



DEPARTMENT OF THE AIR FORCE

59TH MEDICAL WING (AETC)  
LACKLAND AIR FORCE BASE TEXAS

21 MAR 2016

MEMORANDUM FOR SGVT

ATTN: CAPT LYNDSEY FERRIS

FROM: 59 MDW/SGVU

SUBJECT: Professional Presentation Approval

1. Your paper, entitled **Anoxic Brain Injury Secondary to Metabolic Encephalopathy** presented at **Optometry and Vision Science** with MDWI 41-108, and has been assigned local file #**16110**.
2. Pertinent biographic information (name of author(s), title, etc.) has been entered into our computer file. Please advise us (by phone or mail) that your presentation was given. At that time, we will need the date (month, day and year) along with the location of your presentation. It is important to update this information so that we can provide quality support for you, your department, and the Medical Center commander. This information is used to document the scholarly activities of our professional staff and students, which is an essential component of Wilford Hall Ambulatory Surgical Center (WHASC) internship and residency programs.
3. Please know that if you are a Graduate Health Sciences Education student and your department has told you they cannot fund your publication, the 59th Clinical Research Division may pay for your basic journal publishing charges (to include costs for tables and black and white photos). We cannot pay for reprints. If you are 59 MDW staff member, we can forward your request for funds to the designated wing POC.
4. Congratulations, and thank you for your efforts and time. Your contributions are vital to the medical mission. We look forward to assisting you in your future publication/presentation efforts.

Linda Steel-Goodwin

LINDA STEEL-GOODWIN, Col, USAF, BSC  
Director, Clinical Investigations & Research Support



**PROCESSING OF PROFESSIONAL MEDICAL RESEARCH/TECHNICAL PUBLICATIONS/PRESENTATIONS**

**1st ENDORSEMENT (59 MDW/SGVU Use Only)**

TO: Clinical Research Division 59 MDW/CRD Contact 292-7141 for email instructions.	22. DATE RECEIVED 3/2/2016	23. ASSIGNED PROCESSING REQUEST FILE NUMBER 16110
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24. DATE REVIEWED 2 Mar 2016	25. DATE FORWARDED TO 502 ISG/JAC
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26. AUTHOR CONTACTED FOR RECOMMENDED OR NECESSARY CHANGES:  NO  YES If yes, give date. 3 Mar 2016  N/A

27. COMMENTS  APPROVED  DISAPPROVED  
The author added the DoD disclaimer statement to the abstract. Both the abstract and manuscript are approved.

28. PRINTED NAME, RANK/GRADE, TITLE OF REVIEWER Rocky Calcote, PhD, Clinical Research Administrator	29. REVIEWER SIGNATURE CALCOTE.ROCKY.D.1178245844 <small>Digitally signed by CALCOTE ROCKY D.1178245844 DN: cn=US, ou=5, o=Department of Defense, ou=PA, ou=USAF, ou=CALCOTE ROCKY D.1178245844 Date: 2016.03.02 11:31:53 -0500</small>	30. DATE
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**2nd ENDORSEMENT (502 ISG/JAC Use Only)**

31. DATE RECEIVED	32. DATE FORWARDED TO 59 MDW/PA
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33. COMMENTS  APPROVED (In compliance with security and policy review directives.)  DISAPPROVED

34. PRINTED NAME, RANK/GRADE, TITLE OF REVIEWER	35. REVIEWER SIGNATURE	36. DATE
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**3rd ENDORSEMENT (59 MDW/PA Use Only)**

37. DATE RECEIVED March 17, 2016	38. DATE FORWARDED TO 59 MDW/SGVU March 18, 2016
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39. COMMENTS  APPROVED (In compliance with security and policy review directives.)  DISAPPROVED  
Abstract is approved as well.

