Electrical Injuries

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Headache, muscle spasms/weakness, gait disturbance, sensory loss are among a host of physical complaints (+ organ dysfunction with lightning particularly); as (cognitive and emotional) Sx seem to increase on a post-acute level, diffuse cerebral injury is postulated, with damage to the limbic system being a potential basis for continued symptomology (Pliskin et al, '95). Visual retention is unimpaired in comparison with tbi; and is not my understanding that entrance/exit wounds are much help in predicting what 'route' may have been taken by the current ('barotrauma' can occur without visible wounds). LOC doesn't always occur. The other confusing factor is the perceived (unsupported by research however) similarity btw electrical injury and tbi; if someone experienced concussion as well, teasing out the differences should include all the usual suspects (as above + malingering) plus looking at visual retention (worse in tbi than in electrical injury) and ruling out PTSD. Hope that is helpful; a couple of references follow that are good but a few years old (haven't looked at this for a while...); but some of the major players to read are: Neil Pliskin, Robert Heilbronner, M. Capelli-Schellpfeffer, R. Lee, J. Fink (and there are others I have certainly omitted, but this is a good place to begin IMHO). You may also wish to contact Joe Gubbay, as he posted some references last year.

Respectfully (and please don't anyone yell at me)

Lauren

Neuropsychological Dysfunction in Severe Accidental Electrical Shock: Two Case Reports

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Abstract

There has been a relative absence of studies that have longitudinally examined the neuropsychological profiles of women who have sustained severe accidental electrical shocks. A case is reported of a college-educated woman who received an estimated
120-V electrical shock. Neuropsychological assessments conducted at 2 months, and at 1 and 2 years postinjury, revealed a diversity of deficits indicative of diffuse, mild to moderate neurocognitive dysfunction, as well as symptomatology consistent with depression and posttraumatic stress disorder. For comparison, a second case of a man who received a 69,000-V electrical injury is also presented. Although only minimal neurocognitive deficits were observed in this individual, he exhibited a similar psychological profile. The results of this study are discussed in light of the contrasting neurocognitive findings but consistent psychological presentations across the two cases.

Introduction

There have been few published reports of the neuropsychological profiles of patients who have received severe electrical shocks. Hopewell (1983) first provided neuropsychological data on a 23-year-old male patient who suffered a high-voltage electrical injury. The patient remained disoriented until the 10th day postinjury, at which time his storage and retrieval strategies for verbal material were noted to be severely impaired. Neuropsychological assessment conducted 50 days postinjury indicated mild deficits in storage and retrieval of noncontextual verbal material, memory for auditory digits, attention in a rhythm identification task, right-hand grip strength, and expressive and receptive language difficulties. Hopewell noted that these impairments were suggestive of greater left, versus right, cerebral hemisphere dysfunction and were consistent with previous EEG results.

In another study, Daniel, Haban, Hutcherson, Bolter, and Long (1984) presented neuropsychological data on 11 patients (10 men and 1 woman) who had sustained electrical-current injuries (220-800 V). Results of neuropsychological evaluations conducted 1 to 36 months postinjury indicated a diversity of impairments among these patients on tasks assessing sensory, motor, perceptual-motor, language, complex-integrative, intellectual, and memory functions. Although there was no characteristic pattern of deficits across these individuals, 7 of these patients exhibited a Halstead-Reitan Impairment Index greater than 0.8 (i.e., moderate to severe impairment). Further, 8 of the 9 patients who completed the Minnesota Multiphasic Personality Inventory (MMPI; Hathaway & McKinley, 1970) displayed profiles indicative of significant emotional maladjustment (e.g., somatic preoccupation and depression with anxiety).

Similarly, Hooshmand, Radfar, and Beckner (1989) reported on 16 patients (13 men and 3 women) who had received alternate current electrical injuries (i.e., 120 V-500 kV). Findings from neuropsychological assessments conducted 3 to 12 months postinjury indicated recent memory, concentration, judgment, and verbal and nonverbal achievement deficits in all 16 patients. Fourteen of the patients also suffered from severe depression, and 12 experienced at least one seizure.

