31st Annual International Conference of the IEEE EMBS
Minneapolis, Minnesota, USA, September 2-6, 2009

A Study of Long Term Symptomatology Reported in Non-Head-Involved Low Voltage Electrical Contacts

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Abstract—**The appearance of non-resolving non-path-related symptomatology following some low voltage (120/240 volt) electrical contacts has proven to be a scientific puzzlement. The problem is that the best of our diagnostic technology is not yet technologically advanced enough to image the mechanism of injury. Still, in the context of this wealth of data, by inference, it is more likely than not that the underlying mechanism of the injury is of a highly diffuse nature and exists at a cellular level. These issues will be explored through the presentation of the first results from an ongoing, decade long study into electrical injury.**

I. Introduction

There is an ever increasing body of literature, spanning the last two decades that recognizes a class of electrical injury that is defined by symptomatology that is not proportionate to the parameters of the shock (voltage, current, duration, energy) and often manifests with symptoms that are remote to the theoretical current pathway[1-15]. (NOTE: For discussion purposes and consistent with the traditional analysis of electrical contacts, the author defines the *theoretical current pathway* as the shortest linear path from entry point to exit point. The actual current path, while not known, must by definition adhere to the basic physical premises that define current flow in a body containing components of multiple and varying resistivities. [1, 2]) This author has descriptively referred to this class of electrical injury as "*Diffuse Electrical Injury*" or "*DEI*." [1, 2] While most electrical injuries can be linked to the parameters of the contact, the nature of this class of injury is not a function of "voltage, current, and/or wound size".[3] Neuropsychological test performance in some cases does not correlate to "injury related characteristics (e.g. voltage)" [4]. A lack of a correlation has been noted between voltage and loss of consciousness, excluding those cases where the loss of consciousness and injury due to electrical shock are caused by secondary blunt force trauma [5]. Common to the body of research is a recognition that the remote symptomatology not only includes physical ailments but often includes neurological and neuropsychological symptoms that can exist even in the total absence of a theoretical current path that includes the brain [1-4], [6,7, 12]. The studies suggest that neuropsychological sequelae after electrical contact, even when remote to the theoretical current path, rarely occur absent other substantial physical injury [8- 9]. With much lower frequency, electrical injury is observed to manifest neuropsychological symptomatology absent substantial or even measurable other tissue injury [10]. MRIs, CTs and nerve conduction studies offer only inconclusive support for the presence of physical injury in such cases [7,8,11] although some work has been done to suggest that more sophisticated scanning techniques may hold the diagnostic key [9].

In the evolution of research in this area, of note is that the early work does not account for some influencing variables. Perhaps the most significant variable is how on-going litigation effects patient presentation and how that may influence study results. [7, 10] More recent work in the field has considered the impact of secondary factors through analyses that control, anticipate, or attempt to eliminate previously ignored influences such as that related to secondary gain or the effect of patient underperformance on testing. [12,13]

Looking at the broad scope of work in the field [1-15] and in particular at a summary of the many studies done over the past few decades [14], much becomes obvious. Recent work [9,12,13,15] supports the hypothesis that there is a common symptomatology that is consistent across a broad spectrum of electrical contacts that is not explained by the known, defined, and observable mechanisms of electrical injury.

At issue is if there is enough data to conclude that this common symptomatology has an organic basis. Most studies to date have either involved small numbers or have not clearly separated injury along the boundaries of the contact parameters such that the study group was non-homogenous consisting of victims of a broad spectrum of electrical contacts [12,14]. Most studies have not accounted for individuals participating in the study who are involved in litigation [1,6,7,9,10]. At least one recent study however found that involvement in litigation did not yield significantly different results from those not involved [12].

Manuscript received April 7, 2009.

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One study (11 data points), while recognizing the validity of diffuse symptomatology also concluded that a significant percentage of the study population presented with indicators of underperformance on testing [13]. At least two studies have results suggesting an organic link to the non-path symptomatology. [9,16]

II. Methodology

Presented herein are the results of a study with a large population (N=157) reporting fairly homogenous shock parameters. The group is defined by non-head-involved, limb to limb, low-voltage (120/240V) electrical contacts with non-resolving remote symptomatology more than 6 months post-contact.

