FURTHER IDENTIFICATION AND TREATMENT MODALITIES IN TELEPHONE MEDIATED LIGHTNING STRIKE

by

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ABSTRACT

This paper reports the results of a prospective survey of people injured by lightning impulses transmitted by the public telephone system. The results are compared with those of a previous retrospective survey. Various deficiencis in the methodology of the latter survey have been addressed.

A division into a population with severe injury and a population with mild injury is made based on medical history and examination taken immediately after a strike. The best predictors of severe injury were found to be the presence of symptoms beyond one week after the strike, and also the initial presence of musculoskeletal injuries. Psychological upset is also seen to be a significant factor in severe injury.

The only physical parameter of strike which could be used as a predictor of severe injury was the presence of concomitant power system damage. The importance of earth bonding between power and telephone system is thus supported in a protection strategy.

The first author finally draws on experience in treating patients with these injuries to propose a treatment regimen for those with ongoing symptoms. The importance of evaluating and treating psychological and physical aspects is stressed.

I. INTRODUCTION

At a previous meeting, the authors (Andrews, et al., 1988) reported the results of a retrospective study of people who had been subjected to lightning strike delivered via their telephone lines. At that stage it was pointed out that this phenomenon had been very little studied and represented a significant source of morbidity and mortality in the Australian environment. Since that time, further study has been undertaken and the object of this paper is to report the results of the new work.

The dearth of literature on the subject was alluded to in the previous study and very little new literature has come to light since that time. Most writers regard the "telephone mediated" circumstance as only being an extension of "in the field" lightning strike. The injuries are therefore presented merely as a further mechanism of more general field lightning injuries. Little attention is paid to the circumstance in its own right, and it has already been stated (Andrews, et al., 1988) that significant differences exist both in the magnitude of the insult and the method of delivery of the injuring agent.

Eriksson, et al., (1988), report results of post mortem examinations for lightning victims in Sweden. They cite two cases where victims died when subject to a lightning surge while using the telephone. Notable in this report is the immediate localisation of all manifestations of injury to the face, head and neck. This is strikingly in consonance with the findings of the present study and will be alluded to later. It is also in consonance with the previous study.

Frayne, et al., (1988), also report a case of a man struck while using the telephone and again the localisation of his symptoms were to the head and neck with a marked bias to neurological disability. A significant finding of the previous study (Andrews, et al., 1988) was that the injuries were locally mediated rather than centrally mediated, although

some personality change was noted indicating a certain global element of cerebral damage.

The previous study was conducted in a retrospective fashion and therefore suffered from certain deficiencies. Marked among these deficiencies was the need for subjects to recall their injuries after a substantial period, and therefore firstly a degree of selective recall, and secondly a degree of inaccurate recall, existed in the reporting process. There was also a degree of biased sample selection and these problems were alluded to at the time.

The current research aimed to rectify some of these deficiencies.

II. AIM OF RESEARCH

Bearing in mind the deficiencies of the previous sampling method, it was decided to gain access as quickly as possible to all persons who had recently been subjected to such an injury immediately the injury occurred. The aim was thus to provide recent sampling of the complete spectrum of injury. It was felt that less bias would be introduced into the sampling process in terms of the tendency for more severely injured people to respond to retrospective study, and less recall problem in the reporting process would be evidenced. Also when those injured were examined immediately, a more objective view of the injuries could be obtained by an external observer.

During three lightning seasons from 1988 to 1990 in the immediate regional vicinity of the authors' institution, 18 people reported lightning injuries to Telecom Australia. Twelve of these were examined and ten provided data suitable for inclusion in this study.

An immediate comment is made on these numbers. Firstly, the total number receiving injuries over three lightning seasons is markedly decreased over the incidence discussed in the previous paper (approximately 30/year). Reasons for this need to be advanced. It is felt that Telecom monitoring of this problem has now been active for at least ten years and in that time, those people in areas of maximum risk have been supplied with protection for their telephone apparatus. Therefore the remaining population is a relatively low risk population. Further a substantial public education programme has been undertaken in that time, and, as well, substantial publicity has been given to the authors' research. Public behaviour with regard to telephone usage during thunderstorms has been substantially modified. For these reasons it is reasonable to expect the incidence of telephone mediated lightning injury to have decreased markedly.

