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 psychiatrist, 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>
<thead>
<tr>
<th>TABLE 1. Common Assumptions about the Cognitive Effects of Electrical Injury</th>
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<tbody>
<tr>
<td>The worse the burn, the worse the outcome</td>
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<tr>
<td>There must be entrance / exit wounds for there to be an injury</td>
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<tr>
<td>Electrically injured patients who experience changes are not psychologically stable to begin with.</td>
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<tr>
<td>Electrically injured patients fake cognitive and emotional changes to gain a larger financial settlement and stay off of work</td>
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</table>

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>
<thead>
<tr>
<th>Table 2. Most Common Physical Complaints</th>
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<tr>
<td>EL</td>
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<tr>
<td>Pins and Needles</td>
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<tr>
<td>Headaches</td>
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<tr>
<td>Muscle Twitching</td>
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<tr>
<td>Trouble Walking</td>
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<tr>
<td>Muscle Spasms</td>
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<tr>
<td>Balance Problems</td>
</tr>
<tr>
<td>Pain</td>
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<tr>
<td>Muscle Weakness</td>
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</table>
patients passed symptom validity testing. The home or work environment
or overt emotional or distress levels. All of the EI
apparent until the acutely injured patients return to
were not due to concurrent traumatic brain injury
be attributed to differences in pre-injury IQ, age,
neurologic and psychiatric changes directly related
differences in symptom complaints. Several
memory as compared to EI patients without PTSD
in EI patients, EI patients with post-traumatic
measures of attention, mental speed and motor
those who checked more complaints. Additionally,
consciousness or cardiac arrest did not distinguish
2
Voltage, hospitalization, surgery, loss of
were 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

<table>
<thead>
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<th>TABLE 3. Most Common Cognitive Complaints.</th>
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<tr>
<td>El</td>
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<tr>
<td>----</td>
</tr>
<tr>
<td>Concentration</td>
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<tr>
<td>Finding Right Word</td>
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<tr>
<td>Slower Thinking</td>
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<td>Memory Problems</td>
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<tr>
<td>Distracted</td>
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<td>Hard Think Clearly</td>
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<th>TABLE 4. Most Common Emotional Complaints.</th>
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<td>-------------------------------------------</td>
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<tr>
<td>Stress/Anxiety</td>
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<tr>
<td>Sadness/Depression</td>
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<tr>
<td>Attitude Change</td>
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<tr>
<td>Anger/Temper</td>
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</table>
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.

5. REFERENCES