40. PRINTED NAME, RANK/GRADE, TITLE OF REVIEWER Christopher Carwile, TSgt/E-6, NCOIC, PA	41. REVIEWER SIGNATURE CARWILE CHRISTOPHER STEW ART.1280477229 <small>Digitally signed by CARWILE CHRISTOPHER STEW ART.1280477229 DN: cn=US, ou=5, o=Department of Defense, ou=PA, ou=USAF, ou=CARWILE CHRISTOPHER STEW ART.1280477229 Date: 2016.03.18 14:14:55 -0500</small>	42. DATE March 18, 2016
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**4th ENDORSEMENT (59 MDW/SGVU Use Only)**

43. DATE RECEIVED	44. SENIOR AUTHOR NOTIFIED BY PHONE OF APPROVAL OR DISAPPROVAL <input type="checkbox"/> YES <input type="checkbox"/> NO <input type="checkbox"/> COULD NOT BE REACHED <input type="checkbox"/> LEFT MESSAGE
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45. COMMENTS  APPROVED  DISAPPROVED

46. PRINTED NAME, RANK/GRADE, TITLE OF REVIEWER	47. REVIEWER SIGNATURE	48. DATE
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DEPARTMENT OF THE AIR FORCE  
AIR EDUCATION AND TRAINING COMMAND

16 March 2016

MEMORANDUM FOR 59 MDW/CRD

FROM: 502 ISG/JA (Major Mark Coon)

SUBJECT: Ethics Review for Publication Approval Request

1. **BLUF:** A request for a legal review of a journal article titled "Anoxic Brain Injury Secondary to Metabolic Encephalopathy" was submitted by Capt (Dr.) Lyndsey Ferris. Dr. Ferris plans to publish this piece in *Optometry and Vision Science*, an academic journal. The journal article is legally sufficient as drafted, subject to the guidance provided below.
2. **FACTS:** A journal article titled "Anoxic Brain Injury Secondary to Metabolic Encephalopathy" was submitted for publication. The author plans to publish this research in *Optometry and Vision Science*, an academic journal.
3. **LAWS AND REGULATIONS:** DoD 5500.07-R, Joint Ethics Regulation (JER), section 3-305 establishes the rules governing "Teaching, Speaking and Writing." In accordance with that provision, where a publication will deal in significant part with any ongoing or announced policy, program or operation" of the Air Force, the author is required to include a disclaimer that states that the views presented are those of the author and do not necessarily represent the views of DoD or its Components.
4. **ANALYSIS:** In this case, although the proposed journal article does not "deal in significant part with any ongoing or announced policy, program or operation" of the Air Force, Dr. Ferris' affiliation and/or rank will be included in the article. Moreover, it will be clear that the case study information was obtained as part of her military medical practice. Accordingly, it is prudent for Dr. Ferris to include the abovementioned disclaimer and she has, in fact, done so here. Accordingly, and in light of the fact that there are no other apparent conflicts of interest that would prohibit publication, this journal article is legally sufficient. One should also keep in mind that a Public Affairs review may be needed if one has not already been obtained.
5. **CONCLUSION:** The journal article presented for review contains the legally required disclaimer and is therefore legally sufficient. If you have any questions, please call the undersigned at 671-3362.

Handwritten signature of Mark E. Coon in blue ink.

MARK E. COON, Major, USAF  
Assistant Staff Judge Advocate

I concur.

Handwritten signature of Arlene R. Christilles in blue ink.

ARLENE R. CHRISTILLES  
Chief, Civil Law

1 Introduction:

2 Syndrome of Inappropriate Antidiuretic Hormone (SIADH) is a condition in which the body has normal  
3 adrenal cortical function and normal systemic sodium levels, but an "inappropriate" concentration of  
4 antidiuretic hormone (ADH) in relation to body fluid osmolality.<sup>1-3</sup> SIADH is a fairly common condition,  
5 accounting for up to one-third of all cases of hyponatremia.<sup>1</sup> It can be caused by a variety of conditions,  
6 including brain trauma, hormone-producing neoplasms, advanced age (idiopathic), genetics, nervous  
7 system or pulmonary disorders, medications, endocrine disease, immunosuppressive disease, and  
8 activities such as endurance exercise.<sup>2, 6</sup> Given the wide range of etiologies, SIADH is often broken down  
9 into five main categories: malignancy, lung disease, central nervous system disease, drug use, and  
10 miscellaneous.<sup>3</sup> Treatment of SIADH is often two-pronged: first, treating the hyponatremic state that is  
11 caused by the condition, and second, addressing the underlying etiology of the SIADH.<sup>2, 6-8</sup> Hyponatremia  
12 treatment is largely dependent on the severity and duration of onset, but the overarching goal is to  
13 increase serum sodium levels without secondary neurological complications. This goal can be achieved  
14 through the use of hypertonic saline, loop diuretics with saline, vasopressin-2 receptor antagonist and  
15 fluid restriction.<sup>7</sup>

16 If sudden and severe, hyponatremia can lead to encephalopathy and the development of an acquired  
17 brain injury (ABI).<sup>1-3</sup> These injuries can have significant physical, psychological and visual sequelae,  
18 which if not managed properly can lead to substantial reductions in quality of life. Proper management  
19 involves comprehensive assessment, appropriate therapy tailored to boost the natural neuroplasticity  
20 process of the brain, and patient education.