III. METHODOLOGY

This research relied heavily on the co–operation of Telecom Australia, and that was willingly and readily forthcoming. Telecom Australia and the research team were at pains to be sensitive to issues of confidentiality. The participants in this prospective study were therefore guaranteed that their access to the research team was entirely confidential to the team and the result of any examination was not made available to Telecom Australia. The mechanism for recognising individual injured patients therefore took this into account.

During the period of the study every person who reported an injury to Telecom had their incident investigated by Telecom Australia. At the time of this investigation they were given a letter and verbal encouragement to contact the research team. The letter they received invited them to contact the research team as soon as possible to arrange an interview and examination with regard to their injuries. Co–operation was earnestly sought and verbal encouragement to do so was provided by the Telecom investigator. Whether a person subsequently made contact with the research team or not, however, was a matter of individual initiative and the Telecom officers in fact had no knowledge as to whether subsequent contact was made or not. Confidentiality was thus assured.

All respondents who made contact with the research team were visited and examined immediately by a medical member of the team (CJA). They were asked to consent to a medical examination which included electrocardiography and audiometry. In each case consent as given. The two excluded patients came to the authors' notice outside this mechanism and for the sake of consistency were excluded from the study.

The response to the invitation in this study was double that of the previous study and although the numbers are small, represent

a consistent cross-section of the injured population.

The mechanism was however, was not without minor criticism and the major disappointment was the delay occasioned in some cases by some respondents in returning the form and making contact with the research team after the visit of the Telecom investigator. This was remedied part way through the study by allowing the respondent the option, at their own initiative, of returning the form to the research team via the Telecom investigator, should they so desire. The sacrifice in confidentiality was not considered by the majority to be of any moment.

The analysis to which the data were subjected aimed at identifying a particular risk group within the injured population. Cluster analysis was used in the previous study and three lightning strike syndromes were identified. Data was accumulated in two ways. Firstly on the examination visit, information regarding the circumstance of the strike, (physical details), was collected, as was comprehensive medical details of injuries sustained. Subsequent to that, with the respondent's consent, a copy of the Telecom report of technical matters surrounding the strike was obtained and used to supplement the physical details referred to above. As these were more comprehensive than the author's own assessment of the physical circumstances, the Telecom report was relied on heavily for the physical details.

Cluster analysis was applied to the subjects based purely on the medical details of their examination. This initial clustering allowed the grouping of individuals into categories of severity of injury. In this first analysis the physical variables derived from the Telecom report were then added to the data. Statistical analysis was applied to them to see if there were significant differences in the physical surroundings of particular strikes given that the categories of severity of injury had already been fixed. It was thus hoped to identify particularly risky circumstances based on the severity of injury sustained during the strike.

A second analysis was conducted for comparison in which clustering was applied to the whole data set, just as in the previous study, with all the physical data included in the clustering process. This was done as a check on data consistency and for a wider view of the significant factors participating in the clustering process.

The results were then compared.

IV. RESULTS AND DISCUSSION

IV.1 Numbers

A gratifyingly high response was obtained to this methodology, of the order of 60% of total strikees. This is roughly double the response obtained in the retrospective survey and was felt to be an adequate response.

Comments have already been made regarding the absolute size of this sample.

IV.2 Presentation of Data

An examination was made of the data in raw form and this is presented in Table 1, which has been ordered to reflect the groupings later derived from the cluster analysis. The absolute symptoms that were seen mirror those that were seen in the previous study. Symptomatology was divided as before, into short term and long term symptomatology. The natural break point for this, was approximately one week for short term injuries, versus greater than one week for long term symptoms. The break point for the previous study was in fact into three groups, one day, one week and longer. However, examination of the data for this study showed the above to be a more natural division.

It was quite noticeable that the number of both short term and also long term symptoms that were reported were smaller than in the retrospective study. This is regarded as confirmation of the bias by which individuals magnify over a period of time the symptomatology that they had experienced a long time previously. The current set of symptoms, as found in this study, would seem to be a more realistic indication of the symptomatology of the injury.

The symptomatology in the short term centres around three or four major areas.

Firstly, there is a group of ear symptoms appearing in three of the respondees, where pain, tinnitus and altered sensation were noted. Secondly, a group of burns were seen, however, only in two of the respondees. Facial, neck, and arm pain, including alteration in sensation, were seen in three of the respondees, however psychiatric symptoms, largely centring around anxiety, were seen in six of the respondees, often to a

marked degree.