Miller (1993) provided brief neuropsychological overviews of three electrical-injury patients. One case involving a 35-year-old woman suggested some severe cognitive impairments; however, the nature of these deficits was not provided. She also developed a chronic pain syndrome, sleep disturbances, irritability, anxiety, and depression postinjury. A second patient, a

49-year-old man, displayed a diversity of unspecified neuropsychological impairments that were attributed to a right-sided stroke suffered secondary to electric-shock-induced cardiac arrhythmia. Neuropsychological evaluation of a third electrical-shock case, a 45-year-old man, revealed impaired verbal and visuospatial memory, concentration, and sensory and motor abilities as well as significant anxiety and depression. It should be noted, however, that in all three cases neither the intensity of the electrical shocks received nor the specific neuropsychological measures utilized (or their scores) were provided.

Barrash, Kealey, and Janus (1996) presented neuropsychological data on 18 adult survivors (17 men and 1 woman) of high-voltage (more than 1,000 V) electrical injuries who were evaluated during the acute (up to 1 month), short-term (1-6 months), long-term (more than 6 months), or all periods postinjury. Across epochs, impairments were observed in verbal learning, and there was delayed recall of verbal material. Compromised attention was also noted in many of these individuals. These findings reportedly were very similar to a matched traumatic brain injury control group. Furthermore, the authors indicated that depression, anxiety, and irritability were "widespread" in this group of shock patients, especially beyond the acute epoch.

Other studies have focused primarily on the psychological- psychiatric features associated with accidental electrical shocks. Kelley, Pliskin, Meyer, and Lee (1994) recently reported the case of a 34-year-old man who received a 7,200-V shock 4.5 years earlier. Neuropsychiatric examination revealed that the patient was suffering from posttraumatic stress disorder and also met diagnostic criteria for psychological factors affecting physical condition as he acknowledged that stress worsened his physical symptoms (i.e., limb pain and weakness). On the MMPI, the patient's clinical profile was consistent with depression, although he failed to meet diagnostic criteria for an affective disorder.

Gourbiere, Corbut, and Bazin (1994) examined 2,080 cases (all but three cases were men) of high-voltage (> 1,000) and low-voltage (=< 1,000) electrical injuries. Among these, there were 51 cases of posttraumatic stress disorder and various "postconcussion" syndromes, with the most common symptoms being headache and dizziness. A number of cases were also found to have mood disturbances (i.e., irritability). The authors noted that patients' organic pathologies were never sufficient to account for their symptomatology.

Taken together, the published neuropsychological studies of accidental electrical-shock victims to date have largely involved adult, male patients who have not completed significant levels of higher education or college degrees. Results of these investigations suggest that survivors of electrical shocks may suffer from a diversity of neuropsychological difficulties, the most common of which appear to be short-term memory impairments and affective disturbances, characterized by depression, anxiety, and posttraumatic stress symptomatology.

There has been a relative absence of published studies that have longitudinally examined the neuropsychological profiles of relatively educated women who have sustained severe accidental electrical shocks. The purpose of this study is to report on such a woman who, on repeated neuropsychological examinations, exhibited a diversity of test performances indicative of neurocognitive and psychological dysfunction. An additional case of a male patient is also presented to demonstrate the diverse neurocognitive, but similar psychological profiles that may be seen among electrical shock patients.

Method

Participants

Case one. DR was a 38-year-old, right-handed, married, White female who received a severe accidental electrical shock in

September 1993 secondary to plugging in a television set. She received an estimated 120-V shock due to faulty electrical wiring (i.e., absence of ground fault breakers) and the presence of water (i.e., due to roof leaks) in the wall area surrounding the electrical outlet. The shock jolted her backward and resulted in a bodily sensation that felt as if current "went across (her) heart." There was no report of loss of consciousness. She also sustained a first- to second-degree electrical entrance burn to her right hand. Within minutes, DR developed chest pains, difficulty breathing, heart "fluttering," dizziness, equilibrium disturbances, right-hand swelling, and right-arm numbness. The patient was transported to a local hospital where she remained for 7 days due to severe dizziness, equilibrium disturbances, nausea, and "stabbing" headaches. After discharge, she was bedridden for over 1 month secondary to equilibrium difficulties.

Due to her slow recovery, DR was admitted to a tertiary-care medical center in early October 1993. On arrival at this facility, she became dizzy and nauseated and experienced an approximately 12-min loss of consciousness. EKG and EEG monitoring revealed no significant abnormalities. MRI and CT scan findings were within normal limits (WNL), and electromyography of the right upper extremity demonstrated no evidence of peripheral nerve injury.

