

## A SHOCKING NEUROLOGICAL RARITY

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Electrical injuries occur relatively infrequently but can lead to various immediate and delayed neurological and neuropsychological consequences. Many physicians are familiar with high voltage injury with significant full thickness burns, peripheral nerve damage, and possibly brain ischaemia secondary to cardiorespiratory arrest. Other indirect neurological consequences are traumatic brain and spinal cord injury secondary to a fall after the electrical injury. Neurologists may be less familiar with delayed spinal cord damage and a clinical picture such as a lower motor neuron syndrome, amyotrophic lateral sclerosis, or transverse myelitis – days or decades following the electrical injury.

Even rarer, and the focus of this article, is what has been referred to as diffuse electrical injury where there are diffuse symptoms, both 'path related' and remote to the theoretical current pathway (the linear path of the electrical current from entry point to exit point). This produces remote physical, neurological or neuropsychological symptoms that may be present without any obvious gross external injury and even in the total absence of a current path that includes the brain or spinal cord. These cases often frustrate both the neurologist and the patient as the neurologist struggles to find 'objective' proof on which to base treatment, and the patient becomes increasingly upset that no one seems to believe their symptoms.

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# Diffuse e

# Electrical injury

## CASE ILLUSTRATION

A previously healthy 32-year-old man was working at home when he received a shock to his dominant right hand after touching a faulty 110-volt power outlet next to the stove. He was thrown backwards but did not hit his head or body. He denied any loss of consciousness, and he had a clear recollection of what had occurred. He called his regular physician and went to the clinic for an examination. No entry or exit wounds, burns or evidence of any gross external trauma were noted. His vital signs and ECG were normal and he was sent home. The next day he awoke with what he called 'muscle spasms' in his right upper arm and shoulder. He spoke with his physician over the telephone who advised the patient to 'rest, apply ice, and take acetaminophen (paracetamol) if necessary. The muscle spasms should resolve in a few days'. Unfortunately, within about 3 weeks, the patient began to experience a 'pins and needles' sensation in his right hand and arm. He also noted generalised muscle aches, and muscle fatigue, that interfered with his daily activities. He complained of headaches, anxiety, irritability, insomnia, and concentration problems. He was given a trial of several non-steroidal anti-inflammatory drugs without relief.

His primary physician referred him to a physiotherapist and, when there was no improvement after 2 months, the patient reported that his primary physician suggested to him that his symptoms were more likely 'psychological' than 'medical' and recommended referral to a psychologist. The patient, like many others, was quite offended by this suggestion, thinking that the physician was saying that he must be 'crazy, or making up the symptoms'. He promptly demanded referral to a neurologist, remarking, 'I want to see an expert'. However, the patient became increasingly frustrated when the first neurologist stated that he was not an 'expert in electrical injury' and told him he needed to find another neurologist, which caused further delay.

## ON EXAMINATION

The second neurologist found the patient to be alert and cooperative. There was no discoloration of his right arm. The cranial nerves were intact. He was tender on palpation of his cervical spine and right posterior shoulder. His neck had a full range of movements, although he complained of pain with full rotation of his head to the right. Muscle tone and strength were normal in all extremities, although he grimaced when testing power in his right arm. The reflexes

were normal. He had decreased light touch over his right hand and lower arm which did not correspond to any particular nerve or dermatomal distribution, but light touch, temperature, and pain sensation was normal in all other areas.

A cervical spine X-ray and MRI, and EMG, were all normal – there was nothing to suggest spinal cord or root compression, or brachial neuritis for example. Amitriptyline was prescribed for his chronic pain, insomnia and possible neuropathy although exactly where the lesion might have been in the nervous system is difficult to say. On his return visit, he reported only minimal improvement in his sleep pattern and no change in his other chronic symptoms. He eventually gained some relief with gabapentin and ultracet (tramadol and paracetamol), but was unable to try alternative treatments that were not covered by his healthcare plan. The patient moved and was lost to follow-up.