Cardiovascular findings were evidenced in only three respondees, and consisted of tachycardia, which may well have been a manifestation of an anxiety state. Other minor symptoms, the largest one of which was generalised musculoskeletal pain in three cases, was also seen. The duration of these initial injuries ranged from one to five days, with the majority less than three.

Long term symptoms were seen in only three of the ten subjects. This represents a larger percentage of the total than found in the previous study wher approximately 10% were found to have significant ongoing symptoms. Two of these three indicated marked psychological disturbance and problems have continued to date. The remaining symptoms centred entirely around continuing musculoskeletal pain, particularly in the arm, face and neck.

Thus a first conclusion is that the major long term sequelae of this sort of lightning strike are pain (particularly musculoskeletal) and psychological disturbance.

IV.3 Cluster Analysis

The first analysis divided the subjects cleanly into two groups (Fig.1.).

Subjects six and ten formed a separate cluster from the remainder of the subjects. Examination of these subjects' data indicates that they are in fact two of the three subjects who demonstrated long term and continuing upset. Thus a predictor for severity of injury would seem to be duration of symptoms. It is interesting that subject nine was left out of this cluster by the clustering process. However, examination of that subject's data shows that his continuing symptoms were mild and the other two subjects were in fact quite debilitated. Once again the major continuing problem was psychological upset and pain. In the case of subject nine, psychological upset was not as prominent.

Each of the data items contributing to the cluster analysis were then examined for statistical significance between the two groups seen. All the variables representing long term symptomatology were significantly different ($P<.05$) between the two groups. Further the only variables in the short term symptomatology that were significantly different between the groups were those representing arm pain and altered arm sensation. In this study these particular variables could be used as discriminators for long term injury and thus severity of injury. It was noticeable that none of the physical circumstances discriminated between the particular groups, (initially based on the physical data collected by the author.)

When the physical data collected by Telecom Australia was added to the study, only two reached significance. Those two were the variables relating to associated power system damage with the given strike. Particularly there was no significance to variables like storm intensity, storm history, phone line construction, housing construction or terrain. The fact that these variables did not reach significance may be a reflection of the small sample size. However, consistent significance with associated power system damage adds credence to the stated Telecom Australia view that entry into a dwelling via associated power system strike, is a highly important means of entry of the injuring impulse. Further comments on this matter will be made later.

The second analysis, (Fig.2.), allowed the clustering to proceed on the basis of all variables including Telecom physical data. The clustering in this process showed an almost identical division into two cluster classes. This time however, subjects six, nine and ten were clustered into a group of greater severity than the first analysis. In retrospect it may be seen that subject nine only joined with the lightly injured group at a very late stage in the clustering process in the previous analysis and so may be regarded as "a floater". Once again the division on severity of injury is made on the basis of long term symptomatology alone and these are the only medical variables which reached statistical significance.

In the second case the physical data of significance also included whether the victim was wearing shoes or not. This may well represent a chance association. However the analysis shows that severity of injury is statistically positively associated with the wearing of shoes. This may represent a tendency to capacitive coupling to the impulse rather than direct conductive coupling. One author, (MD), has previously drawn attention to the phenomenon of a "capacitive spark", as opposed to a "conductive spark".

The only other variable shown to be of significance in this second analysis was whether the victim was thrown or not by the

impulse. This would seem naturally a correlate with severity of injury and could well indicate a degree of musculoskeletal trauma which could give rise to long term musculoskeletal disability.

V. IMPRESSIONS FOR THERAPY

It is noticeable in this study, as in the previous study, that injuries, and particularly injuries of severe degree, are local to the passage of electric current and are not derived from a central causation for continuing symptomatology.

Subsequent to this study, the author has been called upon to treat a number of these victims, something which was specifically precluded in the previous research methodology. Having completed the study, it was felt by the first author that he was ethically able to undertake such treatment.

The major features of injury are psychological and musculoskeletal. And this finding of the study has been borne out as an impression of the presentation of these people clinically. Further clinical impressions are now described.

The pain which the victims present with is very local to the line of the strike. It is felt to have been neuritic in origin, that is, derived from direct peripheral nerve cell damage. This is borne out by the clinical nature of the pain and secondly, by a plausible connection with the passage of electric current. That is, the electric current specifically and selectively damages the sensory nerve terminals and peripheral sensory neural conducting pathways which are traversed by the current. This is further borne out by success that the first author has had in treating these injuries with carbemazepine and/or clonazepam. These are agents known to be of particular use in neuritic pain. A standard dose regimen has been used gradually decreasing the dosage until the minimum to achieve control is found. Although the symptoms lasting greater than 1 week have been classified as long term, in fact they appear to improve gradually over six to eight months and the need for medication is finally removed.

