Canad. M. A. J.
Feb. 1, 1959, vol. 80

Special Article

ELECTRICAL SHOCK*

WILLS MACLACHLAN, B.A.Sc., P.Eng.,
Maple, Ont.

ELECTRICAL SHOCK is a major hazard to the field forces of electrical utilities. As well as putting measures into effect to lessen this hazard, the utilities have trained all of their field forces in artificial respiration, based primarily on the work of Sir Edward Scharpey Schafer.

The Canadian Electrical Association instituted in 1922 a medal and certificate of award for employees of electrical utilities who successfully resuscitated a person who stopped breathing as a result of an electrical shock. The application forms for these awards detail most of the pertinent information of the accident and resuscitation. Up to June 30, 1957, 191 medals and 7 bars had been awarded, as a result of the saving of 186 lives.

In a large electrical utility, all of the electrical shock cases resulting in cessation of breathing in which artificial respiration was applied were recorded. These include those in which artificial respiration was successful in saving life and those in which it was not successful. An analysis of these two sets of data is shown in the following tables, with comments.

Analysis by Potential of Circuit

An analysis has been made of the medal cases and those of the large utility by potential of circuit involved in the shock. The results are shown in Table I.

TABLE I.

Potential of circuit	*Medal cases— % lives saved*	*Large utility series—% successful cases*
- 749 volts	13	100
750 v - 4999 "	47	48
5000 v - 39999 "	27	63
40000 v - —	9	80
Lightning	1	0
Induced current	1	20
Not given	2	—
Total	100	60

Over the 35-year period, manual artificial respiration (Schafer prone pressure) was successful in resuscitating 60% of all cases in the large utility series. It should be noted that the lowest percentage of successful cases was obtained with potentials of 750-4999 volts, where the highest percentage of medals was given. One is led to believe that shocks in this range are more numerous and very severe, probably because of the close contact. Extra precautions are needed in this range. In the under 749 volt range artificial respiration was successful in all cases in the large utility. Ventricular fibrillation either was absent in these cases or passed off. It should also be noted that 13% of the medal cases were in this range. The supply of rubber protective equipment, the development of safe practices, and training of men and close supervision may reduce the incidence of these accidents.

*An analysis of data from records of the Canadian Electrical Association Resuscitation medal cases and records of electrical shock cases of a large electrical utility over a 35-year period.

Analysis by Time of Day

An analysis of the cases by the hour of the day is shown in Table II.

TABLE II.

Hour of day	*Medal cases— % lives saved*	*Large utility series—% successful cases*
Midnight - 6 a.m.	1	33
6 a.m. - 7 "	1	—
7 " - 8 "	2	40
8 " - 9 "	4	50
9 " - 10 "	8	33
10 " - 11 "	10	54
11 " - 12 noon	9	59
12 noon - 1 p.m.	3	75
1 p.m. - 2 "	8	65
2 " - 3 "	11	65
3 " - 4 "	17	64
4 " - 5 "	12	80
5 " - 6 "	5	66
6 " - midnight	9	60
Total	100	60

Taking the normal day as from 8 a.m. to 12 noon and from 1 p.m. to 5 p.m., 31% of the medal cases concerned the morning and 48% the afternoon. In the large utility the success rate was 49% in the morning and 68% in the afternoon. No explanation is as yet available for this, nor is there one for the low point of successful cases between 9 and 10 in the morning. Is decrease of blood sugar at this time a factor? Fundamental research is very much indicated.

Analysis by Month

An analysis of the cases by month of the year is shown in Table III.

TABLE III.

Month of year	*Medal cases— % lives saved*	*Large utility series—% successful cases*
January	3	72
February	4	72
March	2	50
April	9	72
May	8	61
June	16	58
July	16	50
August	12	46
September	12	74
October	8	66
November	6	69
December	4	—
Total	100	60

Some years ago, an investigation was made of the hours worked per month by the field staffs of a group of electrical utilities over an 11-year

period. This study showed that only 28% of the hours worked per year were worked in June, July and August. This was a surprise, as it is generally thought that much more time is put in during the summer months. Table III shows that the months June, July and August were related to 44% of the medal cases, during which period the percentage of successful cases was low (48%), whereas for the other months of the year it was 67%. It is clear from this that electrical shock during the summer months is commoner and much more severe. Probably light clothing and perspiration are distinct factors.