21 Case Report:

22 A twenty-four-year-old Active Duty Military Caucasian male reported to the Southern Arizona Veterans  
23 Affairs Health Care System's (SAVAHCS) Traumatic Brain Injury (TBI) eye clinic for evaluation and  
24 treatment of constant bilateral visual blur, right-sided peripheral vision loss and difficulty reading. The  
25 patient denied any medication use. His ocular history was significant for a congenital constant right  
26 esotropia, longstanding reduced depth perception, and bilateral overacting inferior oblique muscles. He  
27 reported spectacle wear beginning at age five years, but denied any history of previous vision therapy or

28 treatment for his esotropia. His medical history was significant for a brain injury incurred approximately  
29 four months prior during Basic Military Training.

30 An extensive review of the patient's medical record revealed that eighteen weeks prior he was  
31 transported to an emergency room for treatment after being discovered ill in his bunk. Upon presenting to  
32 the emergency room, the patient's condition worsened: he became incoherent, suffered a seizure, and  
33 developed acute respiratory failure. Diagnostic testing including laboratory work-up, radiology studies,  
34 and electroencephalogram (EEG) was performed, and the patient was found to have severe  
35 hyponatremia with a serum sodium level of 109 mmol/L (normal 136-145), leukocytosis, with a white  
36 blood cell (WBC) count of  $26.2 \times 10^3/\text{mm}^3$  (normal 4.3-9.5), and rhabdomyolysis, with a creatine  
37 phosphokinase (CPK) value of 3,475 IU/L (normal 39-308 IU/L). Other findings included fever, dysphagia,  
38 and an irregular delta wave with generalized slowing on EEG consistent with mild acute encephalopathy.<sup>4</sup>  
39 Magnetic resonance imaging (MRI) of the brain showed generalized hyperintensity also consistent with  
40 mild encephalopathy. All other diagnostic testing including serum and urine analysis, chest x-rays, and  
41 lymphatic vessel density values was normal.

42 The patient received rapid treatment for his hyponatremia with intravenous (IV) hypertonic saline to  
43 increase serum sodium levels. While no evidence of infectious pathogens were detected in either serum  
44 or urine samples, the patient was also given IV broad spectrum antibiotics as his elevated WBC count  
45 and fever raised suspicion of possible bacterial infection. Given the patient's severely hyponatremic state  
46 in the context of his normal extracellular volume (euvoemia) and hormonal levels, he was diagnosed with  
47 an acute episode of SIADH with a secondary moderate anoxic brain injury.<sup>1</sup> The patient spent  
48 approximately one month hospitalized for his injuries, then spent one week in a non-military inpatient  
49 rehabilitation facility for treatment of mild aphasia, ataxia, and right hemiparesis.

50 Two months after the initial incident, the patient transferred his care to the SAVAHCS, where he was  
51 enrolled for healthcare and rehabilitative services secondary to his anoxic brain injury. His initial visit was  
52 in the SAVAHCS Eye Clinic for a neuro-ophthalmology consult. Evaluation revealed best-corrected visual  
53 acuities (VA) of  $20/30^{+1}$  OD and OS, saccadic dysfunction, oculomotor (fixation) dysfunction, and a  
54 complete right homonymous hemianopia (Figure 1). The neuro-ophthalmologist referred the patient to

55 the TBI eye clinic for additional evaluation and treatment and ordered a repeat MRI of the brain (Figure  
56 2), which revealed regions of hyperintensity of the left occipital lobe consistent with areas of increased  
57 metabolic function after brain damage.<sup>5</sup>