Subsequent to her accident, DR developed a variety of health-related problems. Initially, she suffered an abnormal sense of smell where "everything smelled bad" and there was a "buzzing sensation" throughout her body. These symptoms spontaneously remitted after several months. In March 1994, she began experiencing "electrical shock" sensations in the left side of her face that radiated to the teeth and gums. Frequent nerve-block injections were required for approximately 3 months to manage the chronic pain. In mid-1995, she suffered another episode of hyperesthesia secondary to left superior alveolar nerve damage, which her orthodontist concluded was attributable to electrical shock. This problem was again successfully treated with nerve-block injections. She also experienced (in 1995) shock sensations in her left auditory nerve and reported that an audiological evaluation had revealed 25% hearing loss in her left ear.

At the time of the second evaluation (1994), the patient suffered from severe, unlocalizable stabbing headaches, chronic neck pain, dizziness, and right-sided face and arm numbness. During 1995, she continued to suffer from migraine headaches, with shortness of breath and right-hand weakness or tingling as well as chronic pain in the back of the neck. By the 1994 evaluation,
she had required eyeglass prescription changes twice since the accident and occasionally perceived movement in stationary objects within her peripheral visual fields, bilaterally. Additionally, between September 1994 and August 1995, an ophthalmologist had confirmed her reports of multiple, bilateral blind spots, with increasing visual field deficits, and she continued to perceive "phantom" objects and movement within her peripheral visual fields.

Between the 1994 and 1995 assessments, DR also suffered several (four plus) episodes of syncope, which she described as occurring suddenly, without vertigo. She reportedly was able to hear people's voices (which sounded garbled) during these events but was unable to respond to her environment. The episodes lasted for up to 1 hr and were followed by severe, incapacitating fatigue and headaches the following day. During the last (September 1995) syncopal episode prior to this evaluation, she reportedly suffered a significant drop in blood pressure. Results of an EEG and a head MRI conducted at this time were interpreted as normal.

Across the 1994 and 1995 neuropsychological evaluations, DR continued to suffer a variety of cognitive difficulties that were reported to be nonexistent prior to her electrical injury. She indicated that her anterograde memory was poor, although her retrograde memory appeared intact. She reported impairments in her organizational, concentration, and spelling abilities as well as her right-handed fine-motor skills and verbal fluency. DR also acknowledged periods of disorientation while driving, slowed cognitive processing, and distractibility.

The patient continued to experience a significant fear of electricity, anxiety over events or places associated with her accident, frequent nightmares -- many involving the place where the accident occurred -- and night sweats associated with these dreams. Her nightmares reportedly had increased in frequency by the 1995 assessment. She also continued to experience a great deal of stress and frustration secondary to her inability to return to work, related financial concerns, negative interactions with the workman's compensation office, and concerns that her workman's compensation might be discontinued (in 1995). Across assessments, DR reportedly suffered from significant depression (since her injury) as well as difficulty sleeping, increased irritability and anger, loss of libido, low self-esteem, decreased self-confidence in her intellectual and vocational abilities, and mild marital problems. During the last two evaluations, DR acknowledged that she had been seeing a psychologist for treatment of her depression and anxiety, as well as taking Zoloft and Klonopin.

In contrast, at the time of her last two neuropsychological evaluations, no overt signs of significant depression or anxiety were noted. The patient appeared cooperative and pleasant, and she attended well to task instructions. Her concentrational abilities throughout the evaluations appeared adequate, and she seemed to put forth good effort across tasks.

DR's medical history was positive for a left mastectomy in December 1989 -- secondary to breast cancer -- and a simultaneous tubal ligation. At the time of the second evaluation (1994), she was nearing completion of a 5-year trial of tamoxifen citrate (Nolvadex; 10 mg., bid), an anticancer agent. In contrast, she was not receiving any oncological chemotherapy at the time of the 1995 evaluation. Furthermore, there were no reports of additional prescription medication usage across assessments (with the exception of Zoloft and Klonopin). She denied significant alcohol, tobacco, or unprescribed drug usage.

DR reportedly graduated from college with grades primarily in the A to B range. After graduation, she was employed in a teaching position, a job she held for more than 16 years, until her accident. To date, she had been unable to return to work since this incident secondary to her continuing physical and cognitive difficulties. At the time of this study, the patient was not pursuing any litigation related to her injury.

