucleation	4/62 = 6.45%	0.0159 = 1.59%[28]	4.1
Pupillary anomaly	1/62 = 1.613%	0.01 = 1% (anisocoria, ages 1 to 74 years)[23]	1.6
Visual-field defects	13/40 = 32.5%	†	†

† Our search did not find documentation for those conditions in a randomly selected adult population.
ABI, Acquired brain injury; ***m/f***, male-to-female.

physical, cognitive, or language difficulties precluded some of the procedures. Much of the information regarding the patient interview was obtained by social workers at PT and QN, and made available to the examining doctors before the appointment time. Each patient had received a medical examination as part of the intake procedure at PT and QN.

All patients whose data are included in this article have either been tested for visual perceptual

abilities or were scheduled for these tests. It is planned that these results will be the subject of another report. All of these patients' medical records were reviewed for completeness and clinical judgment according to SUNY's Quality Assurance and Improvement policies.

Results

The results are presented in Table 2. The various ocular/visual conditions are listed in the first column of this table in groupings we considered clinically logical. The second column reports the occurrence of each condition in our sample in fraction form (i.e., the number of subjects having the condition[s] divided by the total number of subjects who were able to be tested). The fraction is then converted into a percentage. The third column indicates the occurrence of each condition reported to be found in a random adult population. The superscripted letter following the fraction indicates the source of this information. The daggers denote that our search did not find documentation for those conditions in a randomly selected adult population. The fourth column indicates the ratio comparing the occurrence of a condition in our sample relative to a normative reference. Thus, a ratio of '3' indicates the condition occurred three times more frequently in our sample relative to a normative reference.

The data will be reported in two ways; from the standpoint of the magnitude of the ratio where normative information is available, and then by comparison of our findings with those of other published reports of the occurrence or frequency of these conditions in ABI samples.

Exo deviations included all categories of intermittent and constant exotropia and convergence insufficiency. These conditions were prevalent in almost 42% of our sample—which is approximately 20 times the occurrence in a random population. A study by Cohen et al.[11] indicated approximately a 40% incidence of convergence insufficiency in their sample of TBI patients. Hellerstein et al.[6] compared the visual findings of 16 non-TBI age-matched controls with the same number of TBI subjects. They found statistically significant differences in several clinical findings that were components of our exo deviations category: the TBI group had greater exophoria at distance and near, and a more receded near point of convergence (NPC) than the control group.

Eso deviations included all categories of intermittent and constant esotropia, along with convergence excess. Our data showed a low occurrence of these conditions, as is reported in a random population. Indeed, a review of the pertinent clinical literature[2,4-6] indicated that these conditions are not remarkably prevalent in the ABI population.

Vertical deviations included all categories of intermittent and constant vertical strabismus, and vertical phorias greater than one prism diopter. Our sample manifested these conditions six times more often than in a random, adult population. While it is common clinical knowledge that a supranuclear, nuclear, or infranuclear lesion can result in a manifest or latent vertical deviation,[12] we could find no reference to the occurrence of these conditions in an ABI population.

Oculomotor dysfunctions included compromised fixation, pursuit, and saccadic eye movements. Our subjects showed an occurrence of almost 40%. Although the groupings are not exactly the same, this rather high figure is consistent with the findings of others in selected ABI patient samples.[2,4,5]

While our protocol included three types of testing for accommodation (see entry *"g"* in the *Methods* section above), only the category of accommodative insufficiency was determined in six of our subjects. This translated to approximately 10%. The same figure has been previously reported,[13] while Gianutsos et al.[3] found an occurrence of 69% for accommodative insufficiency in their sample of 55 severely brain-damaged patients. An overall younger patient population may have been used in the study by Gianutsos et al.[3] in comparison to that performed by Al-Qurainy.[13]

External eye pathologies were found in almost 23% of our sample. This is approximately twice that found in a random population. While we could find no numerical estimate for the occurrence of these conditions in the ABI population in our literature review, the presence of anterior segment pathology has been noted anecdotally.[1,7,14]

About 5% of our subjects had a lid defect, in comparison to 2.1% in a random adult population.

Additionally, these conditions have been previously reported in the ABI population.[15]

Previous surgically removed crystalline lenses or cataracts were present in some 24% of our sample—compared with 12.3% in a random population. Although we could not find estimates of the presence of these conditions in the ABI population for comparison, pathology of the crystalline lens is recognized as being a consequence of ABI.[15]

The occurrence of optic nerve pathology associated with suspected or confirmed glaucoma in our sample was some 19%, as compared with approximately 8% in a random population. This is significant in that the mean age of the men and women in our sample was approximately 42 years, and glaucoma is considered to be a geriatric disease, with the vast majority of cases occurring in persons more than 60 years of age.[16]

In a random adult population, approximately 8.33% of the men and 0.5% of the women manifest some form of inherited color vision defect.