58 Eighteen weeks after the initial incident, the patient presented to the TBI eye clinic for evaluation where  
59 the authors became involved with his care. His detailed chief complaints included mild bilateral visual  
60 blur, right-sided vision loss with trouble ambulating, and reading and information processing difficulties. A  
61 detailed examination was conducted (Table 2). Relevant findings included best-corrected VA OD 20/32,  
62 and OS 20/20<sup>-2</sup>, a 2<sup>Δ</sup> constant right esotropia at distance and near, a right homonymous hemianopia  
63 bifurcating fixation and involving 40 degrees of the patient's right visual fields, saccadic dysfunction with  
64 2<sup>+</sup> overshooting worse in right gaze, and a visual information processing dysfunction of abnormal form  
65 constancy with a Test of Visual Perceptual Skills (TVPS, 3<sup>rd</sup> ed., Academic Therapy Publications, Novato,  
66 CA) score of zero (equivalent age < 4 years old). Accommodative function testing was conducted and  
67 revealed reduced accommodative amplitudes of 6.50 D OD and 6.75 D OS. Throughout the examination,  
68 the provider conversed with the patient covering a wide variety of topics to assess the patient's range and  
69 severity of symptoms. The patient's responses, along with the exam findings, were taken into account  
70 when developing the visual management plan.

71 Visual Rehabilitation:

72 Vision rehabilitation was chosen to manage the patient's visual symptoms with a therapy plan focusing on  
73 techniques to improve oculomotor skills and visual exploration. Visual exploration training, reinforced by  
74 ongoing occupational therapy, would address his ambulation concerns. Training consisted of a one-hour  
75 in-office session every week with an experienced vision therapist and daily at-home supplemental  
76 activities (Table 1).

77 The patient returned for re-evaluation after five weeks of vision therapy. Post-vision therapy results were  
78 generally positive (Table 2). He displayed improvement in his saccadic and visual information processing  
79 functions in addition to a significant reduction in his visual symptoms. Saccadic testing revealed trace  
80 overshooting and his TVPS form constancy score increased from zero to 16 (equivalent age ≥18 years  
81 old). Moreover, the patient noted a complete resolution of his reading difficulties and stated that extended

82 reading sessions had become comfortable and enjoyable again. He also reported an improvement in his  
83 reading comprehension and memory. Finally, the patient described improved ambulation and felt as  
84 though his hemianopia was not inhibiting his daily activities.

85 The patient underwent a total of thirty-six weeks of vision therapy. At the final encounter, the patient  
86 continued to show a persistent right homonymous hemianopia, but displayed stable saccadic,  
87 oculomotor, and visual information processing skills. He denied any return of his initial visual symptoms  
88 and expressed pleasure at the improvement in his visual skills. He was instructed to continue his  
89 previously prescribed home-based therapy as a maintenance mechanism.

90 Discussion:

#### 91 Syndrome of Inappropriate Antidiuretic Hormone

92 One of the leading causes of hyponatremia, SIADH is a condition in which antidiuretic hormone is  
93 produced in excessive levels in relation to the body's normal osmolality.<sup>1-3</sup> SIADH etiology is generally  
94 grouped into five main categories: malignancy, lung disease, central nervous system disease, drug use,  
95 and miscellaneous.<sup>2,6</sup> It can affect individuals of any age and health level, but is typically seen in  
96 individuals of poor health suffering from chronic disease states.<sup>1-3</sup> The amount of antidiuretic hormone  
97 (ADH) secreted by the pituitary gland is based primarily on the concentration of extracellular solute ions  
98 (mainly sodium) in the body.<sup>2</sup> It acts on the collecting duct of the nephrons causing increased resorption  
99 of water.<sup>2</sup> With higher serum ADH concentrations, more water is reabsorbed into the blood stream  
100 thereby causing dilution of serum and resulting in hyponatremia. As this process continues and less  
101 water is passed through the kidneys, the urine solute concentration increases, leading to urinary  
102 hypernatremia.<sup>2</sup>

103 The clinical diagnosis of SIADH is largely a diagnosis of exclusion.<sup>3,5</sup> There are multiple conditions that  
104 should be ruled out prior to a diagnosis of SIADH including but not limited to: cerebral salt wasting,  
105 cardiac failure, hyperglycemia, vomiting, diarrhea, and polydipsia or polyuria.<sup>1</sup> Current key diagnostic  
106 guidelines (Table 3) include normal adrenal cortical and thyroid function, normal water body concentration  
107 (euvolaemia), hyponatremia <135 mmol/L and effective serum osmolality <275 mOsm/kg, urinary sodium