Case two. MJ was a 45-year-old, right-handed man who received a severe electrical shock (approximately 69,000 V) in July 1993 while working as a powerline puller for a utility company. The accident occurred as the line came into contact with a utility truck against which he was leaning. The electrical arc first entered his right hip and exited his right foot, resulting in severe
burns. As he was falling, he received a second shock when he reached out with his left hand and again made contact with the truck. Emergency department records were unavailable to determine loss of consciousness; however, MJ reported a retrograde amnesia of 2 hr and intermittent anterograde amnesia lasting 1 week. MJ was hospitalized 37 days for debridement of burns on both feet and left arm and hand, for skin grafting, and for surgical amputation of two toes on his right foot. His initial
hospitalization was unremarkable, and his wounds were healing satisfactorily at the time of discharge. Multiple subsequent hospitalizations followed but were limited to plastic surgeries and care of infections directly related to the electrical injuries.

During the 8 months subsequent to this injury, MJ experienced 12 near-syncopal episodes, all of which were characteristically dissimilar and ranged from being immobilized for several minutes to sudden feelings of dizziness and unsteadiness. Not one of these episodes was accompanied by vertigo, heart palpitations, or headache. EEG, EKG, and 24-hr cardiac monitoring failed to detect cardiac arrhythmia or seizure activity, and these episodes resolved spontaneously in March 1994.

Physical and occupational therapy following hospitalization was directed toward teaching MJ to ambulate with the expectation that he could return to his former work within 1 year. In spite of his willingness to work, however, by April 1994, it was clear that MJ was experiencing psychological distress about returning to the environment of his accident, and he had doubts about his vocational abilities. He was subsequently enrolled in therapy at a behavioral medicine clinic. MJ reported a reduction in his ability to tolerate ongoing stressors that were present premorbidly that chiefly centered around his family and health concerns. Additionally, he had recently become fearful that he was developing lung cancer because he was experiencing a persistent cough. MJ was a 1/2-pack-per-day smoker, with a positive family history of lung cancer.

In addition to psychosocial stressors, MJ was experiencing latent cognitive dysfunction. He reported poor memory, including forgetting names and appointments, reduced concentration, inability to maintain his attention while reading, and difficulty recognizing familiar faces or the context in which he had previously seen the individuals. Noncognitive changes included increased frustration, distractibility, tearfulness, anhedonia, reduction in libido, and suicidal ideation. He also reported a recent distressful dream of standing beside a truck with a ball of fire around him.

MJ was neuropsychologically evaluated 18 months after his electrical shock injury. His educational background was 8th grade plus a General Education Degree, with no history of learning or developmental disabilities or specific academic deficiencies. He had not returned to work since the injury and was not pursuing litigation at the time of his neuropsychological assessment.

Procedure

To evaluate the patients' current cognitive-behavioral functioning across assessments, comprehensive neuropsychological tests were administered. All testing was conducted in sound-attenuated testing rooms by experienced neuropsychological test technicians. The standardized administration and scoring procedures for each test were strictly followed. After brief rapport-building sessions and lengthy interviews, with few exceptions, the following tests were administered to each patient: the Wechsler Adult Intelligence Scale-Revised (WAIS-R; Wechsler, 1981), Wide Range Achievement Test-Revised Level 3 (WRAT-R3; Jastak Associates Inc., 1984), Peabody Individual Achievement Test-Revised (PIAT-R; Markwardt, 1989), the Halstead-Reitan Neuropsychological Test Battery (Reitan, 1979; Reitan & Wolfson, 1993), Dynamometer Test (Reitan, 1979; Reitan & Wolfson, 1993), Grooved Pegboard Test (Klove, 1963), Paced Auditory Serial Addition Test (PASAT; Spreen & Strauss, 1991), the Logical Memory and Visual Reproduction subtests from the Wechsler Memory Scale-Revised (WMS-R; Wechsler, 1987), Selective Reminding Test (Buschke & Fuld, 1974), Rey Auditory Verbal Learning Test (Rey, 1964), and the Minnesota Multiphasic Personality Inventory-2 (MMPI-2; Hathaway & McKinley, 1989).

The results of a previous (late 1993) neuropsychological evaluation of DR, conducted by a licensed clinical psychologist, were obtained to make a further longitudinal comparison to her 1994 and 1995 neuropsychological test results.