## UNDERSTANDING DIFFUSE ELECTRICAL INJURY

What makes diffuse electrical injury such a treatment quandary for the clinician unfamiliar with the syndrome is that it has components of several other syndromes: headache, concentration problems, irritability, and insomnia similar to post traumatic brain injury; generalized muscle aches and fatigue suggestive of the chronic fatigue syndrome or fibromyalgia; and anxiety, concentration problems, and insomnia that might suggest post-traumatic stress disorder or depression. Not surprisingly, these patients are often labeled as having a 'chronic pain syndrome'. If you speak about such a case to other physicians, you may hear two common myths: firstly, that the lack of external injury or burns equals no injury, and secondly that low voltage exposures do not cause significant neurological or neuropsychological symptoms. Certainly the literature has debated whether the syndrome is of organic or psychogenic origin. And treatment, in the absence of any diagnostic support for a physical cause, frequently is given for non-organic diagnoses such as anxiety, depression, conversion disorder and somatization disorder. Patients involved in litigation were, and unfortunately still are, commonly suspected of malinger or exaggerating their symptoms.

However, despite the fact that electrical injury is rare, and studies have been limited by small sample sizes, they do suggest that electrical injury survivors (peripheral contact only, no direct mechanical electrical contact to the

head, no secondary head trauma) can develop a neuropsychological syndrome (Table 1). This includes somatic, neuropsychological and neurological and/or path related symptoms. In neuropsychological studies, the most frequently demonstrated impairment is within the memory domain. A comparison of 63 patients, the majority with diffuse electrical injury, with a control group of 22 healthy electricians found that the patients reported a similar post-injury syndrome of somatic, neuropsychological and emotional complaints. Furthermore, these complaints were not directly related to the severity of their physical injury as measured by surgery and hospital statistics, voltage exposure, litigation, or return to work status. Patients exposed to less than 1 000 V (historically referred to as low voltage in medical studies) and those exposed to more than 1 000 V had the same degree of symptom complaints (Plisken *et al.* 1998). Questions still remain as to how electrical exposure with current paths excluding the brain affects central nervous system function. There are numerous possibilities, such as diffuse cerebral injury, with disturbance of the limbic system or hypothalamic–pituitary axis. Perhaps the electrical injury triggers a degenerative process that only becomes apparent over time, which might explain why some patients have a delay in the onset of their neurological and psychological symptoms.

### MANAGING DIFFUSE ELECTRICAL INJURY

Finally, how should the neurologist approach this rare type of injury? Although many of the common neurological studies are normal, it is prudent to start with a comprehensive physical (including neurological) examination, EEG, EMG, and MRI of the relevant part of the nervous system to the symptoms. If possible, SPECT and functional MRI may prove useful, although costs and availability are prohibitive in most places. A thorough neuropsychological evaluation is highly recommended, as well as a measure of personality and any psychopathology given the frequency of psychiatric complaints. Although there is no formal evidence base, treatment is best provided with a multidisciplinary approach that combines follow-up physical examination, medication, psychiatric/psychological individual and group support, and bio-behavioural approaches such as bio-feedback to improve the patient's ability to control their pain. Alternative approaches,

which may improve the patient's energy level and strength, include exercise such as walking, swimming and yoga, as well as acupuncture and therapeutic massage. Depending on the individual patient's complaints, they may benefit from a tricyclic such as amitriptyline, or any of the current anticonvulsants/mood stabilizers (valproic acid, gabapentin, topiramate, etc) that help with neuralgia and chronic pain. Many patients can benefit from a hypnotic because they frequently experience parasomnias. It is important to address the patient's psychological needs as they learn to cope with their symptoms, and some may benefit from other antidepressants or stimulants directed at specific symptoms. Unfortunately, patients who have not recovered from the initial effects after 3 months are at risk of long-term sequelae and disability (Primeau *et al.* 1995). One of the most important factors in their management is finding a neurologist willing to listen and to persevere in the treatment of this rare disorder.

## Questions still remain as to how electrical exposure with current paths excluding the brain affects central nervous system function

**Table 1** Symptoms of diffuse electrical injury

SOMATIC	NEUROPSYCHOLOGICAL	NEUROLOGICAL
General exhaustion, fatigue and physical weakness	Sadness/depression, Insomnia or other sleep disorders	Tingling and numbness in hands and arms
Chronic diffuse pain	Personality change	Muscle aches, spasms, and twitches
Weakness in joints	Increased emotional sensitivity	Weakness of grip
Stiffness in joints	Lack of concentration	Tingling and numbness in legs
Chest pains	Lack of motivation	Dizziness
	Unusual anxiety	Headache
	Memory loss – short term	
	Unexplained moodiness	
	Irritability	