108 concentration >40 mOsm/kg and no recent use of diuretics.<sup>1-3</sup> Once these key guidelines are met, SIADH  
109 can further be classified into four subtypes (Table 4), depending on specific clinical findings.<sup>2</sup> Regardless  
110 of subtype, treatment of hyponatremia resulting from SIADH is largely dependent on severity and  
111 symptomology. In the case of this patient, clinical testing and a thorough medical review ruled out any  
112 current or historic pathologic or malignant condition as well as drug use. This narrowed the cause of the  
113 patient's SIADH down to the miscellaneous category, which includes subcategories of transient SIADH  
114 secondary to nausea, pain or stress, hereditary SIADH, exercise associated SIADH, and idiopathic  
115 SIADH.<sup>3</sup> The patient had no previous episodes of SIADH, nor did he have any family history of SIADH.  
116 Prior to the onset of SIADH, the patient was in the early phases of Basic Military Training with the United  
117 States Army. He was in a high stress environment and was undergoing intensive physical activities. In  
118 addition, he was required to partake in specific meal and hydration plans. Any of these factors could  
119 have triggered the episode of SIADH. While over-hydration was hypothesized as a possible determinant,  
120 the exact causation was never pinpointed, leading to a generalized diagnosis of idiopathic SIADH.

121 Hyponatremia may result in a range of symptoms, depending largely on the chronicity and severity of the  
122 condition. Low-level hyponatremia may have symptoms of mild headache, confusion, concentration and  
123 memory lapses, as well as stability and gait changes.<sup>1-2</sup> As the severity of hyponatremia increases,  
124 symptoms rapidly elevate and can include limb weakness, disorientation, psychosis, seizures, and  
125 respiratory arrest.<sup>2</sup> In cases of moderate to severe acute hyponatremia (serum sodium  $\leq 125$  mmol/L in  
126  $\leq 48$  hours), encephalopathy can occur due to the rapid change in extracellular osmolality. If not treated  
127 promptly, this cerebral edema can result in brain herniation, significant brain damage and even death.<sup>2-3</sup>

128 The patient in this case was diagnosed with a moderate to severe case of acute idiopathic SIADH. His  
129 severe hyponatremic state resulted in both respiratory arrest and cerebral edema, both of which  
130 contributed to the development of his anoxic brain injury.

131 Acquired brain injury:

132 Acquired brain injury (ABI) is a non-congenital injury to the brain. For patients to be diagnosed with an  
133 ABI, they generally must have one or more of the following causative conditions documented in their  
134 medical record: a period of decreased consciousness level, amnesia, skull fracture, neurological and/or

135 neuropsychological abnormalities, and/or intracranial lesion(s).<sup>8</sup> The two main ABI categories are  
136 traumatic (TBI) and non-traumatic.<sup>8</sup> Traumatic brain injuries are fairly common and have a significant  
137 burden on the healthcare system. In the United States over 3.5 million people or approximately 1% of the  
138 population, suffered a traumatic brain injury in 2009 alone<sup>9-10</sup>. This accounts for \$56 billion in long-term  
139 health costs annually.<sup>9-10</sup> TBIs result from penetrating or non-penetrating (concussive) forces on the brain  
140 and have gained national attention over the past decade in pastimes such as the National Football  
141 League (NFL<sup>®</sup>) and with military activities including Operation ENDURING FREEDOM (OEF), Operation  
142 IRAQI FREEDOM (OIF), and Operation NEW DAWN (OND).<sup>11-13</sup> In fact, TBIs have been characterized  
143 as the “signature injury” of recent military operations as studies have shown TBIs to be present in up to  
144 9.6% of all OED, OIF, and/or OND veterans, and in 80-93% of veterans who received polytrauma care.<sup>11,</sup>  
145 <sup>13</sup>