Results

Case one. For DR, the results of repeated neuropsychological assessments were indicative of diffuse, mild to moderate, cognitive-behavioral dysfunction, although slight improvement was noted in her neurocognitive abilities by the third evaluation. An overview of DR's neuropsychological test results collected across three different assessment dates is provided in Table 1.

On WAIS-R testing conducted during the first testing date, DR obtained Verbal (99), Performance (104), and Full Scale (101) IQs that fell within the average range. She did, however, display a borderline performance on a verbal subtest (i.e., Digit Span) assessing concentration and immediate memory for digits on the first assessment.

Her WAIS-R Verbal, Performance, and Full Scale IQs obtained during the second and third assessments also fell within the average range of intellectual abilities; however, they were slightly lower than the scores obtained during the first assessment. During the second administration (1994) of the WAIS-R, a borderline performance was noted on one performance (i.e., Digit Symbol) subtest assessing concentration and visuomotor speed. On the WRAT-R3 Reading Recognition and Spelling subtests administered in 1994, DR's abilities were WNL, as was her performance on the PIAT-R Reading Comprehension subtest. In contrast, on the WRAT-R3 Arithmetic subtest, her skills were significantly below average for someone of her age and educational level. Her performance on the PIAT-R Comprehension subtest remained WNL at the time of the third assessment.

On the 1995 administration of the Aphasia Screening Test, there was evidence of mild constructional, naming, spelling, and ideomotor impairments. DR's performances on the Category Test, a measure of nonverbal abstract reasoning, were mildly to moderately impaired during the first two evaluations but were WNL by the third (1995) administration. On tasks assessing cognitive processing speed and flexibility (i.e., Trail Making Test) administered during the first assessment, DR's Part A task completion time was moderately to severely impaired, whereas her Part B task completion time was mildly to moderately deficient. Her performances on both parts of this test during the second assessment were moderately to severely impaired, whereas she exhibited only mild impairment on these tasks during the third assessment. Her performance on a measure of sustained attention to nonverbal auditory stimuli (i.e., Seashore Rhythm Test), administered in 1994, was mildly defi cient but was WNL at the time of the 1995 evaluation. On both (1994 and 1995) administrations of the PASAT, a four-part test evaluating rapid problem-solving abilities, DR exhibited moderate to severe impairment on Series 1 and 2, and the test was subsequently discontinued on Series 3 due to extremely poor performances. Across tasks assessing upper extremity motor speed (i.e., Finger Tapping Test) and manual dexterity and eye-hand coordination (i.e., Grooved Pegboard Test) administered during the last two assessment dates, DR demonstrated moderate to severe impairment with the right hand. She also displayed moderate to severe impairment of her right-handed grip strength during the last two assessments and mild to moderate impairment with her left-handed grip strength during the third assessment. No other deficits in executive controlled functions were noted during any of the assessments.

On a sensory-perceptual examination administered in 1994, DR exhibited mild bilateral dysgraphesthesia, one tactile suppression error at the right face, and three left visual-field suppression errors. During the 1995 evaluation, DR demonstrated bilateral finger agnosia (right greater than left), one right tactile (hand) suppression error, two left tactile (face) suppression errors, and two left-ear suppressions. All other auditory, tactile, and visual sensory results were WNL.

Across the last two evaluations, DR's performances on the Tactual Performance Test, a measure of psychomotor problem solving and tactile discrimination, continued to be mildly to moderately impaired when she used her right and both hands. Her total time on the test was also mildly deficient across the last two assessments, as was her spatial memory for the test's block locations during the 1995 evaluation.

A number of reliable memory deficits were exhibited during the first assessment. On the Denman Neuropsychology Memory Scale, DR's performances on the Immediate Recall of a Story, Memory for Digits, and Delayed Recall of a Story (i.e., Verbal Memory subtests) were judged to be deficient. Her overall Verbal Memory Quotient (86) was within the low-average range. In contrast, all of her Nonverbal Memory subtests were within the average to above-average range, as were her overall Nonverbal and Full Scale Memory Quotients. There was, however, a clinically significant difference between her Verbal and Nonverbal Memory Quotients in favor of her nonverbal memory.