No deficits of color vision or contrast sensitivity were evident in the 20 patients who were able to be tested. The remaining subjects could not respond to these tests because of cognitive or behavioral limitations. In a random adult population, approximately 8.33% of the men and 0.5% of the women manifest some form of inherited color vision defect. Additionally, anomalies of both color vision[17,18] and contrast sensitivity[19,20] have been reported in individual cases with cerebral compromise.

The occurrence of posterior pole retinopathies was approximately 9.7%, as compared with approximately 1.5% in a random adult population. While retinopathies have been reported in the ABI population, their occurrence has not been determined.[15]

An increased occurrence of retinal defects or detachments was evident in our patient sample relative to a random adult population. Approximately 1.6% of our ABI sample manifested retinal defects or detachments, as compared with 0.08% in a random adult population. Retinal defects and detachments have been previously reported as sequelae of ABI.[15]

Peripheral retinal and vitreoretinal degenerations were found in 9.7% of our ABI subjects. These conditions have been described as visual sequelae to ABI.[15] However, we were unable to find an estimate of the occurrence for a random adult population or a selected ABI sample.

The occurrence of blindness and enucleation in our sample was 6.45%, as compared with 1.59% in a random adult population. We were unable to find comparative occurrence data for a selected ABI sample. However, our result is significant in that for each of the ABI cases in our sample, the blindness and enucleation occurred as a result of the trauma.

Pupillary anomalies were found in approximately 1.6% of our ABI subjects. This is very similar to findings in a random adult population.

Visual-field defects were found in 32.5% of the 40 patients who were able to be reliably tested. We were unable to find documented occurrence of these conditions in a random adult population. It is clinical wisdom that visual field disorders are a frequent sequelae of ABI. Indeed, Zihl[21] stated they are the most frequent impairment after brain damage. He reported an occurrence of 75% of homonymous visual-field defects in 392 patients who were examined between 1978 and 1986. Our figure seems to be more in accordance with other researchers previously cited.[2,3]

Discussion

This study investigated the occurrence of a wide variety of ocular and visual dysfunctions in an adult sample of individuals who had incurred ABI. As compared with a random adult population, there was a significantly higher occurrence of exo deviations, and this has been reported previously.[6,11] We also found a significantly higher presence of vertical deviations and oculomotor dysfunctions. While the occurrence of the former condition in the ABI population has not—to the best of our knowledge—been previously reported in the literature, the latter has.[2,4,5] When all of these conditions are undiagnosed and/or

untreated, they can seriously compromise the rehabilitative progress of the patient.[22]

In terms of ocular pathologies, dry eye and blepharitis were present in a significant number of our sample. These conditions can be the result of overall poor health, poor hygiene, or occur as side effects of various medications.[1] When these conditions are not recognized or treated, they can result in the patient experiencing blurred and/or double vision. Nearly 25% of the subjects had been treated surgically for cataracts, or had this condition at the time of the examination. Optic nerve pathologies such as glaucoma, either suspected or diagnosed, were of a relatively high occurrence, as were pathologies of the retina and vitreous. Physical trauma to the eye resulted in blindness to four of our subjects.

While no color vision and contrast sensitivity deficits were diagnosed, it should be kept in mind that approximately only one third of the subjects were able to be reliably tested for these conditions because of cognitive or behavioral limitations. It is noteworthy that about 65% of our subjects were able to respond reliably to either confrontation or computerized visual-field testing. Furthermore, almost 32.5% of the sample manifested some type of visual-field defect. Nevertheless, as a result of the inherent subjectivity of these tests, it is probable that the results for color vision, contrast sensitivity, and visual-field testing underestimated their occurrence in our sample.

We did not report the occurrence of refractive conditions because we were looking for entities that were likely to be secondary to the trauma. Nevertheless, approximately 50% of our subjects needed glasses for the first time, a replacement for lost glasses, or a change of prescription.

This study provides evidence that various ocular and visual dysfunctions were present in our sample to a degree greater than are expected in a random population of adults. While these conditions are of consequence with all patients, they are particularly detrimental to ABI patients, who virtually always have other physical and/or cognitive impairments. Therefore, it is imperative that the patient, the family, and other involved professionals be fully informed of the ocular and visual conditions, their physical and functional consequences, and all treatment options for patients with ABI. Further, it has been our experience that when optometric treatment is conducted to ameliorate these conditions—in many instances—there is a positive impact on the patient's overall rehabilitation regimen and quality of life.

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