Psychological factors are seen to be prominent when these people present and it is a clinical impression of the first author that the majority of people having continuing problems are of the more obsessional type of personality. This is not necessarily derived from the current data. It represents a clinical impression and is a plausible extension of the anxiety states seen in this study. The obsessional personality finds it difficult to cope with situations beyond immediate control. Issues of control of destiny and control of health are very strong in the obsessional. Many of the patients report frustration at having continuing problems they don't understand and that are foreign to their experience. In their perception the loss of control is made worse because "no-one else seems to understand" the syndrome either. They feel that the good health of which they had been totally in control previously had now been independently snatched from them and this created anxiety in itself, and particularly anxiety generated by being subject to the unknown. All this plausibly connects with psychological feelings of ongoing anxiety and mixed anxiety depression. The author has therefore found it useful to add a degree of tricyclic anti-depressant medication (particularly clomipramine) to the above pain relief. The basis for doing this is to provide relief from the obsessional features of the psychological disturbance as well as to provide primary anti-depressant action. Tricyclics also are known to be useful adjuncts to pain relief modalities.

Thus the regimen of anti-neuritic pain relief and anti-depressant therapy has become close to the author's standard.

VI. IMPLICATIONS FOR PROTECTION STRATEGIES

It was hoped that this study would indicate clearly particular groups of subjects that were at risk of injury due to their physical circumstances, and thus to allow the authorities to concentrate on protecting those particular individuals. This has not turned out to be the case. The only positive association which could be drawn from the study was the association with power system strikes and the severity of cross coupling between the power system and the telephone system. This is something that is not altogether unknown already. Perhaps the study can be regarded as providing positive reinforcement for the insistence on earth bonding between the telephone system and power supply system by Telecom as a matter of priority in service protection.

Particularly, no geographical or terrain

feature, or feature of storm intensity has been found to be significant in this study even though the numbers were small. The only formal parameter not measured has been earth resistivity. Otherwise the study is felt to be have been comprehensive.

VII. CONCLUSIONS

This study has provided the first prospective detailed examination of people struck by lightning which was mediated via the public telephone system. It has had a gratifyingly high response and in the currently Australian climate, represents a comprehensive examination of the injuries. The broad findings of the previous retrospective study have been confirmed in that the majority of injuries seen, and particularly those of severe degree, are local to the line of current and not mediated centrally. The best predictors of severity of injuries and their duration are the presence of musculoskeletal pain and the presence of symptoms lasting longer than possibly three days, and at least one week. The major physical parameter found to be of significance in predicting injury severity has been the presence of power system damage and this provides a measure of reinforcement for the current policy of regarding earth bonding as a significant step in system protection. Impressions of treatment have also been given particularly recommending the use of anti-neuritic pain relief, and anti-depressant therapy.

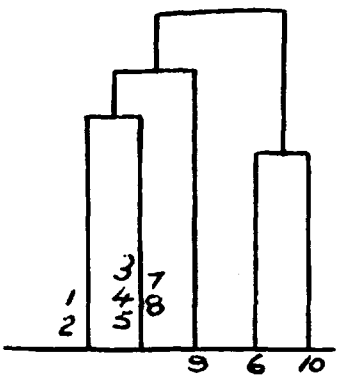

Fig 1. Dendrogram Analysis I

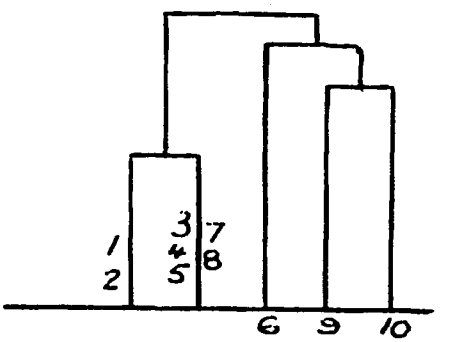

Fig 2. Dendrogram Analysis II

VIII. REFERENCES

Andrews, C.J., Darveniza, M., *Telephone Mediated Lighting Injury; An Australian Survey*, Proceedings 3rd International Conference Lightning Static Electricity, National Severe Storms Lab, Norman Oklahoma, 1988.