During the second assessment date, DR's performances on the WMS-R Logical Memory I and II subtests (i.e., tests of

immediate and delayed contextual verbal memory) were mildly and moderately deficient respectively, although they had improved to WNL by the third assessment. On the WMS-R Visual Reproduction I subtest (i.e., a test of immediate nonverbal-figural memory) administered during the second assessment, her performance was moderately impaired; however, on the Visual Reproduction II subtest (i.e., a test of delayed nonverbal-figural memory), she was able to recall the majority of the material that she had remembered initially. In contrast, at the time of the third evaluation, her Visual Reproduction II score was mildly deficient as compared with her immediate recall of this material. Across the last two assessments, DR also exhibited moderate impairments of her immediate free recall and long-term retrieval strategies on the Selective Reminding Test, a task assessing memory for noncontextual verbal material. Mild deficits were also noted in her long-term storage strategies and delayed recall of this verbal material during the third assessment. All other memory results were WNL.

On the MMPI-2, administered across the three evaluations, DR exhibited similar validity and clinical profiles. The validity scales indicated valid profiles, although she may have been presenting a somewhat negative view of herself and focusing on her physical symptomatology during the first two administrations. Her clinical profiles indicated a diversity of somatic complaints that may have worsened in times of stress and suggested that she was overcontrolled, expressed negative feelings only indirectly, and was plagued by insecurity and self-doubt (Graham, 1990). She acknowledged feeling sad, depressed, anxious, and tense, and she endorsed an elevated level of unusual thoughts or sensations. She may have also felt a need to demonstrate to others that she was logical and reasonable.

Case two. In contrast, MJ's neuropsychological test results were reflective of only minimal neurocognitive impairment. An overview of MJ's neuropsychological test results is provided in Table 1.

On the WAIS-R, MJ obtained a Verbal IQ (114) that fell within the above-average range, and Performance (102) and Full Scale (109) IQs that were in the average range. On the WRAT-R3 Reading Recognition, Spelling, and Arithmetic subtests, MJ's abilities were WNL, as was his performance on the PIAT-R Reading Comprehension subtest. On the Trail Making Test, MJ's performance was mildly deficient on Part A but WNL on Part B. On the Grooved Pegboard Test, his nondominant hand performance was mildly deficient, as was his left-handed grip strength on the Dynamometer Test.

On a sensory-perceptual examination, MJ exhibited mild bilateral dysgraphesthesia and one suppression error within each visual field. MJ's performances on the Tactual Performance Test were WNL when he used his right and both hands but mildly to moderately deficient when he used his left hand. All of MJ's other neurocognitive test results were WNL.

On the MMPI-2, the validity scales suggested that MJ may have been presenting a somewhat negative view of himself. MJ's clinical profile, which indicated amplified emotional sequelae, was consistent with patients who are experiencing acute levels of somatic and emotional distress and are highly preoccupied with unusual somatic sensations. He endorsed relatively high levels of depressive symptoms, suspiciousness and social withdrawal, rumination, anxiety, and unusual thoughts or sensations. Results also indicated that MJ's use of denial and repression as primary defenses was ineffective in blocking his experience of depression and anxiety. The overall profile was consistent with the high levels of physical and emotional distress that are likely accompanied by significant disruptions in sleep, concentration, and logical thinking.

Discussion

This article has presented the neuropsychological profiles of two patients who sustained severe accidental electrical shocks. The first case was a longitudinal examination of a 38-year-old, college-educated woman who received a shock of approximately 120 V secondary to plugging a television into a wall outlet affected by water damage. Across evaluations, DR exhibited

patterns of test performances indicative of diffuse, mild to moderate neurocognitive dysfunction that persisted over time (i.e., assessments), although slight improvement was noted in such abilities as her nonverbal abstract reasoning, cognitive processing speed, sustained concentration to nonverbal stimuli, and contextual verbal memory by the third (1995) evaluation. Her measured intellectual abilities across assessments also appeared somewhat lower than expected when compared with her premorbid level of vocational functioning and her history of higher education. Additionally, DR's right, upper extremity motor and tactile impairments were likely attributable to her right-arm numbness and weakness that arose secondary to her electrical shock.