146 TBIs can be classified as mild, moderate, or severe with mild TBIs being most prevalent (80%).<sup>9</sup> While  
147 not as common, non-traumatic brain injuries encompass a wide range of etiologies ranging from anoxia  
148 and metabolic disorders to stroke, neoplasm and even medication use.<sup>8</sup> Data on non-traumatic ABIs are  
149 not as robust as with TBIs. In 2013, all causes of non-traumatic ABIs were estimated to have an  
150 incidence of 917,000 annually in the United States.<sup>14</sup> Of the multiple potential causes of ABIs, cerebral  
151 vascular accidents are the most common (85%) followed by tumor (7%) and then aneurysms (3%).<sup>14-15</sup>  
152 Anoxic brain injuries are rare, and national data is not available on their prevalence at this time. While  
153 overall healthcare costs for non-traumatic brain injuries are not currently available, healthcare costs  
154 related to strokes alone is estimated at \$34 billion annually.<sup>15</sup> Brain injuries often result in both short and  
155 long-term physical, cognitive and psychological symptoms, including visual dysfunction. As such, patient  
156 management including proper diagnostic evaluations and therapeutic management is critical to long-term  
157 recovery.<sup>8-9, 16</sup>

158 The sequelae and recovery of ABI largely depend on the location, severity, and chronicity of damage.<sup>8-9, 16</sup>  
159 The brain is capable of biochemical, physiological and anatomical recovery and reorganization (i.e.  
160 neuroplasticity) at any stage in life.<sup>17-18</sup> The neuroplasticity process is naturally occurring and can be  
161 broken down into two main categories or phases: recovery and compensation.<sup>17</sup> The recovery phase

162 involves affected tissue recovering its initial function.<sup>18</sup> In the compensation phase new tissue takes over  
163 a function originally performed by the damaged tissue.<sup>18</sup> These phases are not mutually exclusive and  
164 often occur synergistically.

165 When it comes to rehabilitation or active engagement of the recovery and compensation phases of  
166 neuroplasticity, providers should be cognizant of neural strategies for improvement.<sup>16-18</sup> After injury, it is  
167 very common for patients to develop avoidance patterns on tasks they now find difficult. Lack of  
168 engagement hinders the neuroplasticity process, minimizing the ability of the patient to recover and adapt  
169 to their post-ABI state. Therefore, rehabilitation should be aimed at actively engaging the patient, and  
170 should involve three basic stages: resuscitation, recruitment, and retraining.<sup>18</sup> Resuscitation means  
171 engaging the previously damaged regions of brain tissue, recruitment involves engaging new brain tissue  
172 regions; and retraining focuses on training either damaged or normal tissue to perform new tasks.<sup>18</sup>  
173 Finally, providers should be aware of the general timeline for ABI recovery. Studies reveal that visual  
174 recovery peaks between three and six months post-brain injury in stable disease.<sup>19-22</sup> After six months, it  
175 is unlikely that further recovery via resuscitation will occur. However, the ability of the brain to adapt via  
176 recruitment and retraining does not decrease, and can persist indefinitely, given continued patient  
177 engagement.<sup>18-20</sup>

178 The patient in this case began vision therapy while in the peak phase of ABI recovery, and concluded  
179 active vision therapy almost nine months after his initial injury. While the patient presented with  
180 significant symptomology and oculomotor dysfunction, he had largely been avoiding the activities causing  
181 him the greatest ocular discomfort. Active engagement via vision therapy targeted the patient's  
182 rehabilitative pathways and resulted in significant improvement of this patient's skills and in the near  
183 complete relief of his reported symptoms. At nine months post-injury, it is highly unlikely the patient would  
184 experience any additional improvement in his visual system because the neuroplasticity process of  
185 resuscitation is likely complete. However, the patient might benefit from continued therapeutic  
186 intervention as maintenance mechanisms to strengthen his newly re-developed visual pathways. In fact,  
187 throughout his treatment regimen, the patient continued to express his satisfaction with his treatment  
188 plan, and when asked, maintained that he felt the therapy was beneficial for him in improving his visual

189 function. As demonstrated in this case, the ability of providers to recognize the phases of the  
190 neuroplasticity process and the typical recovery timeline can enhance rehabilitative outcomes by guiding  
191 patient-specific management strategies to maximize the rehabilitative process.<sup>17-18, 21</sup>

192 Visual dysfunction secondary to ABI can impact every part of the visual system due to the complex  
193 afferent and efferent nature of the visual pathway, and the high degree of cognitive interpretation.<sup>8-9, 21-24</sup>  
194 Patients often report long-term symptoms across multiple facets of their visual system including  
195 oculomotor dysfunction (0-56%), photophobia (0-16%), visual blur (19-66.7%), dry eye (9-10.4%), visual  
196 field loss (0-38.8%), diplopia (3-40%), and information processing dysfunction (51-59%).<sup>8-9,25</sup> Due to the  
197 prevalence of these symptoms, patients often present to their local eye care provider seeking evaluation  
198 and treatment.

