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RECENT ADVANCES IN UNDERSTANDING THE NEUROBEHAVIORAL ASPECTS OF ELECTRICAL INJURY

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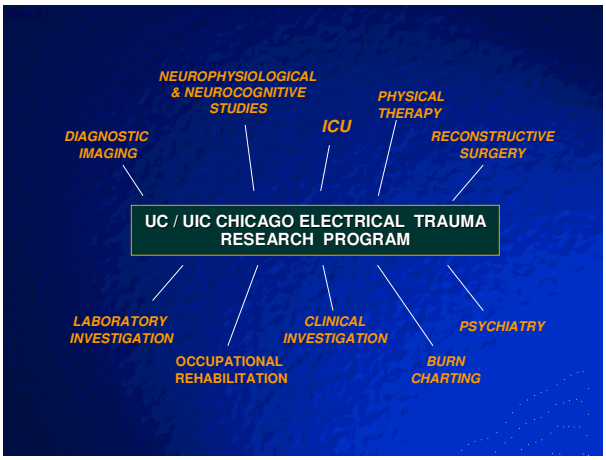
1. INTRODUCTION

Electrical injuries (EI) are more common and have been more studied than lightning injuries. However, there are many clinical similarities in the long term effects of the injuries including cognitive impairment and personality changes.

The Chicago Electrical Trauma Research Program (ETP) is a multidisciplinary program which includes neuropsychologists, a burn surgeon, an emergency physician, a psychiatrist, a radiologist, a pain specialist, a neurologist and rehabilitation specialists including a physiatrist, occupational and physical therapists (Figure 1). In addition, other specialists are consulted as necessary for patient care and evaluation.



Although the ETP currently conducts evaluations of both electrical and lightning survivors whose injuries occurred months to years earlier, the majority of the program's studies have been conducted on electrical trauma patients with reasonably acute injuries. These, as well as recent fMRI neuroimaging studies are the ones that we will review in this paper.

2. Symptom Complaints

There have been many common assumptions about survivors of electrical trauma and the cognitive symptomatology they exhibit (Table 1).

TABLE 1. Common Assumptions about the Cognitive Effects of Electrical Injury

The worse the burn, the worse the outcome
There must be entrance / exit wounds for there to be an injury
Electrically injured patients who experience changes are not psychologically stable to begin with.
Electrically injured patients fake cognitive and emotional changes to gain a larger financial settlement and stay off of work

In multiple controlled studies, psychiatric morbidity has been consistently shown to be prevalent among EI patients well into the long-term phase of recovery, with PTSD and depression being the most prevalent diagnoses in this population.

Using the Neuropsychological Symptom Checklist, a standardized test which includes physical, cognitive, and emotional symptoms, Pliskin et al (1998) compared a control group of 22 healthy electricians matched for age, educational level, and work experience to 63 EI survivors who had suffered peripheral injuries from domestic or commercial power sources (Tables 2-4).

Table 2. Most Common Physical Complaints

	EI	Controls	P
Pins and Needles	49%	18%	.01
Headaches	48%	14%	.003
Muscle Twitching	44%	18%	.005
Trouble Walking	43%	0%	.0005
Muscle Spasms	41%	14%	.006
Balance Problems	41%	0%	.0008
Pain	40%	18%	.001
Muscle Weakness	40%	0%	.004

TABLE 3. Most Common Cognitive Complaints.

	EI	Controls	P
Concentration	49%	0%	.0001
Finding Right Word	49%	18%	.01
Slower Thinking	46%	9%	.004
Memory Problems	44%	18%	.05
Distracted	43%	14%	.002
Hard Think Clearly	38%	0%	.001

TABLE 4. Most Common Emotional Complaints.

	EI	Controls	P
Stress/Anxiety	49%	14%	.007
Sadness/Depression	48%	14%	.01
Attitude Change	41%	9%	.02
Anger/Temper	30%	5%	.03

Voltage, hospitalization, surgery, loss of consciousness or cardiac arrest did not distinguish those who checked more complaints. Additionally, litigation was not associated with differing levels of symptom complaints.

Only 'Time Since Injury' accounted for differences in symptom complaints. Several reasons were hypothesized including delayed neurologic and psychiatric changes directly related to the electrical exposure as well as the fact that problems in these areas may not become apparent until the acutely injured patients return to the home or work environment

3. Neuropsychological Functioning

In a second set of controlled investigations of EI and neuropsychological functioning, 29 EI patients performed significantly more poorly on measures of attention, mental speed and motor skills compared to 29 matched healthy electricians (Pliskin et al 2006). None of these findings could be attributed to differences in pre-injury IQ, age, education, or occupation. In addition, the findings were not due to concurrent traumatic brain injury or overt emotional or distress levels. All of the EI patients passed symptom validity testing.

Likewise, in a separate study examining the effects of psychiatric injury on cognitive functioning in EI patients, EI patients with post-traumatic stress disorder (PTSD) showed decreased verbal memory as compared to EI patients without PTSD (Ammar et al 2006).

4. Functional Imaging

Although EI neurocognitive deficits and symptom problems have been well described, neuropsychological testing alone will not be informative in clarifying issues of underlying etiology. However, functional brain imaging may provide stronger evidence that cognitive deficits observed on behavioral measures have an organic basis (Ramati 2006).

Deficits in working memory were suggested from the results of an adequately controlled behavioral study in EI patients (Pliskin 1999). Working memory is a building block of most other cognitive abilities including learning. Working memory is subserved by an extensive neural network connecting discrete neuroanatomical regions. It was hypothesized that functional magnetic resonance imaging (fMRI) could be used to tap into this network to provide a broader view of brain functioning in the EI patient compared with controls.

The commonly available clinical diagnostic MRI is merely an anatomic or static picture. fMRI involves use of a powerful research magnet which is capable of differentiating between actively functioning vs resting areas of the brain, 'lighting up' based on the concentration of oxygenated hemoglobin. By using activities or tests designed to target language perception, for instance, areas of language processing can be differentiated from those used simply to hear verbalized nonsense sounds.

A set of oculomotor tasks was designed to tap into several different aspects of neural circuitry underlying working memory. These included sensory (visual) based component, a memory based component and a predictive (learning) based component. The tasks were presented as stimuli projected onto the screen of a patient's visor while in the fMRI. Normal, matched controls performed the same tasks.

Preliminary findings were initially surprising but, on further thought, supported another frequent problem of easy mental fatigability that many survivors find incapacitating. Since the majority of the study subjects were injured by electricity, more lightning survivors need to be studied before the findings can be generalized.

5. Summary

There is a neuropsychological syndrome post-electrical injury that involves physical, cognitive and emotional changes. The complaints are not directly related to severity of physical injury, voltage exposure or litigation or return to work status and symptoms persist after litigation settles. EI patients perform more poorly on

measures of attention, processing speed and motor skills. Early results from fMRI studies are helping to provide evidence that the differences shown on neuropsychological test batteries indeed have an organic basis.

Taken together, these investigations suggest that EI is associated with neurocognitive and neuropsychiatric changes that mandates a comprehensive multidisciplinary approach for effective triage, assessment and long-term rehabilitation efforts for EI survivors.

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