**COMMENT BY PROF MICHAEL SHARPE**

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This paper describes the development of a variety of symptoms after an electric shock. The authors imply that these symptoms are due to damage to the central nervous system. This may be the case but it is notable that the symptoms they list overlap strikingly with those of a range of other symptom syndromes – including those conventionally regarded as psychiatric, such as fibromyalgia, chronic fatigue syndrome, whiplash, other chronic pain syndromes, depression, and anxiety (Wessely *et al.* 1999). Whilst strongly agreeing with the authors about the unhelpfulness of regarding symptoms that are not clearly explained by disease as necessarily psychological or malingered, it would seem wiser to be more aetiologically neutral about the question of injury, or damage, to the nervous system in this case. The authors present no evidence of structural changes to the nervous system. Other mechanisms that do not imply injury, such as sensitization, are plausible (Ursin *et al.* 2001). Clinically, whilst patients may be greatly relieved to have their experience and beliefs about their symptoms validated as ‘diffuse electrical injury’ rather than simply ‘symptoms occurring after electric shock’, this does carry implications about the symptoms that may be unhelpful. Firstly, it labels the symptoms as being caused by the shock and so may prevent exploration of other aetiologically relevant factors such as life stresses. Secondly, it may mean that appropriate treatments are neglected, although interestingly the treatment for diffuse electrical injury is extremely similar to that recommended for the other syndromes mentioned above. Third, it may lead the patient to believe they have a permanent disabling condition and then to shape their life accordingly, when in fact it may be treatable. So whilst I would strongly support the authors’ contention of taking such patients seriously and not dismissing a biological basis (Sharpe *et al.* 2001), I would be more circumspect about assuming the presence of ‘injury’ and the distinctness of the syndrome – for both scientific and clinical reasons.

**PRACTICE POINTS**

- Significant injury to the nervous system can occur even without entry or exit burns.
- Low voltages can produce symptoms similar to high voltage contacts.
- Neurological symptoms can be delayed in onset.
- Be vigilant – diffuse electrical injury often flies below the diagnostic radar.

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## RESPONSE BY DRS BERG AND MORSE

We appreciate Dr Sharpe's comments and acknowledge that the symptoms of diffuse electrical injury have components that can be found in other conditions such as fibromyalgia, chronic fatigue syndrome, anxiety and depression. However, compared to these, it is notable that the symptom pattern of diffuse electrical injury most commonly occurs within 3–8 weeks of the injury, and it does not include some of the more common characteristics of the chronic fatigue syndrome (sore throat, tender lymph nodes) or of fibromyalgia (multiple specific tender points). Also, diffuse electrical injury includes some electrical current path-related symptoms that are not present in any of the other disorders.

We clearly stated that a comprehensive examination and work-up, including a thorough neuropsychological evaluation, is highly recommended to explore all aetiologically relevant factors. But we very much disagree that, following such an evaluation, the diagnosis of diffuse electrical injury carries greater stigma than failing to make an accurate diagnosis, or that appropriate treatments might be neglected. On the contrary, since many physicians are unaware of research that documents the presence of a pattern of somatic, neurological and neuropsychological symptoms after electrical injury without other aetiological factors (Heilbronner & Heilbronner 1994; Duff & McCaffrey 2001; Lee 1997), inappropriate psychological or physical labels are currently given without scientific merit. Further, there is no reason to believe that patients will view themselves as 'permanently disabled' simply by giving their symptoms a name. The symptoms they experience are present despite what they believe about them. We agree with Dr. Sharpe that, while acknowledging that the symptom pattern following electrical shock occurs, some psychological adjustment to

these changes is necessary. However, the latter without the former places an unnatural burden of responsibility on the patients with such injuries, whereas acknowledging the former allows for appropriate care, rehabilitation and patient education. It is hoped that early recognition and treatment, with expectation of remission, will prevent the risk of long-term disability suggested by Primeau (1995).

Post-concussive syndrome is an excellent example of this general issue. Prior to the axonal shearing model, the mild head injury patients were labeled as somatoform or diagnosed with 'compensation neurosis'. Now the syndrome is well accepted in the U.S.A. and funded for research, which has resulted in improved education and treatment for this previously disenfranchised population.

We clearly acknowledge that the question of how electrical exposure affects central nervous system function is purely theoretical at this time, but we believe that current research points toward an organic basis. Clearly more research needs to be conducted to better understand the extent to which pathophysiology is organically based, but increased awareness of diffuse electrical injury as a distinct syndrome has the potential to benefit patients.

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