199 Regardless of the nature of the ABI, a comprehensive evaluation of the visual system is critical in  
200 identification and quantification of visual sequelae. These sequelae can be broken down into four main  
201 categories: ocular motility, visual information processing, accommodation/vergence, and visual field  
202 defects (Figure 4). Within these categories, providers should ensure binocular vision testing is conducted  
203 to provide quantitative evaluations of visual function. Goodrich et al. developed excellent guidelines for  
204 examining patients with TBI as part of their Delphi Study.<sup>26</sup> These guidelines include seven procedures  
205 recommended for each TBI evaluation to assess the main oculomotor categories of visual sequelae, but  
206 do not include assessments of visual processing.<sup>26</sup> At a minimum, testing should include evaluations of  
207 best-corrected visual acuity, extra-ocular movement, cover test, near point of convergence, saccades,  
208 pursuits and fixation.<sup>14, 26</sup> Accommodation and vergence assessments should include amplitude and  
209 facility. Visual fields should be evaluated utilizing confrontations. If a deficit is suspected, automated  
210 visual field testing should be performed. Finally, while not as common in the general optometric  
211 repertoire, providers should evaluate the patient's visual information processing system including testing  
212 for visual neglect and memory, form constancy, midline shift, automaticity and spatial awareness.<sup>21</sup> By  
213 evaluating these regions, providers will be able to determine the type and extent of the patient's visual  
214 dysfunction (Table 5) allowing for development of an appropriate management plan.<sup>10, 18, 20, 22</sup>

215 The patient in this case had ABI-related sequelae involving multiple systems including vision, speech, and  
216 fine and gross motor muscle control. His visual system sequelae included oculomotor, visual field, and  
217 visual information processing deficits. His fixation and saccadic dysfunction, specifically his saccadic  
218 overshooting worse in right gaze, can be attributed to the dense scotoma in his right visual field. The  
219 patient could track a moving object (pursuit), but as it moved into his right field scotoma, he lost the object  
220 and overshot his fixation, having to track back and re-fixate using his functioning left visual field to locate  
221 the object again. In the area of visual-perceptual skills, testing revealed the patient suffered from reduced  
222 form constancy, which is the ability of a person to perceive an object and find it among other forms,  
223 regardless of size, orientation or color.<sup>27-29</sup> Abnormal form constancy can 1) affect a patient's reading  
224 ability -especially with changes in font style, color or size-, 2) impact spatial awareness including size  
225 constancy and distances-, and 3) cause problems with attention and focus.<sup>28</sup> In this case, the patient's  
226 reduced form constancy at his initial neuro-ophthalmology visit and early TBI eye clinic visits may have  
227 contributed to his mild reductions in visual acuity.

228 As was demonstrated in this case, proper management of visual dysfunction often involves active  
229 rehabilitation in the form of vision therapy. Vision therapy is widely used to treat a multitude of visual  
230 dysfunctions, and multiple studies have shown its effectiveness for treating disorders of the visual system,  
231 especially in ABI patients.<sup>21, 30-32</sup> Thiagarajan et al. noted up to an 80% improvement in the visual status of  
232 mild TBI patients after only six weeks of bi-weekly therapy sessions.<sup>30</sup> Therapy should focus on the  
233 regions suffering deficits and, if managed properly, it may bolster the natural neuroplasticity process.<sup>17-18,</sup>  
234 <sup>20, 30</sup> There are a multitude of vision therapy tasks that can be chosen and tailored specifically for the  
235 patient's visual dysfunction.<sup>18, 20, 22, 25</sup> The key to maximizing patient recovery is maintaining active patient  
236 engagement.<sup>17-18</sup> As such, providers should be aware of the various uses of vision therapy activities and  
237 understand that any one particular activity can be modified to target desired visual functions, maintain  
238 appropriate challenge levels, and enhance patient interest levels.<sup>18, 20</sup> Modification will also help prevent  
239 false positive gains secondary to patient familiarity with a given task. For example, a patient may be  
240 presented with a rotator and asked to follow a specific target around as the table rotates; this activity  
241 primarily engages the oculomotor (fixation and pursuit) system. As the patient begins to master the task,  
242 the provider can make the task more complex by giving the patient pegs to place on the rotating board in