Eriksson, A., Ornehult, L., *Death by Lightning*, American Journal of Forensic Medicine and Pathology Vol. IX, issue 4, pp. 295-300, 1988.

TABLE I RAW SYMPTOM SUMMARY

	RESPONDENT										KEY
PARAMETER	1	2	3	4	5	7	8	9	6	10	
Short Term Symptom				(Now Significant p < .05)							
Loss of Conc.	A	N	N	N	A	A	A	Y	A	N	A=Altered Conc. Y=Yes N=No
Ear Paraesthesia	+									++	
Pain		+								+++	
Tinnitus	+	+									
Burns Presence	Y			Y				Y			
Site	3			1				2			1=arm,leg,chin 2=mouth 3=singed hair
Arm Paraesthesia									++	++++	
Pain									++	++++	
Facial Swelling	+									++	
Nausea/Pain abdo		N						P	P		N=nausea P=pain
Tachycardia							++	+		+	
Haemoptysis								+			
Muscular Pain						1,3		2		3	1=Thorax 2=Back 3=Neck
Duration of initial Sympts	5	2	0	2	0	3	1	3	1	3	(Days)
Long Term Symptoms				(All significant p <.05)							
Nil	Y	Y	Y	Y	Y	Y	Y				
Duration								C	C	C	Currently Continuing
Psych. upset									+++	+	
Abdominal Pain								+	+		
Arm Pain/Paraes									+	+++	
Weakness										+++	
Headache									+		
Muscular Pain								+		+++	
Examination	In all cases, objectively normal										

TABLE 1 (continued)

	RESPONDENT										KEY
PARAMETER	1	2	3	4	5	7	8	9	6	10	
Telecom "Physical" Data	(* significant p <.05 Analysis 1)										
(supplemented by teams data)	(+ significant p <.05 Analysis 2)										
Location	U	U	R	R	U	U	R	U	S	U	U=Urban S=Suburban R=Rural
Topography	F	H	F	U	F	F	H	F	H	U	U=undulating H-hilly F=flat
Distance to nearest hill		20		200			0		25		(metres)
Storm intensity	L	L	L	L	M	S	S	M	?	L	Light, Mod, Severe
Concurrent Lighting	N	M	O	O	M	N	F	F	?	O	Light, Occas, Mod, Freq
Strike Distance	400	N	N	N	N	200	N	250	25	N	Not known, Otherwise Metres
Local Storm History	M	M	L	?	L	M	M	L	M	M	Light, Moderate
Power System Feed	O	U	O	O	U	O	O	U	O	U	)Overhead, Underground
Retic	O	U	O	U	U	O	U	U	U	U	)
Damaged in Strike	N	N	N	N	N	N	N	N	Y	N	* +
Appliances Damaged	N	Y	N	N	N	N	N	N	N	Y	* +
Phone Feed	U	U	U	O	U	U	U	U	U	U	
Retic	U	U	U	O	U	U	U	U	U	U	
Phone Damage	1	3	0	1	1	0	0	4	0	3	Scale 0-4
Building Constr.	B	B	T	B	B	B	F	B	B	C	Fibro, Brick, Concrete
High/Low Set	L	L	H	L	L	L	L	L	L	H	
Roof	M	T	M	?	T	M	M	M	T	.	Metal, Tile, .=Not applicable
Building Frame	M	T	T	T	T	T	M	M	T	?	Metal, Tile, ?=Unknown
Floor Height	O	O	A	O	O	O	O	O	O	A	On/Above ground
Floor Material	C	C	T	C	C	T	C	C	T	C	Timber/Covered Concrete
Body Contact	O	O	O	G	O	P	P	P	P	G	Good/Poor/No Earth
Shoes	N	N	N	Y	N	Y	N	Y	Y	Y	+
Handset Thrown	Y	N	Y	Y	D	D	N	Y	N	Y	Yes/No/Dropped
Service made faulty	Y	Y	N	Y	Y	N	N	Y	N	Y	
Sparks seen	N	N	N	Y	Y	N	N	Y	Y	N	
Self Thrown	N	Y	N	N	N	N	N	Y	N	Y	+
Acoustic Shock	3	3	0	0	0	2	1	0	0	0	Scale 0-3