These results appeared consistent with her history of severe accidental electrical shock and past research involving primarily male patients with similar injuries (Daniel et al., 1984; Hooshmand et al., 1989; Hopewell, 1983; Miller, 1993). Specifically, this research has also found that victims of electrical shock may exhibit a variety of cognitive deficits, including impairments of memory (Daniel et al., 1984; Hooshmand et al., 1989; Hopewell, 1983; Miller, 1993), retrieval and storage strategies (Hopewell, 1983), motor abilities (Daniel et al., 1984; Hopewell, 1983; Miller, 1993), sensory-perceptual functions (Daniel et al., 1984; Miller, 1993), perceptual motor skills (Daniel et al., 1984), intellectual abilities (Daniel et al., 1984), and complex-integrative functions (Daniel et al., 1984). Furthermore, the neuropsychological sequelae that are often noted after electrical shock have been suggested to resemble that which is seen secondary to closed head injury (Daniel et al., 1984; Hopewell, 1983).

There was no evidence that DR's neuropsychological impairments were related to her history of breast cancer and subsequent tamoxifen citrate (Nolvadex) chemotherapy. In fact, even though she was no longer receiving chemotherapy for breast cancer by the time of the 1995 evaluation, she continued to exhibit diffuse neurocognitive deficits. Support for this position also comes from the patient's and her husband's self-reports that neither noticed any decline in her cognitive abilities until after her electrical
shock accident. Additionally, the Physician's Desk Reference (Medical Economics Data Production Co., 1995) does not report any adverse effects of tamoxifen citrate (Nolvadex) on patients' cognitive functions.

Alternatively, it is possible that tamoxifen citrate (Nolvadex) contributed to at least some of her reported visual (perception of phantom objects and movement within her peripheral visual fields, multiple blind spots) and physical (e.g., syncopal episodes, headaches, dizziness, and night sweats) symptoms. According to the Physician's Desk Reference (Medical Economics Data Production Co., 1995), tamoxifen citrate (Nolvadex) has been associated with visual disturbances, including corneal changes, cataracts, and retinopathy, as well as with adverse reactions such as hot flashes and, infrequently, dizziness and light-headedness. It should be noted, however, that although she had completed her course of tamoxifen citrate (Nolvadex) prior to the 1995 evaluation, she continued to experience syncopal episodes and night sweats. Furthermore, there were no reports of significant adverse reactions or symptoms before the patient's electrical shock, despite the fact that she had been receiving tamoxifen citrate (Nolvadex) for several years prior. Thus, although the possibility exists that this drug may have contributed to her symptomatology, it does not appear to account for all of her somatic complaints.

There were also no indications that DR's psychotropic medications negatively impacted her neurocognitive performances because no adverse side effects (e.g., drowsiness, ataxia, etc.) were observed or self-reported. Based on DR's observed behavior during testing, her neurocognitive results did not appear to have been significantly affected by depression or anxiety. Her affect was situationally and socially appropriate, and no overt signs of anxiety or depression were noted throughout testing. She also displayed good attention and concentration and appeared to put forth good effort on tasks across evaluations.

Finally, motivational issues or secondary gain did not appear to have contributed to her observed neuropsychological deficits

because DR reported that she was prohibited from pursuing any legal action against her former employer. Thus, although no cause and effect can be determined, it seems likely that DR's neurocognitive deficits are related to her accidental electrical shock versus a function of the other, potentially confounding variables noted here.

In contrast, MJ exhibited a pattern of neurocognitive performances reflective of only minimal cognitive-behavioral impairment. Specifically, he displayed mildly deficient visual scanning and psychomotor tracking as well as mild bilateral dysgraphesthesia. MJ's nondominant upper extremity grip strength, manual dexterity, and psychomotor problem solving and tactile discrimination were also mildly deficient; however, these impairments were likely related to the patient's peripheral left arm and hand injuries and burns that he sustained as a result of his electrical shock. The remainder of MJ's neurocognitive results were WNL. Furthermore, based on his generally intact cognitive and behavioral functions, MJ's reported (i.e., self-report and MMPI-2 results) depressive symptomatology did not appear to have a significant negative impact on his neurocognitive performances.