In 1999 a website was established that directed those searching for information on their electrical injury to an interactive survey site. At the survey site, individuals self-reported the experience and effects of their electrical contact along with pertinent life demographics. (NOTE: Details of how the site was established, site validity, and other related important aspects are found in reference number 1.)

Respondents were asked to check from almost 200 phrases that described that which they felt or experienced. As of 2009, over 900 surveys have been received and placed within the study database. Each electrical injury has been characterized by time since injury, voltage of contact, duration of contact, entry and exit wounds, duration of unconsciousness, age, gender, locale, race, and litigation history (or lack thereof). Symptomatology has been further broken out by time that symptoms arose following contact (pre-existing, first 48 hours post-contact, within first three weeks, between three weeks and six months, beyond six months.)

Surveys that were incomplete, redundant, or which did not meet the pre-established demographics were filtered. The respondent group consisted of all remaining surveys.

Survey data was compared using Chi Squared analysis to three separate baselines to ascertain if frequency of symptom occurrence differed with each of the baselines. One baseline was established from the respondent group using their pre-injury data. One baseline was established from the full database excluding the respondent group. The third baseline consisted of data gathered from a separate group who had never suffered an electrical contact requiring any form of treatment.

Sub-analysis along demographic lines was also conducted on the respondent group. Individuals in litigation were compared with those not in litigation. Individuals claiming loss of consciousness were compared with those who claimed no loss of consciousness.

III. WEB-BASE VERSUS CLINICAL DATA GATHERING

Web-based self-reporting surveys are a widely accepted part of the modern research landscape. Current literature supports the concept that the World-Wide Web holds great promise as a mechanism for questionnaire-based research [17-20]. A study by Davis [18] found that findings from web-based questionnaire research are comparable with results obtained using standard procedures such as paper-and-pencil format in a researcher's office. Studies have demonstrated that research subjects are just as likely to respond to a Web survey as a mail survey, and that the computerized Web interface may also facilitate self-disclosure [18,9]. Furthermore, many of the criticisms of online data collection are common to other survey research methodologies [20].

In any tool for research data gathering there are predictable limitations that must be considered in the design of the instrument and accounted for in the end analysis. The early results reported from the web-based survey [1] were quite similar to results achieved by other researchers using clinically based methodologies [3,6,7,8,11,12,15].

Web-based data gathering yielded two great advantages. The first was that there was a world-wide audience which produced a sample size far in excess of studies previously conducted. This allowed for highly detailed and specific studies to be run on large N sub-sets of the larger database. The sub-sets could be characterized by groups with very similar electrical contact characteristics and/or social demographics. The second advantage was that since all surveys were anonymous, there was no motive to misrepresent or to underperform. Absent any benefit that might drive one toward intentional underperformance or deception, it is likely that the survey responses are more apt to be an honest presentation.

Of course, web-based data gathering has certain limitations. Anyone is free to respond to the on-line survey and respondents do not undergo broad spectrum diagnostic testing or neuropsychological studies as is typical in clinical studies. Since historically, the type of injury being studied yielded diagnostic data that is at best inconclusive, the absence of such studies is likely not a significant issue. As a result, in clinical research, much of the information gathered has come from patient self-reporting not much different from that gathered in the web-based study.

On balance, and based on results taken in the context of the full body of research, it would appear that the use of the web-based survey has proven to be both beneficial and valid for this area of research.

IV. Results

Table I contains the survey group demographics applicable to the database sub-set as described. Table II and III contain results for the group described in Table I. Table II contains the most commonly reported physical complaints (P>.99) based on rate of reported occurrence six months post shock. Table III contains the most commonly reported cognitive/psych symptoms. (P>.99) based on rate of reported occurrence six months post shock. Baseline occurrence rates for both Tables II and III are given for a combination of those in the database reporting a shock less than 6 months

post-occurrence and the group who were defined as the no-shock baseline. (These numbers are typical for all baseline groups.)