243 different patterns, requiring the patient to follow specific color schemes or placement strategies while  
244 placing those pegs, providing distractions in the form of extraneous noise (e.g., music, requiring the  
245 patient to state certain words or carry a conversation) or even requiring the patient to maintain certain  
246 postures (e.g., sitting, standing on one leg, balancing on a balance board, etc.) while performing the  
247 activity. Any task can be modified and keeping that concept in mind aids providers in developing and  
248 adjusting therapeutic management to maximize patient engagement and recovery.<sup>17-18, 20</sup>

249 In addition to the visual system, providers should also be aware of the psychological and physical  
250 sequelae from which ABI patients may be suffering. Studies have shown that intensive therapy targeting  
251 the sequelae of ABIs can lead to earlier and more long-term improvement in symptoms.<sup>25, 33</sup> These  
252 patients should receive appropriate systemic rehabilitative care as early in their recovery phase as  
253 possible.<sup>29</sup> Rehabilitative therapy with active patient engagement is key to maximizing recovery, not only  
254 through the visual pathways that eye care providers are so familiar with, but also through other disciplines  
255 such as physical and/or occupational therapy.<sup>10, 16-18, 24, 33</sup> Providers should determine if their patients are  
256 receiving appropriate systemic care for their ABI, and if not, have a general network of health care  
257 providers to which they can refer their patients for additional rehabilitative services. The patient in this  
258 case was enrolled in the Veterans Affairs Polytrauma System of Care and received care for the multiple  
259 systems impacted by his ABI including visual and occupational therapies. Specialists were able to  
260 actively monitor the patient's progress in all facets of therapy and communicate with fellow healthcare  
261 providers when necessary. This interdisciplinary approach ensured the patient was receiving appropriate  
262 healthcare for his sequelae and helped to bolster the rehabilitative process. Regardless of patients'  
263 backgrounds, if providers suspect the presence of acquired brain injury and the patient is not receiving  
264 the appropriate systemic care, referral to a primary care doctor and/or general neurologist for an initial  
265 assessment is warranted, with the understanding that the patient may be further referred to subspecialties  
266 for additional care.

267 Conclusion:

268 Syndrome of Inappropriate Secretion of Antidiuretic Hormone (SIADH) is a metabolic condition that  
269 causes hyponatremia, and in severe cases, encephalopathy and brain injury. Acquired brain injuries

270 result from any non-congenital insult to the brain and are fairly common. They can cause significant  
271 physical, functional and psychological disturbances. Damage to the visual pathways can produce visual  
272 field, ocular motility and binocular deficits. As such, the visual system should undergo a comprehensive  
273 evaluation to determine the extent of ocular and visual involvement, and management should be actively  
274 tailored to boost the natural neuroplasticity process and challenge the patient's specific areas of  
275 dysfunction to achieve their goals. Comprehensive rehabilitative treatment is important and patients  
276 should be advised to seek care for their non-visual complications. Finally, some recovery and adaptation  
277 can be expected, but it is largely influenced by patient engagement. Proper education on expectations  
278 and participation are critical to maximize patient buy-in, enhance the rehabilitative process, and improve  
279 the patient's quality of life.

280 **Disclaimer:**

281 The views expressed are those of the authors and do not reflect the official views or policy of the  
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Figure Legends:

Figure 1: Automated visual field testing conducted 2 months after the initial incident showing a homonymous hemianopic defect.

Figure 2A/B: T<sub>2</sub>-weighted fluid attenuated inversion recovery (FLAIR) MRI of the brain (A, axial view) (B, coronal view), conducted 3 months after initial incident; note the regions of hyperintensity on the patient's left occipital lobe.

Figure 3: Common Visual Sequelae of Acquired Brain Injury