Taken together, these two cases exemplify the range of neurocognitive impairments (or lack thereof) that may be seen in victims of electrical shock. The neurocognitive variability observed across cases was likely a function of multiple factors that interacted to determine the nature and severity of their electrical injuries. Although a thorough discussion of these factors (see Cooper, 1984; Dendooven, Lissens, Bruyninckx, & Vanhecke, 1990; Fontanarosa, 1993; Kobernick, 1982, for reviews) is beyond the scope of this article, these parameters include voltage, amperage, resistance of tissues, tissue susceptibility, diameter or surface area of tissue contact, type of current, duration of current, and current pathway. Demographic variables, such as age and gender, and psychosocial, interpersonal, and economic issues, may have also affected shock outcomes. With this diversity of factors (most of which may vary widely in their range of possible values) interacting with one another (Cooper, 1984; Hunt, Mason, Masterson, & Pruitt, 1976; Reilly, 1994; Solem, Fischer, & Strate, 1977), it is not surprising that the nature and severity of electrical injuries are not easily predicted and may vary considerably across individuals.

Despite differing neurocognitive profiles exhibited by these cases, their MMPI-2 clinical profiles were remarkably similar. Across three administrations of the MMPI-2 to DR and one to MJ, both patients displayed significant elevations on scales 1, 2, 3, 7, and 8, with scale 3 consistently being the most elevated clinical scale. Their profiles indicated endorsement of a diversity of somatic complaints that may have worsened in times of stress, as well as a range of depressive symptomatology and significant anxiety, nervousness, or both. Both patients also acknowledged elevated levels of unusual thoughts and sensations. Overall, the patients' MMPI-2 results were not surprising in light of their history of severe electrical shock and their persistent physiological and neuropsychological sequelae.

Clinical interviews with these patients also revealed a number of notable similarities in their psychological presentations that appeared congruent with their MMPI-2 profiles. Both patients acknowledged significant depressive symptomatology, which included decreased libido and self-confidence in their vocational abilities, as well as increased irritability, anger, or both, and decreased tolerance of stress. Increased distractibility was also reported. Furthermore, both patients acknowledged persistent anxiety or psychological distress secondary to thoughts of their electrical shock incidents and the possibility of returning to the environments where these events occurred.

In addition, both patients reported distressful dreams or nightmares involving their electrical-shock accidents. In sum, such psychiatric symptomatology is suggestive of the presence of both major depressive and posttraumatic stress disorders. The findings of depressive and posttraumatic stress disorder symptomatology in these patients is also consistent with previous reports that have found similar symptomatology in victims of electrical shock (Gourbiere et al., 1994; Kelley et al., 1994). In addition to their similar psychological presentations, both patients reportedly had suffered multiple syncopal or near-syncopal episodes subsequent to their electrical shocks. Across cases, these postshock syncopal episodes, which were generally not

preceded by vertigo, continued to occur for months (i.e., MJ) and years (i.e., DR) following their electrical injuries. Follow- up EEGs and EKGs were interpreted as normal; however, a significant drop in DR's blood pressure was documented during one of these events. As noted earlier, although the possibility exists that at least some of DR's syncopal episodes represented adverse reactions to tamoxifen citrate (Nolvadex), she continued to experience occasional syncopal episodes after discontinuation of this drug. Furthermore, it is also interesting that MJ suffered similar syncopal episodes, despite the fact that he had never received tamoxifen citrate (Nolvadex).

Thus, although the exact precipitants or mechanisms responsible for these events remain unclear, they may be related to episodes of neurally mediated hypotension or vasovagal syncope that, in turn, may be precipitated by stressful situations (Bou-Holaigah, Rowe, Kan, & Calkins, 1995; Herlevsen & Andersen, 1987). Some support for this hypothesis is found in a study by Herlevsen and Andersen (1987). The authors reported an electrical shock (220 V) case with a history of vasovagal reactions (in response to the sight of blood and cannulas) who suffered a cardiac arrest on insertion of an intravenous cannula. Herlevsen and Andersen suggested that patients who have experienced vasovagal reactions prior to their electrical injuries may be at increased risk for cardiac conduction disturbances after their shocks, especially during times of psychological distress. Although neither patient in this study had any known history of neurally mediated hypotension or vasovagal syncope, it is possible that their electrical shocks increased their susceptibility for this disorder, especially during episodes of significant psychological distress, which, in turn, resulted in their syncopal events.

Future research is needed to longitudinally examine large groups of patients who have suffered severe, accidental electrical shocks as compared with matching control groups that have not sustained such events. Studies are also required that focus primarily on women (as compared with controls) who have received significant electrical injuries. Finally, such studies should examine the prevalence of postshock syncopal episodes as well as the precipitants or mechanisms underlying these events.

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