TABLE I
GROUP DEMOGRAPHICS
(120/240 VOLT NON-HEAD INVOLVED SUB-SET)

N (120/240 Volt)	157
Median Time to Report	716 days
Males/Females	85/71
Single/Married/Other	51/81/25
Involved in Litigation	55
No loss Of Consciousness	85
No Entry Burn	104
No Exit Burn	102

TABLE II
MOST COMMON PHYSICAL SYMPTOMS
BASED ON OCCURANCE RATE – POST 6 MONTHS

SYMPTOM	PERCENT BASELINE	PERCENT >6 MONTHS
"Muscle Aches"	12.61	56.41
"General fatigue"	9.66	51.28
"Tingling in Hands"	6.3	49.36
"Muscle Spasms or Twitches"	9.66	47.44
"General physical weakness"	8.4	46.79
"General exhaustion"	7.56	42.95
"Numbness in Hands"	7.14	42.95
"Tingling in arms"	4.62	42.31
"Muscle Cramps"	5.46	39.1
"Stiffness in joints"	6.3	39.1
"Pins and needles in hands"	4.62	39.1
"Chronic general pain"	4.62	38.46
"Weakness in joints"	5.88	37.82
"Weakness in Grip"	4.2	37.18
"Extreme physical sensitivity"	2.52	36.54
"Numbness in Arms"	4.2	36.54
"Headache"	10.5	35.9
"Sexual dysfunction"	1.26	32.69

V. DISCUSSION

The symptomatology reported by this group is consistent with expectations based on prior and other published studies. What stands out is that this is a large group made homogenous by the similarity in shock parameters among the group. All were subjected to low-voltage contacts. Most suffered little or no external injury. Most did not lose consciousness. For the respondent population, the energy of the contact was quite small. The predicted outcome for these shock victims (based purely on the parameters of the shock) would have been that the shock would cause no lasting injury. What has occurred instead is that the respondent group is reporting a life altering event causing profound life changes.

When comparing results for individual gender groups, no significant differences were observed. When comparing results for those involved in litigation and those not involved in litigation, also no significant differences were found. When separating out groups based on time to report, there does appear to be some differences in the nature of reported symptomatology over time. (This needs to be analyzed further before any conclusions are drawn.)

TABLE III
MOST COMMON COGNITIVE/PSYCH SYMPTOMS
BASED ON OCCURANCE RATE – POST 6 MONTHS

SYMPTOM	PERCENT BASELINE	PERCENT >6 MONTHS
"Insomnia or other sleep disorders"	7.56	44.87
"Unusual anxiety"	7.56	44.23
"Fear of electricity"	7.56	44.23
"Reduced attention span/lack of concentration"	5.04	42.95
"Lack of motivation"	4.62	42.31
"Personality swings"	3.36	41.67
"General forgetfulness"	8.82	41.03
"Unexplained sadness"	2.1	38.46
"Chronic general pain"	4.62	38.46
"Unexplained moodiness"	2.1	37.82
Increased Emotional Sensitivity	2.94	37.18
"Short term memory loss(forget recent events)"	2.94	32.69
"Easily confused"	2.94	32.05
"Feeling of Hopelessness"	2.94	32.05

The individuals in this study, as with other studies, have manifested both path and non-path related symptoms. The nature of the symptomatology is clearly disproportionate to the parameters of the contact. There is a pattern to the reported symptomatology as well as the chronology of the symptomatology.

VI. CONCLUSIONS

The question to ask at this point is not if this type of symptomatology is possible following this class of electrical contact. This symptomatology has been demonstrated in the many studies already published. The question goes more to the nature of the mechanism that causes the onset of such a serious response to a low energy electrical contact. The logical conclusion given the multiple studies and the consistency of the results is that this is an organic response brought about by a mechanism that is either of a diffuse nature occurring at the cellular level or brought about through an unknown biochemical sequence of events triggered by the electrical contact which has served as the initiating event. Until such a time that diagnostic testing and imaging reaches the level of resolution of the mechanism of this injury, the explanation of that mechanism will be limited to speculation and theory. The existence of the injury has through multiple independent studies by multiple researchers using multiple different methodologies been successfully demonstrated.

The author notes that this is the first and most preliminary presentation of a small subset of data from a rather extensive study. It is likely that continued analysis will yield a far more extensive and detailed set of conclusions regarding the nature of electrical injury.

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