Analysis of Medal Cases for Elapsed Time Between Shock and Start of Artificial Respiration

An examination was made of the medal cases for the elapsed time between shock and the start of artificial respiration. It was not possible to make a comparison in this analysis with the results in the large utility. Employees in this utility had had the importance of prompt application of artificial respiration after shock stressed for over 35 years. In both successful and unsuccessful cases artificial respiration was started in less than three minutes in 85% of the cases. This again emphasizes the importance of prompt application of artificial respiration, as pointed out in earlier papers. The analysis of medal cases is shown in Table IV.

TABLE IV.

Time between shock and start of artificial respiration	*% cases*
- 59 seconds	45
1 minute -1 minute 59 seconds	13
2 minutes - 2 minutes 59 "	13
3 " - 4 " 59 "	13
5 " - 9 " 59 "	5
10 " - —	5
Not given	6
Total	100

It is clear that prompt application of artificial respiration is very important, for 71% of the recoveries in the medal cases were obtained when artificial respiration was started in less than three minutes. It is of interest that in 5% of the medal cases artificial respiration was started after 10 minutes. Prompt resuscitation is very desirable, but where there is an unavoidable delay a life may yet be saved.

The medal cases were analyzed according to the time elapsing between the start of artificial respiration and spontaneous breathing (Table V).

Although 65% were breathing under 20 minutes, 17% needed artificial respiration for more than 30 minutes, some for hours. This clearly shows the necessity in some cases of continuing artificial respiration for extended periods, of training in changing the operator and of having all men trained. Quoting Jex-Blake in the *British Medical Journal* of March 1913, "Nothing less than the onset of rigor mortis should be taken as evidence of death here."

TABLE V.—TIME OF ARTIFICIAL RESPIRATION UNTIL ONSET OF SPONTANEOUS RESPIRATION

	% cases
- 4 minutes 59 seconds	11
5 minutes - 9 " 59 "	26
10 " - 14 " 59 "	11
15 " - 19 " 59 "	17
20 " - 29 " 59 "	16
30 " - —	17
Not given	2
Total	100

It is acknowledged that in studying actual cases from the field one cannot be as dogmatic as in animal experiments in the laboratory where one variable can be studied and the other variables controlled, and the experiment repeated many times. Yet in field cases one is studying the problem as it actually occurs.

CONCLUSION

Men adequately trained in manual artificial respiration (without the use of apparatus) have saved the lives of a high percentage of those who received severe electrical shocks. To increase the number of lives saved, fundamental research into the effect of the passage of electrical current through animal cells, nerves and organs is needed. Based upon this research, practical remedial measures should be developed that can be put into effect in the field.

REFERENCES

1. JEX-BLAKE, A. J.: *Brit. M. J.*, 1: 425, 492, 548, 601, 1913.
2. URQUHART, R. W. I.: *J. Indust. Hyg.*, 9: 140, 1927.
3. URQUHART, R. W. I. AND NOBLE, E. C.: *Ibid.*, 11: 154, 1929.
4. ETTINGER, G. H.: *Am. J. Physiol.*, 105: 457, 1933.
5. *Idem*: *Ibid.*, 111: 406, 1935.
6. BANTING, F. G. *et al.*: *Canad. M. A. J.*, 39: 226, 1938.
7. MACLACHLAN, W.: *J. Indust. Hyg.*, 12: 291, 1930.
8. *Idem*: *Ibid.*, 16: 52, 1934.
9. *Idem*: *Electrical Engineering*, 70: 871, 1951.

DO-IT-YOURSELF MEDICINE

"Finally, let us consider the progress of the recently graduated resident as he enters practice. Here for the first time he is made aware of the great gap which separates the teaching hospital and the workaday world of practice. The marvelously interesting and unusual cases in the wards are gone; in their place he finds patients with the most prosaic complaints. When the patient with something out of the ordinary does come along, as he does inevitably, where are the laboratory facilities of his training years? He learns to his sorrow that urinary gonadotropins and catechols, irradiated triolein uptakes, and blood-ammonia determinations are not easy to come by. Then, too, he often finds that some of the routine laboratory work available to him is not of the quality provided by the more skilled technicians of his medical school. I am certain that many a budding young internist feels as the rich man Dives did in the parable when he called from his place of torment upon the beggar Lazarus in Abraham's bosom and heard from the patriarch's lips the answer, 'Between us and you there is a great gulf fixed; so that they which would pass from hence to you cannot!' "—A. M. Snell: *A.M.A. Arch. Int. Med.*, 102: 926, 1958.